

# DIRECCIÓN DE NUEVAS CREACIONES

## SOLICITUD FASE NACIONAL - PCT

### 1 Título de la Invención(200 caracteres o espacios máximos)

SISTEMA DE LAGO FLOTANTE Y MÉTODOS PARA TRATAR AGUA DENTRO DE UN LAGO FLOTANTE

### 2 Datos del Solicitante

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☐ PASAPORTE

☐ CEDULA DE EXTRANJERIA  
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Número reivindicaciones:

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Pago Reivindicaciones:

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11

### Reducción de tasas.

*Declaro que carezco de medios económicos para presentar la solicitud de patente.*

☐ SI ☒ NO

**Nota: En caso de ser persona natural y carecer de medios económicos, y por lo tanto, aplique la reducción de tasas a que se refiere la resolución vigente en tarifas, debe firmar la presente solicitud bajo la gravedad de juramento.**

- ☐ Micro, pequeñas y medianas empresas  
☐ Universidades públicas o privadas  
☐ Entidades sin ánimo de lucro

**Debe aportar los documentos que se indican en el numeral 17 de anexos**

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### Documentos Anexos

- ☒ Reivindicaciones  
☒ Descripción  
☐ Dibujos y/o Figuras  
☒ Resumen

- ☐ Certificado Depósito Material Biológico
- ☐ Uso de Conocimiento tradicional
- ☐ Listado de secuencias
- ☐ Artes finales 12 x 12 cm
- ☒ Poderes, si fuere el caso
- ☐ Copia de la primera solicitud si se reivindica prioridad
- ☐ Traducción simple de la primera solicitud, si se reivindica prioridad
- ☒ Otros Anexos

# **SISTEMA DE LAGO FLOTANTE Y MÉTODOS PARA TRATAR AGUA DENTRO DE UN LAGO FLOTANTE**

## **Referencias Cruzadas a Solicitudes Relacionadas**

La presente solicitud reivindica prioridad de Solicitud Provisional E.E.U.U. No. 61/900.308, presentada el 5 de Noviembre de 2013, que se incorpora como referencia en su totalidad.

## **Campo de la Invención**

La presente invención se refiere a un método y sistema para tratar y construir lagos flotantes, que son contruidos dentro de grandes cuerpos de agua, donde la calidad del agua y/o características estéticas dentro de lagos flotantes cumpliendo con diferentes estándares recreacionales o estándares más exigentes.

## **Antecedentes**

En todo el mundo, existe un gran número de cuerpos de agua en los cuales las condiciones microbiológicas, fisicoquímicas, y/o estéticas del cuerpo de agua no son aceptables para propósitos recreacionales, tal como baño y la práctica de deportes acuáticos que tienen contacto directo con el agua. La calidad del agua en estos cuerpos de agua es tal que plantea riesgos sanitarios y de seguridad potenciales a las personas que entran en directo contacto con el agua. Además, las condiciones estéticas de estos cuerpos de agua podrían no ser atractivas, agradables, y/o ideal que pueden desalentar aún más el uso recreativo. Estanques de campos de golf, estanques de retención, estanques de parques públicos, represas, ríos, lagos, el océano, bahías del océano, bahías de ríos y similares son ejemplos de cuerpos de agua que pueden tener condiciones microbiológicas, fisicoquímicas, y/o estéticas haciendo al cuerpo de agua inadecuado para usos recreacionales. Estos cuerpos de agua pueden ser encontrados en el medio de ciudades con una gran población, o lugares rurales o con baja población.

Como la población mundial continúa creciendo, la tierra se está convirtiendo en un recurso escaso con muchas áreas de tierras siendo ocupadas a gran velocidad. Áreas costeras atraen a mucha gente debido a la proximidad del mar o ríos. Sin embargo, el rápido desarrollo de estas áreas a menudo resulta en tierras disponibles para ser utilizadas

para viviendas o industrias que limitan la oportunidad de usar las áreas para propósitos recreacionales. En áreas no costeras, muchas personas no tienen acceso o no viven cerca de cuerpos de agua que tienen una calidad de agua y/o condiciones estéticas adecuadas para el uso recreacional. Dentro de las ciudades con una gran población que tienen cuerpos de agua naturales o artificiales, la tierra disponible es típicamente usada para viviendas o industrias sin dejar espacios en tierra firme para generar cuerpos de agua que pueden mejorar la calidad de vida de las personas en estas ciudades proporcionando la oportunidad para la práctica de deportes acuáticos y otros usos recreacionales asociados con un cuerpo de agua. Además, los cuerpos de agua ubicados dentro de áreas densamente pobladas podrían no ser adecuados para uso recreacional debido a escombros, contaminación, y/o condiciones inseguras del cuerpo de agua (tal como fondos inclinados, poca claridad, y topografía subacuática desconocida).

Muchas personas alrededor del mundo aspiran a tener acceso a lugares que tengan cuerpos de agua similares a mares tropicales, donde la calidad del agua tiene una baja turbiedad, alta transparencia y claridad que genera un efecto de agua cristalina y fondos de arena blanca que crean una característica estética que es atractiva y deseable. La claridad del agua dentro de mares tropicales atrae a turistas de todo el mundo. Por ejemplo, en el año 2012, las áreas dentro y alrededor del Caribe recibieron cerca de 25 millones de turistas, 5,4% más que el año 2011 y se espera que dicho número continúe creciendo anualmente. Dado el gran número de cuerpos de agua alrededor del mundo, existe una necesidad de transformar cuerpos de agua antiestéticos y con un poca calidad de agua con el fin de que sean capaz de usarlos efectivamente para propósitos recreacionales en una manera segura. Por lo tanto, sería deseable transformar un cuerpo de agua o una porción de los mismos para proporcionar un cuerpo de agua que tiene calidad de agua y cualidades estéticas proporcionadas por un mar tropical. La capacidad para transformar tales cuerpos de agua proporcionaría desarrollo económico para las comunidades locales, como así también mejorar el estilo de vida de un gran sector de la población de alrededor de todo el mundo trayendo un ambiente de mar tropical atractivo a un cuerpo de agua existente que no es adecuado para propósitos recreacionales.

Se han realizado varios estudios en lagos, embalses y estanques de Estados Unidos. Por ejemplo, de los más de 17 millones de acres de lagos, embalses y estanques evaluados, más del 44% se encontraron desmejorados por uno o más usos. Se encontró que estos

cuerpos de agua fueron afectados por nutrientes, metales, sedimentación, sólidos disueltos totales, y exceso de crecimiento de algas, entre otros efectos. Se determinó que más del 41% de los lagos dentro de Estados Unidos poseen un alto o moderado riesgo a la exposición potencial a toxinas de algas, las cuales podrían potencialmente tener un amplio rango de impacto en la salud de los humanos. Estos estudios también encontraron que existen más de 140.000 cuerpos de agua que potencialmente podrían ser usados para propósitos recreacionales, tal como baño o para la práctica de deportes acuáticos que tienen un contacto directo con el agua, si la calidad del agua y/o las condiciones estéticas fueran más adecuadas. Generalmente, estos cuerpos de agua no son adecuados para propósitos recreacionales debido a la mala calidad del agua y/o a las condiciones estéticas que no cumplen con los estándares de calidad del agua recreacional o estética.

Además, muchos cuerpos de agua existentes, tanto naturales como artificiales, no son adecuados para propósitos recreacionales y deportes acuáticos por razones de seguridad asociadas con peligros físicos, tal como corrientes fuertes, bordes costeros peligrosos, y/o características del fondo inciertas o peligrosas, y virtualmente ninguno de ellos tienen características estéticas de mares tropicales. En estos cuerpos de agua, los bañistas o aquellos que practican deportes acuáticos podrían estar expuestos a uno o más riesgos. Por ejemplo, pueden ocurrir ahogos si es que los bañistas o participantes de deportes acuáticos son atrapados en una marea u otros tipos de corrientes o atrapados por obstáculos sumergidos. Los bañistas o participantes de deportes acuáticos pueden también ser heridos por resbalones o caídas en las rocas o tipos generales de escombros y/o por áreas de playa u otras áreas del borde costero con pendientes que pueden ser poco conocidas y representan un riesgo para la seguridad.

Con el fin de permitir propósitos recreacionales, un cuerpo de agua generalmente debe cumplir con regulaciones estrictas específicas para evitar contaminación microbiana y/o física química que pueden causar efectos negativos en la salud para los usuarios recreacionales. Esto es de especial importancia en grupos de población específicos que tienen un alto riesgo de enfermedad, tal como los jóvenes y adultos mayores. Además, los efectos de las algas se deben tomar en cuenta, ya que varias enfermedades humanas han sido reportadas que están asociadas con especies tóxicas de algas que pueden ser encontradas en cuerpos de agua. Tales regulaciones ayudan a controlar la calidad micro-

bacteriológica y/o físico química del agua para proporcionar agua que es segura para el uso recreacional que implican el contacto directo con el agua.

Existen también muchos cuerpos de agua que tienen una calidad de agua adecuada para propósitos recreacionales pero no son estéticamente atractivos debido a que los fondos están cubiertos con sedimentos, escombros, y/o lodo que proporcionan una coloración oscura y desagradable al cuerpo de agua. Los requerimientos para la calidad del agua para propósitos recreacionales que a menudo incluyen requerimientos dirigidos a la condición estética del agua. Estos requerimientos generalmente establecen que el cuerpo de agua debería estar libre de escombros flotantes, algas flotantes, aceite, espuma y otros materiales que puedan establecerse para formar depósitos, libres de sustancias que pueden producir color objetable, olor, sabor o turbidez, y libre de sustancia que producen una vida acuática indeseable. Las regulaciones requieren que el agua de áreas recreacionales sean lo suficientemente limpias para permitir a los usuarios estimar la profundidad, ser capaces de ver fácilmente peligros sumergidos, y detectar escombros sumergidos o peligros físicos, tal como rocas y fondos inclinados. Generalmente, la cantidad de luz que puede alcanzar el fondo del cuerpo de agua es determinante en la claridad del agua. Sin embargo, la profundidad de la penetración de la luz en cuerpos de agua naturales o artificiales puede ser afectada por plantas microscópicas suspendidas y animales, partículas de minerales suspendidas, manchas que imparten color, aceites y espumas, y escombros flotantes y suspendidos tal como hojas, basura, y otros.

Existen muchos lugares a través del mundo que se podrían ver beneficiados con grandes cuerpos de agua que tengan una calidad de agua adecuada y/o condiciones estéticas para propósitos recreacionales y la práctica de deportes acuáticos. Sin embargo, tales grandes cuerpos de agua no pueden ser tratados con tecnologías actuales o con tecnología de filtración de piscinas convencionales por las razones obvias basadas en sus grandes tamaños, que requerirían nuevas estructuras, y altas cantidades considerables de químicos y energía. En muchos casos, modificaciones estructurales de los cuerpos de agua naturales o artificiales deberían también ser realizadas dirigidas a condiciones estéticas, tal como cambiar el fondo que está cubierto con sedimentos, escombros, y/o lodo, y condiciones peligrosas, tal como proporcionar inclinaciones seguras para las áreas de playa, entre otros requerimientos. Actualmente no existen tecnologías económicamente viables que proporcionen un cambio completo de toda la calidad del agua de grandes lagos

u otros cuerpos de agua naturales o artificiales y/o proporcionar una coloración atractiva a cuerpos de agua que ya poseen una buena calidad de agua pero que tienen características anti estéticos que desaniman el uso recreacional. Por lo tanto, existe una necesidad de un sistema y métodos capaces de transformar un cuerpo de agua natural o artificial para proporcionar un área dentro del cuerpo de agua que tenga calidad de agua y/o cualidades estéticas adecuadas para el uso recreacional y la práctica de deportes náuticos.

### **Arte Previo**

La patente de E.E.U.U. No. 4.087.870 divulga un ensamble de piscina flotante que incluye paredes hechas de una hoja flexible, una porción de borde flotante, y un ensamble de filtro. La piscina flotante está diseñada para tratamiento de piscinas convencional y proporciona características operacionales similares una instalación de piscina permanente, tal como un sistema de filtración centralizado que filtra el volumen total de agua de la piscina flotante desde 1 a 6 veces por día y una concentración química permanente. Tal sistema no sería adecuado para el uso con un gran lago flotante, ya que usa tratamiento de agua de piscinas convencional y tecnología de filtración que son técnica y económicamente inviables para aplicar a un gran lago flotante.

El documento U.S. 2005/0198730 divulga un aparato de piscina flotante. Los componentes estructurales principales están contruidos de un plástico reforzado con fibra de vidrio a prueba de agua que es rígido, lo que resulta en costos considerablemente altos de materiales y no proporcionan la flexibilidad para hacer frente a al movimiento de agua y cargas estructurales asociadas con un gran lago flotante. Además, tal aparato es muy difícil de escalar a grandes lagos flotantes debido a sus limitaciones estructurales.

### **Resumen**

La presente invención se relaciona a lagos flotantes y al tratamiento de agua en dichos lagos. La presente invención además se relaciona a grandes lagos flotantes instalados dentro de un cuerpo de agua natural o artificial.

Las dimensiones del lago flotante, incluyen profundidad y área superficie del lago flotante, que puede variar en función de las necesidades y recursos existentes, como también el área de superficie y otras características físicas del cuerpo de agua. El lago flotante puede estar provisto con un sistema de aplicación de químicos; un sistema de

filtración incluyendo un dispositivo de succión móvil y filtros; un sistema de espumadera y puede también comprender un sistema de coordinación. El sistema y método de la presente invención puede estar configurado para proporcionar ahorros significantes de costos debido a costos de capital, consumo de energía y uso químico más bajos que los sistemas convencionales. Esto es debido a que la activación de los métodos de la presente solicitud basados en requerimientos reales del cuerpo de agua, a través de la evaluación de variables específicas, también debido a los estándares de ORP más bajos requeridos comparados con el tratamiento de piscina convencional, y debido al uso de un sistema de filtración eficiente basado en el color del fondo de los lagos flotantes.

La presente invención se relaciona a un método para el tratamiento de agua en un lago flotante instalado en un cuerpo de agua, el lago flotante tiene paredes y fondo, donde el fondo del lago flotante está construido de un material flexible que tiene un Módulo de Young de hasta 20 GPa. El método generalmente comprende aplicar un oxidante al agua en el lago flotante para mantener un nivel de ORP de al menos 550 mV para un mínimo de alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas; aplicar un floculante al agua en el lago flotante antes de que la turbidez del cuerpo de agua exceda 5 NTU; succionar con un dispositivo de succión móvil cuando el componente de color negro del fondo del lago flotante exceda el 30% en una escala de CMYK, donde el dispositivo de succión móvil succiona una porción de agua desde el fondo del lago flotante que contiene sólidos sedimentados; filtrar el agua succionada por el dispositivo de succión móvil y devolver el agua filtrada al lago flotante; y suministrar agua al lago flotante para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de la superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días y donde el agua es suministrada al lago flotante en una tasa de reposición de acuerdo a la siguiente ecuación:

$$\textit{Tasa de Reposición} \geq \textit{Tasa de Evaporación} + \textit{Tasa de Limpieza} + \textit{Tasa de Fuga}.$$

La presente invención también se relaciona a la estructura de un lago flotante. Un lago flotante de la invención generalmente comprende un fondo flexible que tiene un Módulo de Young de menos que alrededor de 20 GPa; paredes que tienen un borde, donde el borde comprende un sistema de flotación; un sistema de bombeo para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de la superficie del

lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días; un sistema de aplicación de químicos para aplicar químicos tal como un oxidante o floculante al agua del lago flotante, un dispositivo de succión móvil capaz de moverse por todo el fondo flexible del lago flotante y succionar una porción de agua desde el fondo que contienen sólidos sedimentados, un sistema de filtración en comunicación fluida con el sistema de succión móvil, donde el sistema de filtración recibe la porción de agua succionada por el sistema de succión móvil; una línea de retorno para devolver el agua filtrada desde el sistema de filtración al lago flotante. El sistema puede también comprender un sistema de coordinación, donde el sistema de coordinación activa la operación del sistema de aplicación de químicos.

### **Breve Descripción de las Figuras**

La Figura 1 muestra una realización de un lago flotante de acuerdo con la presente invención.

La Figura 2 muestra un acercamiento de una realización de un lago flotante de acuerdo a la presente invención.

La Figura 3 es una ilustración esquemática de la sección transversal de un lago flotante de acuerdo a la presente invención.

Las Figuras 4A a 4C son ilustraciones esquemáticas de las estructuras en capas usadas en lagos flotantes de la presente invención.

La Figura 5 es una ilustración esquemática de una realización de un lago flotante de acuerdo a la presente invención.

La Figura 6 es una ilustración esquemática de una realización de un lago flotante de acuerdo a la presente invención.

La Figura 7 es una ilustración esquemática de una realización de un lago flotante de acuerdo a la presente invención.

La Figura 8 es una ilustración esquemática de una realización de un dispositivo de succión de acuerdo a una realización de la presente invención.

Las Figuras 9A y 9B muestran realizaciones del lago flotante de la Figura 1.

Las Figuras 10A y 10B son ilustraciones esquemáticas de un sistema de marco estructural para el lago flotante de la Figura 1.

Las Figuras 11A y 11B son ilustraciones esquemáticas de una sección inflable para el lago flotante de la Figura 1.s.

La Figura 12A es una ilustración esquemática de diferentes disposiciones de las secciones inflables dentro del fondo del lago flotante de la Figura 1.

Las Figuras 12B y 12C son ilustraciones esquemáticas de una sección transversal parcial de las secciones inflables de la Figura 12A.

### **Descripción Detallada**

La siguiente descripción detallada se refiere a los dibujos adjuntos. Aunque las realizaciones de la invención pueden ser descritas, modificaciones, adaptaciones y otras implementaciones son posibles. Por ejemplo, sustituciones, adiciones, o modificaciones pueden ser hechas a los elementos ilustrados en los dibujos, y los métodos descritos aquí pueden ser modificados mediante la sustitución, reordenamiento, o la adición de etapas de los métodos descritos. En consecuencia, la siguiente descripción detallada no limita el alcance de la invención. Aunque los sistemas y métodos están descritos en términos de “comprenden” varios aparatos o etapas, los sistemas y métodos pueden también “consistir esencialmente de” o “consiste de” los varios aparatos o niveles, al menos que se establezca lo contrario.

### **Sistemas y Métodos de la Presente Invención**

La presente invención se relaciona a sistemas de lago flotante y métodos para el tratamiento y mantención de la calidad de agua en los lagos flotantes.

La presente invención se relaciona a grandes lagos flotantes con agua cristalina similar a los mares tropicales, donde los grandes lagos flotantes son generalmente instalados dentro de un cuerpo de agua natural o artificial, tal como un océano, río, lago, embalse, lagunas, represas, estanques, canales, puertos, estuarios, arroyos, bahías de

océano, bahías de ríos, u otros cuerpos de agua. Aunque la invención presenta realizaciones como “dentro de” varios cuerpos de agua, será apreciado por aquellos expertos en el arte que la realización puede incluir un borde que es adyacente a un borde costero o playa.

La presente solicitud también se relaciona a un método para el tratamiento de grandes lagos flotantes, con el fin de tomar ventaja de cuerpos de agua a través del mundo que sufren de una mala calidad del agua y/o malas características estéticas, y para ayudar a mejorar la calidad de vida de las personas alrededor del mundo. Los lagos flotantes de la presente solicitud permiten el uso recreativo, junto con la práctica de deportes acuáticos en condiciones seguras, y pueden generar un impacto geográfico sin precedentes en las comodidades de las ciudades alrededor del mundo. Los lagos flotantes de la presente solicitud generan una característica estética que no podría ser generada económicamente con las tecnologías actuales, causando un impacto mayor en el uso de cuerpos de agua naturales o artificiales que no fueron considerados útiles antes.

Las dimensiones del lago flotante, incluyendo profundidad y área de la superficie del lago flotante, pueden variar basado en la necesidad de recursos existente, como también del área de la superficie y otras características físicas del cuerpo de agua, tal como obstáculos sumergidos, profundidad, y similares, en la cual el lago flotante es construido. Por ejemplo, en algunas realizaciones, el lago flotante puede tener un área de superficie de al menos 5.000 m<sup>2</sup>, o al menos 10.000 m<sup>2</sup>, o al menos 20.000 m<sup>2</sup>.

Una realización del método para el tratamiento está dirigida a proporcionar tratamiento de grandes lagos flotantes que están instalados dentro de cuerpos de agua naturales o artificiales. Tales cuerpos de agua naturales o artificiales pueden tener calidad de agua que no cumpla con requerimientos sanitarios y/o estéticos para propósitos recreacionales, o con más requerimientos exigentes. Se proporcionan sistemas de lagos flotantes diseñados especialmente, los cuales permiten aplicar el método de la presente invención.

De acuerdo a las realizaciones, el lago flotante puede ser instalado en aguas naturales o artificiales. Las Figuras 1 y 2 muestran una realización ejemplar de un lago flotante instalado en una vía fluvial. El lago flotante puede, por ejemplo, proporcionar una característica de agua recreacional en una ciudad u otro municipio en un área que de otra

manera no ofrece calidad de agua y/o condiciones estéticas adecuadas para usos recreacionales. El lago flotante puede ser instalado para mejorar las condiciones del agua que son inadecuadas para usos recreacionales debido a contaminación química o biológica, preocupaciones de seguridad, o razones estéticas.

El lago flotante puede ser construido para proporcionar flotabilidad y para acomodarse a los cambios en el nivel del cuerpo de agua circundante. Por ejemplo, el sistema de lago flotante puede estar diseñado para ser capaz de flotar con cambios en el nivel del agua del cuerpo de agua circundante. En tal caso, cuando el nivel del agua del cuerpo de agua circundante baja (por ejemplo, en marea baja), el sistema de lago flotante completo puede ser bajado con la superficie del cuerpo de agua natural. Por otro lado, cuando el nivel de agua del cuerpo de agua circundante aumenta, el lago flotante puede subir con este. Esto es porque los sistemas de flotación del sistema de lago flotante proporcionan flotabilidad al lago flotante y son capaces de mantener la superficie del lago flotante en o cerca del nivel de la superficie del cuerpo de agua circundante. En realizaciones alternativas, al menos alguna parte del fondo del lago flotante puede entrar en contacto con el fondo del cuerpo de agua circundante en niveles de agua bajos, o puede estar en contacto con el fondo en todo momento.

Cambios en los niveles del agua y movimiento del agua en el lago flotante y en el cuerpo de agua circundante debido a mareas, corrientes, y olas naturales causadas por el viento y otros fenómenos pueden causar cambios en la presión en contra o cargas sobre el fondo del lago flotante. La estabilidad estructural del lago flotante puede ser tomada en cuenta en el diseño de la estructura, por ejemplo, para hacer frente a las cargas generadas cuando la estructura se fija verticalmente en una posición relativa al fondo del cuerpo de agua circundante. La estructura puede ser diseñada para hacer frente a tales cargas proporcionando un flexible pero estable fondo que puede oscilar o mover de acuerdo al movimiento del cuerpo de agua circundante. También, la estructura puede comprender un sistema de anclaje que proporciona soporte vertical y/u horizontal al sistema de lago flotante para enfrentar las fuerzas bajo el agua.

De acuerdo a una realización que se muestra en la Figura 3, el lago flotante 1 puede comprender un fondo flexible 2 y paredes 3. El fondo 2 y paredes 3 pueden comprender un recubrimiento 200 construido de materiales impermeables que son capaces de mantener un

cuerpo de agua dentro del lago flotante y esencialmente separar el agua de adentro del lago flotante del cuerpo de agua natural o artificial circundante. Ejemplos de materiales adecuados, pero no limitados a, gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, Tablero de fibras, madera, poliamidas, membranas de PVC, telas, telas compuestas, geo membranas, acrílicos, entre otros, y combinaciones de los mismos. El recubrimiento 202 del fondo 2 puede ser continuo con el recubrimiento 203 de las paredes 3. En una realización alternativa, el recubrimiento 202 del fondo 2 está construido de diferentes materiales que los del recubrimiento 203 de las paredes 3.

De acuerdo a una realización, el fondo 2 y/o paredes 3 comprenden una pluralidad de capas, donde tales capas pueden ser de materiales iguales o diferentes, y los cuales pueden variar en su permeabilidad. Se pueden proporcionar capas adicionales para ayudar a evitar la filtración de agua del lago flotante en el cuerpo de agua circundante. Con el fin de reducir la pérdida de agua del lago flotante al cuerpo de agua circundante, se puede proporcionar de un sistema de recolección o drenaje entre las diferentes capas del fondo. También, varias estructuras pueden ser usadas para proporcionar un cierto nivel de rigidez al fondo y/o paredes del lago flotante. Un fondo 2 con una cierta cantidad de flexibilidad podrá resistir mucho mejor pinchazos, roturas, y otros daños al lago flotante<sup>1</sup>.

El módulo de Young o módulo elástico de un material es una medida de la elasticidad del material. Los números más altos indican un material más rígido y los números más bajos un material más elástico. Con el fin de proporcionar un fondo flexible, el módulo de Young de los materiales o componentes usados en el fondo 2 es típicamente no más que alrededor de 100 GPa, alrededor de 50 GPa, alrededor de 20 GPa o alrededor de 15 GPa o 10 GPa, permitiendo así que el componente del fondo tenga flexibilidad y vuelva a su estado natural en lugar de deformarse considerablemente o romperse debido a las cargas aplicadas al material por el agua circundante, agua del lago flotante o presiones resultantes de, por ejemplo, la acción de un dispositivo de succión móvil.

De acuerdo a realizaciones, el recubrimiento 200 está hecho de componentes flexibles con un módulo de Young de hasta alrededor de 20 GPa. En una realización, el recubrimiento 200 está hecho de componentes flexibles con un módulo de Young de hasta alrededor de 10 GPa. En otra realización, el recubrimiento 200 está hecho de componentes

flexibles con un módulo de Young de alrededor de 0,01 hasta alrededor de 20 GPa. En otra realización, el recubrimiento 200 está hecho de componentes flexibles con un módulo de Young de alrededor de 0,01 hasta alrededor de 15 GPa. En aún otra realización, el recubrimiento 200 está hecho de componentes flexibles con un módulo de Young de alrededor de 0,01 hasta alrededor de 10 GPa. Diferentes porciones del recubrimiento 200 (por ejemplo, el recubrimiento del fondo 202 o recubrimiento de la pared 203) puede estar construido de diferentes componentes.

El fondo flexible 2 proporciona muchos beneficios al lago flotante 1. Por ejemplo, un fondo flexible 2 ofrece una opción de bajo costo para las estructuras del lago flotante, que puede resistir presión sin ser pinchado o dañado, es fácil de instalar, y se puede acomodar al movimiento del agua de adentro y fuera del lago flotante. Por otro lado, un fondo completamente rígido sería muy caro, difícil de instalar, y sería fácilmente dañado debido a las grandes cargas generadas por el cuerpo de agua circundante. Mediante el uso de fondos completamente rígidos, las cargas generadas por el agua circundante podrían causar que se aflojen los materiales, que se rompa la estructura, y que el agua contenida dentro del lago flotante sea contaminada y mezclada con el agua circundante, por lo tanto, no alcanzar la calidad del agua y/o condiciones estéticas para propósitos recreacionales.

El fondo 2 del lago flotante 1 puede comprender uno o más materiales y configuraciones. En realizaciones, el lago flotante 1 puede tener un fondo 2 configurado en una o más capas. Como se muestra en las Figuras 4A – 4C, el fondo 2 puede tener una estructura en capas. En una realización mostrada en la Figura 4A, la estructura en capas del fondo 2 puede comprender una sola capa. En otra realización mostrada en la Figura 4B, la estructura en capa del fondo 2 puede comprender dos capas. En aún otra realización mostrada en la Figura 4C, la estructura en capas del fondo 2 puede comprender múltiples capas.

Las diferentes capas pueden ser combinadas para proporcionar al fondo 2 con diferentes características, tal como durabilidad, impermeabilidad, estabilidad, y resistencia y/o flexibilidad. En una realización, el fondo 2 y paredes 3 están construidas de materiales iguales o diferentes. Alternativamente, el fondo 2 puede estar construido de materiales diferentes que las paredes 3, o puede tener una estructura de capas diferente. El módulo de

Young del material del fondo es usado para referirse al fondo como un todo, el cual puede comprender uno o más materiales distintos en diferentes configuraciones.

De acuerdo a realizaciones, el fondo 2 comprende componentes o materiales tales como, gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, tableros de fibra, madera, poliamidas, membranas de PVC, telas, acrílicos, entre otros, y combinaciones de los mismo que son capaces de proporcionar un fondo flexible con un módulo de Young global de hasta 20 GPa. En muchas realizaciones, cada una de las capas del fondo 2, independientemente, tienen un módulo de Young de a lo más 20 GPa.

En una realización ejemplar, el fondo 2 y paredes 3 comprenden una capa de tela, por ejemplo una tela compuesta, tal como tela impermeable Hipora® que consiste de una tela de nylon con inyección de poliuretano con características impermeables. La tela puede ser cosida y sellada para generar el fondo 2 y paredes 3 del lago flotante 1, creando una estructura que puede sostener el agua en el lago flotante 1 sustancialmente separar del agua circundante, y proteger el agua del lago flotante de la infiltración de agua circundante.

En otra realización ejemplar, el fondo 2 y paredes 3 comprenden una capa de polietileno lineal de baja densidad (“LLDPE” por sus siglas en inglés). Por ejemplo, el fondo 2 y paredes 3 pueden comprender una geo membrana de LLDPE que puede ser termo fusionado, soldado, o pegado junto con un sellante adecuado para el contacto prolongado con agua. En otra realización ejemplar, el fondo 2 y paredes 3 comprenden una capa de un materia de PVC de alta resistencia. Otros materiales adecuados incluyen geotextiles, materiales de PVC, materiales elastoméricos o aerosoles de polímero o como geo compuestos multi capa de bitumen. El grosor del recubrimiento puede ser de cualquier grosor adecuado para el propósito y puede ser ajustado para encajar con los requerimientos del lago flotante 1, por ejemplo, durabilidad, resistencia a pinchazos, estabilidad, y resistencia/flexibilidad. El grosor del recubrimiento puede ser, por ejemplo, alrededor de 0,4 mm, 0,5 mm, 0,75 mm, 1mm, o más grueso. El recubrimiento puede ser incluido como una capa en la estructura en capas, tal como la estructura multi capa en la Figura 4C. Sellantes adecuados para unir secciones del fondo 2 unas a las otras o a las paredes 2 son las cintas de butilo, que son cintas resistentes al agua, auto-pegables, flexible y de sellado adhesivo flexible capaces de adherirse a plásticos. Materiales prueba de agua y técnicas de

sellado, tal como termo fusión, soldado o pegado, también permiten generar una estructura que pueden sustancialmente separar el agua en el lago flotante 1 del agua circundante.

El fondo puede también incluir uno o más marcos estructurales. Los marcos estructurales pueden ser contruidos para acomodar una configuración modular del sistema de lago flotante. Como se puede ver en la Figura 10A, el lago flotante 1 puede comprender uno o más marcos estructurales 15 ubicado en el fondo del lago flotante 1. Los marcos estructurales pueden ser contruidos para ser posicionados por debajo o encima de la estructura en capas del fondo 2, o entre las capas. Sin embargo, los marcos estructurales están preferentemente posicionados por debajo del fondo con el fin de proporcionar la estructura pero sin afectar la impermeabilidad del lago flotante. El marco estructural 15 puede unirse en una configuración basada en la forma del fondo del lago flotante 1 para proporcionar estabilidad adicional al fondo. En la Figura 10B, se muestra una realización del lago flotante 1, que comprende un fondo 2 con marcos estructurales 15, paredes 3, y sistemas de flotación 5. En al menos algunas realizaciones, se pueden proporcionar también marcos estructurales en las paredes 3 del lago flotante 1, para proporcionar más estabilidad y para mantener la forma del lago flotante 1. El marco estructural 15 puede estar conectado al borde 4 y/o al sistema de flotación 5.

El marco estructural 15 puede ser contruido de materiales rígidos o flexibles. Los materiales pueden ser seleccionados para ser adecuados a las condiciones bajo el agua, ya que el marco estructural estará generalmente ubicado bajo el agua. Marcos rígidos, tuberías, o perfiles para generar un marco estructural rígido pueden ser contruidos de cualquier material adecuado. Ejemplos de materiales rígidos incluyen metales, tal como acero o aluminio, plásticos, madera, y concreto, entre otros materiales. Marcos flexibles, tuberías, mangueras, o perfiles para generar un marco estructural flexible pueden ser contruidos de cualquier material adecuado para construir un marco flexible. Ejemplos de materiales flexibles incluyen plásticos, gomas, telas, y nylon, entre otros materiales.

El marco estructural 15 puede ser contruido de componentes del marco 150 que pueden ser conectados mediante el uso de conectores 151. Los conectores 151 y materiales de conector pueden ser seleccionados basados en la configuración de diseño y materiales de los componentes del marco 150. Conectores del marco 151 pueden incluir materiales flexibles y rígidos. Conectores del marco 151 adecuados incluyen anillos, sistemas de

juntura mecánica tal como soldadura, placas, tornillos, cables, entre otros. Los conectores 151 pueden además ser usados para conectar los componentes del marco 150 al resto de la estructura del lago flotante 1.

De acuerdo a realizaciones, las paredes 3 pueden adicionalmente incluir un borde 4, como se muestra en las Figuras 3 y 5-7. El borde 4 puede comprender componentes del marco estructural 150 y puede estar al menos parcialmente cubierto por el recubrimiento 200. El borde 4 del lago flotante 1 puede comprender un sistema de flotación 5 (como se muestra en las Figuras 3 y 5-7). El sistema de flotación 5 proporciona flotabilidad y permite mantener un nivel de agua en el lago flotante 1 que genera una presión positiva en el lago flotante 1. El sistema de flotación 5 puede también proporcionar estabilidad al perímetro del lago flotante 1 y puede ayudar al lago flotante 1 a mantener su forma de superficie. El sistema de flotación 5 puede comprender una pluralidad de elementos de flotación distribuidos entre el perímetro del lago flotante 1, o un elemento de flotación continuo circundante al perímetro del lago flotante 1. El sistema de flotación 5 puede estar unido al recubrimiento 200, y/o puede estar al menos parcialmente cubierto por el recubrimiento 200, tal como se muestra en la Figura 5-7. El sistema de flotación 5 puede además estar unido al marco estructural 15.

El sistema de flotación 5 entre el borde 4 o paredes 3 del lago flotante 1 puede comprender diferentes materiales de flotación y equipamiento, tal como sistemas de poliuretano; sistemas de poliestireno, tales como poliestireno extruido y perlas de poliestireno expandido; sistemas de polietileno; sistemas llenados con aire, tales como cámaras de aire, bolsas de aire de goma o bolsas de aire de vinilo; y los sistemas contruidos de otros materiales adecuados tales como plásticos, espumas, gomas, vinilo, resinas, concreto, aluminio, y diferentes tipos de maderas, entre otros. Ejemplos de materiales de flotación disponibles comercialmente son Royalex® (un material compuesto que comprende de una capa exterior de vinilo y plástico duro de acrilonitrilo butadieno estireno (ABS, por sus siglas en inglés) y una capa interior de espuma de ABS, Styrofoam, y espumas de polietileno, de celda cerrada, extruidas, de alto rendimiento, tales como Ethafoam™.

El tamaño y tipo de los elementos de flotación pueden ser determinados basados en el volumen del lago flotante 1, y en la cantidad de agua dispuesta en el lago flotante 1, y la

flotabilidad deseada para ser proporcionada por los elementos de flotación. Por ejemplo, el sistema de flotación 5 puede ser dimensionado para proporcionar flotabilidad suficiente al lago flotante 1 de modo que el lago flotante 1 permanezca flotando (es decir, que no entre en contacto con el fondo del cuerpo de agua circundante) incluso con presiones internas altas. Alternativamente, el sistema de flotación 5 y la profundidad del lago flotante 1 puede estar diseñado de manera tal que al menos alguna porción del fondo del lago flotante 1 entra en contacto con el fondo del cuerpo de agua circundante.

En una realización, se puede agregar características adicionales al lago flotante 1. Por ejemplo, el borde 4 del lago flotante 1 puede estar construido para comprender playas, calzadas, paseos peatonales, pontones, barandas, sistemas de entradas inclinadas, y/o varios otros servicios. Las características adicionales también pueden estar opcionalmente unidos ya sea al perímetro exterior o al perímetro interior del lago flotante 1, tal como diques flotantes, que pueden ser estructuras modulares o fijas, plataformas flotantes, pontones, y otros.

El lago flotante 1 puede ser anclado o fijado en un lugar dentro del cuerpo de agua circundante. Por ejemplo, el lago flotante 1 puede ser anclado al fondo del cuerpo de agua circundante, y/o puede ser fijado o unido al borde costero del cuerpo de agua circundante. El lago flotante 1 puede comprender múltiples puntos de anclaje 210 desde el cual el lago flotante puede ser atado con cuerdas 220 a los puntos de anclaje correspondientes o anclajes en el fondo a lo largo del borde costero del agua circundante, como se muestra en la Figura 3. El número y ubicación de los puntos de anclaje 210 pueden ser configurados basados en el tamaño del lago flotante 1, y el tamaño y condiciones (por ejemplo, condiciones del clima típicas, mareas y corrientes) del agua circundante. Los puntos de anclaje 210 pueden ser reforzados y pueden comprender cualquier material adecuado, por ejemplo, plástico, metal, concreto y combinaciones de los mismos. Acuerdo a una realización, las cuerdas 220 que conectan el lago flotante 1 a los anclajes pueden ser ajustable y/o extensibles. Esto permitirá el aumento de flexibilidad dependiendo de la necesidad. Por ejemplo, si se observa un aumento en corrientes u olas en el cuerpo de agua circundante, la longitud de la cuerda puede aumentar (o disminuir), manual o automáticamente, para prevenir las fuerzas resultantes del estrés del material del lago flotante.

En una realización, el lago flotante 1 está diseñado y configurado para estar unido a tierra firme a lo largo de una sección del borde 4 del lago flotante 1. Como se puede ver en la Figura 9<sup>a</sup>, el lago flotante 1 puede ser anclado directamente a tierra firme o por un sistema de muelle 10 que proporciona una entrada adecuada y segura a personas desde tierra firme al sistema de lago flotante. En otra realización, como se muestra en la Figura 9B, el lago flotante 1 está separado de la tierra firme y está ubicado frente al borde costero del cuerpo de agua circundante. El lago flotante 1 puede estar conectado a tierra firme por un sistema de muelle/puente 11 que permite la segura y adecuada entrada de personas desde tierra firme al sistema de lago flotante. En otra realización, el sistema de lago flotante no está conectado a tierra firme y se puede acceder a través del cuerpo de agua natural o artificial circundante.

De acuerdo a una realización, una presión positiva es proporcionada en el lago flotante 1. La presión positiva dentro del lago flotante puede ser usada para asegurar que el agua contenida en el lago flotante 1 no será contaminada por el agua circundante en caso de un pinchazo o daño en el fondo 2 y paredes 3, y ayudar a mantener la forma del lago flotante 1. La presión positiva dentro del lago permitirá que el agua de dentro del lago flotante 1 salga al cuerpo de agua circundante, y por lo tanto, el agua dentro del lago flotante 1 no sería contaminada. Con el fin de mantener la presión positiva en caso de daño en el fondo 2 o paredes 3 del lago flotante 1, el agua puede ser agregada al lago flotante 1 en una tasa que mantenga una presión positiva dentro del lago flotante 1.

De acuerdo a una realización, la presión positiva puede ser mantenida dentro del lago flotante 1 manteniendo la superficie 6 del agua en el lago flotante 1 sobre el nivel del agua 100 del cuerpo de agua circundante, es decir, sobrellenando ligeramente el lago flotante 1. Sin tal sobrellenado, el lago flotante 1 asumirá su forma normal y volumen. Sin embargo, como las paredes 3 y fondo 2 del lago flotante 1 están contruidos con materiales flexibles, los materiales se curvan debido al peso del agua cuando el lago flotante 1 es sobrellenado. El curvado de los materiales causará que el nivel real del agua en el lago flotante 1 sea similar o igual al nivel de agua circundante, mientras que aún se mantenga la presión positiva deseada.

Aunque en la práctica el nivel del agua se igualará aproximadamente con el nivel del agua circundante, el aumento teórico en el nivel del agua puede ser usado para calcular

el volumen adicional necesario del agua para crear la presión positiva deseada. Por ejemplo, si el nivel del agua dentro del lago flotante se desea que sea 2 mm sobre el nivel del agua del agua circundante, el volumen del nivel sobre el agua puede ser calculado multiplicando la superficie del agua por la altura del nivel sobre el agua. En la práctica, sin embargo, debido a la flexibilidad de las paredes 3 del lago flotante 1, es decir, la estructura que separa el volumen del lago flotante del agua circundante, cuando el volumen sobre el nivel es agregado, las paredes 3 del lago flotante 1 se expande, y el nivel real de agua en el lago flotante será similar o igual al nivel del agua circundante.

En una realización preferida, la presión positiva debería ser al menos alrededor de 20 Newtons por metro cuadrado ( $\text{N/m}^2$ ) sobre la superficie interna del lago flotante para prevenir que agua proveniente del agua circundante ingrese al lago flotante 1 en caso de un pinchazo u otro daño. En otras realizaciones, la presión positiva es de al menos alrededor de 10  $\text{N/m}^2$ , alrededor de 15  $\text{N/m}^2$ , alrededor de 18  $\text{N/m}^2$ , alrededor de 25  $\text{N/m}^2$ , o alrededor de 30  $\text{N/m}^2$ . Una presión positiva de al menos 20  $\text{N/m}^2$  es equivalente a mantener la superficie 6 del agua en el lago flotante 1 en al menos alrededor de 2 mm sobre la superficie 100 del agua circundante, generando un volumen del agua que está sobre el nivel del agua circundante. Tal como se discutió, el aumento en el nivel del agua es teórico y en realidad las paredes 3 y el fondo 2 del lago flotante 1 se flexionan para acomodar el volumen de agua extra, entre el nivel de agua del lago flotante 1 y el cuerpo de agua circundante para que sean aproximadamente iguales. Por lo tanto, tal presión positiva puede también estar basado en el volumen de agua extra que excede el volumen de agua inicial del lago flotante 1 en su estado natural (no flexionado).

La presión positiva puede ser mantenida en el lago flotante 1 mediante el bombeo de agua en lago que se requiera para mantener la presión deseada por medio de un sistema de bombeo. Por ejemplo, la presión positiva puede ser mantenida mediante el bombeo de agua por un período de tiempo que no es menor que el 50% del tiempo dentro de un período de 7 días. Preferentemente, la presión positiva es mantenida continuamente en el lago flotante. La presión interna más alta en el lago flotante 1 es contra balanceada por la flotabilidad proporcionada por el sistema de flotación 5. De acuerdo a una realización, el tamaño del sistema de flotación 5 y la flotabilidad proporcionada por los materiales de flotación está configurado para que corresponda a la carga ejercida por la presión positiva causada por el volumen de agua extra y por los usuarios y equipamientos que están en el

lago flotante 1 o en su perímetro. El tamaño y forma del sistema de flotación 5 puede ser ajustado (agregando o removiendo material de flotación) con el fin de cambiar su flotabilidad para dar cuenta de las cargas resultantes.

De acuerdo a una realización, el lago flotante 1 puede comprender un sistema de coordinación, donde el sistema de coordinación puede recibir información sobre la calidad del agua y parámetros físico químicos, procesar la información, y activar los procesos para mantener los parámetros de calidad del agua y otros parámetros físico químicos dentro de límites preestablecidos. El lago flotante puede comprender un sistema de coordinación para mantener la calidad del agua y otros parámetros físico químicos en el lago flotante dentro de rangos predeterminados. El sistema de coordinación permite activar la operación de diferentes procesos, que pueden ser hechos automáticamente con un ensamble de coordinación y unidades de control que reciben información, o manualmente ingresando y/o procesando la información manualmente.

En realizaciones opcionales, el sistema de coordinación incluye un número de sensores dispuestos dentro y alrededor del lago flotante. La información de los sensores puede ser ingresada, ya sea manual o automáticamente, en un computador que procese la información. La coordinación significa que puede simplemente proporcionar instrucciones para ser llevadas a cabo por una persona, o pueden dirigir la acción correcta automáticamente.

De acuerdo a una realización ejemplar mostrada en la Figura 5, el sistema de coordinación comprende un ensamble de coordinación 20 capaz de obtener y/o recibir información (desde, por ejemplo, sensores dispuestos dentro y alrededor del lago flotante 1 y el agua circundante), procesar la información y activar los procesos (ya sea para proporcionar instrucciones o para activar tales procesos automáticamente) basados en la información recibida. El ensamble de coordinación 20 puede incluir una unidad de control 22, tal como un computador, y al menos un dispositivo de monitoreo 24, tal como un sensor. El sensor puede ser un medidor de potencial oxidación reducción (“ORP”, por sus siglas en inglés), un medidor de turbidez, u otro aparato para medir un parámetro de calidad del agua. De acuerdo a otras realizaciones, el ensamble de coordinación 20 puede incluir dos o más dispositivos de monitoreo 24 para otros parámetros de calidad de agua, tal como pH, alcalinidad, dureza (Calcio), cloro y crecimiento microbiano, entre otros.

De acuerdo a realizaciones alternativas, el sistema de coordinación puede ser reemplazado por una o más personas para obtener y/o ingresar y/o procesar información manualmente, o activar y/o realizar procesos para mantener los parámetros de calidad del agua y/p otros parámetros físico químicos. Los procesos pueden comprender la incorporación de químicos para tratamiento de agua y/u operación de un dispositivo de succión móvil, entre otros.

De acuerdo a una realización, el sistema de coordinación puede comprender un sistema automatizado. El sistema automatizado puede ser programado para monitorear continuamente parámetros de calidad del agua y/o parámetros físico químicos o para preestablecer intervalos de tiempo, y activar uno o más sistemas. Por ejemplo, el sistema automatizado puede activar la incorporación de químicos para el tratamiento de agua al detectar el paso de un umbral de un valor predeterminado. De acuerdo a una realización alternativa, el sistema de coordinación comprende controlar manualmente la incorporación de químicos de tratamiento basado en una determinación empírica o visual de los parámetros de calidad del agua.

El lago flotante 1 puede comprender un sistema para agregar químicos de tratamiento al agua. De acuerdo a la realización mostrada en la Figura 5, el sistema para agregar químicos de tratamiento comprende un sistema de aplicación de químicos 30. El sistema de aplicación de químicos 30 puede ser automatizado y puede ser controlado por la unidad de control 22 del ensamble de coordinación 20.

De acuerdo a una realización alternativa mostrada en la Figura 6, el sistema de aplicación de químicos 30 puede ser operado o activado manualmente basado en los parámetros de calidad del agua. Por ejemplo, los parámetros de calidad del agua pueden ser obtenidos manualmente, mediante métodos empíricos o analíticos, tal como algoritmos, basado en experiencia, inspección visual, o usando un sensor, y la información sobre los parámetros de calidad del agua pueden ser procesados manualmente o mediante el ingreso a un dispositivo de procesamiento (por ejemplo, un computador). Basado en la información sobre los parámetros de calidad del agua, operación del sistema de aplicación de químicos 30 puede ser activado manualmente, por ejemplo, activando un interruptor.

El sistema de aplicación de químicos 30 puede ser operado en terrero o a través de una conexión remota (por ejemplo, mediante internet), donde la información es enviada a

una unidad de procesamiento central y que se puede acceder a través de una conexión remota, permitiendo la activación de la operación del sistema de aplicación de químicos 30.

El sistema de aplicación de químicos 30 puede comprender al menos un depósito de químicos, una bomba para dosificar los químicos, y un aparato dispensador. El sistema de aplicación de químicos 30 puede comprender múltiples depósitos de químicos para albergar químicos de tratamientos separados, tal como oxidantes, floculantes, y otros. La bomba puede ser activada por una señal de la unidad de control 22 o manualmente mediante la activación de un interruptor ya sea en terreno o remotamente. El aparato dispensador puede comprender cualquier mecanismo dispensador adecuado, tal como un inyector, un aspersor, un dispensador, tubería, o combinaciones de los mismos.

La Figura 7 muestra una realización alternativa donde los químicos pueden ser dosificados manualmente en el agua o usando un mecanismo de aplicación de químicos separado. Por ejemplo, los parámetros de calidad del agua pueden ser obtenidos manualmente, visualmente, o usando un sensor, y la información sobre los parámetros de calidad del agua pueden ser procesados manualmente o ingresándola en un dispositivo de procesamiento (por ejemplo, un computador). Basado en la información sobre los parámetros de calidad del agua, los químicos pueden ser agregados manualmente en el agua.

El fondo 2 del lago flotante 1 puede ser limpiado usando un dispositivo de succión móvil 42 que es capaz de moverse por el fondo 2 del lago flotante para remover partículas sedimentadas del fondo 2. El fondo 2 del lago flotante 1 puede ser limpiado intermitentemente para proporcionar una coloración atractiva al cuerpo de agua y evitar la acumulación de material sedimentado y escombros encontrados en el fondo 2. Típicamente, el dispositivo de succión móvil 42 es capaz de limpiar un fondo 2 flexible con un módulo de Young de hasta 20 GPa.

El lago flotante 1 típicamente incluye también un sistema de filtración 40. De acuerdo a una realización, la filtración de sólo una porción del agua en el lago flotante es suficiente para mantener la calidad del agua dentro de los parámetros de calidad del agua y físico químicos deseados. Como se ve en las Figuras 5-7, el sistema de filtración 40 incluye al menos un dispositivo de succión móvil 42 y un sistema de filtración asociado 44. El

dispositivo de succión móvil 42 está configurado para succionar una porción del agua desde el fondo 2 del lago flotante 1 que contiene escombros, partículas, sólidos, flóculos, materiales floculados, y/u otras impurezas que se han asentado en el fondo 2. Succionar y filtrar esta porción del volumen del agua en el lago flotante proporciona la calidad del agua deseada sin un sistema de filtración que filtre el volumen de agua completo del lago flotante, el cual está en contraste a las tecnologías de filtración de piscina convencional que requiere filtrar el volumen de agua completo 1 a 6 veces por día.

De acuerdo a una realización, el dispositivo de succión móvil 42 es capaz de moverse por el fondo 2 del lago flotante 1. Sin embargo, para maximizar la eficiencia de la remoción de escombros, partículas, sólidos, flóculos, materiales floculados, y/u otras impurezas que se han asentado en el fondo 2, el dispositivo de succión móvil 42 puede ser configurado de tal manera que su movimiento crea una mínima dispersión de los materiales sedimentados. En realizaciones, el dispositivo de succión móvil 42 está configurado para no incluir partes, tal como cepillos que podrían funcionar como re dispersor de una porción sustancial de los materiales sedimentados del fondo 2 del lago flotante 1 durante la operación del dispositivo de succión.

La activación de la operación del dispositivo de succión móvil 42 puede ser controlado por un sistema de coordinación que incluye una unidad de control 22 o manualmente por un operador. De acuerdo a una realización mostrada en la Figura 5, activar la operación del dispositivo de succión móvil 42 es controlada por la unidad de control 22. Las Figuras 6 y 7 muestran realizaciones alternativas donde el dispositivo de succión móvil 42 es activado manualmente, por ejemplo, activando un interruptor o enviando un mensaje de activación.

El dispositivo de succión móvil 42 puede comprender una bomba, o una bomba separada o estación de bombeo que puede proporcionar la succión del agua y el bombeo del agua succionada al sistema de filtración 44. El sistema de filtración 44 generalmente incluye uno o más filtros, tal como filtro de cartucho, filtro de arena, microfiltro, ultrafiltro, nanofiltro, o una combinación de los mismos. El dispositivo de succión móvil 42 está típicamente conectado al sistema de filtración 44 por una línea recolectora 43 que comprende de una manguera flexible, manguera rígida, una tubería, entre otros. El sistema de filtración 44 puede estar ubicado por todo el perímetro del lago flotante 1, en una

instalación flotante, o por toda la línea costera del cuerpo de agua circundante. La capacidad del sistema de filtración 44 se escala generalmente a la capacidad del dispositivo de succión móvil 42. El sistema de filtración 44 filtra el flujo de agua desde el dispositivo de succión móvil, que corresponde a una pequeña porción del volumen de agua en el lago flotante. El agua filtrada desde el sistema de filtración 44 es devuelta al lago flotante por una línea de retorno 60 que comprende una manguera flexible, manguera rígida, una tubería, un canal abierto, entre otros. La ubicación del agua que es devuelta puede ser optimizada para minimizar los costos de bombeo de agua.

Comparado a un sistema de filtración convencional con capacidad de filtrar el cuerpo de agua completo en la piscina 1 a 6 veces por día, el sistema de filtración 44 de la presente solicitud puede estar configurado para tener una capacidad de filtración que es alrededor de 1/10 del sistema de convencional, o alrededor de 1/30 del sistema de convencional, o alrededor de 1/60 del sistema de convencional, o alrededor de 1/100 del sistema de convencional, o alrededor de 1/300 del sistema de convencional. Esto se traduce en que diariamente la capacidad de filtración está en el rango de alrededor de 1:10, o alrededor de 1:25, alrededor de 1:50, alrededor de 1:75, alrededor de 1:100, alrededor de 1:200, o alrededor de 1:300 del volumen del lago flotante. El consumo de energía del sistema de filtración es aproximadamente proporcional al tamaño y, así, se pueden esperar ahorros significantes de costos con un consumo de energía más bajo, y que requiere un pequeño equipamiento para el proceso de filtración.

En una realización, el dispositivo de succión móvil 42 puede comprender un sistema magnético adaptado para limpiar fondos flexibles debajo del agua. Se puede alcanzar una limpieza mejorada de un lago flotante con un fondo flexible con un dispositivo de succión móvil que es capaz de adherirse al material del fondo con componentes magnéticos opuestos. Como se muestra en la Figura 8, el dispositivo de succión magnético móvil 420 tiene un sistema magnético que comprende un componente interno 430 y un componente externo 435. El componente interno 430 está ubicado en el fondo 2 del lago flotante 1 dentro del lago flotante 1, en contacto con el agua del lago flotante 1. El componente interno 430 puede incluir al menos un aparato succionador 431. El componente externo 435 está ubicado fuera del lago flotante 1 en contacto con el agua circundante.

El sistema magnético puede comprender dos o más componentes magnéticos (432, 436) capaces de atraerse uno al otro. Los componentes magnéticos 432, 436 pueden tener ya sea un campos magnéticos opuestos, o al menos uno de los componentes magnéticos tiene un campo magnético y uno o más componentes magnéticos son ferromagnéticos (es decir, atraído por el campo magnético). El compuesto interno 430 del dispositivo de succión móvil 420, que incluye el aparato de succión 431, comprende un primer componente magnético 432. El componente interno 430 con el primer componente magnético 432 está ubicado por la superficie interna del fondo 2 del lago flotante 1. El componente externo 435 comprende un segundo componente magnético 436 que está ubicado en la superficie externa del fondo y está en contacto con el agua circundante. El primer y segundo componente magnético 432, 436 están alineados en ubicaciones correspondientes por el fondo 2 del lago flotante 1 de esta manera la atracción magnética mantiene la alineación del primer y segundo componente magnético 432, 436. El sistema magnético es así capaz de mantener el dispositivo de succión móvil 420 por el fondo flexible 2 del lago flotante 1. Los componentes interiores y exteriores 430, 435 del dispositivo de succión móvil 420 pueden comprender cepillos, rodillos, rieles, bandas de rodaje, u otros mecanismos de propulsión del dispositivo de succión magnético móvil 420 por el fondo 2.

En una realización, el componente interno 430 es propulsado por el fondo 2 del lago flotante, y debido a las interacciones entre el primer y segundo componente magnético 432, 436, el componente externo 435 es arrastrado, de esta manera permanecerá adyacente al componente interno 430. En una realización alternativa, en lugar de que el componente interno 430 arrastre al componente externo 435, el componente externo 435 es propulsado por el lado externo de la superficie del fondo 2 y empuja al componente interno 430 y al aparato de succión 431 con este. Esto puede ser realizado, por ejemplo, proporcionando la superficie externa del fondo 2 con un sistema de propulsión que puede comprender rieles, bandas de rodaje u otra configuración permitiendo que el componente externo 435 arrastrarse por la superficie externa del fondo 2. Proporcionar un sistema de propulsión por la superficie externa del fondo 2 permite un componente interno más barato y liviano 430.

En otra realización, el dispositivo de succión móvil 42 comprende un medio de succión móvil flexible que se mueve a través del fondo del lago flotante, donde el lago flotante 1 proporciona un fondo estable para que el dispositivo de succión móvil se mueva.

El medio s de succión móvil flexible se puede adaptar al fondo estable, el cual es flexible, con el fin de limpiarlo exhaustivamente.

En aún otra realización, el fondo 2 del lago flotante 1 comprende una estructura en capas. Como se puede ver en las Figuras 11A y 11B, en una realización ejemplar, la estructura en capas comprende un material en capa tal como material tipo cojín, llenado con aire, agua, u otro líquido capturado entre las capas, funcionando con un *cojín* extra 16 con agua o aire entre el agua dentro del lago flotante y el agua circundante. El *cojín* 16 puede proporcionar al fondo 2 estabilidad y permitir, por ejemplo, una operación más eficiente del aparato de succión. El cojín puede también ser llenado con materiales de espuma expandible.

En otra realización, el recubrimiento comprende una serie de secciones inflables 17 en el recubrimiento, distribuidas por el fondo 2 del lago flotante 1. Como se muestra en la Figura 12A, las secciones inflables 17 están unidas al fondo y pueden ser infladas de esta manera la sección inflable 17 se expande hacia arriba (Figura 12B) o hacia abajo (Figura 12C) del fondo 2, dependiendo de la configuración y fabricación de las secciones inflables 17. Se recomienda que las secciones inflables 17 sean configuradas en el lado externo del fondo (como se muestra en la Figura 12C), en el lado del cuerpo de agua circundante, con el fin de evitar afectar el fondo liso del lago flotante.

Las secciones inflables 17 pueden tomar una variedad de formas. En una realización, las secciones son sustancialmente rectangulares, cubriendo el área de superficie completa del recubrimiento 200 y separándola en secciones separadas. En otras realizaciones, sin embargo, las secciones inflables 17 tienen otras formas, por ejemplo, triangular o pentagonal, como sea necesario para soportar efectivamente la operación del dispositivo de succión 42 y contrarrestar fuerzas externas. Las secciones inflables 17 pueden también tomar la forma de tuberías, formando el perímetro de las varias formas, reduciendo así el área de superficie que necesita ser inflada. El inflado de las secciones puede ser realizado de cualquier manera usual, por ejemplo, proporcionando al recubrimiento 200 con conductos de inflado integrado, conectado a una o más bombas, ya sea de forma permanente o cuando sea necesario. Aunque en la mayoría de las realizaciones, las secciones inflables 17 están infladas con aire, pueden ser usados gases más purificados u otros fluidos, tal como agua o fluidos que tienen menos densidad que la

del agua circundante. También, algunas de las secciones inflables 17 de una pluralidad de secciones inflables 17 pueden ser llenadas con un líquido o gas, mientras que otras son llenadas con otro líquido o gas, o las secciones inflables 17 pueden ser llenada con una mezcla de líquido y gas (por ejemplo agua y aire), para alcanzar diferentes flotabilidades dentro de las secciones.

Estas secciones inflables 17 pueden estar infladas permanentemente durante la instalación o ser selectivamente infladas cuando sean necesario. Por ejemplo, la sección inflable 17 puede estar permanentemente o selectivamente inflada para causar que el fondo sea suficientemente estable para soportar el peso y movimiento del dispositivo de succión 42. Otros usos de las secciones inflables selectivamente puede ser cuando se esperan ciertas fuerzas, por ejemplo, vientos u olas aumentadas – causada por tormentas o grandes barcos.

El recubrimiento con las secciones inflables 17 pueden también estar incorporado dentro de una estructura más grande. La estructura más grande puede ser un recubrimiento 200 más grueso, donde las secciones inflables 17 comprenden una capa adicional del recubrimiento 200. Las otras capas pueden o no tener sus propias secciones inflables 17. Si la(s) otra(s) capa(s) tiene/tienen secciones inflables 17, tales secciones pueden estar alineadas respectivamente con las secciones inflables 17 adicionales. También, el recubrimiento del fondo 202 puede estar unido a estructuras rígidas (por ejemplo marcos estructurales 15), para permitir proporcionar tensión al material del fondo y unirse a sistemas de anclaje.

El lago flotante 1 puede también incluir un sistema de espumadera 50. El sistema de espumadera 50 puede ser usado para separar escombros flotantes y aceites y grasas del agua. Como se muestra en las Figuras 5-7, el sistema de espumadera 50 puede incluir un espumador 52 que roza la superficie del agua del lago flotante 1, en comunicación fluida con un sistema de separación 54. El espumador 52 está generalmente conectado al sistema de separación 54 mediante una línea de conexión 53 que comprende una manguera flexible, manguera rígida, una tubería, un canal abierto, entre otros. Debido a las diferentes naturalezas y calidad de impurezas (por ejemplo, aceite, grasa y escombros flotantes) en el agua espumada comparada con las impurezas del fondo 2 del lago flotante 1, el agua espumada usualmente no necesita ser filtrada. Por lo tanto, de acuerdo a una realización, el

sistema de separación 54 puede comprender un desengrasante (por ejemplo un aparato de sobre flujo) para la separación de aceites y grasas del agua y una pantalla filtro grueso para separar escombros. El agua desde el sistema de separación 54 puede ser devuelta al lago flotante a través de una línea de retorno 60. La línea de retorno 60 puede ser la misma, puede estar separada de la línea de retorno del sistema de filtración 40. De acuerdo a una realización, el sistema de espumadera 50 incluye múltiples espumadores 52 que pueden ser esparcidos por el perímetro del lago flotante 1. La Figura 5 muestra un espumador 52 y un segundo espumador 52 mostrado en líneas de trazos para representar una pluralidad de espumadores. La operación del sistema de espumadera 50 es preferentemente continua o puede alternativamente ser intermitente. La operación del sistema de espumadera 50 puede ser controlado por la unidad de control 22 (Figura 5) o manualmente (Figura 6).

### **Operación del Lagos Flotantes**

Actualmente, piscinas flotantes son muy poco comunes, y las piscinas flotantes encontradas en el mercado son pequeñas en tamaño y son operadas como piscinas convencionales. Piscinas flotantes convencionales son típicamente construidas y operadas de acuerdo a los estándares de piscinas, que requieren altos y permanentes niveles de químicos y de filtración del cuerpo de agua completo desde 1 a 6 veces por día. La aplicación de tecnología de piscina convencional a los lagos flotantes de la presente invención daría lugar a dos problemas principales: (1) alto costo de aplicación de tecnología de piscina a grandes cuerpos de agua debido al uso de altas tasas de químicos y de filtración del volumen de agua completo desde 1 hasta 6 veces por día con un sistema de filtración centralizado convencional; y (2) un peligro posible que podría ocurrir en caso de daño al fondo o paredes del lago flotante. Tecnología diferente y un método de mantención debe ser usado para mantener la los estándares de sanidad en grandes lagos flotantes porque usando tecnología de piscina convencional, el agua con alto contenido químico podría potencialmente se liberada en el cuerpo de agua circundante, afectando adversamente la vida acuática y marina o el entorno del agua fresca. Por lo tanto, el uso de tecnología de piscina convencional debería ser evitado con el fin de conservar energía y para proteger el ecosistema del cuerpo de agua circundante.

De acuerdo a una realización, la calidad del agua y/o condiciones físico químicas son mantenidas en el lago flotante 1 mediante procesos que comprenden agregar químicos de tratamiento y de remoción de escombros, partículas, sólidos, flóculos, materiales floculados, y/u otras impurezas desde el fondo del lago flotante de acuerdo a los parámetros de calidad del agua y/o condiciones físico químicas. Calidad del agua en el lago flotante 1 puede ser obtenida, por ejemplo, por parámetros específicos tal como potencial oxidación reducción (“ORP”), turbidez, pH, alcalinidad, dureza (Calcio), cloro, crecimiento microbiano, entre otros. El sistema de aplicación de químicos puede ser activado oportunamente por el sistema de coordinación para mantener los parámetros de calidad del agua dentro de los límites establecidos. Los sistemas pueden ser activados basados en una necesidad real, resultante en la aplicación de cantidades más pequeñas de químicos usando menos energía que en métodos de tratamiento de agua de piscina convencional.

En realizaciones, los parámetros de calidad del agua pueden ser obtenidos manualmente, por ejemplo mediante una inspección visual, usando un medidor de calidad del agua (por ejemplo, una sonda, tal como una sonda de pH, un medidor de turbidez, un colorímetro, o un medidor de ORP), u obteniendo una muestra y medir la calidad del agua usando un método analítico. La Información sobre los parámetros de calidad del agua puede ser obtenida ingresándola al sistema de coordinación. En una realización, un sistema de coordinación automatizado puede ser programado para monitorear continuamente los parámetros de calidad del agua o en intervalos de tiempo preestablecidos, para comparar los resultados de un parámetro predeterminado y activar uno o más sistemas cuando el umbral del parámetro ha sido pasado. Por ejemplo, el sistema automatizado puede activar la incorporación de químicos de tratamiento o la operación de un sistema de filtración al detectar el paso de un umbral del parámetro predeterminado. En una realización alternativa, los parámetros de calidad del agua pueden ser obtenidos manualmente y la información ingresada en el sistema de coordinación, o los resultados pueden ser comparados con un valor predeterminado y la incorporación de químicos de tratamiento puede ser activado manualmente. Químicos de tratamiento usados para mantener la calidad del agua en el lago flotante puede comprender cualquier químico de tratamiento de calidad del agua adecuado. Por ejemplo, los químicos de tratamiento puede comprender oxidantes, floculantes, coagulantes, alguicidas, agentes esterilizantes, o agentes reguladores de pH.

De acuerdo a una realización preferente, los químicos de tratamiento comprenden un oxidante y un floculante.

Los parámetros de calidad del agua pueden ser obtenidos de acuerdo a los requerimientos del lago flotante o en ciertos intervalos de tiempo. En una realización el ORP (u otro parámetro de calidad del agua) del agua es determinado ya sea por un dispositivo de monitoreo 24 (sistema de la Figura 5), tal como un sensor, o por métodos empíricos o analíticos, tal como algoritmos basados en experiencia, o inspección visual (sistemas de las Figuras 6 y 7).

El ORP del agua en el lago flotante es mantenido en un ORP mínimo para un período mínimo de tiempo dentro de ciclos de 52 horas para proporcionar agua que tiene la calidad de agua deseada. Un oxidante es aplicado al agua en el lago flotante para mantener un ORP sobre un valor mínimo por un período de tiempo mínimo dentro de un ciclo de 52 horas (por ejemplo, el ciclo de tratamiento). En realizaciones, el nivel de ORP es mantenido en alrededor de 550 mV o más alto. Dicho nivel mínimo de ORP es mucho más bajo que el nivel de ORP mantenido típicamente en piscinas para alcanzar una desinfección suficiente. El tiempo de tratamiento de ORP dentro del ciclo de 52 horas puede ser continuo, periódico, intermitente, o discontinuo. En realizaciones, el período de tiempo mínimo es de alrededor de 10 hasta alrededor de 20 horas dentro del ciclo de 52 horas. Aunque es posible mantener el nivel de ORP mínimo continuamente, es decir, 24 horas por día, el nivel de ORP puede también se mantenido solamente durante períodos específicos, por ejemplo, períodos mínimos, el doble de período mínimo, o separados por intervalos de 4, 6, 8, 10 o 12 horas durante los cuales el nivel de ORP no es mantenido. El oxidante puede ser seleccionado de compuestos a base de halógeno, sales de permanganato, peróxidos, ozono, persulfato de sodio, persulfato de potasio, un oxidante producido por un método electrolítico, o combinaciones de los mismos. La cantidad de oxidante agregado al agua (la “cantidad efectiva”) puede ser predeterminada o puede ser determinada (por ejemplo, por el dispositivo de control 22 en la Figura 5 o manualmente) basado en el ORP medido y en el aumento deseado del ORP del agua.

La turbidez del agua puede también ser monitoreado para mantener la calidad del agua en el lago flotante 1. Floculantes y/o coagulantes pueden ser agregados para agregarse, aglomerarse, unirse, y/o coagular sólidos en suspensión, materia orgánica,

materia inorgánica, bacterias, algas y similares en partículas que se asientan en el fondo del lago flotante. Por ejemplo, floculantes pueden ser agregados al agua con el fin de inducir la floculación de sólidos suspendidos que causan turbidez, tal como materia orgánica e inorgánica, y por lo tanto ayuda en el proceso de sedimentación de esas partículas donde pueden ser removidas por el dispositivo de succión móvil. Generalmente, el floculante o coagulante es aplicado o dispersado en el agua por el sistema de aplicación de químicos. Floculantes o coagulantes adecuados incluyen, pero no están limitados a, polímeros sintéticos tal como polímeros cuaternarios que contienen amonio y polímeros policatiónicos (por ejemplo, policuaternio), polímeros catiónicos y aniónicos, sales de aluminio, clorhidrato de aluminio, alumbre, sulfato de aluminio, óxido de calcio, hidróxido de calcio, sulfato ferroso, cloruro férrico, poliacrilamida, aluminato de sodio, silicato de sodio, quitosano, gelatina, goma guar, alginato, semillas de moringa, derivados de almidón, u otros componentes con propiedades floculantes, y combinaciones de los mismos.

En una realización, la adición de floculantes es activado antes de que la turbidez del agua exceda un valor predeterminado, tal como 2 NTU (Unidades nefelométricas de turbidez), 3 NTU, 4 NTU, o 5 NTU. El sistema de coordinación puede ser usado para activar la adición de floculantes y/o coagulantes antes de que la turbidez del agua exceda el valor predeterminado con el fin de causar la floculación y sedimentación de materia orgánica e inorgánica. La fracción de agua en la cual los flóculos recolectan o sedimenta es generalmente la capa de agua del fondo 2 del lago flotante 1. Los flóculos sedimentan en el fondo 2 del lago flotante 1 y pueden entonces ser removidos por el sistema de succión móvil 42 sin requerir que toda el agua del lago flotante 1 sea filtrada, por ejemplo, sólo una pequeña fracción es filtrada. La “pequeña fracción” de agua que es filtrada puede ser menos que alrededor de 30%, menos que alrededor de 25%, menos que alrededor de 20%, menos que alrededor de 15%, menos que alrededor de 10%, menos que alrededor de 9%, menos que alrededor de 8%, menos que alrededor de 7%, menos que alrededor de 6%, menos que alrededor de 5%, menos que alrededor de 4%, menos que alrededor de 3%, menos que alrededor de 2%, menos que alrededor de 1%, menos que alrededor de 0,9%, menos que alrededor de 0.8%, menos que alrededor de 0.7%, menos que alrededor de 0.6%, o menos que alrededor de 0,5% por día del volumen total de agua del lago flotante. La cantidad de floculante agregado al agua puede ser predeterminado o puede ser determinado (por ejemplo, por el dispositivo de control 22 en la Figura 5 o manualmente)

basado en la turbidez y en la reducción deseada en la turbidez del agua. El químico de tratamiento de agua puede preferentemente tener además propiedades de alguicida.

Dosificar los químicos de tratamiento de agua, tal como oxidantes y floculantes, puede ser hecho teniendo en cuenta la posible contaminación y peligros al cuerpo de agua circundante en caso de daño en el fondo o paredes de la estructura flotante, o en caso de que el agua contenida dentro del lago flotante sea transferida al cuerpo de agua circundante por alguna otra razón.

La sedimentación de partículas, sólidos, flóculos, materiales floculados, y/u otras impurezas al fondo 2 del lago flotante 1 puede causar un cambio en la apariencia del color del fondo 2 del lago flotante 1. Por ejemplo, las impurezas sedimentadas pueden hacer que el color del fondo 2 parezca más oscuro que el color original. De acuerdo al método, el color del fondo 2 del lago flotante 1 es monitoreado, y cuando el color ha cambiado mediante una cantidad predeterminada, se activa la succión de agua e impurezas desde el fondo 2 del lago flotante 1. El color medido o percibido, que puede ser obtenido mediante métodos empíricos o analíticos, tal como algoritmos basados en experiencia, inspección visual, equipamiento automatizado, u otros, pueden ser comparados a un valor predeterminado, tal como un aumento en el componente de color (por ejemplo, negro) del color real el fondo 2.

Se apreciará por aquellos expertos en el arte que en el contexto del color del fondo 2, el término “fondo” se refiere a la superficie de la capa que está más arriba del fondo 2 que está visible desde arriba del fondo 2.

En una realización ejemplar, el color del fondo 2 del lago flotante 1 puede ser monitoreado por cambios en el componente negro en una CMYK u otra escala de color adecuada. La escala de color CMYK usa cuatro colores expresados en porcentajes: cian, magenta, amarillo y negro. El componente K de la escala CMYK es el componente negro del color. Por ejemplo, un color con CMYK 15%, 0%, 25%, y 36% representa un color con 15% cian, 0% magenta, 25% amarillo, y 36% de componente negro. El componente negro del fondo del lago puede ser evaluado por la comparación visual del color del fondo del lago con tablas de CMYK estándares o paletas de colores, y determinando el componente negro de acuerdo al porcentaje encontrado en la tabla CMYK. Alternativamente otros componentes de color pueden ser usados.

Escalas de color alternativas, tal como  $L^*a^*b^*$  (también conocida como Lab o CIELAB), X-Y-Z, RGB, o HEX, también pueden ser usadas. En la escala  $L^*a^*b^*$ , el color es medido en tres ejes: L, a, y b, donde el eje L mide la luminosidad. Un valor L de 100 indica blanco y  $L=0$  indica negro. Cuando las impurezas sedimentadas en el fondo 2 del lago flotante 1 y el color percibido del fondo 2 alcanza  $L=30$ , se activa la operación del dispositivo de succión 42.

De acuerdo a una realización, el color del fondo 2 del lago flotante 1 es monitoreado usando un dispositivo de monitoreo 24, tal como un colorímetro. De acuerdo a una realización alternativa, el color del fondo 2 del lago flotante 1 puede ser determinado por inspección visual comparando el color del fondo 2 del lago flotante 1 con una paleta de color. El color del fondo 2 del lago flotante 1 puede ser visualizado desde la superficie del agua, o, en particular cuando la turbidez es alta (por ejemplo, más que alrededor de 7 NTU), usando una mirilla transparente unida a un tubo que permite la visualización del fondo 2 del lago flotante 1.

El fondo 2 del lago flotante 1 puede ordinariamente tener un color que da un color placentero y apariencia al agua en el lago flotante 1. Por ejemplo, el fondo 2 del lago flotante 1 puede tener un material coloreado o puede ser pintado un color tal como blanco, amarillo o azul. En una realización ejemplar, el color del fondo 2 del lago flotante 1 es medido por el dispositivo de monitoreo 24 (por ejemplo, un colorímetro) del ensamble de coordinación 20. El color percibido del fondo 2 del lago flotante 1 puede ser comparado a un color real u original mediante métodos empíricos o analíticos, tal como algoritmos basados en experiencia, inspección visual, comparación con guías de colores, colorímetro, espectrofotómetros, y otros.

La operación del dispositivo de succión móvil 42 puede ser activada a través del sistema de coordinación. En una realización mostrada en la Figura 5, la operación del dispositivo de succión móvil 42 puede ser activada por la unidad de control 22. En otras realizaciones mostradas en las Figuras 6 y 7, la operación del dispositivo de succión móvil 42 puede ser activada manualmente.

De acuerdo a una realización, la operación del dispositivo de succión móvil 42 es activado antes de que el color del fondo 2 del lago flotante 1 exceda un valor predeterminado (por ejemplo, antes de que el componente de color negro del fondo exceda

el 30% en una escala de CMYK (u otra escala de color adecuada)). En una realización, la operación del dispositivo de succión móvil 42 es activado mediante la unidad de control 22 del ensamble de coordinación 20.

El color del fondo 2 del lago flotante 1 puede ser además monitoreado para determinar un punto final de la operación del dispositivo de succión móvil 42. Por ejemplo, si el componente de color negro del fondo 2 del lago flotante 1 disminuye bajo el valor predeterminado, la operación del dispositivo de succión móvil 42 puede ser detenida. Dicho valor puede ser, por ejemplo, donde el componente negro es 10% de unidades sobre el valor del componente negro del color real del fondo 2, o 5 unidades arriba, o 3 unidades arriba. Por ejemplo, si el color original del fondo 2 en la escala CMYK es de 15%, 0%, 25%, 10%, (el componente negro siendo 10%), el valor puede ser establecido en 20% negro, 15% negro, o 13% negro. El valor puede ser predeterminado basado en el color real del fondo 2 del lago flotante 1 y el nivel deseado de limpieza del lago flotante 1.

El color de un gran lago flotante puede ser monitoreado en múltiples ubicaciones por todo el lago. Si el lago flotante incluye múltiples dispositivos de succión 42, el fondo 2 puede selectivamente se limpiado en áreas para evitar que el color del fondo 2 exceda un valor predeterminado.

El dispositivo de succión 42 es preferentemente un dispositivo de succión móvil que es capaz de limpiar un fondo flexible 2 con un módulo e Young de hasta 20 GPa. El dispositivo de succión móvil 42 se mueve a través del fondo flexible 2 del lago flotante 1, succionando cualquier material sedimentado en el agua. El agua succionada e impurezas son entonces enviadas a un sistema de filtración 44 que separa las impurezas del agua. El agua succionada por el dispositivo de succión móvil 42 puede ser enviada al sistema 44 mediante el uso de una bomba o una estación de bombeo.

Después de la succión y filtración, el agua filtrada puede ser devuelta en el lago flotante. El punto de retorno del agua filtrada en el lago flotante debería se diseñada con el fin de minimizar costos de energía de bombear tal flujo de agua.

Los escombros de la superficie y aceites pueden ser removidos del lago flotante mediante el uso del sistema de espumadera 50. El sistema de espumadera 50 puede

comprender espumadores flotantes o pueden ser instalados por el perímetro del lago flotante 1.

El agua debería ser suministrada al lago flotante 1 con el fin de compensar la evaporación, el agua que se pierde del lago flotante por propósitos de limpieza, y por la eventual tasa de filtración. Las tasas de evaporación dependen de las condiciones meteorológicas de la ubicación del lago flotante.

De acuerdo a una realización, el agua es suministrada al lago flotante 1 en una tasa que es suficiente para mantener una presión positiva y para reemplazar el agua perdida debido a la limpieza, filtración y evaporación de acuerdo a la siguiente ecuación:

$$\textit{Tasa de Reposición} \geq \textit{Tasa de Evaporación} + \textit{Tasa de Limpieza} + \textit{Tasa de Filtración}$$

La tasa de reemplazo incluye agua debido a filtración, incluyendo pérdidas causadas por el daño a las paredes 3 o fondo 2 del lago flotante 1. La tasa de limpieza corresponde a la tasa de agua que se pierde dentro del proceso de filtración del agua succionada. Cabe señalar que aunque el sistema de filtración es un sistema cerrado, ya que el agua succionada por el dispositivo de succión móvil 42 que limpia el fondo flexible 2 es enviada a un sistema de filtración 44 y es entonces devuelta en el lago flotante 1, tal ciclo puede comprender pérdida de agua debido al proceso de retro lavado del sistema de filtración, o si algo de agua es dejada en el medio de filtración con impurezas, entre otras. Por lo tanto, la tasa de limpieza corresponde a la pérdida efectiva de agua debido a los procesos de retro lavado del sistema de filtración u otras pérdidas, tal como pequeñas pérdidas con la red de tuberías y otros sistemas y equipamientos.

Dichas tasas son generalmente medidas en el volumen de agua que es suministrada al lago flotante por unidad de tiempo.

El lago flotante 1 puede ser alimentado con agua de reemplazo desde el cuerpo de agua circundante. El agua de reemplazo del cuerpo de agua circundante puede ser analizada con el fin de determinad si puede ser alimentada directamente al lago flotante 1, o si necesita ser tratada previamente para ser alimentada en el lago flotante 1. Por ejemplo, el agua de reemplazo puede ser analizada usando el estándar de color Platino-Cobalto para

evaluar si el agua puede ser alimentada directamente al lago flotante 1. La escala Platino-Cobalto asigna al color un número estándar en el rango de 1 hasta 500<sup>+</sup>. La prueba de Platino-Cobalto consiste en comparar un espécimen de 100 mL (previamente filtrada si es que existe cualquier turbidez visible) con los colores estándar que han sido preparados de acuerdo a los requerimientos de ASTM. De acuerdo a una realización, el agua de reemplazo para el lago flotante 1 tiene un color verdadero más bajo que 30 Pt-Co. También, la calidad microbiana del agua de reemplazo puede ser también probada previamente a ser alimentada en lago flotante 1. En una realización preferente, el agua de reemplazo contiene menos que 2.000 CFU/ml (unidades formadoras de colonias por mililitro) en el fin de alimentarla directamente al lago flotante 1. Si el agua de reemplazo tiene un color verdadero más alto que 30 Pt-Co, o si el agua de reemplazo del cuerpo de agua circundante tiene más que 2.000 CFU/ml de bacteria, el agua es típicamente pre tratada antes de ser alimentada en el lago flotante 1. Si el agua del cuerpo de agua circundante tiene un color verdadero más bajo que 30 Pt-Co, y menos que 2.000 CFU/ml de bacteria, el agua puede ser usada directamente o pre tratada antes de ser alimentada en los lagos flotantes. En otras realizaciones, el agua de otras fuentes puede también ser usada como agua de reemplazo para los lagos flotantes.

En otra realización el lago flotante comprende paredes permeables. Es posible que el agua circundante tenga una calidad de agua adecuada para propósitos recreacionales, pero no que no sea estéticamente atractiva debido a que el fondo ha sido cubierto con sedimentos, escombros, o lodo que proporciona una coloración o sensación oscura y desagradable al cuerpo de agua. En tal caso, un lago flotante puede ser proporcionado donde las paredes son permeables y permiten al agua de buena calidad atravesarlas, pero el fondo aún comprende un material sólido, flexible. Proporcionando un fondo sólido, es decir, uno que es estable y continuo y que resiste la presión causada por el dispositivo de succión móvil, al lago flotante le permite, proporcionad un color placentero al fondo y así al agua, y permite al dispositivo de succión moverse a través del fondo, succionando materia orgánica e inorgánica sedimentada. Por lo tanto, en el caso que estas condiciones del cuerpo de agua natural o artificial sean adecuadas para propósitos recreacionales, las paredes pueden ser construidas de materiales permeables que permitan la incorporación de agua directamente desde el cuerpo de agua circundante. En una realización, la

permeabilidad del material que forma las paredes puede ser seleccionad o para proporcionar una tasa de permeabilidad particular.

Otras realizaciones del lago flotante comprenden sistemas para controlar la temperatura del agua. Por ejemplo, el lago flotante puede estar construido para mantener una temperatura del agua que es más alta que la temperatura del agua circundante. En climas fríos, las aguas naturales podrían ser de una calidad adecuada para el uso recreacional, pero pueden ser demasiado frías durante la mayoría o todo el año para bañarse o deportes acuáticos. Con el fin de proporcionar una temperatura de agua cálida en un lago flotante 1, el fondo del lago puede ser de un color más oscuro, tal como azul oscuro, verde, café, o negro. Un fondo coloreado oscuro permite que la radiación solar caliente el agua en el lago flotante 1 a una temperatura sobre la que tiene el agua circundante. Por ejemplo, la temperatura en el lago flotante 1 puede ser 4-10 °C más cálida que el agua circundante. El fondo y paredes del lago flotante 1 pueden también estar contruidos de material aislante, facilitando además la retención del calor en el lago flotante 1.

El sistema de lago flotante de la presente invención poder ser usado para otros propósitos, tal como para propósitos de enfriamiento industrial, por ejemplo para centrales térmicas, centros de datos, fundiciones, los sistemas de HVAC residenciales e industriales, plantas de energía termo-solar, industrias de papel, refinerías, plantas nucleares, entre otros procesos de enfriamiento residenciales o industriales. Por ejemplo, un sistema de lago flotante de la invención puede ser instalada dentro de un gran cuerpo de agua con el fin de proporcionar sistemas de enfriamiento industriales con agua de enfriamiento de alta calidad en un bajo costo y disipar el calor del agua de enfriamiento calentada sin afectar significativamente las propiedades del gran cuerpo de agua natural o artificial en el que el lago flotante está instalado. En una realización, el lago flotante comprende un área de superficie desde alrededor de 50 hasta alrededor de 30.000 m<sup>2</sup> por MW de enfriamiento requerido para el proceso industrial. El agua del lago flotante generalmente contiene cantidades reducidas significativamente de materia orgánica comparada al cuerpo de agua natural o artificial en el cual está instalado, proporcionando así un intercambio de calor en un proceso industrial con agua de enfriamiento de alta calidad que minimiza la contaminación biológica y previene una acumulación indeseable en las tuberías del

intercambiador de calor que puede reducir la capacidad de transferencia de calor. En una realización, el lago flotante puede estar configurado para incluir una línea de alimentación operativamente conectando al lago flotante con un intercambiador de calor en el proceso industrial para alimentar el intercambiador de calor con agua de enfriamiento desde el lago flotante y una línea de retorno del agua desde el intercambiador de calor al lago flotante. El agua de enfriamiento es tratada de acuerdo a los métodos de la invención y reciclada en el lago flotante para lograr un sistema de enfriamiento sostenible en el tiempo.

### **Ejemplos**

El siguiente ejemplo es ilustrativo, y existen otras realizaciones y están dentro del alcance de la presente invención.

#### **Ejemplo 1**

Un lago flotante con un área de superficie de 8m x 8m con una profundidad promedio de 2,5 m fue construido con el fin de probar la tecnología de la presente solicitud. El lago flotante tenía paredes impermeables y el fondo hecho de una sola capa de 1 mm de material de PVC, donde el fondo presentó un módulo de Young de 3 GPa. El material de PVC fue termo fusionado para obtener la estructura del lago flotante, y se unieron materiales de flotación al perímetro de la superficie para proporcionar estabilidad estructural y mantener la forma del lago flotante.

El lago flotante fue instalado en un estanque de irrigación con un área de superficie de más de 6.000 m<sup>2</sup> que contenía agua de mala calidad no adecuada para propósitos recreacionales. El estanque de irrigación contenía agua con alta turbidez, un fondo cubierto con sedimentos que proporcionaba una coloración oscura al agua, y una alta concentración de materia orgánica. Se midieron los parámetros clave de la calidad de agua en el lago circundante. Se encontró que el recuento total de bacterias fue de 300 CFU/ml y que el color verdadero medido con la escala Platino-Cobalto fue de 35. Por lo tanto, el agua del cuerpo de agua circundante fue pre tratada antes de ser alimentada al lago flotante. Aunque el agua cumplió con los requerimientos bacteriológicos, no cumplió con los requerimientos de color verdades, y por lo tanto fue tratada antes de alimentarla al lago flotante.

El lago flotante fue diseñado para tener una presión positiva calculando el volumen extra necesario para alimentar el lago flotante, el cual es equivalente a tener un nivel de agua que está sobre el nivel del agua del estanque. La presión positiva fue escogida para que fuese al menos 20 N/M<sup>2</sup>. Ya que la superficie del lago flotante fue de 64 M<sup>2</sup> el mínimo teórico del volumen sobre nivel fue calculado en 0,128 m<sup>3</sup> de acuerdo a la siguiente ecuación:

$$\text{Volumen sobre nivel (m}^3\text{)} \geq 0.002 \text{ m} \times 64 \text{ m}^2$$

$$\text{Volumen sobre nivel (m}^3\text{)} \geq 0.128 \text{ m}^3$$

Consecuentemente, ya que el nivel del agua dentro del lago flotante se deseó que fuera 2 mm sobre el nivel del agua del agua circundante, el volumen total de agua necesaria para alcanzar este volumen sobre nivel fue calculado en 0,128 m<sup>3</sup>. En la práctica, sin embargo, se descubrió que, debido a la flexibilidad de las paredes del lago flotante, es decir, la estructura que separa el volumen del lago flotante del agua circundante, cuando fue agregado el volumen sobre nivel, las paredes del lago flotante se expandieron. Esta expansión causó que el nivel de agua real en el lago flotante fuera igual al nivel del agua circundante, como así también las presiones positivas deseadas.

El volumen sobre nivel diseñado fue de 0,5 m<sup>3</sup>, que corresponde a una presión positiva equivalente a una altura del agua dentro del lago flotante de 7,8 mm sobre el nivel del agua circundante, a una presión positiva de alrededor de 76 N/m<sup>2</sup>. Dicha presión positiva fue mantenida para proporcionar a los bordes del lago flotante dispositivos de flotación que compensaron el peso del agua.

Un sistema de coordinación activó la aplicación de agentes oxidantes para mantener el nivel de ORP de 570 mV por 18 horas dentro de ciclos de 52 horas, y también se activó la aplicación de una composición floculante para evitar que la turbidez del agua exceda 5 NTU. El agente oxidante aplicado fue hipoclorito de sodio, agregado en una concentración de 1 ppm durante la aplicación. La incorporación del floculante causó que la floculación de impurezas permitió que fueran sedimentadas en el fondo del lago flotante.

Un sistema de coordinación también activó la operación de un dispositivo de succión móvil, enviando una señal al operador apropiado del dispositivo, y donde el dispositivo de succión móvil permitió limpiar el fondo construido de PVC con un módulo de Young de alrededor de 3 GPa. El dispositivo de succión móvil fue diseñado

especialmente y comprende un sistema magnético que permite limpiar el fondo flexible. El dispositivo de succión comprende un componente interno que fue ubicado en la superficie interna del fondo del lago flotante y un componente externo ubicado en la superficie externa del fondo del lago flotante. Los componentes internos y externos fueron atraídos magnéticamente y permitió limpiar el fondo flexible del lago flotante succionando el material sedimentado.

El dispositivo de succión fue activado antes del aumento del componente negro en el fondo excedido en 30% en una escala CMYK comparado con el color original. El componente de color negro del fondo fue evaluado a través de comparación visual con una escala de CMYK. El dispositivo de succión fue operado, y se movió a través del fondo del lago flotante succionando las impurezas sedimentadas.

El agua succionada por el dispositivo de succión fue bombeada a través de mangueras flexibles a un sistema de filtración que fue ubicado en el borde del estanque de irrigación.

El agua fue suministrada al lago flotante para mantener una presión positiva en el lago flotante. El agua de reemplazo compensada por la tasa de evaporación, que fue estimada en 2 mm por día, y una flujo de agua muy pequeño correspondiente a la tasa de limpieza. Por lo tanto, la tasa de reemplazo fue calculada para mantener un volumen sobre nivel positivo de acuerdo a la tasa de limpieza y la tasa de evaporación. El flujo de agua de reemplazo fue intermitente, y permitió mantener una presión positiva equivalente para mantener el nivel de agua del lago flotante entre 5 mm y 1 cm sobre el agua circundante por más del 50% del tiempo dentro de períodos de 7 días.

Como comparación, los parámetros de calidad del agua fueron obtenidos desde el lago flotante y el cuerpo de agua circundante:

Tabla 1: Comparación de Calidad del Agua en el Cuerpo de Agua Circundante y el Lago Flotante

| <b>Parámetro</b>            | <b>Unidad</b> | <b>Lago Flotante</b> | <b>Estanque de Irrigación Circundante</b> |
|-----------------------------|---------------|----------------------|-------------------------------------------|
| Color Verdadero             | Pt-Co         | 10                   | 35                                        |
| Cuenta Total Bacteriológica | CFU/ml        | <5                   | 300                                       |
| Turbidez                    | NTU           | 2                    | 10                                        |

|                                                                        |                         |                                              |                                              |
|------------------------------------------------------------------------|-------------------------|----------------------------------------------|----------------------------------------------|
| Claridad (Transparencia horizontal con Visualización con Disco Secchi) | Medida del Disco Secchi | Más de 20 metros de transparencia horizontal | Menos de 1 metro de transparencia horizontal |
|------------------------------------------------------------------------|-------------------------|----------------------------------------------|----------------------------------------------|

El lago flotante y método del Ejemplo 1 proporcionó un cuerpo de agua seguro y estéticamente atractivo que presentó una mejor coloración y calidad del agua que el estanque circundante.

Aunque ciertas realizaciones de la invención han sido descritas, pueden existir otras realizaciones. Aunque la especificación incluye una descripción detallada, el alcance de la invención es indicado por las siguientes reivindicaciones. Más aún, aunque la especificación ha sido descrita en lenguaje específico para características estructurales y/o actos metodológicos, las reivindicaciones no están limitadas por las características antes descritas. En su lugar, las características específicas y actos descritos anteriormente son divulgadas como aspectos ilustrativos y realizaciones de la invención. Varios otros aspectos, realizaciones, modificaciones, y equivalentes de las cuales, después de leer la descripción aquí contenida, ellos mismos pueden sugerir a un experto ordinario en el arte sin apartarse del espíritu de la presente invención o el alcance de la materia reivindicada.

## **Reivindicaciones**

1. Un método para tratamiento de agua en un lago flotante, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua, tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el lago flotante incluye paredes y un fondo, y donde al fondo del lago flotante está construido de un material flexible que tiene un módulo de Young de hasta 20GPa, donde el método comprende:
  - a. aplicar un oxidante al agua para mantener un nivel de ORP de al menos 550 mV por un mínimo de alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas.
  - b. aplicar un floculante al agua antes de que la turbidez del agua exceda 5 NTU;
  - c. activar la operación de uno o más dispositivos de succión móviles antes de que el componente negro del fondo del lago flotante exceda el 30% en una escala de CMYK, donde el dispositivo de succión móvil succiona una porción del agua desde el fondo que contiene sólidos sedimentados;
  - d. filtrar el agua succionada por el dispositivo de succión móvil y devolver el agua filtrada al lago flotante, proporcionando así la remoción de sólidos sedimentados del agua en el lago flotante sin filtrar el volumen total del agua en el lago flotante; y
  - e. suministrar agua al lago flotante para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde el agua suministrada tiene un color verdadero de hasta 35 Pt-Co y menos que 2.000 CFU/ml del recuento de bacterias, y donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días y donde el agua es suministrada al lago flotante en una tasa de reposición de acuerdo con la siguiente ecuación:

$$\textit{Tasa de Reposición} \geq \textit{Tasa de Evaporación} + \textit{Tasa de Limpieza} + \textit{Tasa de Filtración}$$

2. El método de la reivindicación 1, CARACTERIZADO porque el lago flotante tiene un área de superficie más grande que 5.000 m<sup>2</sup>.

3. El método de la reivindicación 1, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos de materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y esencialmente separa el agua de dentro del agua flotante del cuerpo de agua natural o artificial circundante.
4. El método de la reivindicación 1, CARACTERIZADO porque el fondo del lago flotante comprende sistemas que proporcionan estabilidad para la operación de un dispositivo de succión, tal como sistemas de tipo cojín, marcos estructurales, una pluralidad de capas, cámaras, o combinaciones de los mismos.
5. El método de la reivindicación 1, CARACTERIZADO porque el oxidante es seleccionado del grupo que consiste de un compuesto a base de halógeno, sales de permanganato, peróxidos, ozono, persulfato de sodio, persulfato de potasio, un oxidante producido por un método electrolítico, o combinaciones de los mismos.
6. El método de la reivindicación 1, CARACTERIZADO porque el floculante es seleccionado del grupo que consiste de polímero catiónico, polímero aniónico, sal de aluminio, clorhidrato de aluminio, alumbre, sulfato de aluminio, polímeros que contienen amonio cuaternario, policuaternio, óxido de calcio, hidróxido de calcio, sulfato ferroso, cloruro férrico, poliacrilamida, aluminato de sodio, silicato de sodio, quitosano, gelatina, goma guar, alginato, semilla de moringa, derivados de almidón, y combinaciones de los mismos.
7. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo del lago flotante proporciona una coloración específica al cuerpo de agua.
8. El sistema de lago flotante de la reivindicación 7, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
9. El método de la reivindicación 1, CARACTERIZADO porque la aplicación de químicos es activada por un sistema de coordinación.

10. El método de la reivindicación 1, CARACTERIZADO porque la operación del dispositivo de succión es activada por un sistema de coordinación.
11. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo es determinado por métodos empíricos, algoritmos, basados en experiencia, inspección visual, o equipamiento automatizado.
12. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil es capaz de limpiar un fondo flexible con un módulo de Young de menos de 20 GPa.
13. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un sistema magnético capaz de mantener el dispositivo de succión móvil en el fondo flexible.
14. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un dispositivo flexible.
15. El método de la reivindicación 1, CARACTERIZADO porque el sistema de filtración está ubicado en una instalación flotante o en la tierra.
16. El método de la reivindicación 1, CARACTERIZADO porque el agua de reposición es alimentada al lago flotante a través de un sistema de bombeo.
17. Un sistema de lago flotante artificial, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el sistema comprende:

- a. un lago flotante que comprende un fondo flexible que tiene un módulo de Young menor que alrededor de 20 GPa y las paredes tienen un borde, donde el borde comprende un sistema de flotación;
  - b. un sistema de aplicación de químicos para aplicar un oxidante o floculante al agua en el lago flotante; donde el sistema de aplicación de químicos es activado para aplicar un oxidante al agua en el lago flotante para establecer un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas;
  - c. un sistema de bombeo para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.
  - d. un dispositivo de succión móvil capaz de moverse por el fondo flexible del lago flotante y succionar una porción de agua desde el fondo que contiene sólidos sedimentados;
  - e. un sistema de filtración en comunicación fluida con el sistema de succión móvil, donde el sistema de filtración recibe la porción de agua succionada por el sistema de succión móvil; y
  - f. una línea de retorno para devolver el agua filtrada desde el sistema de filtración al lago flotante.
18. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante tiene una superficie más grande que 5.000 m<sup>2</sup>.
19. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos con materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y que esencialmente separan el agua de dentro del lago flotante del cuerpo de agua natural o artificial circundante.

20. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una sola capa impermeable para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
21. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una pluralidad de capas para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
22. El sistema de lago flotante de la reivindicación 21, CARACTERIZADO porque la pluralidad de capas pueden ser del mismo o diferentes materiales y tener diferente permeabilidad.
23. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende un marco estructural que comprende uno o más componentes del marco capaz de proporcionar más estabilidad y/o una configuración modular al fondo.
24. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque el fondo comprende conectores del marco entre los componentes del marco.
25. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante incluye uno o más rieles para proporcionar conexión entre el fondo flexible y uno o más componentes del marco.
26. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales rígidos.
27. El sistema de lago flotante de la reivindicación 26, CARACTERIZADO porque los materiales rígidos de los componentes del marco comprenden metal, aleaciones metálicas, plásticos, madera, concreto, o combinaciones de los mismos.

28. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales flexibles.
29. El sistema de lago flotante de la reivindicación 28, CARACTERIZADO porque los materiales flexibles de los componentes del marco comprenden goma, plástico, tela, nylon, o combinaciones de los mismos.
30. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales flexibles.
31. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales rígidos.
32. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una o más celdas de tipo cojín capaces de proporcionar un fondo estable.
33. El sistema de lago flotante de la reivindicación 32, CARACTERIZADO porque las celdas de tipo cojín están llenadas con un fluido que comprende gas o líquido, o un material de espuma expandible, o combinaciones de los mismos.
34. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de flotación comprende uno o más elementos de flotación seleccionados del grupo que consiste de sistemas de poliuretano; sistemas de poliestireno, tales como poliestireno extruido y perlas de poliestireno expandido; sistemas de polietileno; sistemas llenados con aire, tales como cámaras de aire, bolsas de aire de goma o bolsas de aire de vinilo; y sistemas contruidos de otros materiales adecuados tales como plásticos, espumas, gomas, vinilo, resinas, concreto, aluminio, diferentes tipos de maderas, y combinaciones de los mismos.

35. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante comprende una o más características seleccionadas de playas, calzadas, paseos peatonales, pontones, barandas, o sistemas de entradas inclinadas.
36. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y/o paredes del lago flotante están anclados al fondo del cuerpo de agua circundante para hacer frente a corrientes marinas, vientos, mareas y condiciones del clima específicas del cuerpo de agua circundante y el entorno.
37. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende uno o más puntos de anclaje conectados a puntos de anclaje correspondientes en el fondo del cuerpo de agua circundante.
38. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante es anclado a tierra firme para proporcionar una entrada al sistema de lago flotante.
39. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante está separado de tierra firme por una distancia, y la entrada desde tierra firme al lago flotante es proporcionada por uno o más muelles y puentes que conectan la tierra firme al lago flotante.
40. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende un sistema de coordinación.
41. El sistema de lago flotante de la reivindicación 40, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para recibir información con respecto a parámetros de calidad del agua, procesa la información, y activa el medio de aplicación de químicos y/o activa la operación del dispositivo de succión móvil, y/o sistema de filtración.

42. El sistema de lago flotante de la reivindicación 41, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para activar la operación del dispositivo de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala de CMYK.
43. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el material del fondo es un material flexible seleccionado del grupo que consiste de gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, Tablero de fibras, madera, poliamidas, membranas de PVC, telas, telas compuestas, geo membranas, acrílicos, y combinaciones de los mismos.
44. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque las paredes comprenden un material permeable que permite al agua del cuerpo de agua en el cual el lago flotante está instalado pasar a través de las paredes en una tasa de permeabilidad predeterminada.
45. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema comprende una pluralidad de dispositivos de succión móviles, donde el sistema de filtración comprende una pluralidad de filtros.
46. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color que proporciona una coloración específica al agua en el lago flotante.
47. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
48. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque además comprende una línea de alimentación desde el lago flotante a un sistema intercambiador de calor en un proceso industrial para alimentar el intercambiador

de calor con agua del lago flotante y una línea de retorno de agua desde el intercambiador de calor del proceso industrial al lago flotante.

49. Un sistema de lago flotante artificial construido dentro de un cuerpo de agua circundante, el sistema CARACTERIZADO porque comprende:

- a. un lago flotante dispuesto en un cuerpo de agua circundante, el lago flotante comprende agua y un fondo flexible que tiene un módulo de Young de menos que alrededor de 20 GPa y paredes que tienen un borde, el fondo y paredes definen un volumen, donde el borde comprende un sistema de flotación, y donde el lago flotante tiene un área de superficie de al menos 5.000 m<sup>2</sup>;
- b. un sistema de aplicación de químicos adaptado para aplicar un oxidante o floculante al agua en el lago flotante;
- c. uno o más dispositivos de succión móvil capaces de moverse por el fondo flexible del lago flotante y succionar una porción del agua desde el fondo, donde el agua contiene sólidos sedimentados;
- d. un sistema de filtración que comprende una pluralidad de sistemas de filtración, donde el sistema de filtración está en fluida comunicación con uno o más sistemas de succión móviles, donde el sistema de filtración recibe la porción de agua succionada por uno o más sistemas de succión móvil;
- e. una línea de retorno en fluida comunicación con el sistema de filtración para devolver el agua filtrada al lago flotante;
- f. un sistema de coordinación dispuesto y configurado para activar el sistema de aplicación de químicos para mantener un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de cualquier ciclo de 52 horas, el uno o más dispositivos de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala CMYK; y
- g. un sistema de bombeo construido para bombear el agua en el lago flotante y para mantener una presión positiva de al menos 20 Newtons por cada metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.

50. Un método para tratamiento de agua en un lago flotante, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua, tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el lago flotante incluye paredes y un fondo, y donde al fondo del lago flotante está construido de un material flexible que tiene un módulo de Young de hasta 20GPa, donde el método comprende:

- a. aplicar un oxidante al agua para mantener un nivel de ORP de al menos 550 mV por un mínimo de alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas.
- b. aplicar un floculante al agua antes de que la turbidez del agua exceda 5 NTU;
- c. activar la operación de uno o más dispositivos de succión móviles antes de que el componente negro del fondo del lago flotante exceda el 30% en una escala de CMYK, donde el dispositivo de succión móvil succiona una porción del agua desde el fondo que contiene sólidos sedimentados;
- d. filtrar el agua succionada por el dispositivo de succión móvil y devolver el agua filtrada al lago flotante, proporcionando así la remoción de sólidos sedimentados del agua en el lago flotante sin filtrar el volumen total del agua en el lago flotante; y
- e. suministrar agua al lago flotante para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde el agua suministrada tiene un color verdadero de hasta 35 Pt-Co y menos que 2.000 CFU/ml del recuento de bacterias, y donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días y donde el agua es suministrada al lago flotante en una tasa de reposición de acuerdo con la siguiente ecuación:

$$\text{Tasa de Reposición} \geq \text{Tasa de Evaporación} + \text{Tasa de Limpieza} + \text{Tasa de Filtración}$$

51. El método de la reivindicación 1, CARACTERIZADO porque el lago flotante tiene un área de superficie más grande que 5.000 m<sup>2</sup>.

52. El método de la reivindicación 1, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos de materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y esencialmente separa el agua de dentro del agua flotante del cuerpo de agua natural o artificial circundante.
53. El método de la reivindicación 1, CARACTERIZADO porque el fondo del lago flotante comprende sistemas que proporcionan estabilidad para la operación de un dispositivo de succión, tal como sistemas de tipo cojín, marcos estructurales, una pluralidad de capas, cámaras, o combinaciones de los mismos.
54. El método de la reivindicación 1, CARACTERIZADO porque el oxidante es seleccionado del grupo que consiste de un compuesto a base de halógeno, sales de permanganato, peróxidos, ozono, persulfato de sodio, persulfato de potasio, un oxidante producido por un método electrolítico, o combinaciones de los mismos.
55. El método de la reivindicación 1, CARACTERIZADO porque el floculante es seleccionado del grupo que consiste de polímero catiónico, polímero aniónico, sal de aluminio, clorhidrato de aluminio, alumbre, sulfato de aluminio, polímeros que contienen amonio cuaternario, policuaternio, óxido de calcio, hidróxido de calcio, sulfato ferroso, cloruro férrico, poliacrilamida, aluminato de sodio, silicato de sodio, quitosano, gelatina, goma guar, alginato, semilla de moringa, derivados de almidón, y combinaciones de los mismos.
56. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo del lago flotante proporciona una coloración específica al cuerpo de agua.
57. El sistema de lago flotante de la reivindicación 7, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
58. El método de la reivindicación 1, CARACTERIZADO porque la aplicación de químicos es activada por un sistema de coordinación.

59. El método de la reivindicación 1, CARACTERIZADO porque la operación del dispositivo de succión es activada por un sistema de coordinación.
60. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo es determinado por métodos empíricos, algoritmos, basados en experiencia, inspección visual, o equipamiento automatizado.
61. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil es capaz de limpiar un fondo flexible con un módulo de Young de menos de 20 GPa.
62. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un sistema magnético capaz de mantener el dispositivo de succión móvil en el fondo flexible.
63. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un dispositivo flexible.
64. El método de la reivindicación 1, CARACTERIZADO porque el sistema de filtración está ubicado en una instalación flotante o en la tierra.
65. El método de la reivindicación 1, CARACTERIZADO porque el agua de reposición es alimentada al lago flotante a través de un sistema de bombeo.
66. Un sistema de lago flotante artificial, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el sistema comprende:
- g. un lago flotante que comprende un fondo flexible que tiene un módulo de Young menor que alrededor de 20 GPa y las paredes tienen un borde, donde el borde comprende un sistema de flotación;

- h. un sistema de aplicación de químicos para aplicar un oxidante o floculante al agua en el lago flotante; donde el sistema de aplicación de químicos es activado para aplicar un oxidante al agua en el lago flotante para establecer un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas;
- i. un sistema de bombeo para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.
- j. un dispositivo de succión móvil capaz de moverse por el fondo flexible del lago flotante y succionar una porción de agua desde el fondo que contiene sólidos sedimentados;
- k. un sistema de filtración en comunicación fluida con el sistema de succión móvil, donde el sistema de filtración recibe la porción de agua succionada por el sistema de succión móvil; y
- l. una línea de retorno para devolver el agua filtrada desde el sistema de filtración al lago flotante.

67. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante tiene una superficie más grande que 5.000 m<sup>2</sup>.

68. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos con materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y que esencialmente separan el agua de dentro del lago flotante del cuerpo de agua natural o artificial circundante.

69. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una sola capa impermeable para separar el agua de dentro del lago flotante del cuerpo de agua circundante.

70. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una pluralidad de capas para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
71. El sistema de lago flotante de la reivindicación 21, CARACTERIZADO porque la pluralidad de capas pueden ser del mismo o diferentes materiales y tener diferente permeabilidad.
72. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende un marco estructural que comprende uno o más componentes del marco capaz de proporcionar más estabilidad y/o una configuración modular al fondo.
73. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque el fondo comprende conectores del marco entre los componentes del marco.
74. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante incluye uno o más rieles para proporcionar conexión entre el fondo flexible y uno o más componentes del marco.
75. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales rígidos.
76. El sistema de lago flotante de la reivindicación 26, CARACTERIZADO porque los materiales rígidos de los componentes del marco comprenden metal, aleaciones metálicas, plásticos, madera, concreto, o combinaciones de los mismos.
77. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales flexibles.

78. El sistema de lago flotante de la reivindicación 28, CARACTERIZADO porque los materiales flexibles de los componentes del marco comprenden goma, plástico, tela, nylon, o combinaciones de los mismos.
79. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales flexibles.
80. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales rígidos.
81. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una o más celdas de tipo cojín capaces de proporcionar un fondo estable.
82. El sistema de lago flotante de la reivindicación 32, CARACTERIZADO porque las celdas de tipo cojín están llenadas con un fluido que comprende gas o líquido, o un material de espuma expandible, o combinaciones de los mismos.
83. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de flotación comprende uno o más elementos de flotación seleccionados del grupo que consiste de sistemas de poliuretano; sistemas de poliestireno, tales como poliestireno extruido y perlas de poliestireno expandido; sistemas de polietileno; sistemas llenados con aire, tales como cámaras de aire, bolsas de aire de goma o bolsas de aire de vinilo; y sistemas contruidos de otros materiales adecuados tales como plásticos, espumas, gomas, vinilo, resinas, concreto, aluminio, diferentes tipos de maderas, y combinaciones de los mismos.
84. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante comprende una o más características seleccionadas de playas, calzadas, paseos peatonales, pontones, barandas, o sistemas de entradas inclinadas.

85. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y/o paredes del lago flotante están anclados al fondo del cuerpo de agua circundante para hacer frente a corrientes marinas, vientos, mareas y condiciones del clima específicas del cuerpo de agua circundante y el entorno.
86. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende uno o más puntos de anclaje conectados a puntos de anclaje correspondientes en el fondo del cuerpo de agua circundante.
87. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante es anclado a tierra firme para proporcionar una entrada al sistema de lago flotante.
88. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante está separado de tierra firme por una distancia, y la entrada desde tierra firme al lago flotante es proporcionada por uno o más muelles y puentes que conectan la tierra firme al lago flotante.
89. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende un sistema de coordinación.
90. El sistema de lago flotante de la reivindicación 40, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para recibir información con respecto a parámetros de calidad del agua, procesa la información, y activa el medio de aplicación de químicos y/o activa la operación del dispositivo de succión móvil, y/o sistema de filtración.
91. El sistema de lago flotante de la reivindicación 41, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para activar la operación del dispositivo de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala de CMYK.

92. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el material del fondo es un material flexible seleccionado del grupo que consiste de gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, Tablero de fibras, madera, poliamidas, membranas de PVC, telas, telas compuestas, geo membranas, acrílicos, y combinaciones de los mismos.
93. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque las paredes comprenden un material permeable que permite al agua del cuerpo de agua en el cual el lago flotante está instalado pasar a través de las paredes en una tasa de permeabilidad predeterminada.
94. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema comprende una pluralidad de dispositivos de succión móviles, donde el sistema de filtración comprende una pluralidad de filtros.
95. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color que proporciona una coloración específica al agua en el lago flotante.
96. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
97. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque además comprende una línea de alimentación desde el lago flotante a un sistema intercambiador de calor en un proceso industrial para alimentar el intercambiador de calor con agua del lago flotante y una línea de retorno de agua desde el intercambiador de calor del proceso industrial al lago flotante.
98. Un sistema de lago flotante artificial construido dentro de un cuerpo de agua circundante, el sistema CARACTERIZADO porque comprende:

- h. un lago flotante dispuesto en un cuerpo de agua circundante, el lago flotante comprende agua y un fondo flexible que tiene un módulo de Young de menos que alrededor de 20 GPa y paredes que tienen un borde, el fondo y paredes definen un volumen, donde el borde comprende un sistema de flotación, y donde el lago flotante tiene un área de superficie de al menos 5.000 m<sup>2</sup>;
- i. un sistema de aplicación de químicos adaptado para aplicar un oxidante o floculante al agua en el lago flotante;
- j. uno o más dispositivos de succión móvil capaces de moverse por el fondo flexible del lago flotante y succionar una porción del agua desde el fondo, donde el agua contiene sólidos sedimentados;
- k. un sistema de filtración que comprende una pluralidad de sistemas de filtración, donde el sistema de filtración está en fluida comunicación con uno o más sistemas de succión móviles, donde el sistema de filtración recibe la porción de agua succionada por uno o más sistemas de succión móvil;
- l. una línea de retorno en fluida comunicación con el sistema de filtración para devolver el agua filtrada al lago flotante;
- m. un sistema de coordinación dispuesto y configurado para activar el sistema de aplicación de químicos para mantener un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de cualquier ciclo de 52 horas, el uno o más dispositivos de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala CMYK; y
- n. un sistema de bombeo construido para bombear el agua en el lago flotante y para mantener una presión positiva de al menos 20 Newtons por cada metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.



Figura 1



Figura 2

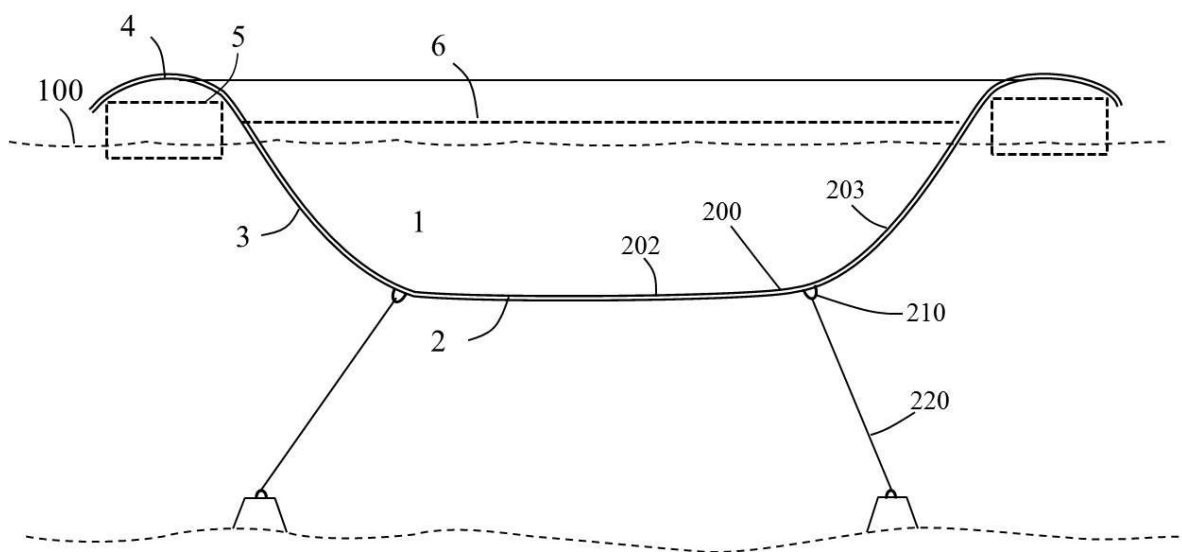


Figura 3



Figura 4A

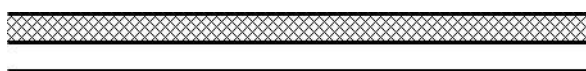


Figura 4B

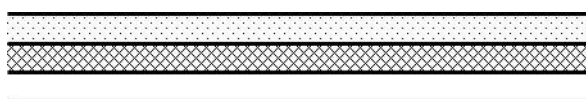


Figura 4C

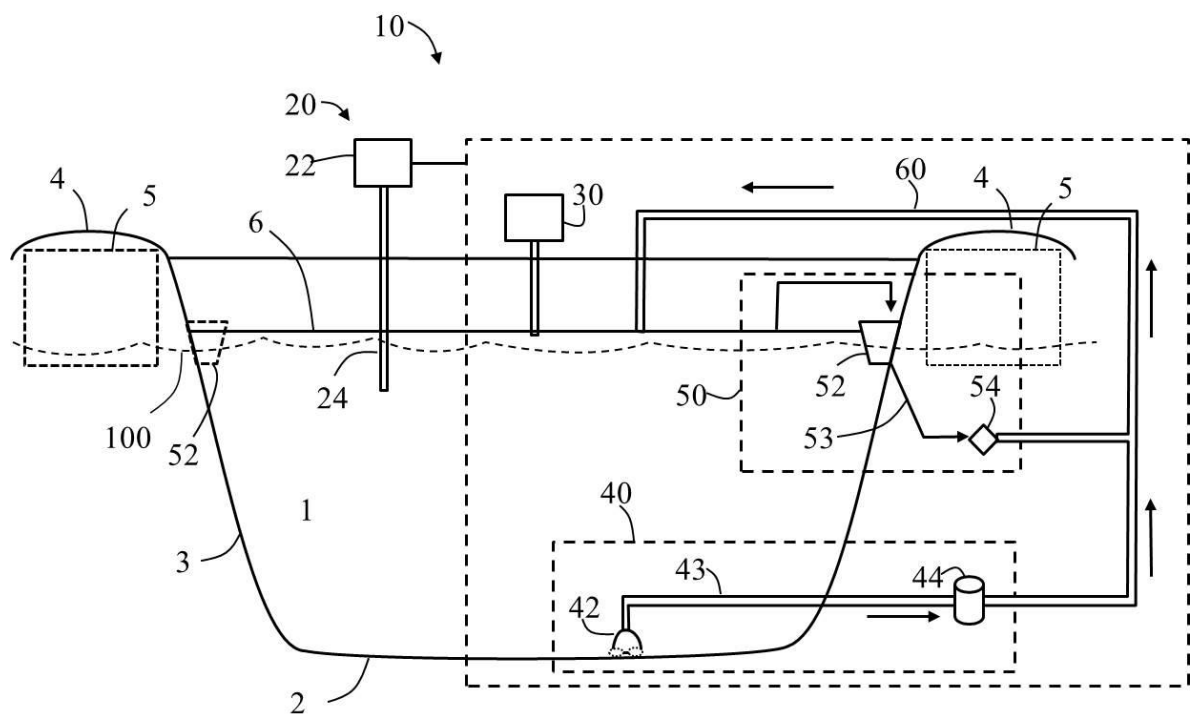


Figure 5

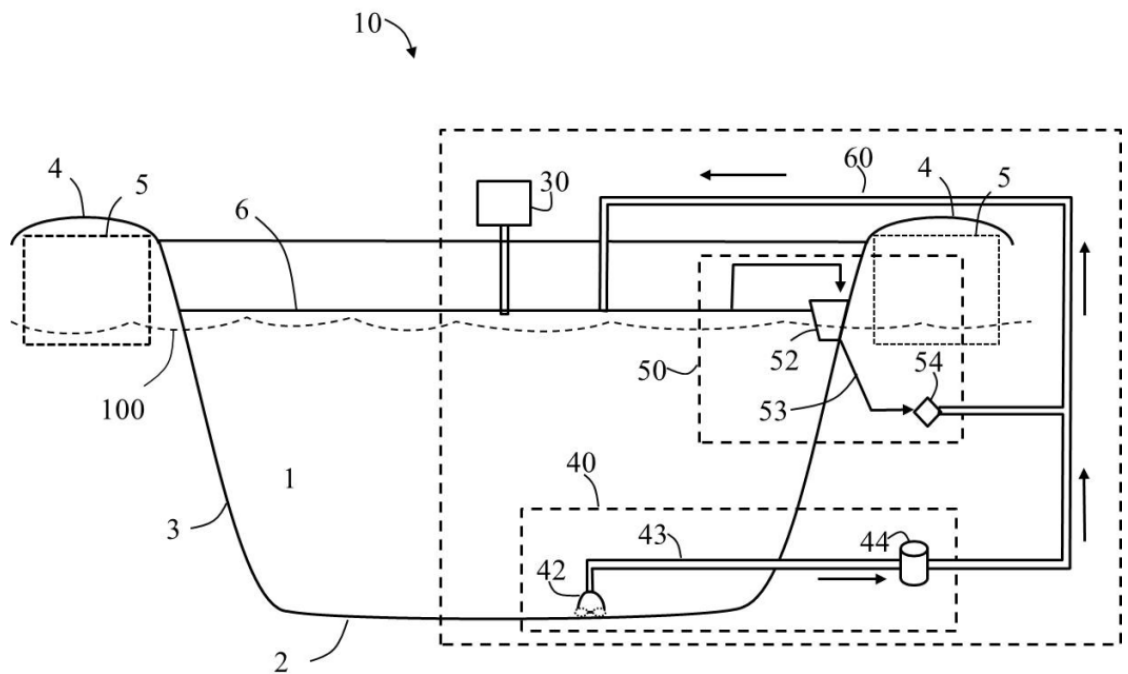
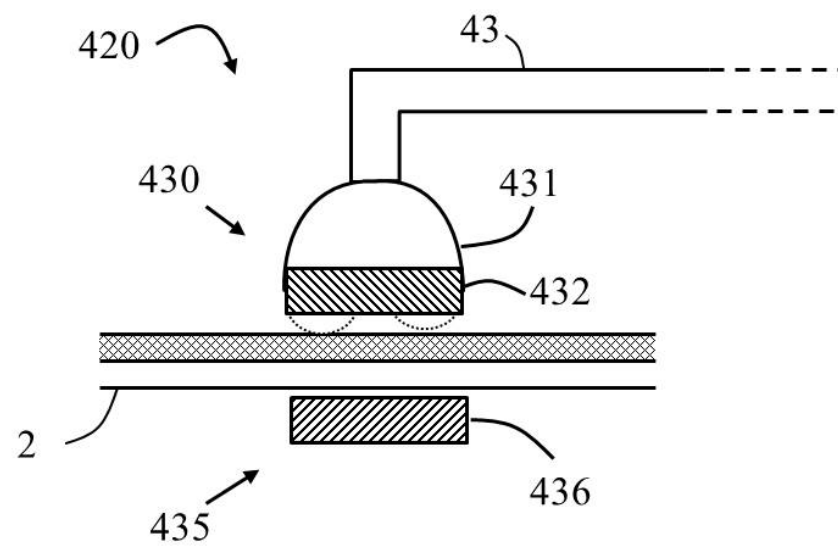
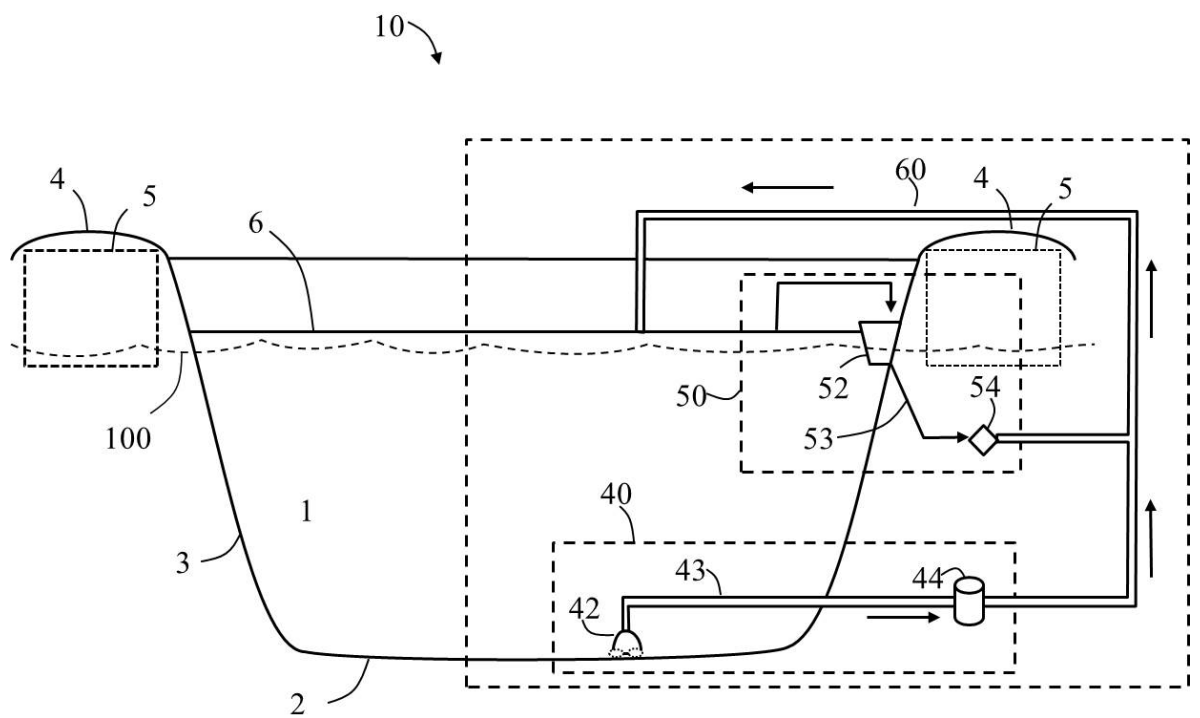


Figure 6



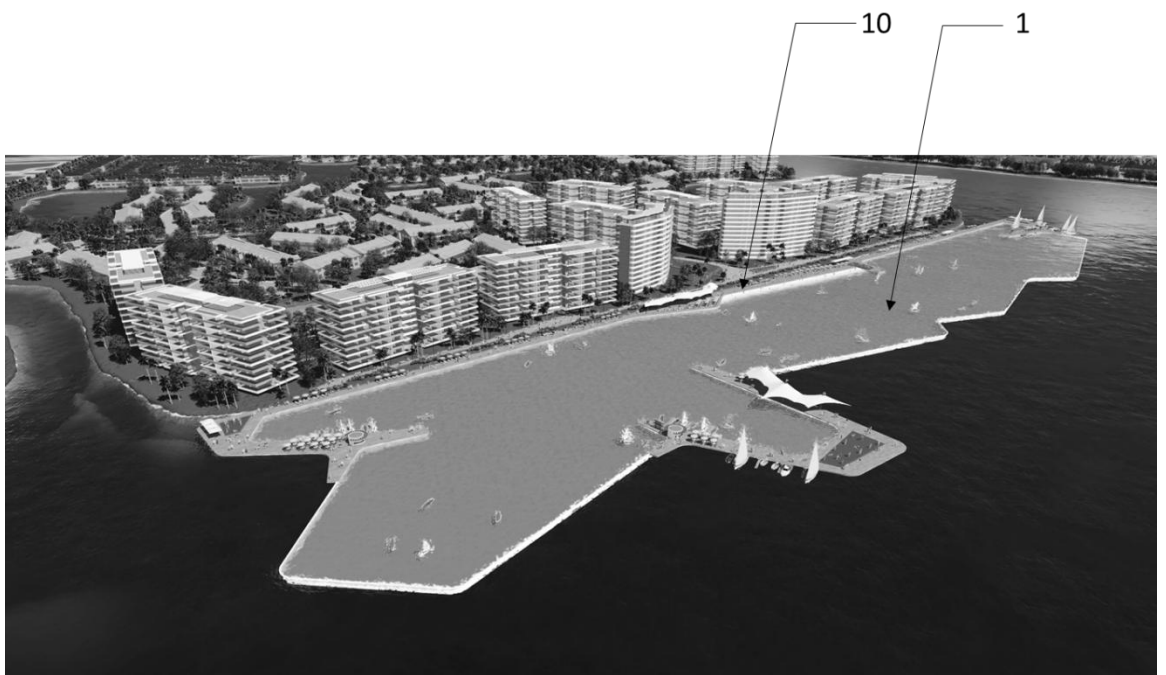


Figura 9A

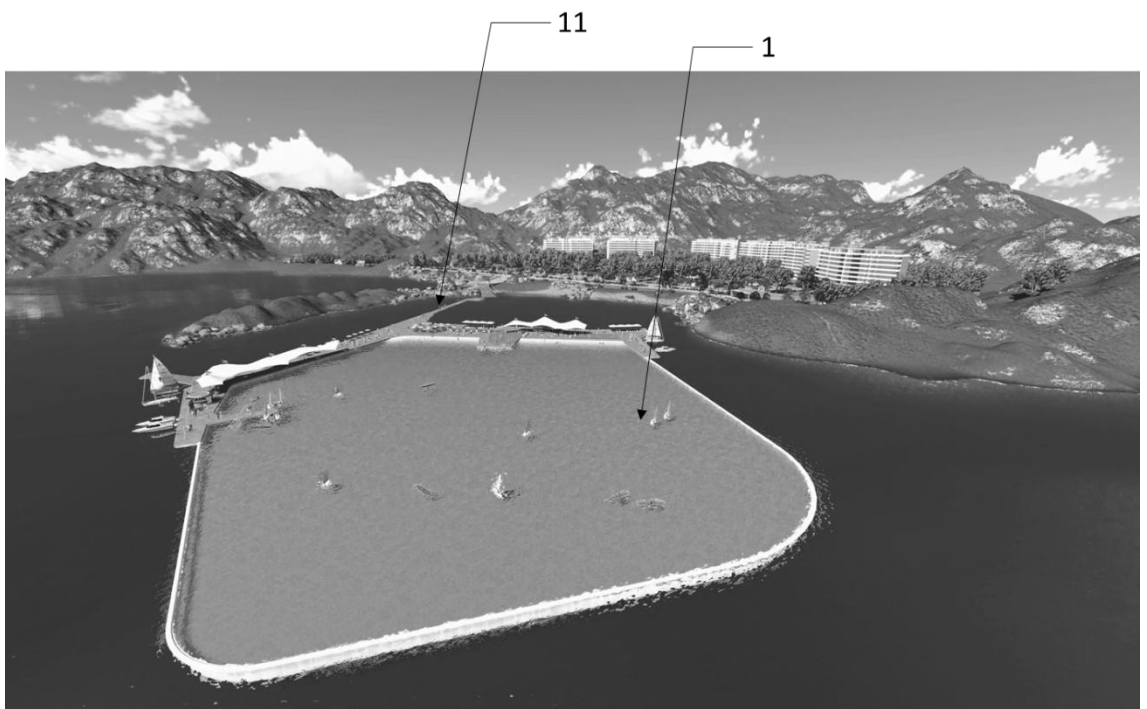


Figura 9B

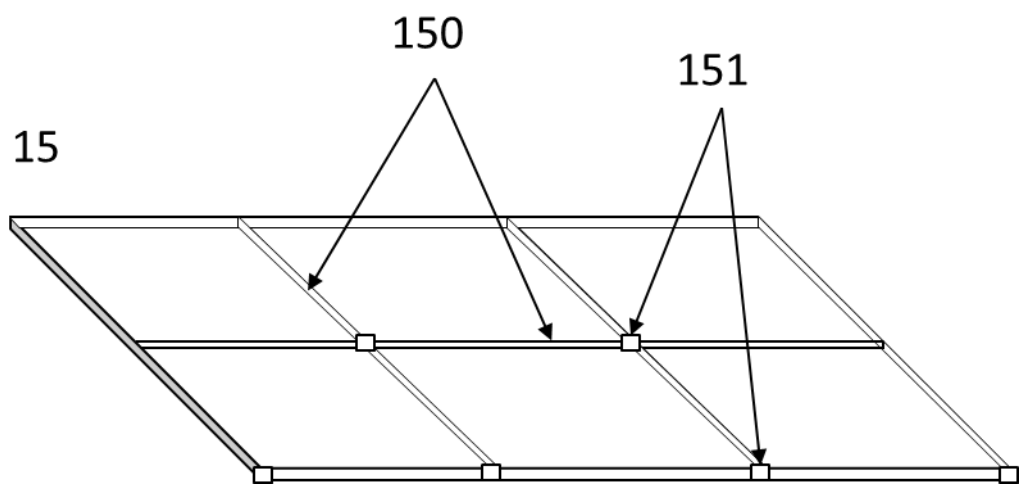


Figura 10A

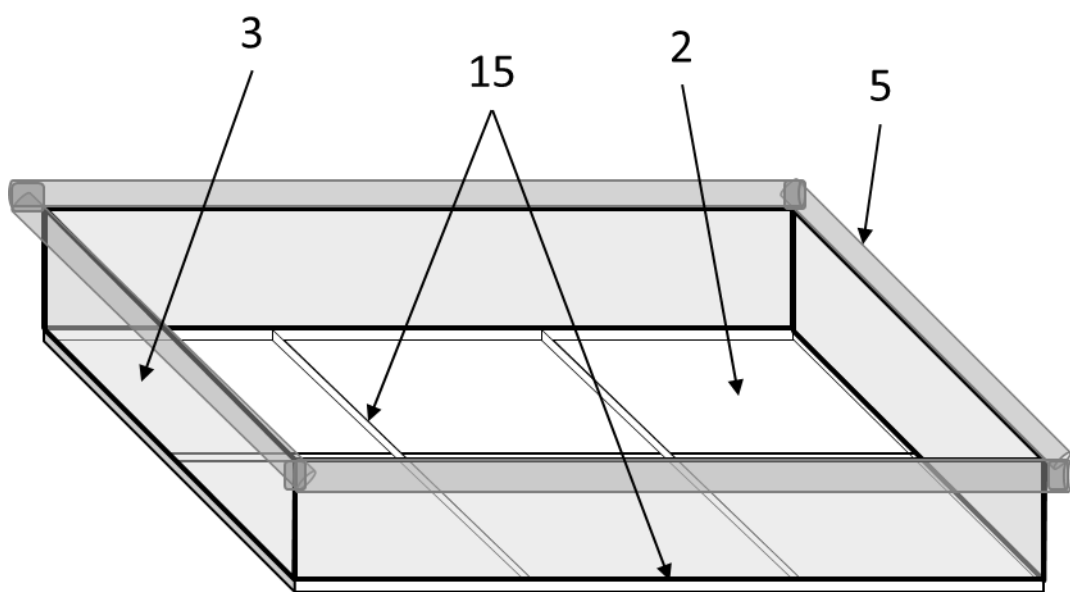


Figura 10B

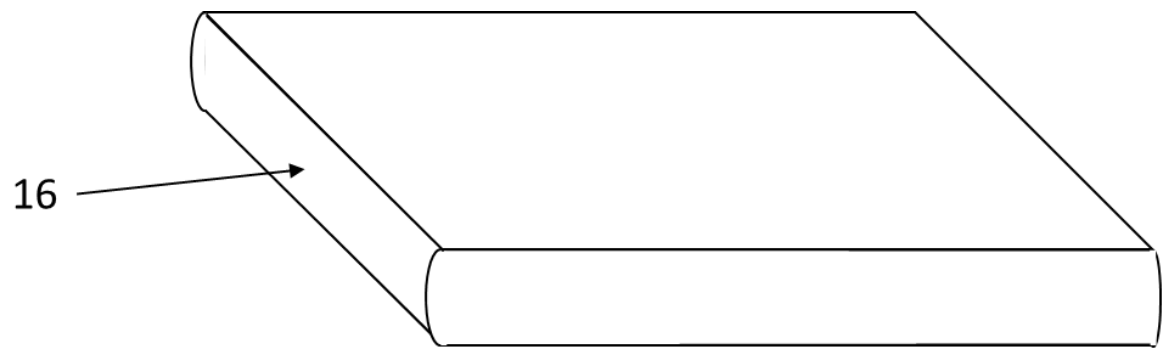


Figura 11A

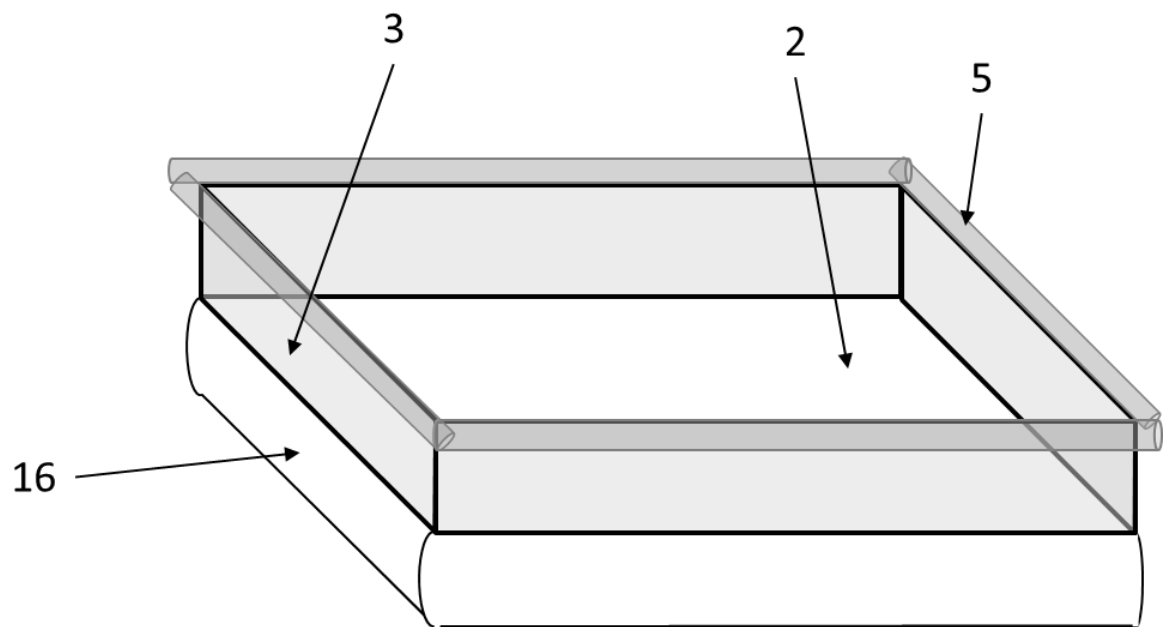


Figura 11B

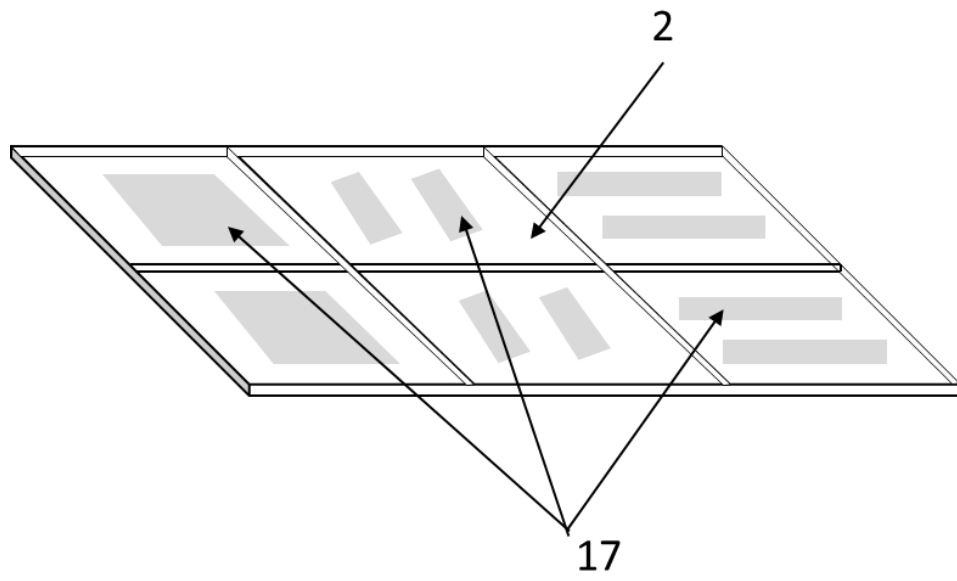


Figura 12A

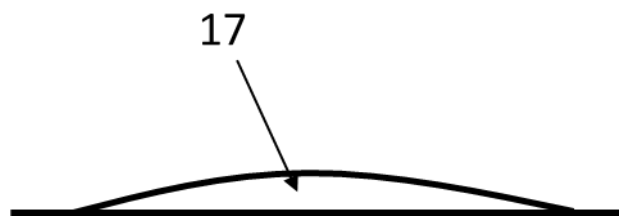


Figura 12B

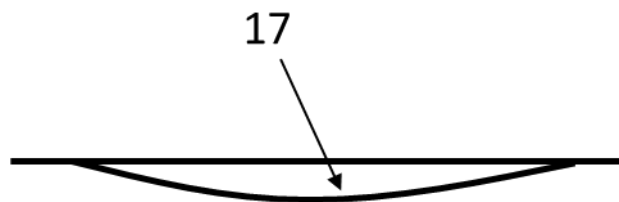


Figura 12C

## **Resumen**

La presente invención se relaciona a lagos flotantes y al tratamiento de agua en tales lagos. La presente invención además se relaciona a grandes lagos flotantes que pueden ser instalados dentro de un cuerpo de agua natural o artificial para mejorar condiciones del agua que son inadecuados para usos recreacionales. El lago flotante puede ser proporcionado con un sistema de aplicación de químicos; un sistema de filtración incluyendo un dispositivo de succión móvil y filtros; un sistema de espumadera, y opcionalmente un sistema de coordinación.

## **Reivindicaciones**

1. Un método para tratamiento de agua en un lago flotante, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua, tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el lago flotante incluye paredes y un fondo, y donde al fondo del lago flotante está construido de un material flexible que tiene un módulo de Young de hasta 20GPa, donde el método comprende:
  - a. aplicar un oxidante al agua para mantener un nivel de ORP de al menos 550 mV por un mínimo de alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas.
  - b. aplicar un floculante al agua antes de que la turbidez del agua exceda 5 NTU;
  - c. activar la operación de uno o más dispositivos de succión móviles antes de que el componente negro del fondo del lago flotante exceda el 30% en una escala de CMYK, donde el dispositivo de succión móvil succiona una porción del agua desde el fondo que contiene sólidos sedimentados;
  - d. filtrar el agua succionada por el dispositivo de succión móvil y devolver el agua filtrada al lago flotante, proporcionando así la remoción de sólidos sedimentados del agua en el lago flotante sin filtrar el volumen total del agua en el lago flotante; y
  - e. suministrar agua al lago flotante para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde el agua suministrada tiene un color verdadero de hasta 35 Pt-Co y menos que 2.000 CFU/ml del recuento de bacterias, y donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días y donde el agua es suministrada al lago flotante en una tasa de reposición de acuerdo con la siguiente ecuación:

$$\textit{Tasa de Reposición} \geq \textit{Tasa de Evaporación} + \textit{Tasa de Limpieza} + \textit{Tasa de Filtración}$$

2. El método de la reivindicación 1, CARACTERIZADO porque el lago flotante tiene un área de superficie más grande que 5.000 m<sup>2</sup>.

3. El método de la reivindicación 1, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos de materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y esencialmente separa el agua de dentro del agua flotante del cuerpo de agua natural o artificial circundante.
4. El método de la reivindicación 1, CARACTERIZADO porque el fondo del lago flotante comprende sistemas que proporcionan estabilidad para la operación de un dispositivo de succión, tal como sistemas de tipo cojín, marcos estructurales, una pluralidad de capas, cámaras, o combinaciones de los mismos.
5. El método de la reivindicación 1, CARACTERIZADO porque el oxidante es seleccionado del grupo que consiste de un compuesto a base de halógeno, sales de permanganato, peróxidos, ozono, persulfato de sodio, persulfato de potasio, un oxidante producido por un método electrolítico, o combinaciones de los mismos.
6. El método de la reivindicación 1, CARACTERIZADO porque el floculante es seleccionado del grupo que consiste de polímero catiónico, polímero aniónico, sal de aluminio, clorhidrato de aluminio, alumbre, sulfato de aluminio, polímeros que contienen amonio cuaternario, policuaternio, óxido de calcio, hidróxido de calcio, sulfato ferroso, cloruro férrico, poliacrilamida, aluminato de sodio, silicato de sodio, quitosano, gelatina, goma guar, alginato, semilla de moringa, derivados de almidón, y combinaciones de los mismos.
7. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo del lago flotante proporciona una coloración específica al cuerpo de agua.
8. El sistema de lago flotante de la reivindicación 7, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
9. El método de la reivindicación 1, CARACTERIZADO porque la aplicación de químicos es activada por un sistema de coordinación.

10. El método de la reivindicación 1, CARACTERIZADO porque la operación del dispositivo de succión es activada por un sistema de coordinación.
11. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo es determinado por métodos empíricos, algoritmos, basados en experiencia, inspección visual, o equipamiento automatizado.
12. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil es capaz de limpiar un fondo flexible con un módulo de Young de menos de 20 GPa.
13. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un sistema magnético capaz de mantener el dispositivo de succión móvil en el fondo flexible.
14. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un dispositivo flexible.
15. El método de la reivindicación 1, CARACTERIZADO porque el sistema de filtración está ubicado en una instalación flotante o en la tierra.
16. El método de la reivindicación 1, CARACTERIZADO porque el agua de reposición es alimentada al lago flotante a través de un sistema de bombeo.
17. Un sistema de lago flotante artificial, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el sistema comprende:

- a. un lago flotante que comprende un fondo flexible que tiene un módulo de Young menor que alrededor de 20 GPa y las paredes tienen un borde, donde el borde comprende un sistema de flotación;
  - b. un sistema de aplicación de químicos para aplicar un oxidante o floculante al agua en el lago flotante; donde el sistema de aplicación de químicos es activado para aplicar un oxidante al agua en el lago flotante para establecer un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas;
  - c. un sistema de bombeo para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.
  - d. un dispositivo de succión móvil capaz de moverse por el fondo flexible del lago flotante y succionar una porción de agua desde el fondo que contiene sólidos sedimentados;
  - e. un sistema de filtración en comunicación fluida con el sistema de succión móvil, donde el sistema de filtración recibe la porción de agua succionada por el sistema de succión móvil; y
  - f. una línea de retorno para devolver el agua filtrada desde el sistema de filtración al lago flotante.
18. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante tiene una superficie más grande que 5.000 m<sup>2</sup>.
19. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos con materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y que esencialmente separan el agua de dentro del lago flotante del cuerpo de agua natural o artificial circundante.

20. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una sola capa impermeable para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
21. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una pluralidad de capas para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
22. El sistema de lago flotante de la reivindicación 21, CARACTERIZADO porque la pluralidad de capas pueden ser del mismo o diferentes materiales y tener diferente permeabilidad.
23. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende un marco estructural que comprende uno o más componentes del marco capaz de proporcionar más estabilidad y/o una configuración modular al fondo.
24. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque el fondo comprende conectores del marco entre los componentes del marco.
25. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante incluye uno o más rieles para proporcionar conexión entre el fondo flexible y uno o más componentes del marco.
26. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales rígidos.
27. El sistema de lago flotante de la reivindicación 26, CARACTERIZADO porque los materiales rígidos de los componentes del marco comprenden metal, aleaciones metálicas, plásticos, madera, concreto, o combinaciones de los mismos.

28. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales flexibles.
29. El sistema de lago flotante de la reivindicación 28, CARACTERIZADO porque los materiales flexibles de los componentes del marco comprenden goma, plástico, tela, nylon, o combinaciones de los mismos.
30. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales flexibles.
31. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales rígidos.
32. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una o más celdas de tipo cojín capaces de proporcionar un fondo estable.
33. El sistema de lago flotante de la reivindicación 32, CARACTERIZADO porque las celdas de tipo cojín están llenadas con un fluido que comprende gas o líquido, o un material de espuma expandible, o combinaciones de los mismos.
34. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de flotación comprende uno o más elementos de flotación seleccionados del grupo que consiste de sistemas de poliuretano; sistemas de poliestireno, tales como poliestireno extruido y perlas de poliestireno expandido; sistemas de polietileno; sistemas llenados con aire, tales como cámaras de aire, bolsas de aire de goma o bolsas de aire de vinilo; y sistemas contruidos de otros materiales adecuados tales como plásticos, espumas, gomas, vinilo, resinas, concreto, aluminio, diferentes tipos de maderas, y combinaciones de los mismos.

35. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante comprende una o más características seleccionadas de playas, calzadas, paseos peatonales, pontones, barandas, o sistemas de entradas inclinadas.
36. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y/o paredes del lago flotante están anclados al fondo del cuerpo de agua circundante para hacer frente a corrientes marinas, vientos, mareas y condiciones del clima específicas del cuerpo de agua circundante y el entorno.
37. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende uno o más puntos de anclaje conectados a puntos de anclaje correspondientes en el fondo del cuerpo de agua circundante.
38. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante es anclado a tierra firme para proporcionar una entrada al sistema de lago flotante.
39. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante está separado de tierra firme por una distancia, y la entrada desde tierra firme al lago flotante es proporcionada por uno o más muelles y puentes que conectan la tierra firme al lago flotante.
40. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende un sistema de coordinación.
41. El sistema de lago flotante de la reivindicación 40, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para recibir información con respecto a parámetros de calidad del agua, procesa la información, y activa el medio de aplicación de químicos y/o activa la operación del dispositivo de succión móvil, y/o sistema de filtración.

42. El sistema de lago flotante de la reivindicación 41, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para activar la operación del dispositivo de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala de CMYK.
43. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el material del fondo es un material flexible seleccionado del grupo que consiste de gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, Tablero de fibras, madera, poliamidas, membranas de PVC, telas, telas compuestas, geo membranas, acrílicos, y combinaciones de los mismos.
44. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque las paredes comprenden un material permeable que permite al agua del cuerpo de agua en el cual el lago flotante está instalado pasar a través de las paredes en una tasa de permeabilidad predeterminada.
45. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema comprende una pluralidad de dispositivos de succión móviles, donde el sistema de filtración comprende una pluralidad de filtros.
46. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color que proporciona una coloración específica al agua en el lago flotante.
47. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
48. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque además comprende una línea de alimentación desde el lago flotante a un sistema intercambiador de calor en un proceso industrial para alimentar el intercambiador

de calor con agua del lago flotante y una línea de retorno de agua desde el intercambiador de calor del proceso industrial al lago flotante.

49. Un sistema de lago flotante artificial construido dentro de un cuerpo de agua circundante, el sistema CARACTERIZADO porque comprende:

- a. un lago flotante dispuesto en un cuerpo de agua circundante, el lago flotante comprende agua y un fondo flexible que tiene un módulo de Young de menos que alrededor de 20 GPa y paredes que tienen un borde, el fondo y paredes definen un volumen, donde el borde comprende un sistema de flotación, y donde el lago flotante tiene un área de superficie de al menos 5.000 m<sup>2</sup>;
- b. un sistema de aplicación de químicos adaptado para aplicar un oxidante o floculante al agua en el lago flotante;
- c. uno o más dispositivos de succión móvil capaces de moverse por el fondo flexible del lago flotante y succionar una porción del agua desde el fondo, donde el agua contiene sólidos sedimentados;
- d. un sistema de filtración que comprende una pluralidad de sistemas de filtración, donde el sistema de filtración está en fluida comunicación con uno o más sistemas de succión móviles, donde el sistema de filtración recibe la porción de agua succionada por uno o más sistemas de succión móvil;
- e. una línea de retorno en fluida comunicación con el sistema de filtración para devolver el agua filtrada al lago flotante;
- f. un sistema de coordinación dispuesto y configurado para activar el sistema de aplicación de químicos para mantener un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de cualquier ciclo de 52 horas, el uno o más dispositivos de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala CMYK; y
- g. un sistema de bombeo construido para bombear el agua en el lago flotante y para mantener una presión positiva de al menos 20 Newtons por cada metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.

50. Un método para tratamiento de agua en un lago flotante, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua, tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el lago flotante incluye paredes y un fondo, y donde al fondo del lago flotante está construido de un material flexible que tiene un módulo de Young de hasta 20GPa, donde el método comprende:

- a. aplicar un oxidante al agua para mantener un nivel de ORP de al menos 550 mV por un mínimo de alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas.
- b. aplicar un floculante al agua antes de que la turbidez del agua exceda 5 NTU;
- c. activar la operación de uno o más dispositivos de succión móviles antes de que el componente negro del fondo del lago flotante exceda el 30% en una escala de CMYK, donde el dispositivo de succión móvil succiona una porción del agua desde el fondo que contiene sólidos sedimentados;
- d. filtrar el agua succionada por el dispositivo de succión móvil y devolver el agua filtrada al lago flotante, proporcionando así la remoción de sólidos sedimentados del agua en el lago flotante sin filtrar el volumen total del agua en el lago flotante; y
- e. suministrar agua al lago flotante para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde el agua suministrada tiene un color verdadero de hasta 35 Pt-Co y menos que 2.000 CFU/ml del recuento de bacterias, y donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días y donde el agua es suministrada al lago flotante en una tasa de reposición de acuerdo con la siguiente ecuación:

$$\text{Tasa de Reposición} \geq \text{Tasa de Evaporación} + \text{Tasa de Limpieza} + \text{Tasa de Filtración}$$

51. El método de la reivindicación 1, CARACTERIZADO porque el lago flotante tiene un área de superficie más grande que 5.000 m<sup>2</sup>.

52. El método de la reivindicación 1, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos de materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y esencialmente separa el agua de dentro del agua flotante del cuerpo de agua natural o artificial circundante.
53. El método de la reivindicación 1, CARACTERIZADO porque el fondo del lago flotante comprende sistemas que proporcionan estabilidad para la operación de un dispositivo de succión, tal como sistemas de tipo cojín, marcos estructurales, una pluralidad de capas, cámaras, o combinaciones de los mismos.
54. El método de la reivindicación 1, CARACTERIZADO porque el oxidante es seleccionado del grupo que consiste de un compuesto a base de halógeno, sales de permanganato, peróxidos, ozono, persulfato de sodio, persulfato de potasio, un oxidante producido por un método electrolítico, o combinaciones de los mismos.
55. El método de la reivindicación 1, CARACTERIZADO porque el floculante es seleccionado del grupo que consiste de polímero catiónico, polímero aniónico, sal de aluminio, clorhidrato de aluminio, alumbre, sulfato de aluminio, polímeros que contienen amonio cuaternario, policuaternio, óxido de calcio, hidróxido de calcio, sulfato ferroso, cloruro férrico, poliacrilamida, aluminato de sodio, silicato de sodio, quitosano, gelatina, goma guar, alginato, semilla de moringa, derivados de almidón, y combinaciones de los mismos.
56. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo del lago flotante proporciona una coloración específica al cuerpo de agua.
57. El sistema de lago flotante de la reivindicación 7, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
58. El método de la reivindicación 1, CARACTERIZADO porque la aplicación de químicos es activada por un sistema de coordinación.

59. El método de la reivindicación 1, CARACTERIZADO porque la operación del dispositivo de succión es activada por un sistema de coordinación.
60. El método de la reivindicación 1, CARACTERIZADO porque el color del fondo es determinado por métodos empíricos, algoritmos, basados en experiencia, inspección visual, o equipamiento automatizado.
61. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil es capaz de limpiar un fondo flexible con un módulo de Young de menos de 20 GPa.
62. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un sistema magnético capaz de mantener el dispositivo de succión móvil en el fondo flexible.
63. El método de la reivindicación 1, CARACTERIZADO porque el dispositivo de succión móvil comprende un dispositivo flexible.
64. El método de la reivindicación 1, CARACTERIZADO porque el sistema de filtración está ubicado en una instalación flotante o en la tierra.
65. El método de la reivindicación 1, CARACTERIZADO porque el agua de reposición es alimentada al lago flotante a través de un sistema de bombeo.
66. Un sistema de lago flotante artificial, CARACTERIZADO porque el lago flotante está instalado dentro de un gran cuerpo de agua tal como un océano, río, lago, embalse, laguna, estanque, canal, estuario, corriente, bahía de océano, bahía de río, represa, estanque, puerto, o bahía, el sistema comprende:
- g. un lago flotante que comprende un fondo flexible que tiene un módulo de Young menor que alrededor de 20 GPa y las paredes tienen un borde, donde el borde comprende un sistema de flotación;

- h. un sistema de aplicación de químicos para aplicar un oxidante o floculante al agua en el lago flotante; donde el sistema de aplicación de químicos es activado para aplicar un oxidante al agua en el lago flotante para establecer un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de un ciclo de 52 horas;
- i. un sistema de bombeo para mantener una presión positiva de al menos 20 Newtons por metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.
- j. un dispositivo de succión móvil capaz de moverse por el fondo flexible del lago flotante y succionar una porción de agua desde el fondo que contiene sólidos sedimentados;
- k. un sistema de filtración en comunicación fluida con el sistema de succión móvil, donde el sistema de filtración recibe la porción de agua succionada por el sistema de succión móvil; y
- l. una línea de retorno para devolver el agua filtrada desde el sistema de filtración al lago flotante.

67. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante tiene una superficie más grande que 5.000 m<sup>2</sup>.

68. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y paredes del lago flotante están contruidos con materiales impermeables que son capaces de mantener un cuerpo de agua dentro del lago flotante y que esencialmente separan el agua de dentro del lago flotante del cuerpo de agua natural o artificial circundante.

69. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una sola capa impermeable para separar el agua de dentro del lago flotante del cuerpo de agua circundante.

70. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una pluralidad de capas para separar el agua de dentro del lago flotante del cuerpo de agua circundante.
71. El sistema de lago flotante de la reivindicación 21, CARACTERIZADO porque la pluralidad de capas pueden ser del mismo o diferentes materiales y tener diferente permeabilidad.
72. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende un marco estructural que comprende uno o más componentes del marco capaz de proporcionar más estabilidad y/o una configuración modular al fondo.
73. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque el fondo comprende conectores del marco entre los componentes del marco.
74. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante incluye uno o más rieles para proporcionar conexión entre el fondo flexible y uno o más componentes del marco.
75. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales rígidos.
76. El sistema de lago flotante de la reivindicación 26, CARACTERIZADO porque los materiales rígidos de los componentes del marco comprenden metal, aleaciones metálicas, plásticos, madera, concreto, o combinaciones de los mismos.
77. El sistema de lago flotante de la reivindicación 23, CARACTERIZADO porque los componentes del marco están contruidos de materiales flexibles.

78. El sistema de lago flotante de la reivindicación 28, CARACTERIZADO porque los materiales flexibles de los componentes del marco comprenden goma, plástico, tela, nylon, o combinaciones de los mismos.
79. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales flexibles.
80. El sistema de lago flotante de la reivindicación 24, CARACTERIZADO porque los conectores del marco están contruidos de materiales rígidos.
81. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo comprende una o más celdas de tipo cojín capaces de proporcionar un fondo estable.
82. El sistema de lago flotante de la reivindicación 32, CARACTERIZADO porque las celdas de tipo cojín están llenadas con un fluido que comprende gas o líquido, o un material de espuma expandible, o combinaciones de los mismos.
83. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de flotación comprende uno o más elementos de flotación seleccionados del grupo que consiste de sistemas de poliuretano; sistemas de poliestireno, tales como poliestireno extruido y perlas de poliestireno expandido; sistemas de polietileno; sistemas llenados con aire, tales como cámaras de aire, bolsas de aire de goma o bolsas de aire de vinilo; y sistemas contruidos de otros materiales adecuados tales como plásticos, espumas, gomas, vinilo, resinas, concreto, aluminio, diferentes tipos de maderas, y combinaciones de los mismos.
84. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante comprende una o más características seleccionadas de playas, calzadas, paseos peatonales, pontones, barandas, o sistemas de entradas inclinadas.

85. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo y/o paredes del lago flotante están anclados al fondo del cuerpo de agua circundante para hacer frente a corrientes marinas, vientos, mareas y condiciones del clima específicas del cuerpo de agua circundante y el entorno.
86. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende uno o más puntos de anclaje conectados a puntos de anclaje correspondientes en el fondo del cuerpo de agua circundante.
87. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante es anclado a tierra firme para proporcionar una entrada al sistema de lago flotante.
88. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el lago flotante está separado de tierra firme por una distancia, y la entrada desde tierra firme al lago flotante es proporcionada por uno o más muelles y puentes que conectan la tierra firme al lago flotante.
89. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema de lago flotante comprende un sistema de coordinación.
90. El sistema de lago flotante de la reivindicación 40, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para recibir información con respecto a parámetros de calidad del agua, procesa la información, y activa el medio de aplicación de químicos y/o activa la operación del dispositivo de succión móvil, y/o sistema de filtración.
91. El sistema de lago flotante de la reivindicación 41, CARACTERIZADO porque el sistema de coordinación está dispuesto y configurado para activar la operación del dispositivo de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala de CMYK.

92. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el material del fondo es un material flexible seleccionado del grupo que consiste de gomas, plásticos, teflón, polietileno de baja densidad, polietileno de alta densidad, polipropileno, nylon, poliestireno, policarbonato, tereftalato de polietileno, fibras, Tablero de fibras, madera, poliamidas, membranas de PVC, telas, telas compuestas, geo membranas, acrílicos, y combinaciones de los mismos.
93. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque las paredes comprenden un material permeable que permite al agua del cuerpo de agua en el cual el lago flotante está instalado pasar a través de las paredes en una tasa de permeabilidad predeterminada.
94. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el sistema comprende una pluralidad de dispositivos de succión móviles, donde el sistema de filtración comprende una pluralidad de filtros.
95. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color que proporciona una coloración específica al agua en el lago flotante.
96. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque el fondo tiene un color blanco, amarillo o celeste, o combinaciones de los mismos.
97. El sistema de lago flotante de la reivindicación 17, CARACTERIZADO porque además comprende una línea de alimentación desde el lago flotante a un sistema intercambiador de calor en un proceso industrial para alimentar el intercambiador de calor con agua del lago flotante y una línea de retorno de agua desde el intercambiador de calor del proceso industrial al lago flotante.
98. Un sistema de lago flotante artificial construido dentro de un cuerpo de agua circundante, el sistema CARACTERIZADO porque comprende:

- h. un lago flotante dispuesto en un cuerpo de agua circundante, el lago flotante comprende agua y un fondo flexible que tiene un módulo de Young de menos que alrededor de 20 GPa y paredes que tienen un borde, el fondo y paredes definen un volumen, donde el borde comprende un sistema de flotación, y donde el lago flotante tiene un área de superficie de al menos 5.000 m<sup>2</sup>;
- i. un sistema de aplicación de químicos adaptado para aplicar un oxidante o floculante al agua en el lago flotante;
- j. uno o más dispositivos de succión móvil capaces de moverse por el fondo flexible del lago flotante y succionar una porción del agua desde el fondo, donde el agua contiene sólidos sedimentados;
- k. un sistema de filtración que comprende una pluralidad de sistemas de filtración, donde el sistema de filtración está en fluida comunicación con uno o más sistemas de succión móviles, donde el sistema de filtración recibe la porción de agua succionada por uno o más sistemas de succión móvil;
- l. una línea de retorno en fluida comunicación con el sistema de filtración para devolver el agua filtrada al lago flotante;
- m. un sistema de coordinación dispuesto y configurado para activar el sistema de aplicación de químicos para mantener un potencial de oxidación reducción (ORP) en el agua de al menos 550 mV por alrededor de 10 hasta alrededor de 20 horas dentro de cualquier ciclo de 52 horas, el uno o más dispositivos de succión móvil antes de que el componente de color negro del fondo exceda el 30% en una escala CMYK; y
- n. un sistema de bombeo construido para bombear el agua en el lago flotante y para mantener una presión positiva de al menos 20 Newtons por cada metro cuadrado del área de superficie del lago flotante, donde la presión positiva es mantenida por al menos el 50% del tiempo dentro de intervalos de 7 días.

# PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

# PCT

To:

Kowalchuk, Katherine M.  
MERCHANT & GOULD PC  
P.O.Box 2903  
Minneapolis, MN 55402-0903  
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL SEARCH REPORT AND  
THE WRITTEN OPINION OF THE INTERNATIONAL  
SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

|                                                     |                                                                               |                          |
|-----------------------------------------------------|-------------------------------------------------------------------------------|--------------------------|
| Date of mailing<br>(day/month/year)                 |                                                                               | 18 May 2015 (18-05-2015) |
| Applicant's or agent's file reference<br>4696.6WOU1 | <b>FOR FURTHER ACTION</b> See paragraphs 1 and 4 below                        |                          |
| International application No.<br>PCT/IB2014/002991  | International filing date<br>(day/month/year)<br>4 November 2014 (04-11-2014) |                          |
| Applicant<br><br>CRYSTAL LAGOONS (CURACAO) B.V.     |                                                                               |                          |

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

**Filing of amendments and statement under Article 19:**

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

**When?** The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

**How?** Directly to the International Bureau of WIPO, 34 chemin des Colombettes  
1211 Geneva 20, Switzerland, Facsimile No.: (41-22) 338.82.70

**For more detailed instructions, see PCT Applicant's Guide, International Phase, paragraphs 9.004 - 9.011.**

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.
3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

- ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.
- ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

**4. Reminders**

The applicant may **submit comments on an informal basis on the written opinion of the International Searching Authority** to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see [www.wipo.int/pct/en/texts/time\\_limits.html](http://www.wipo.int/pct/en/texts/time_limits.html) and the *PCT Applicant's Guide*, National Chapters.

Within **19 months from the priority date, the applicant may request that a supplementary international search be carried out** by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

|                                                                                                                                                                                                                                                                                    |                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Name and mailing address of the International Searching Authority<br> European Patent Office, P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk<br>Tel. (+31-70) 340-2040<br>Fax: (+31-70) 340-3016 | Authorized officer<br><br>ALMALÉ MURILLO, José-Antonio<br>Tel: +49 (0)89 2399-8059 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

|                                                     |                                                                                                  |                                                                                    |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Applicant's or agent's file reference<br>4696.6WOU1 | <b>FOR FURTHER ACTION</b><br>see Form PCT/ISA/220<br>as well as, where applicable, item 5 below. |                                                                                    |
| International application No.<br>PCT/IB2014/002991  | International filing date ( <i>day/month/year</i> )<br>4 November 2014 (04-11-2014)              | (Earliest) Priority Date ( <i>day/month/year</i> )<br>5 November 2013 (05-11-2013) |
| Applicant<br><br>CRYSTAL LAGOONS (CURACAO) B.V.     |                                                                                                  |                                                                                    |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 6 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed  
☐ a translation of the international application into \_\_\_\_\_, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No. III)

4. With regard to the **title**,

- ☐ the text is approved as submitted by the applicant  
☒ the text has been established by this Authority to read as follows:

FLOATING LAKE AND METHODS OF TREATING WATER WITHIN THE FLOATING LAKE

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant  
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 5  
☐ as suggested by the applicant  
☒ as selected by this Authority, because the applicant failed to suggest a figure  
☐ as selected by this Authority, because this figure better characterizes the invention  
b. ☐ none of the figures is to be published with the abstract

## INTERNATIONAL SEARCH REPORT

 International application No  
 PCT/IB2014/002991

## A. CLASSIFICATION OF SUBJECT MATTER

 INV. C02F9/00 E04H4/00 C02F1/44  
 ADD. C02F1/52 C02F1/72 C02F1/00 C02F103/02 C02F103/00  
 C02F103/42

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C02F E04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                               | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 2011/210076 A1 (FISCHMANN TORRES<br>FERNANDO BENJAMIN [CL])<br>1 September 2011 (2011-09-01)<br>paragraph [0002]<br>paragraph [0016] - paragraph [0021]<br>paragraph [0057] - paragraph [0079]<br>paragraph [0133] - paragraph [0136]<br>paragraph [0063]<br>paragraph [0117]<br>paragraph [0061]<br>paragraph [0031]<br>paragraph [0083]<br>-----<br>- / - - | 1-98                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

## \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

7 May 2015

Date of mailing of the international search report

18/05/2015

Name and mailing address of the ISA/

 European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040,  
 Fax: (+31-70) 340-3016

Authorized officer

Oenhausen, Claudia

## INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2014/002991

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                         | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 2013/264261 A1 (FISCHMANN T FERNANDO [CL]) 10 October 2013 (2013-10-10)<br>paragraph [0002]; figures 2-5<br>paragraph [0033] - paragraph [0034]<br>paragraph [0038] - paragraph [0059]<br>paragraph [0072] - paragraph [0078]<br>paragraph [0084]<br>paragraphs [0093], [0149]<br>----- | 1-98                  |
| X         | US 2012/024796 A1 (FISCHMANN T FERNANDO BANJAMIN [CL] FISCHMANN T FERNANDO [CL]) 2 February 2012 (2012-02-02)<br>paragraph [0002]; figures 1-2<br>paragraph [0021] - paragraph [0024]<br>paragraph [0033] - paragraph [0041]<br>-----                                                      | 1-98                  |
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2014/002991

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date         |
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2014/002991

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
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### Information on patent family members

PCT/IB2014/002991

WO 2012134526 A1 04-10-2012

# PATENT COOPERATION TREATY

From the  
INTERNATIONAL SEARCHING AUTHORITY

## PCT

To:

see form PCT/ISA/220

### WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing  
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference  
see form PCT/ISA/220

**FOR FURTHER ACTION**  
See paragraph 2 below

International application No.  
PCT/IB2014/002991

International filing date (day/month/year)  
04.11.2014

Priority date (day/month/year)  
05.11.2013

International Patent Classification (IPC) or both national classification and IPC  
INV. C02F9/00 E04H4/00 C02F1/44 ADD. C02F1/52 C02F1/72 C02F1/00 C02F103/02 C02F103/00 C02F103/42

Applicant  
CRYSTAL LAGOONS (CURACAO) B.V.

**1. This opinion contains indications relating to the following items:**

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

**2. FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0  
Fax: +49 89 2399 - 4465

Date of completion of  
this opinion

see form  
PCT/ISA/210

Authorized Officer

Telephone No. +49 89 2399-0



**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY**

International application No.  
PCT/IB2014/002991

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**Box No. I Basis of the opinion**

---

1. With regard to the **language**, this opinion has been established on the basis of:
  - ☒ the international application in the language in which it was filed.
  - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
  - a. ☐ forming part of the international application as filed:
    - ☐ in the form of an Annex C/ST.25 text file.
    - ☐ on paper or in the form of an image file.
  - b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
  - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
    - ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
    - ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY**

International application No.  
PCT/IB2014/002991

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**Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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1. Statement

|                               |             |                     |
|-------------------------------|-------------|---------------------|
| Novelty (N)                   | Yes: Claims | <u>1-16, 50-65</u>  |
|                               | No: Claims  | <u>17-49, 66-98</u> |
| Inventive step (IS)           | Yes: Claims |                     |
|                               | No: Claims  | <u>1-98</u>         |
| Industrial applicability (IA) | Yes: Claims | <u>1-98</u>         |
|                               | No: Claims  |                     |

2. Citations and explanations

see separate sheet

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**Box No. VII Certain defects in the international application**

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The following defects in the form or contents of the international application have been noted:

see separate sheet

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**Box No. VIII Certain observations on the international application**

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The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

**Re Item V**

**Reasoned statement with regard to novelty and inventive step; citations and explanations supporting such statement**

1 Interpretation of the installation claims

In the following analysis, claims to a system are regarded as claims to an apparatus and not as claims to a method or process. In order to comply with the requirements of clarity, said system should have been defined in terms of its constructional details and not via process steps or contents of the container (s). The conditions of treatment (such as ORP value, time etc) are not taken into account upon examination of the installation.

Nevertheless, there are statements in the description describing the floating lake inside a larger body of water. Attention is drawn to the fact that the installation (the floating lake) can only be examined on its own (materials, size, shape etc) and not together with its surroundings. The surroundings can only be taken into account by defining the floating lake as "suitable for" or "configured for" floating in a larger body of water surrounding it.

2 Reference is made to the following documents (see in particular the passages referred to in the International search report):

D1 US 2011/210076 A1 (FISCHMANN TORRES FERNANDO BENJAMIN [CL]) 1 September 2011

D2 US 2013/264261 A1 (FISCHMANN T FERNANDO [CL]) 10 October 2013

D3 US 2012/024796 A1 (FISCHMANN T FERNANDO BANJAMIN [CL] FISCHMANN T FERNANDO [CL]) 2 February 2012

D4 US 2012/024794 A1 (FISCHMANN T FERNANDO [CL]) 2 February 2012

3 *Remark:* given the objection under item VIII § 1 below, claim 1 will be examined as representing the method and claim 17 will be examined as representing the installation.

4 Novelty

4.1 The present application does not meet the criteria of Article 33(2) PCT, because the subject-matter of claim 17 is not new:

In view of the observation made in § 1 above, all of D1-D4 describe the installation, namely a floatable receptacle made out of a non-permeable material (D1 [], D2 [(13), § 93], D3 [12], D4 [17]), a chemical application system (D1 [§ 90], D2 [18], D3 [6], D4 [4]), a pump (D1 [§ 104], D2 [§ 149], D3 [implicit at least in line (11)], D4 [§ 177]), a movable suctioning device (D1 [fig.s], D2 [22], D3 [3], D4 [5]), filtration (D1 [§ 86], D2 [20], D3 [7], D4 [3]) and a recycling line (D1 [§ 124], D2 [21], D3 [11], D4 [16]).

Again, for the installation, it does not matter for which purpose the water is intended (recreational or not), which chemicals are fed into the water or even the water in the receptacle. Moreover, the container must merely be floatable, e.g. made of a material that allows floating.

4.2 As to claim 1, the parameters define therein come into play.

4.2.1 As to item a) of claim 1 on file, D1-D4 teach the open-ended ORP interval as defined. D1 teaches a "minimal period of 4 hours and in maximal cycles of 48 hours" and "4 hours in 24-hour cycles", D2-D4 teach ORP in relation to time and water temperature.

4.2.2 As to turbidity (item b) of claim 1), D1 and D4 correspond perfectly, D2 tolerates 7 NTU and D3 is silent as to the precise value.

4.2.3 The colour according to item c) of claim 1 is not disclosed in any of D1-D4.

4.2.4 Item e) of claim 1 at hand is not disclosed in D1-D4.

4.2.5 The subject matter as defined by claim 1 is therefore new.

## 5 Inventive step

The present application does not meet the criteria of Article 33(3) PCT, because the subject-matter of claim 1 does not involve an inventive step:

5.1 The problem to be solved by the present invention may therefore be regarded as describes by the applicant in the description p 5 l 19-21 (treating large floating lakes).

5.2 In view of the prior art discussed in the description on p 5, the applicant concludes that known treatments are unsuitable for *large* floating lakes. There is however no definition regarding the size of the installation in claim 1 on file. The sole example on file runs tests in a swimming pool sized floating lake (8x8m<sup>2</sup>). Throughout the description the applicant teaches that the conventional treatment of a conventional pool is not suitable for "larger" installations as the one apparently intended by the application at hand. The example pro-

vided can however not be deemed to endorse the teachings of the general parts of the description, because the pool of the example is smaller than an Olympic swimming pool (cf D1).

- 5.3 It is to be remarked that D1-D4 also discuss "large" water volumes. As an example, D1 specifically refers to Olympic swimming pools (2,500 m<sup>3</sup> and 50×25×2 m) and to the Sunlite Pool of Coney Island having 11,350 m<sup>3</sup> of water, so the technical problem is not new. As there is no quantification of the lake/pool size in claim 1, the proposed technical solution in relation to the technical problem cannot be distinguished. A claim needs to have all essentially features necessary to solve the problem at stake incorporated. As D1-D4 all show, fundamental parameters such as turbidity, pH, colour, disinfection and treatment cycles are standard parameters to supervise for recreational waters.

The problem to be solved by the present invention in view of the state of the art may therefore be regarded as process optimization. Process optimisation is normally routine work for the skilled person which he would carry out in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.

The applicant has not demonstrated any inventive findings in view of the subject matter defined by claim 1 at hand.

- 5.4 The solution proposed in claim 1 of the present application can currently not be considered as involving an inventive step over any of D1-D4, each taken into consideration individually (Article 33(3) PCT).
- 5.5 However, if the water to be treated in the floating pool were to be taken from the surrounding water (more unpleasant according to the example on file) and is treated such that it is usable for recreation activities, there may be a potential for a treatment method, provided that the independent claim be properly worded.

## 6 Independent claims

The same reasoning applies, *mutatis mutandis*, to the subject-matter of the corresponding independent claims 49, 50, 66 and 98, respectively, which therefore is/are also considered not new and/or inventive.

## 7 Dependent claims

Dependent claims 2-16, 18-48, 51-65 and 67-97 do not contain any features which, in combination with the features of any claim to which it/they refers/refer, meet the requirements of the PCT in respect of novelty and/or inventive step, see D1-D4.

For D2 it is to be remarked that the water can be used in further applications such as an external industrial process (heat sink). This is to be compared with dependent claim 97 on file, for example.

It is observed that dependent claims can only be considered as meeting the requirements of the PCT with respect of novelty and inventive step (Article 33 (2) and (3) PCT) in combination with the features of the independent claims to which they refer.

#### **Re Item VII**

##### **Certain defects in the international application**

- 1 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D4 is not mentioned in the description, nor are these documents identified therein.
- 2 Reference signs to the drawings should have been incorporated in the claims (Rule 6(2)(b) PCT).

#### **Re Item VIII**

##### **Certain observations on the international application**

The application does not meet the requirements of Article 6 PCT, because the claim set is not clear:

- 1 Although claims 1 and 50 (method) as well as claims 17, 49, 66 and 98, respectively, have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sought and/or in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness and as such do not meet the requirements of Article 6 PCT.
- 2 Dependent claim 8 is in the claim category "installation" (system) but refers back to the method category claim 7.

- 3      Dependent claims 51-65 following independent claim 50 refer back to claim 1 but they define the same subject matter as claims 2-16, e.g. they are copies.
- 4      Dependent claims 67-97 following independent claim 66 also refer back to an earlier independent claim 17 (predominantly) and to earlier dependent claims 21, 23, 24, 28, 32 and 40 but they largely define the same subject matter as the earlier claims (cf § 3 above).
- 5      The same objection as to claims 7/8 in § 2 above applies to claims 57/56.
- 6      The word "about" or "approximately" appears redundant in ranges (cf for example claim 1, item a)).
- 7      In claim 1 the formula for reposition rate is the same as for the replacement rate according to the description p 24 l 4. There is a contradiction between the description and the claim.



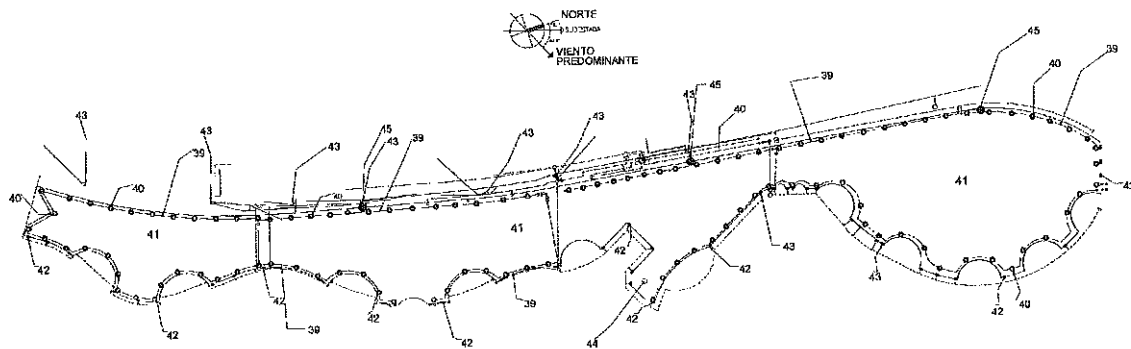
US 20110210076A1

(19) **United States**(12) **Patent Application Publication**  
**FISCHMANN TORRES**(10) **Pub. No.: US 2011/0210076 A1**(43) **Pub. Date: Sep. 1, 2011**(54) **PROCESS TO MAINTAIN LARGE CLEAN  
RECREATIONAL WATER BODIES**(30) **Foreign Application Priority Data**

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DE (US)**(51) **Int. Cl.**  
**C02F 1/52** (2006.01)  
**B01D 35/02** (2006.01)(52) **U.S. Cl. .... 210/724; 210/723**(21) **Appl. No.: 13/076,151**(22) **Filed: Mar. 30, 2011****Related U.S. Application Data**(63) Continuation of application No. 12/884,872, filed on  
Sep. 17, 2010, which is a continuation of application  
No. 11/819,017, filed on Jun. 25, 2007, now Pat. No.  
7,820,055.(57) **ABSTRACT**

The invention discloses a process to implement and maintain large water bodies with color, transparency, and cleanness characteristics similar to swimming pools or tropical seas, at low cost. The present invention also discloses a structure to contain large water bodies, comprising a system for the removal of impurities and surface oils by means of skimmers and a suction device to clean said structure.







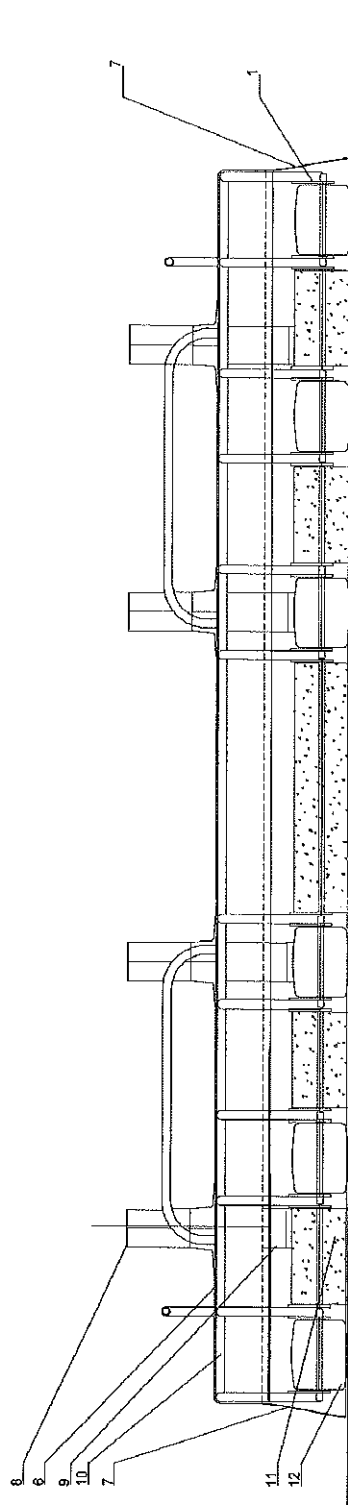


FIGURE 3A

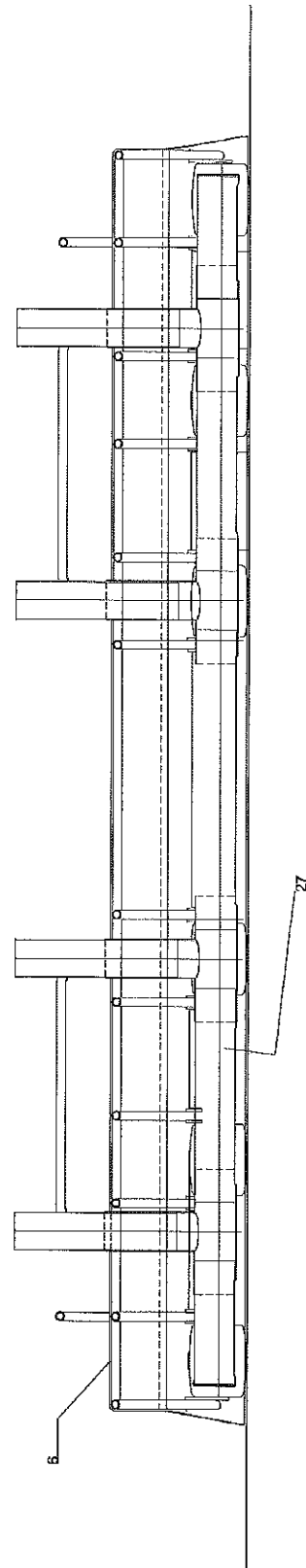


FIGURE 3B

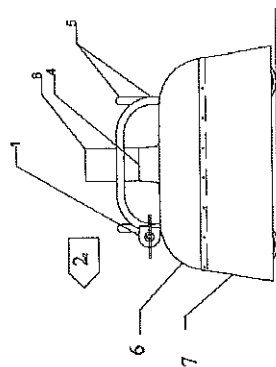


FIGURE 4A

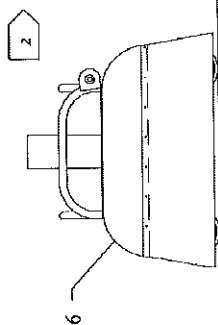


FIGURE 4B

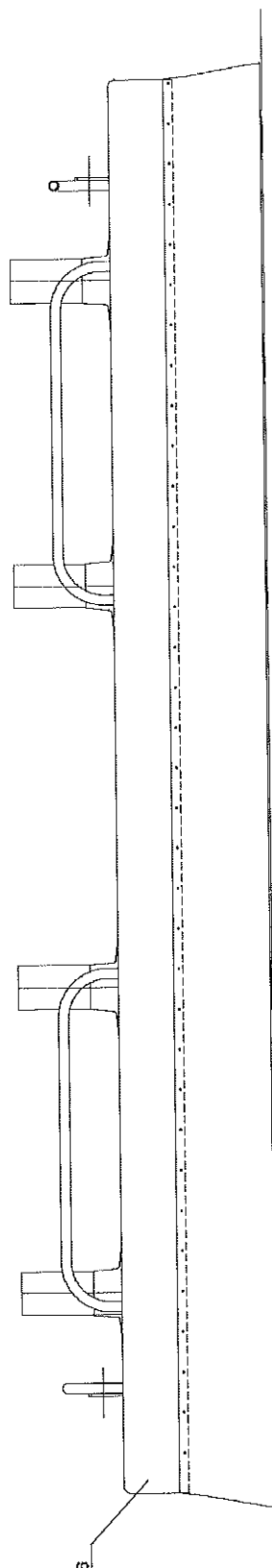


FIGURE 4C

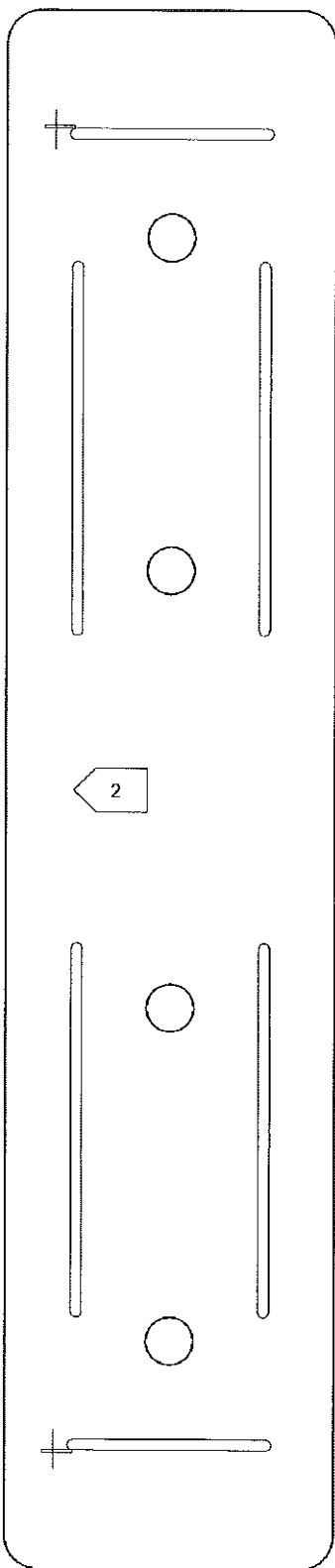
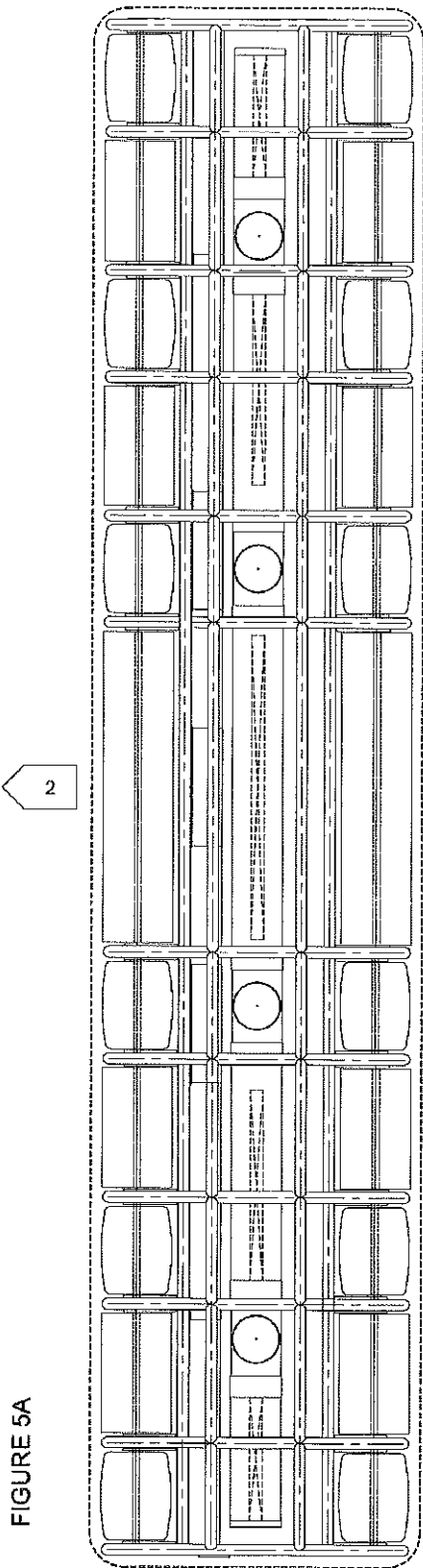


FIGURE 6

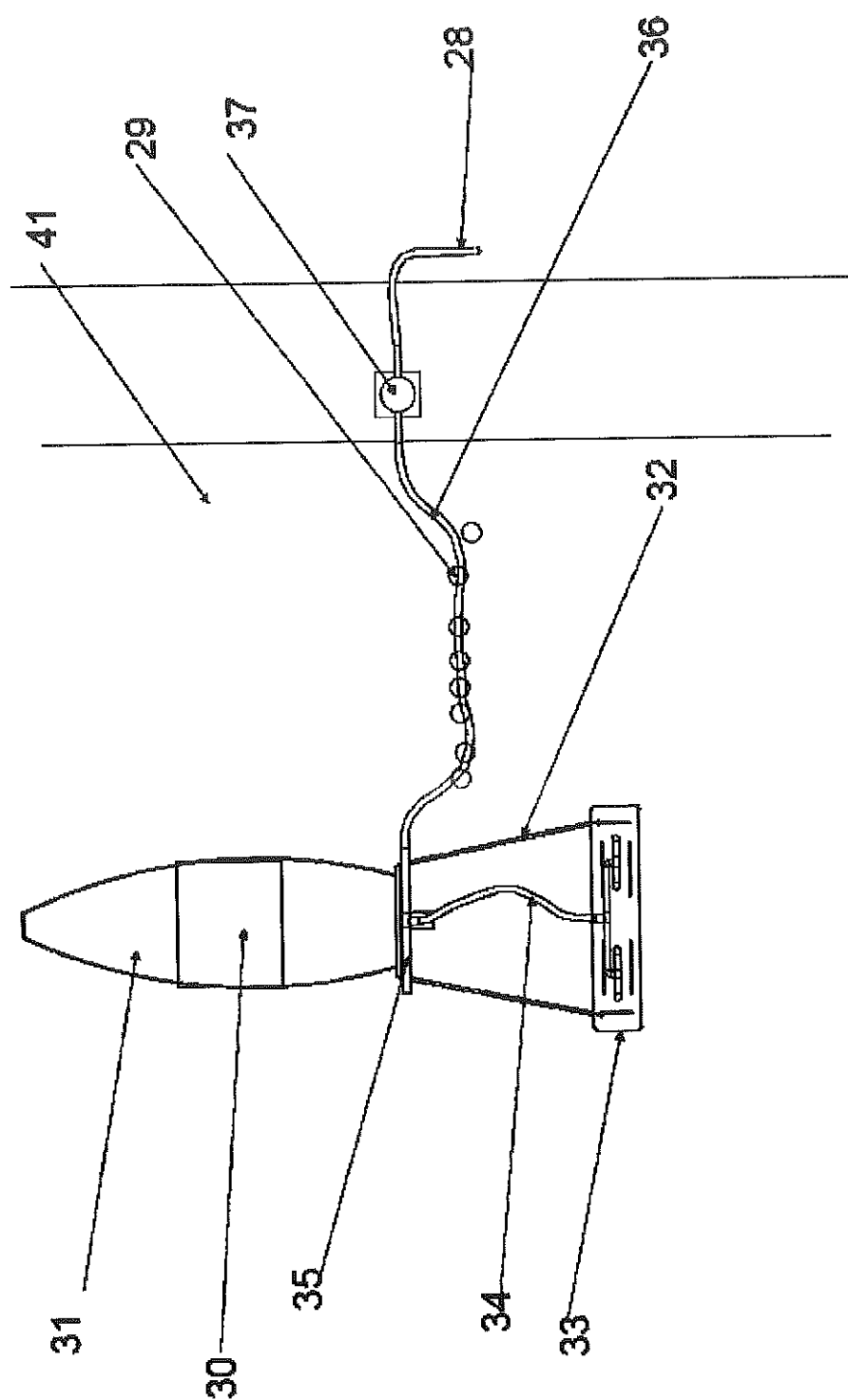


FIGURE 7

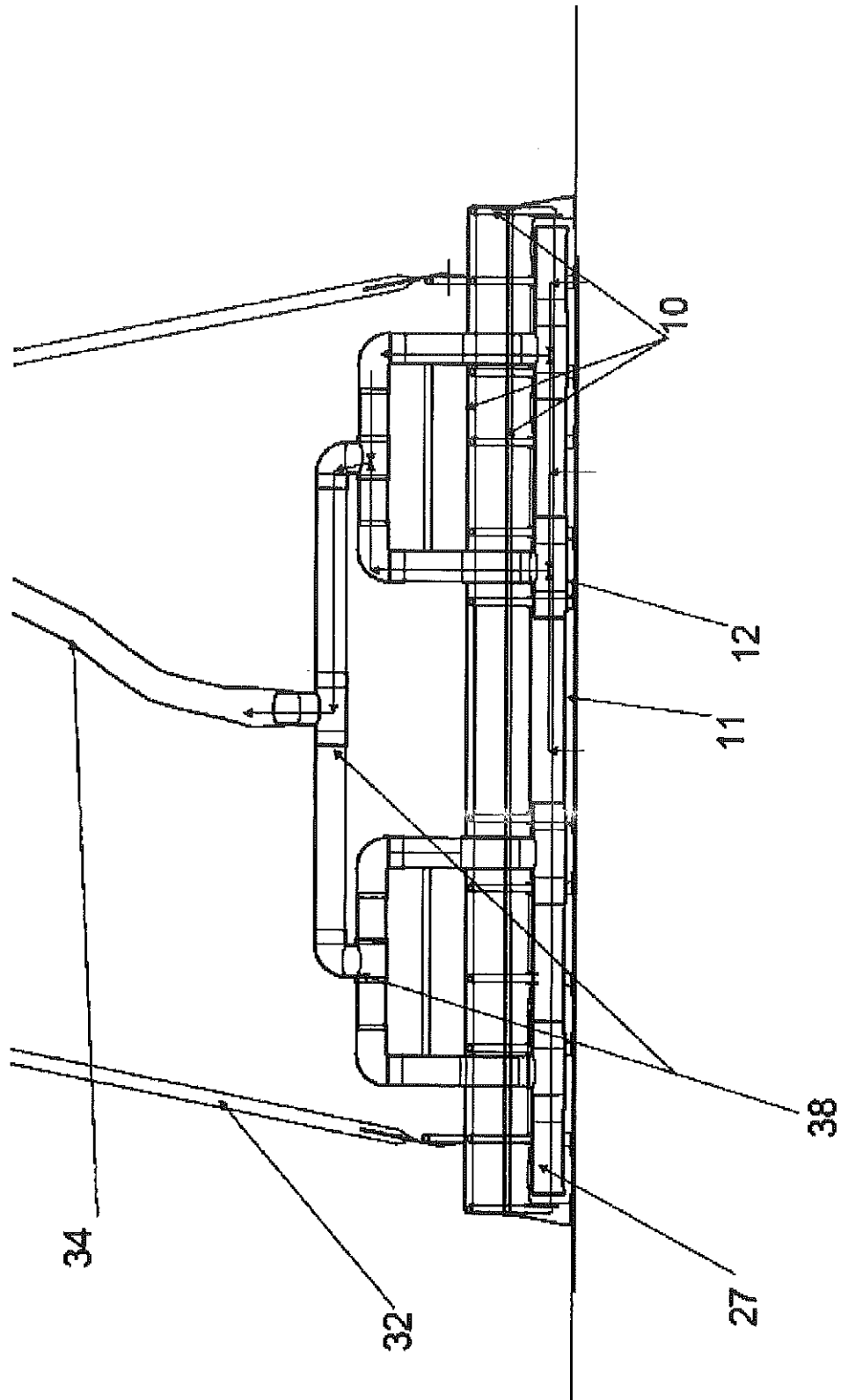


FIGURE 8

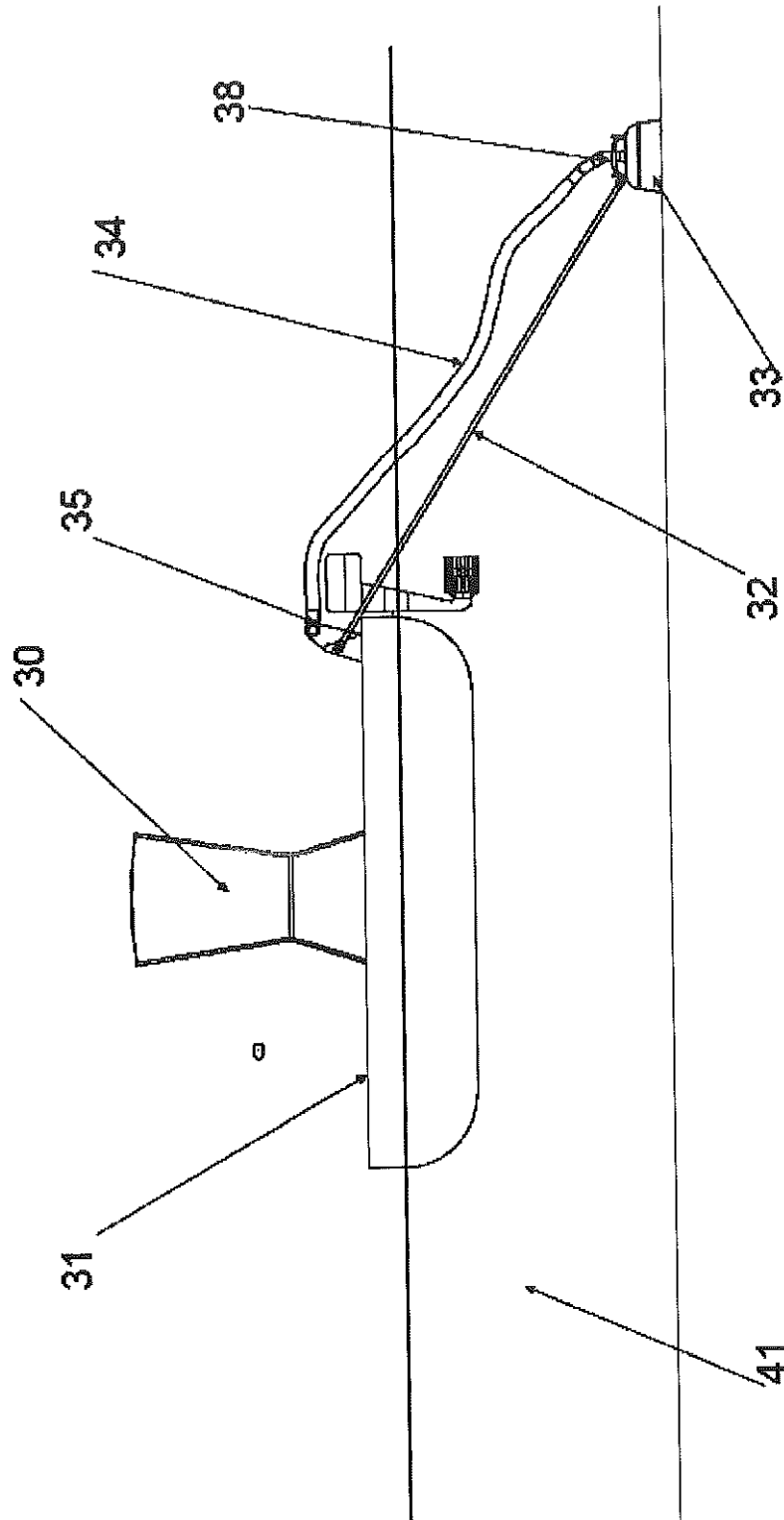


FIGURE 9

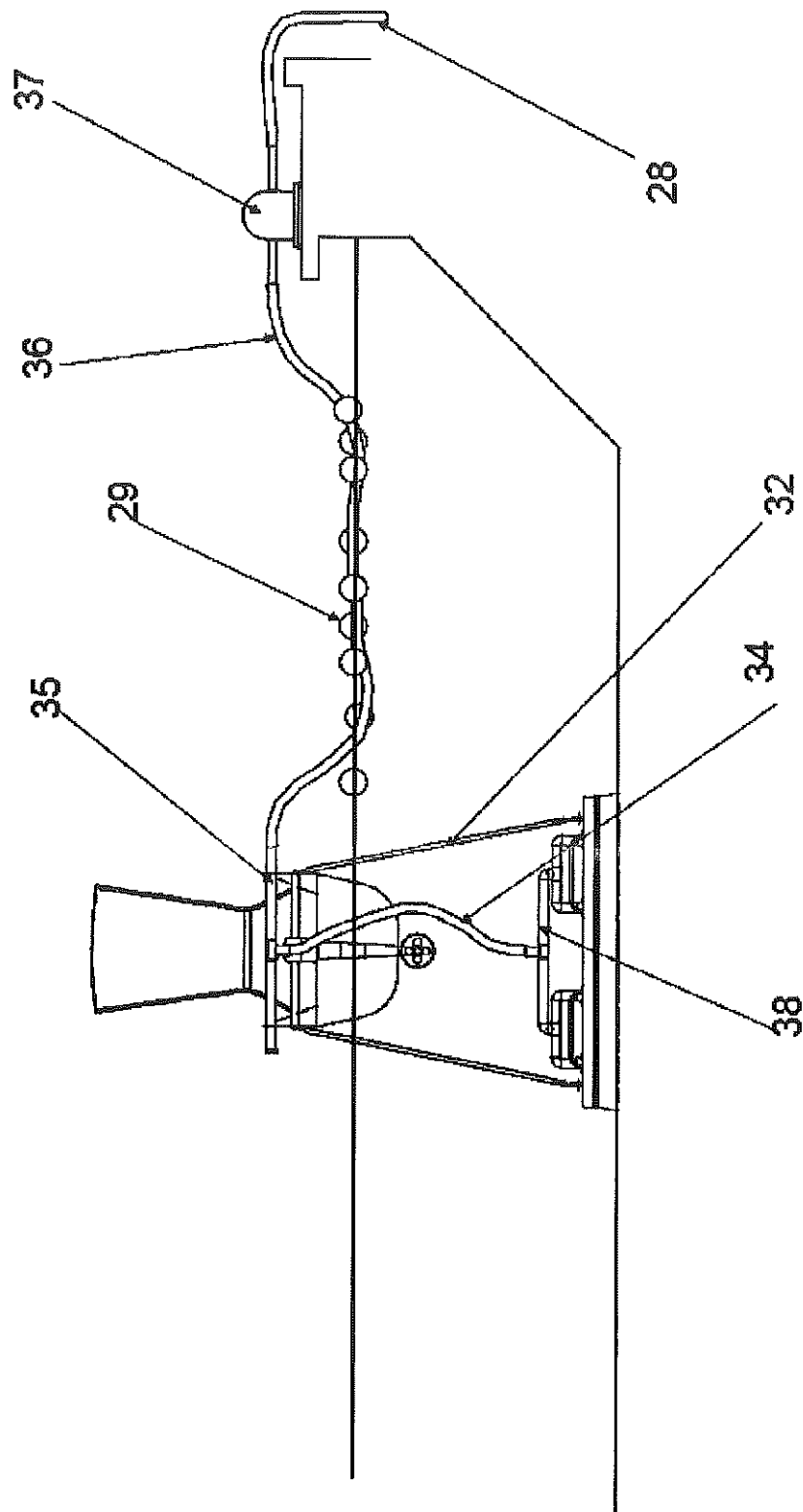
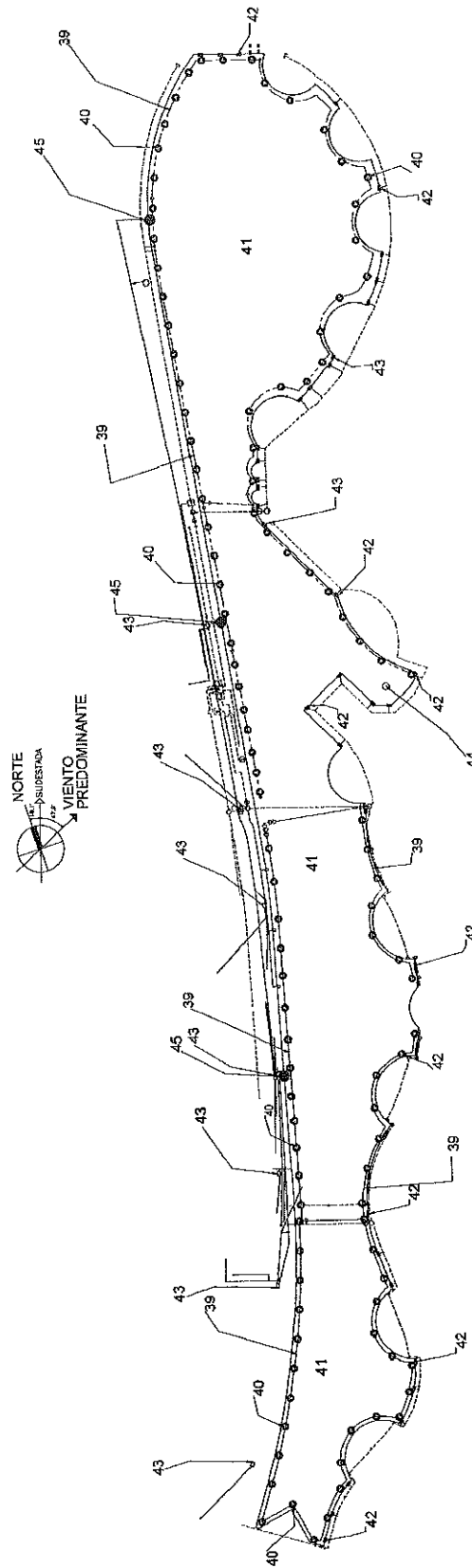


FIGURE 10



## PROCESS TO MAINTAIN LARGE CLEAN RECREATIONAL WATER BODIES

[0001] This application is a Continuation of U.S. Ser. No. 12/884,872, filed 17 Jun. 2010, which is a Continuation of U.S. Ser. No. 11/819,017, filed 25 Jun. 2007, which claims benefit of Serial No. 3225-2006, filed 21 Nov. 2006 in Chile and which applications are incorporated herein by reference. To the extent appropriate, a claim of priority is made to each of the above disclosed applications.

### FIELD OF THE INVENTION

[0002] This invention discloses a process to obtain (i.e., to implement and maintain) large water bodies or volumes for recreational use, such as lakes or ponds with excellent color, high transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost, in particular for water bodies larger than 15,000 m<sup>3</sup>. The invention also comprises a device to extract a particulate material decanted from the water by using the aforementioned process. Furthermore, the present invention discloses a structure to contain large water bodies or volumes, which is specially designed to carry out said process. The decantation process together with the device to extract a decanted material from the water, plus the arrangement of the large volume structure with its functional characteristics of water surface displacement, allow replacing traditional filtration as used in conventional swimming pools that would be very onerous and inefficient in systems having large bodies or volumes.

### BACKGROUND OF THE INVENTION

[0003] When a nutrient enters into water, aerobic organisms consume dissolved oxygen as a result of the induced metabolic activity. Thus, the nutrient exerts a demand on dissolved oxygen availability, which is called biological oxygen demand (BOD). If the amount of organic material in the medium is very high, it can lead to a decrease in dissolved oxygen concentration. At low oxygen levels, aquatic environment promote the growth of anaerobic species.

[0004] Anaerobic metabolism is much slower than aerobic processes (typically more than one order of magnitude) have lower efficiency, and generates various intermediate organic compounds (e.g. organic acids, alcohols, methane). As a result of the lower rate of dissolved organic matter consumption, this will accumulate in the aquatic environment.

[0005] If dissolved oxygen is consumed faster than it can be replenished, water starts to deoxygenate. No strictly aerobic organism, from microorganisms to fish, will survive in said water. Thus, organic contaminants will accumulate and further establish anaerobic conditions, which generate malodorous substances (e.g. sulfides and volatile amines) and partially oxidized organic compounds.

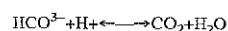
[0006] In addition to bad smell, anaerobic conditions can raise human health issues, because many anaerobic bacteria are pathogenic (for instance, tetanus, and botulism). When the water contains dissolved sulfates, reducing anaerobic bacteria produce H<sub>2</sub>S (corrosive and poisonous).

[0007] The increase of the amount of nutrients required for life in a water body is called eutrophication. Eutrophication is defined as the process of nutrient enrichment in a water body. It is a natural phenomenon in the ageing process of ponds and lakes (eutrophic lakes). On the contrary, a young water body,

poor in nutrients required for life, is called oligotrophic. The nutrient increase in the pond promotes a higher production of aquatic plants and animals. Said organic matter increase generates in its turn an increase of the organic content of sediments. Eutrophication can generate serious problems in superficial water bodies.

[0008] Photosynthesis implies the creation of organic matter from inorganic materials and therefore the production of large amounts of organic substances where there were only little amounts before. When algae/plants die, their components are transformed in organic nutrients that exert an oxygen demand.

[0009] During photosynthetic action, CO<sub>2</sub> is readily consumed, thus producing a rise in pH, which can attain a value over 10. During the night, the inverse reaction occurs, consuming oxygen and generating CO<sub>2</sub>, with which pH tends to drop. Photosynthetic activity has a significant effect on the pH level of the water body, because it affects the reversible reaction.



[0010] Finally, the masses of algae deposited in the shore die and rotten, thus producing anaerobic conditions, which present health dangers (e.g. formation of *Clostridium botulinum*, a strictly anaerobic pathogen microorganism). On the other hand, aquatic plant ramifications retain organic solids that decompose, which exerts a concentrated oxygen demand.

[0011] Generally, nitrogen N and phosphorus P are the limiting factors. In microorganism growth, P is consumed as phosphate, while the major part of bacteria assimilate N under the form of NH<sub>3</sub>, and only some of them assimilate N as NO<sub>3</sub><sup>-</sup>. Inversely, algae assimilate N as NO<sub>3</sub><sup>-</sup> and very few use NH<sub>3</sub>. There are more bacteria able to use NO<sub>3</sub><sup>-</sup> as oxygen source than as N source. According to the approximate stoichiometry of photosynthesis in algae, N:P ratio is in the order of 7:1. According to the Liebig minimum law, an N:P ratio much higher than 7 in a water body indicates that P is the limiting nutrient; on the other hand, an N:P ratio value much lower than 7 implies an N limitation. Some authors suggest that P and N concentrations higher than 0.015 and 0.3 mg/l, respectively, are enough to generate an excessive growth of algae in lake waters.

[0012] The main sources of organic N are proteins, amino acids and urea; on the other side, inorganic N is in the form of NH<sub>3</sub>, NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>. Ammonia is a characteristic product of organic matter decomposition, and it can be microbiologically oxidized to nitrites and nitrates by the action of nitrifying bacteria. These processes occur naturally in water and constitute a major contribution to the biological oxygen demand.

[0013] When artificial water bodies are formed, such as lakes or ponds, water quality deteriorates progressively. Depending on the nutrient contribution, it can be reached any state from equilibrium in which algae, aquatic plants, bacteria, insects and fish survive in stable condition to eutrophication processes in which the excessive contribution of nutrients produces a high proliferation of algae and aquatic plants. When these die, they are decomposed by bacteria in aerobic processes that consume the oxygen. When oxygen decreases, many organic remainders remain deposited in the bottom, thus increasing sediments and suffering processes that increase turbidity, bad smells are produced and the physico-

chemical and sanitary quality of the water is impaired, which reduces the possibilities of recreational use.

[0014] To mitigate these effects different techniques are used, such as aeration systems to increase oxygen levels, algicides and herbicides to control the excessive proliferation of algae and aquatic plants, the use of biological filters to decrease nutrient contribution, fish and zooplankton to reduce algae, nutrient capture by means of chemicals, inoculation of bacteria to digest organic matter, colorants to improve the aesthetic appearance, mechanic removal of algae and aquatic plants, the use of dredges to decrease the amount of sediment, clarifying agents to decrease turbidity, etc.

[0015] The characteristics and quality of the water of these ponds are very different to those of swimming pools. In the first case, an ecological equilibrium between different species must be attained, while in the second case the objective is the removal of organisms and impurities. Therefore, very different turbidity, color and physicochemical characteristics standards are accepted.

[0016] To keep swimming pool water transparent and apt for bathing, filtration systems are used, mainly sand, diatomaceous earth and cartridge filtration systems. The entire water must be filtered every 4 to 12 hours, depending on the type of swimming pool.

[0017] In addition, organic matter oxidants, disinfectants, algicides and eventually pH regulators and clarifiers must be used to keep aesthetic and sanitary conditions. Depending on each country's regulation, swimming pools are required to keep minimal disinfectant residual concentrations or permanent redox potential (ORP) levels between 650 mV and 750 mV.

[0018] The application of the swimming pool technology to large water bodies to obtain optimal water quality is not possible due to the high cost of the installations and the involved operative costs.

[0019] To illustrate this situation, we can recall that if the water body to be filtered is the one described below in the application example of 250,000 m<sup>3</sup>, complying with the minimal regulations of Chilean Swimming Pools (T=2 en NCh 209, example country for the application), 2,983 liters per second are required to be filtered, which corresponds to the water volume treated by a potable water plant for a city. An Olympic swimming pool has 2,500 m<sup>3</sup> (50×25×2 m), which corresponds to 1% of the considered volume in the application example of this patent application.

[0020] The same is true when swimming pools chemicals are to be applied to these volumes. The water volume of the application example of this invention corresponds to 4,000 10-meters-long swimming pools.

[0021] The control of disinfectants in swimming pools and spas by means of the measurement of the (ORP) has been used for many years with good results. ROP measures the oxidizing power of the disinfectant or, in other words, its real concentration-independent chemical activity. Direct measurement of disinfectant concentration can lead to error, because the activity can be decreased depending on pH and the presence of contaminants, even at high concentrations. In fact, studies have demonstrated that bacterial life in water is more dependent on ROP than on oxidant concentration. To remove undesired microorganisms in swimming pools, normally a ROP value between 650 mV and 750 mV is permanently maintained (public swimming pool regulations in developed countries require more than 700 mV permanently)

at a normal pH between 7.2 and 7.6. This is not possible with large water bodies due to the high implied costs.

[0022] The previously exposed facts make maintaining large water bodies (over 15,000 m<sup>3</sup>) using filtration and disinfection technologies similar to those of swimming pools for recreational use largely unviable.

[0023] Therefore, there are no large artificial ponds or dams with the aesthetic and sanitary characteristics of swimming pools or tropical seas that have clarity levels higher than 25 and even 40 meters.

[0024] The technical problem solved with the present invention is the achievement of these characteristics in large water bodies at low cost.

#### STATE OF THE ART

[0025] Invention patents protecting treatment processes for large volumes of water such as ponds and dams were found at world level. In what follows, an analysis of the most relevant documents and their relation with the technology to be protected is performed.

[0026] Invention patent applications JP4115008 and JP7310311 protect artificial ponds connected to the sea that have as objective the purification of sea water. The system allows the entrance of water to the pond, where it follows a path specially designed to remove contaminants or it is conducted to a purification facility to be subsequently returned to the sea. Clearly, the Japanese invention has no relation with the type of pond that is desired to protect in this application.

[0027] The invention patent application FR2740493 protects a pool or artificial lake constructed with a flexible bottom comprising a textile net and concrete. The invention includes a draining system and injectors around the border that allow the diffusion of a liquid to the draining system. The analyzed invention does not have relation with the artificial pond or the process that is to be protected.

[0028] The invention patent application JP59222294 protects a purification process for river and lake water to remove N, P, BOD (biological oxygen demand), etc. that implies pumping the water through a bed filled with certain mineral. The Japanese invention allows cleaning pond water, but based on water pumping through a packed bed, which is equivalent to filtering the liquid. Therefore, the Japanese invention does not have relation with the technology that is to be protected.

[0029] The invention patent application CN1256250 protects a water purification process that includes microflocculation with an inorganic flocculant with high molecular weight and direct deep bed filtration. The analyzed process corresponds to an assisted flocculation with faster and more efficient results, but in no case it affects the novelty or the inventive level of the process of the present invention.

[0030] From the analysis of the former documents, it is possible to conclude that there are no processes or artificial ponds similar to those to be protected, which allow obtaining water bodies larger than 15,000 m<sup>3</sup> for recreational use, with color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost, because in the process of the present invention the traditional filtration step has been substituted by a suspended-solid flocculation step and subsequent cleaning with a suction device, designed for said function, together with the generation of a displacement of surface water that contains impurities and surface oils by means of injecting inlet water and evacuating said water through skimmers (surface slots and dumps) comprised in the

structure, and disinfection has been achieved by the application of controlled oxidation pulses.

[0031] The present invention is related to a process to obtain large water bodies or volumes (wherein the term obtaining is meant to be understood as implementation and maintenance), wherein a structure is provided (having elements required for water treatment and features that produce the desired results) to contain the water, and separation and flocculation (maintenance) processes of particles that make water cloudy and impure are performed, in such a way that flocculated material is suctioned by a suction device once flocculation has taken place, and oily materials are removed through skimmers (surface slots or dumps) of the structure of the present invention, said structure having pipes that feed fresh water to fulfill the desired objective.

#### DESCRIPTION OF THE FIGURES

- [0032] Brief description of the figures.
- [0033] FIG. 1 shows a side view of the suction device.
- [0034] FIG. 2 shows a top view of the structure of the suction device.
- [0035] FIG. 3a shows a front view of the structure of the suction device.
- [0036] FIG. 3b shows a front view of the structure of the suction device.
- [0037] FIG. 4a shows a right side view of the suction device.
- [0038] FIG. 4b shows a left side view of the suction device.
- [0039] FIG. 4c shows a rear view of the suction device.
- [0040] FIG. 5a shows a top view of the structure of the suction device.
- [0041] FIG. 5b shows a top view of the suction device.
- [0042] FIG. 6 shows a schematic view of the cleaning system with the suction device.
- [0043] FIG. 7 shows a detailed schematic view of the suction system with the suction device.
- [0044] FIG. 8 shows a schematic view of the suction device.
- [0045] FIG. 9 shows a schematic view of the structure of the suction device;
- [0046] FIG. 10 shows a top view of the structure of the water body of the present invention.

#### DETAILED DESCRIPTION OF THE FIGURES

[0047] FIG. 1 shows the following components: moving direction (2) of the suction device, PVC pipe for suction connection (8), bottom opening (14) in PVC pipe (27) for bottom suction, sanitary T pipe (9), steel frame (10), auto-lubricated plastic wheels (12), supporting plate (19a) for the axles of the wheels and rollers (19b), plastic-based brushes with synthetic bristles made of polyethylene or the like (20), steel platen with perforations or slots (21) to fasten the brushes (20) in a continuous line.

[0048] FIG. 2 shows the moving direction (2); the frame (10) to which supporting plates (19a) are affixed to support wheels and rollers axles (19b) for high density polyurethane rollers (11) that are intercalated with wheels (12), which are lined up and also supported by supporting plates (19a); a brush line (16) fastened to the perforated platen (21) provided with the structure; and the suction line (27) can be observed in the central zone of the device, formed by a PVC tube with five rectangular bottom openings in wall (14), closed in both ends with a cap made of the same material (17).

[0049] In FIGS. 3a and 3b the device structure is shown, wherein a supporting plate (1) can be observed for the pulling tensors welded to the frame (10), a resin cover reinforced with fiberglass over a galvanized iron network (6), a lateral plastic membrane flap (7), rollers (11), wheels (12) and sanitary PVC pipes (8) having sanitary T pipes (9) at their bottom section, and a PVC suction pipe or line (27) attached to the open endings of said T pipes, said suction pipe or line (27) having openings wherein the opening area will be proportional to the installed suction capacity.

[0050] FIG. 4a shows a lateral right view of the device with the moving direction (2), a supporting plate (1) for the pulling tensors, whereas from the center a PVC suction pipe (8) emerges having a resin fiber collar attached at its base, said resin fiber collar being formed with fiberglass reinforcements (4) for the fastening and sealing of suction tubes, handles (5) for pulling, handling and lifting the device, the resin cover (6) and the lateral membrane flap (7). FIG. 4b shows a left side view of the device indicating the moving direction (2) and the device cover (6). FIG. 4c shows a rear view of the device indicating the device cover (6).

[0051] FIG. 5a shows a top view of the device structure indicating the moving direction (2) and FIG. 5b shows a top view of the device indicating the moving direction (2).

[0052] FIG. 6 shows the cleaning system with the suction device placed in the water body (41), wherein there is a pipe to draining chamber (28), plastic buoys (29) for floating a hose (36), platform (30) for the steersman and the deck operator of the boat (31) for pulling with an incorporated four-stroke engine and protected propeller, a pulling tubular labeled galvanized-steel connecting rod (32) astern, a suction device (33), a connection hose (34) from the boat (31) to the device (33), a connection piece (35) of the connection hose (34) with the suction hose (36), and a suction hose (36) that connects the movable electric suction pump (37) at the lake's shore with the boat (31).

[0053] FIG. 7 shows a longitudinal section of the suction device in which the partial configuration of the structural frame (10), the pulling rod (32) that connects the device (33) (not shown in this figure) to the pulling boat, the set of symmetric suction pieces (38) that connect the suction pipes (27) of the cart with the hose (34) connecting the device to the boat is described. In this figure also appear the projections of wheels (12) and rollers (11).

[0054] FIG. 8 shows a lateral view of the pulling boat (31), the suction device (33) placed in the bottom of the water body (41) of the lake, the placement of the roofed platform (30) for the boat operator, the connecting rods (32) between the device (33) and the boat (31), the symmetrical suction elements (38), and the connecting hose (34) with coupling pipe in the boat (35).

[0055] In FIG. 9, a rear view of the system is shown, indicating the connection hose (34), the pulling rods (32), the set of coupling pieces (38) for symmetrical suction from all four device inlets toward the connecting hose (34), the hose (36) with floats (29) that connects the boat connector (35) with the suction pump on land (37), and the pipe that leads to the drainage (28).

[0056] In FIG. 10, the following elements of the structure can be observed: recycle pipe (39) onto which injectors are arranged; injectors (40) arranged along all the perimeter of the water body; water body (41) contained by the structure; skimmers (42) for removal of floating contaminants such as water with oils; water inlet line and chamber (43) where water

is extracted to feed the lagoon; zone of restricted natural circulation (44); fresh water feeding point (45) to the lagoon.

#### DESCRIPTION OF THE INVENTION

[0057] This invention comprises a process to obtain (i.e., to implement and maintain) large water bodies or volumes for recreational use with excellent color, high transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost, in particular for water bodies larger than 15,000 m<sup>3</sup>, such as artificial ponds or dams for recreational use. The present invention also discloses a structure to contain large water volumes. The invention also comprises a suction cart or suction device to extract a particulate material decanted from the water. The process of the present invention comprises in a first step providing a structure to contain large water volumes such as artificial lakes or ponds, with elements that allow water treatment and features required to obtain the desired aesthetic and sanitary results of having "color, transparency and cleanness similar to swimming pools or tropical seas at low cost".

[0058] The process has a great advantage over the previous art in that the desired characteristics are achieved without needing a filtration system or adding large amounts of chemicals, which opens the possibility to implement and maintain large crystalline water bodies with no size limit.

[0059] The process of the invention comprises the following steps or stages:

[0060] a.—providing a structure with skimmers able to contain a large water body larger than 15,000 m<sup>3</sup>.

[0061] b.—feeding the structure of step (a) with inlet water having iron and manganese levels lower than 1.5 ppm and turbidity lower than 5 NTU.

[0062] c.—measuring water pH, ideally it should be within a range lower than 7.8;

[0063] d.—adding an oxidizing agent to the water contained in the structure of step (a), with which a 600 mV minimal ROP is controlled in water for a minimal period of 4 hours and in maximal cycles of 48 hours;

[0064] e.—adding a flocculating agent in concentrations within 0.02 and 1 ppm with maximal frequencies of 6 days and cleaning the bottom of the structure of step (a) with a suction device to remove precipitated impurities from the bottom of said structure, together with the additional flocculants and;

[0065] f.—generating a displacement of surface water containing impurities and surface oils by means of the injection of inlet water according to step (b), which generates said displacement in such a way to remove said surface water by means of a system for impurities and surface oils removal arranged in the structure of step (a).

[0066] It is worth mentioning that cleaning is performed in such a way that every sector of the structure is cleaned in time intervals no greater than 7 days, in such a way as to replace the traditional filtering performed in conventional size structures.

[0067] In the disclosed structure or lake in step (a) it should be maintained a minimal total water renewal rate of 150 days, preferably 60 days, to avoid the accumulation of oxidation products (ageing).

[0068] Each step of the process to implement and maintain large water bodies is separately detailed below, in the understanding that every obvious change will be encompassed within the scope of the present invention.

[0069] In step (a), a structure or pond is provided to contain a large water body larger than 15,000 m<sup>3</sup>, with elements that

allow water treatment and features required to obtain the desired aesthetic and sanitary results of having "color, transparency and cleanness similar to swimming pools or tropical seas at low cost". The features of the structure provided to carry out steps (b) to (f) of the invention will be noted by the reader when the structure specially designed for this invention is specifically described.

[0070] In step (b), and only in the case where it should be required, a water pre-filtering and treatment can be carried out on the water that is incorporated into the lake, in the case wherein the water contains incrusting micro-mollusks or turbidity levels over 5 NTU. Nevertheless, water inlet should not include micro-mollusks and metals such as iron or magnesium in order to maintain the aforementioned ranges. In other words, low turbidity water is preferable because the process of the present invention does not have a traditional filtration process and the suction device and skimmers would be inefficient in case of receiving high levels of suspended particles, including both organic and inorganic contaminants.

[0071] If in step (c) the pH is higher than 7.8, it is necessary to add bromine salts such as sodium bromide, always keeping minimal bromide concentrations of 0.6 ppm. It is worth mentioning that in the case of sea water, in spite of having pH values higher than 7.8, it naturally contains high bromide levels, and therefore it is not necessary to add this element if the artificial pond or lake is filled with sea water.

[0072] In step (d), to maintain a minimal redox potential of 600 mV in the water for a minimal period of 4 hours in maximal cycles of 48 hours, preferably 24 hours, oxidant agents are added such as: ozone, sodium or potassium persulfate, chlorine derivatives, hydrogen peroxide, bromine derivatives or by electrochlorination. The amount of applied oxidant is controlled by permanent measurement of ROP during the application in such a way that it fulfills the minimal established requirements, i.e. oxidant is added up to achieve a minimal of 600 mV during a period of 4 hours.

[0073] The type of oxidant depends on the cost, among other factors. Hypochlorite produced by electrochlorination and ozone are economical because they are produced in situ, but require high equipment investments.

[0074] The applied amount depends on many factors that vary daily, such as, for instance: temperature, solar radiation, environmental contamination, rain, storms, levels of use, etc. In short, the necessary oxidant amount is determined by ROP measurement.

[0075] Notwithstanding the foregoing and without limiting the invention, it can be stated that the usually used concentrations and the oxidant application ranges are those indicated in Table 1:

TABLE 1

| OXIDANT             | Oxidant Application   |               |
|---------------------|-----------------------|---------------|
|                     | USUAL CONCENTRATION * | MIN-MAX RANGE |
| Ozone               | 0.05 ppm              | 0.01-0.58 ppm |
| Hydrogen peroxide   | 0.04 ppm              | 0.01-0.46 ppm |
| Sodium hypochlorite | 0.16 ppm              | 0.04-1.50 ppm |
| Persulfate          | 0.28 ppm              | 0.07-3.30 ppm |
| Bromines            | 0.22 ppm              | 0.05-1.80 ppm |

\* Total amount added to reach and maintain the minimal 600 mV ROP for 4 hours, divided by the total volume of the water body.

[0076] Step (e) includes adding a flocculating agent and cleaning the bottom of the structure of step (a) with a suction

device in order to remove precipitated impurities from the bottom of the lake, together with the flocculant agents.

[0077] Cleaning is performed in such a way that every sector of the lake is cleaned in time intervals no greater than 7 days, preferably every 4 days. With this step, together with the use of skimmers, traditional filtering processes used in swimming pools are replaced.

[0078] Among flocculants that can be added in this step (e), a cationic polymer is preferred, e.g. HICAT-1™, which is a biodegradable cationic polyelectrolyte with 25% solids, produced by Buckman Laboratories in the United States (it is accepted by the National Health Service of Chile and recommended to be used in swimming pools at concentrations 100 times higher) in concentrations between 0.02 and 1 ppm with maximal frequencies of 6 days, preferably 0.05 ppm every 24 hours; or addition of Crystal Clear™, which is a biodegradable cationic polyelectrolyte produced by AP Aquarium Products in the United States (it is used in aquariums in concentrations 100 times higher) in concentrations between 0.04 and 2 ppm with maximal frequencies of 4 days, preferably 0.16 ppm every 24 hours.

[0079] Additionally, this step can include adding algacides such as quaternary ammoniums (e.g. polyquats) and/or copper compounds (e.g.  $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$  or copper chelates), keeping copper levels between 1 ppb and 1.5 ppm, depending on temperature and sunlight; 0.3 to 1.5 ppm of copper for temperature ranges between 10° C. and 30° C.

[0080] It is important to keep in mind that the objective of the suction device is not only the cleaning of the bottom in the described process, as is the case of vacuum devices of traditional pools, but that said suction device replaces completely the traditional filtering system of swimming pools together with the use of flocculants. Furthermore, the fact that the process contemplates the displacement and removal of superficial water with impurities toward the structure slots complements the action of the suction device.

[0081] In other words, the suction device not only removes material naturally deposited on the bottom (leaves, branches, earth, etc.) but also all the suspended particles that are eliminated by filtration in the case of swimming pools and that are converted into floccules (large particles) and are suctioned by the device in this invention, thus decreasing their removal costs in two orders of magnitude.

[0082] In step (f) it is necessary to control the levels of injection of fresh water to ensure the correct displacement and removal of superficial water with impurities and oils through the skimmers of the structure provided in step (a) of the process of the invention.

[0083] As hereinabove mentioned, to carry out the process to implement and maintain large bodies of water larger than 15,000 m<sup>3</sup> according to the present invention, it is necessary to provide a structure like that shown as an example in FIG. 10.

[0084] The structure or pond according to the present invention includes bottoms and walls built with low permeability materials such as clay and bentonite, coated by a non-porous material, such as a polyvinyl chloride membrane, lineal low density polyethylene or high density polyethylene capable of being cleaned, with a depth of at least 0.5 meters, a system for removing impurities and superficial oils by means of skimmers, a feeding pipe system that allows water replacement by entrance of fresh water, a feed water intake system, which can be marine water, well water, spring water

or water from other sources; in the case of marine water the intake system can be through headers or wells positioned at a depth of more than 6 meters.

[0085] The relevance of the structure to solve the technical problem proposed in the process of the present invention is detailed as follows:

[0086] The structure must have skimmers to remove surface oils and particles, since otherwise they accumulate and deter water quality, even after performing all the chemical treatment steps, since these do not remove floating greases or solids. In this way, the final objective of obtaining "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost" would not be fulfilled without these skimmers. The process of movement of superficial water toward the skimmers caused by fresh water entry together with the flocculant-suction device system replaces the traditional filtering system of swimming pools.

[0087] The structure must have fresh water feeding pipes that allow causing the surface water movement that eliminates floating impurities and oils through the skimmers. These pipes contribute also the fresh water necessary to refresh water at the described rates, since otherwise oxidation sub-products accumulate, which render chemical treatments inefficient and deter water quality, not fulfilling the "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost".

[0088] The structure has a pipe network with injectors that allow an efficient application of the products and water homogenization. In swimming pools this is irrelevant, but in large volume water bodies the existence of isolated stagnant zones creates contamination centers that make disinfection treatments inefficient, thus deterring water quality and not fulfilling the fundamental objective of obtaining "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost".

[0089] The plastic liner must have special non-porous characteristics. In swimming pools this may be irrelevant, but in large volume water bodies cleaning would be unfeasible with adherent linings and a dark layer would form that do not allow obtaining the desired result, namely "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost".

[0090] The bottoms and walls must be built with low-permeability materials such as clay and bentonite, lined with a non-porous material such as polyvinyl chloride membrane, etc. This is the economic way of constructing these large water bodies, since if known building techniques for swimming pools or ponds would be used, the objective of "low cost" would not be obtained.

[0091] Water intake must be done in such a way as to avoid micro-mollusks, since besides blocking recycle pipes, said micro-mollusks adhere to surfaces generating a dark color that prevents obtaining the objective of "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost".

[0092] Water intake must avoid water with metals such as iron and manganese, since this pond does not have traditional filtration and the flocculation treatment and suction device are inefficient at removing inorganic impurities, including metallic contaminants.

[0093] The crystalline structures or ponds must have water intakes that allow using low cost water since, in contrast to

swimming pools that recycle water through their filters, in this case the water from the skimmers and the suction cart or device is disposed of.

[0094] The structure provided in step (a) for the process of the invention has additionally:

[0095] 1) light blue, white or light yellow bottom (liner) color, for the water to take the color of tropical seas, i.e. "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost". This is obvious in the case of swimming pools, but large ponds use dark plastics due to their durability and lower cost; that is the reason why there are no large water bodies with the described colors. For instance, if the plastic would be black (usual in ponds), the desired color would not be obtained even if the water had high quality and transparency.

[0096] 2) a depth over 0.5 meters, preferably between 2 and 5 meters; Depth is important to achieve the desired color "similar to tropical seas", since if it is too shallow the water does not reach turquoise shades of color and resembles a light-colored water body. Moreover, due to the high water transparency of these ponds, if depth is too low UV light penetration deters the liner rapidly, thus not obtaining the desired low cost.

[0097] 3) a recycling system by means of pipes with injectors that allow maintaining water homogeneity and avoiding stagnating zones. This system can be avoided in windy zones.

[0098] 4) the structure must be constructed in such a way that it avoids dragging organic matter such as leaves and soil by effect of wind, watering, etc.

[0099] 5) Optionally, it can be made of cement with coatings such as painting, poliurethanes or fiberglass.

[0100] Therefore, the structure is fundamental for the process of the invention, since in said structure it is also possible to generate a step consisting of the displacement of surface water containing impurities and oils by means of a current generated by fresh water injection through the pipe systems of said structure, thus removing said impurities and oils through said skimmers.

[0101] In the following, the suction device of the present invention is described in detail:

[0102] The suction device to carry out the cleaning of the structure bottoms, which is performed in step (e) of the process of the invention, comprises: a supporting plate, a resin collar reinforced with fiberglass, pulling handles, a resin cover, a lateral membrane flap, a steel frame, high density polyurethane rollers, auto-lubricated plastic wheels, an opening in a PVC pipe to suction the bottom, a brush line comprising plastic-based brushes with synthetic bristles and a steel platen with perforations or slots to fasten the brushes in a continuous line, supporting plates for the axles of the wheels and the rollers, and a suction PVC line with openings (see description of figures for more details).

[0103] The suction device operates by suctioning dirt through connecting hoses by means of a pumping system, said device being pulled by a system that includes a propelling device to move the suction device, such as a boat, for instance, a draining chamber, plastic buoys for aiding a hose to float, a platform for the steersman and the boat's deck operator in case a boat is used as propelling device, a pulling tubular labeled galvanized-steel connecting rod astern, a connection hose between the boat and the cart, a connection piece between the connecting hose and the suction hose that connects the pump placed at the structure edge. In any case, the propelling device of the suction device can also be formed by

a remote mechanical traction system arranged out of the structure or any other propelling device useful to move the suction device.

[0104] The suction device is mainly formed by a structuring frame, a covering carcass with coupling means to be coupled to the pumping system, rolling means for continuous displacement over the surface to be cleaned and cleaning means consisting of a suction line and a brush line to remove the material to be cleaned by means of suction from the pumping system through the suction device.

[0105] The covering carcass comprises a laminar resin body that covers the structuring frame and the rolling and suction means. From the top section of the covering carcass supporting plates emerge for the pulling tensors from the boat, which are internally joined to the structuring frame; at its top section, said carcass also has suction PVC tubes that form coupling means to the pumping system and are attached by their base section to a carcass collar formed in molded resin fiber with glass fiber reinforcements for supporting and sealing said suction tubes; whereas from said carcass collar a resin mantle and a lateral membrane flap project to form the carcass body. Also its top section has handles for pulling, handling and raising the device.

[0106] The structuring frame is a steel frame to which an aligned series of steel plates for supporting the rolling means, which comprise the axles of high density polyurethane rollers and plastic auto-lubricated wheels, is supportively joined, and a perforated or slotted steel platen is likewise attached to support by means of bolts a continuous line of brushes having a plastic base and synthetic polyethylene bristles, or the like, which help in the task of removing the material to be suctioned. To the rear section, the abovementioned supporting plates of the pulling tensors are joined.

[0107] The cleaning means comprise a suction line formed by vertical PVC tubes, corresponding to suction tubes emerging upwardly from the covering carcass, to which T-shaped PVC tubes are attached at their bottom part, which are coupled in turn to horizontal tubes that have suction openings in their bottom part through which the removed material enters to be suctioned and taken out of the pond.

[0108] It is important to keep in mind that the objective of the suction device (suction cart) is not only the cleaning of the bottom in the described process, as is the case of vacuum devices of swimming pools, but that said suction device replaces completely the traditional filtering system of swimming pools together with the use of flocculants and the skimmer system.

[0109] If all the abovementioned elements are not present, water impurities accumulate and deter water quality, and so the final objective of the present invention, i.e. obtaining water bodies with "color, transparency and cleanness characteristics similar to swimming pools or tropical seas" at low cost, would not be obtained.

#### APPLICATION EXAMPLE

[0110] To carry out the process of the invention to implement and maintain water bodies larger than 15,000 m<sup>3</sup> for recreational use with color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost, the following steps or stages were performed:

[0111] A structure similar to an artificial lagoon was built in the central Chilean shore, having a length of 1 kilometer, an area of 80,000 m<sup>2</sup> and a volume of 250,000 m<sup>3</sup> (33°20'59.91"S; 71°39'10.10"W). The bottom was built using clay and

bentonite, and it was lined with lineal low density polyethylene (LLDPE) and high density polyethylene (HDPE) plastic with white and yellow color. The walls were built in cement and clay and lined with LLDPE and HDPE membranes.

[0112] Minimal and maximal depths were 1.2 and 3.5 meters, being 2.8 meters the average depth.

[0113] A pipe system of 100 to 250 mm diameter was installed all around the lagoon borders to facilitate recycling. The system has homogeneously distributed injectors every 10 meters around the entire lagoon that are placed in the bottom to inject the products and maintain water homogeneity. Systems for the removal of impurities and superficial oils by skimmers were installed.

[0114] Water intake for this structure was achieved through headers. Inlet water had 0.08 ppm iron and 0.15 ppm manganese, and a turbidity of 1.4 NTU. The water had a pH of 7.93 and natural bromine concentrations of 48 ppm, and consequently no addition of bromine salts was required. The water was impounded through headers at a depth of 8 m at sea shore. The intake was performed at this depth to avoid incrusting micro-mollusks. The presence of micro-mollusks in sea water causes problems by growing, development and adhesion to piping walls and lagoon structures. Other possible way to avoid incrusting micro-mollusks is the use of water pre-filtering.

[0115] ROP value was maintained over 600 millivolts (mV) during 4 hours in 24-hour cycles. This was achieved by applying oxidants, such as e.g. ozone, hydrogen peroxide, potassium persulfate, electrochlorination or sodium hypochlorite. All the former were tested with good results.

[0116] In an average September day with an air temperature between 10 and 16° C. and a water temperature of 17° C., 0.11 ppm of sodium hypochlorite produced by electrochlorination were applied, which was sufficient to maintain ROP over 600 mV for more than 4 hours. This system is advantageous when working with salt water, because the electrolytic process transforms chloride in sea water in hypochlorite, with no need to add additional chemicals.

[0117] The established regulations for swimming pools in other countries indicate higher ROP values (between 650 and 750 mV) permanently, but this is not economically viable in large volumes of water and in this invention it has been demonstrated that keeping ROP over 600 mV during 4 hours in 24-hour cycles is enough to decrease the growth of microalgae and microorganisms in large water bodies, thus generating low-contamination conditions apt for swimming.

[0118] The bacteria *Escherichia coli*, a bacterial pathogen marker, dies after 100 seconds when exposed to a ROP of 600 mV, and consequently the 4-hour treatments have a high disinfectant power.

[0119] The water body volume of this example equals the volume of 6,000 familiar 8-meters-long swimming pools and is constructed in such a way that it does not receive visible contamination from the surroundings (leaves, soil, water-courses), and consequently contamination received from the environment is very low in relative terms when compared with a swimming pool. Proportionally, human contamination is also insignificant given the high dilution power (for example, 4 swimmers in a familiar pool equal 24,000 swimmers in the lagoon).

[0120] Additionally, the flocculation and bottom cleaning with the suction cart, and the removal of grease and superficial impurities by means of the skimmers allows keeping low organic matter levels, which decreases the use of oxidants.

[0121] Algaecide action was achieved by keeping an average copper level in the water of around 0.3 ppm, and the application was made by using copper salts (copper sulfate pentahydrate) in closed sacs, which is applied in the chambers through which recycling system water passes, in such a way that the salts dissolve slowly, and also by an copper electrode ionization process in which an electric current is applied to said electrodes and copper ions are released into the medium in a controlled way. Measured copper levels varied between 0.1 ppm at a temperature of 10° C. and 1.5 ppm at 30° C. (2 ppm are acceptable in potable water, see Table 4).

[0122] A cationic flocculating polymer was added. The flocculant used was HICAT-1™ in daily applications of 0.04 ppm through the recycling system.

[0123] With the aid of the suction cart or device, the plastic of the bottom of the lagoon was cleaned subsequently to decantation. The device has a system of suction chambers, thus removing all the precipitated impurities together with the polymer, which allows the bottom of the lagoon (membrane) to be seen. The device that cleaned the plastic membrane was pulled by a boat and did not leave any residual layer, because it was a fine cleaning and not a dredging. This cleaning and suction method was permanent and the bottom of the lagoon was cleaned daily, in such a way that the suction system passes by every membrane sector every four days.

[0124] The water was maintained in movement by means of a recycling system that operated 8 hours per day in low-wind seasons, thus keeping water homogeneity. Injectors distributed around the structure throw the water up to a long distance and are placed every 10 meters. It should be mentioned that the water contained by the structure also shows an important circulation as an effect of the wind and it should be possible to decrease the artificial recirculation requirements by a suitable design of the structure, thus sparing energy.

[0125] This recycling system was used to apply chemicals. The water of the structure was completely renewed in a period between 30 and 150 days. The aim of the renewal was to avoid "water ageing", which is the formation of secondary compounds derived from oxidation reactions. The renewal was performed by taking new water through the feeding pipes, independently from the recycling pipes that end at the injectors.

[0126] A superficial water outlet flow was kept by means of the skimmers that remove oils and superficial impurities.

[0127] The amount of added chemicals depends mainly on the temperature and is orders of magnitude lower than those required in swimming pools.

[0128] The total comparative maintenance cost per cubic meter was approximately 3% of the usual cost in swimming pools.

[0129] In this application example, the physicochemical conditions of water were determined to comply not only with regulations for recreational waters with direct contact (see Table 2), which are those applied in this case, but also with regulations for potable water (see Table 4), with the exception of characteristics inherent to sea water, and with regulations for swimming pools (see Table 3), with the exception of chlorine permanent residual levels, which do not apply because of the applied technology.

TABLE 2

| Comparison of the water treated with the process of the invention and the regulation for recreational waters with direct contact (NCh 1333 *) |                              |                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| PARAMETERS                                                                                                                                    | MEASURED VALUE IN THE LAGOON | NCh 1333                                                                                                                 |
| pH                                                                                                                                            | 7.96                         | 6.5 to 8.3<br>except if natural water conditions show different values, but in no case lower than 5.0 or higher than 9.0 |
| Temperature, ° C., maximal                                                                                                                    | 17.7                         | 30                                                                                                                       |
| Clarity, minimal *                                                                                                                            | 35 meters                    | Visualization of Secchi discs at a depth of 1.20 meters                                                                  |
| Visible floating solids and unnatural foams                                                                                                   | Absent                       | Absent                                                                                                                   |
| Floating oils and greases, mg/l, maximal *                                                                                                    | <5                           | 5                                                                                                                        |
| Emulsified oils and greases, mg/l, maximal *                                                                                                  | <5                           | 10                                                                                                                       |
| Color, Pc-Co Scale unit, maximal *                                                                                                            | 10                           | 100                                                                                                                      |
|                                                                                                                                               | Absent                       | Absence of artificial colors                                                                                             |
| Turbidity, Silica units, maximal *                                                                                                            | 0.55                         | 50                                                                                                                       |
| Fecal coliforms/100 ml, maximal *                                                                                                             | <2.0                         | 1,000                                                                                                                    |
| Substances that cause inconvenient smell or taste                                                                                             | Absent                       | Absent                                                                                                                   |

\* Official Chilean regulations were used (Chile was the country of the application example), Chilean rule NCh 1333

TABLE 3

| Comparison of the water treated with the process of the invention and the regulation for swimming pools (NCh 209 *) |                              |               |
|---------------------------------------------------------------------------------------------------------------------|------------------------------|---------------|
| PARAMETERS                                                                                                          | MEASURED VALUE IN THE LAGOON | NCh 209       |
| pH                                                                                                                  | 7.96                         | 7.2-8.2       |
| Free residual chlorine                                                                                              | +                            | 0.5-1.5 (ppm) |
| Copper (algicides) mg/l                                                                                             | 0.38                         | 1.5 maximal   |
| Bromine (disinfectant) mg/l                                                                                         | +                            | 1-3           |
| Foam, grease and suspended particles                                                                                | Absent                       | Absent        |
| Colonies of aerobic bacteria/ml                                                                                     | 2                            | ≤200          |
| Fecal coliforms                                                                                                     | Absent                       | Absent        |
| Total coliforms                                                                                                     | ≤2                           | ≤20           |
| colonies/100 ml                                                                                                     |                              |               |
| Algae, larvae or other living organisms                                                                             | Absent                       | Absent        |
| Clarity                                                                                                             | 35 meters                    | 1.4 meters    |

\* Official Chilean regulations were used (Chile was the country of the application example), Chilean rule NCh 209

+ Do not apply because of the applied technology

TABLE 4

| Comparison of the water treated with the process of the invention and the regulation for potable water (NCh 409 *) |                       |              |                              |                       |
|--------------------------------------------------------------------------------------------------------------------|-----------------------|--------------|------------------------------|-----------------------|
| PARAMETERS                                                                                                         | UNIT                  | ASSAY METHOD | MEASURED VALUE IN THE LAGOON | Official 2005 NCh 409 |
| pH                                                                                                                 | —                     | (I)          | 7.96                         | 6.5 < pH < 8.5        |
| Turbidity                                                                                                          | NTU                   | (I)          | 0.55                         | 2.0                   |
| True color at pH = 7.71                                                                                            | Pt—Co                 | (I)          | 10                           | 20                    |
| Smell                                                                                                              | —                     | (I)          | Odorless                     | Odorless              |
| Taste                                                                                                              | —                     | (I)          | +                            | Tasteless             |
| Ammonia                                                                                                            | mg/l NH <sub>3</sub>  | (I)          | 0.12                         | 1.5                   |
| Total arsenic                                                                                                      | mg/l As               | (I)          | <0.005                       | 0.01 <sup>(1)</sup>   |
| Cadmium                                                                                                            | mg/l Cd               | (I)          | <0.002                       | 0.01                  |
| Zinc                                                                                                               | mg/l Zn               | (I)          | <0.05                        | 3.0                   |
| Total cyanide                                                                                                      | mg/l CN               | (I)          | <0.05                        | 0.05                  |
| Chlorides                                                                                                          | mg/l Cl               | (I)          | 18,914                       | 400 <sup>(2)</sup>    |
| Copper                                                                                                             | mg/l Cu               | (I)          | 0.38                         | 2.0                   |
| Phenolic compounds                                                                                                 | mg/l                  | (I)          | <2                           | 2                     |
| Total chromium                                                                                                     | mg/l Cr <sup>+6</sup> | (III)        | <0.05                        | 0.05                  |
| Fluorine                                                                                                           | mg/l F                | (I)          | <0.10                        | 1.5                   |
| Iron                                                                                                               | mg/l Fe               | (I)          | 0.08                         | 0.3                   |
| Magnesium                                                                                                          | mg/l Mg               | (I)          | 1.030 *                      | 125                   |
| Manganese                                                                                                          | mg/l Mn               | (I)          | <0.01                        | 0.10                  |
| Mercury                                                                                                            | mg/l Hg               | (I)          | 0.001                        | 0.001                 |
| Nitrates                                                                                                           | mg/l NO <sub>3</sub>  | (I)          | 4.54                         | 50                    |
| Nitrites                                                                                                           | mg/l NO <sub>2</sub>  | (I)          | 0.04                         | 3                     |
| Lead                                                                                                               | mg/l Pb               | (I)          | <0.02                        | 0.05                  |
| Total dissolved solids at 105° C.                                                                                  | mg/l                  | (I)          | 34,310 *                     | 1,500                 |
| Selenium                                                                                                           | mg/l Se               | (I)          | 0.001                        | 0.01                  |
| Sulfates                                                                                                           | mg/l SO <sub>4</sub>  | (I)          | 2,494 *                      | 500 <sup>(2)</sup>    |

TABLE 4-continued

| Comparison of the water treated with the process of the invention<br>and the regulation for potable water (NCh 409 *) |                 |                 |                                  |                             |
|-----------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|----------------------------------|-----------------------------|
| Free residual chlorine<br>in laboratory                                                                               | mg/l            | (III)           | <0.05                            | 0.2-2.0                     |
| Nitrate +<br>Nitrite Ratio                                                                                            | —               | (I)             | <1                               | 1                           |
| Organic substance                                                                                                     |                 |                 |                                  |                             |
| Tetrachloroethene                                                                                                     | µg/l            | (*)             | n.d.                             | 40                          |
| Benzene                                                                                                               | µg/l            | (*)             | n.d.                             | 10                          |
| Toluene                                                                                                               | µg/l            | (*)             | 0.01                             | 700                         |
| Xylenes                                                                                                               | µg/l            | (*)             | n.d.                             | 500                         |
| Pesticides                                                                                                            |                 |                 |                                  |                             |
| D.D.T + D.D.D. +<br>D.D.E.                                                                                            | µg/l            | (*)             | n.d.                             | 2                           |
| 2,4 D                                                                                                                 | µg/l            | (*)             | n.d.                             | 30                          |
| Lindane                                                                                                               | µg/l            | (*)             | n.d.                             | 2                           |
| Methoxychlor                                                                                                          | µg/l            | (*)             | n.d.                             | 20                          |
| Pentachlorophenol                                                                                                     | µg/l            | (*)             | n.d.                             | 9                           |
| Secondary products of disinfection                                                                                    |                 |                 |                                  |                             |
| Monochloramines                                                                                                       | mg/l            | (*)             | <0.1                             | 3                           |
| Dibromochloromethane                                                                                                  | mg/l            | (*)             | <0.005                           | 0.1                         |
| Dichlorobromomethane                                                                                                  | mg/l            | (*)             | n.d.                             | 0.06                        |
| Tribromomethane                                                                                                       | mg/l            | (*)             | 0.037                            | 0.1                         |
| Trichloromethane                                                                                                      | mg/l            | (*)             | n.d.                             | 0.2                         |
| Trihalomethanes                                                                                                       | mg/l            | (I)             | <1                               | 1                           |
| MICROBIOLOGICAL ANALYSIS                                                                                              |                 |                 |                                  |                             |
| PARAMETERS                                                                                                            | EXPRESSED<br>AS | ASSAY<br>METHOD | MEASURED<br>VALUE IN THE<br>POND | Official<br>2005 NCh<br>409 |
| Total coliforms                                                                                                       | MPN/100 ml      | (V)             | <2.0                             | <2.0                        |
| <i>Escherichia coli</i>                                                                                               | MPN/100 ml      | (V)-(*)         | ABSENT                           | ABSENT                      |

n.d. Indicates not detected

(\*) Official Chilean regulations were used (Chile was the country of the application example), Chilean rule NCh 409

\* Inherent values of sea water.

[0130] In this example, it has been demonstrated that it is possible to maintain a water body or volume similar to a large-volume (250,000 m<sup>3</sup>) artificial sea water pond with a water quality similar to conventional swimming pools and tropical seas, both in its aesthetic characteristics as in its physicochemical and bacteriological properties. The achieved characteristics have not been found in any existing artificial lagoon in the world up to date (see Google Earth) and this can be demonstrated by satellite comparison of the transparency and color of the lagoon to be protected (33°20'59.91"S; 71°39'10.10"W) with the tens of thousands existing in the world, such as golf court and public park lagoons, dams for recreational use, lagoons of real estate and tourist projects, and even dams over 15,000 m<sup>3</sup> built with swimming purposes (e.g. Piscina do Ramos in Brazil, Darwin Swimming Pool in Australia, Orthlieb Swimming Pool in Casablanca, Morocco).

[0131] We have not found any artificial water body in the world with a volume higher than 15,000 m<sup>3</sup> having crystalline water with this quality, except for the structure similar to an artificial lagoon that we want to protect, which has 250,000 m<sup>3</sup>.

[0132] In a Google Earth™ forum (Internet software for satellite photography of the world) people has been searching for two years for the biggest swimming pool in the world that can be seen from the air. The conclusion, when reviewing

their results, is that the lagoon of the application example is by far the biggest crystalline water body found.

[0133] The biggest known swimming pool in the world that uses traditional filtering and recycling systems is Sunlite Pool of Coney Island, United States, having 11,350 cubic meters of water. In the remaining tens of thousands of large artificial water bodies existing in the world, the water is not filtered or it is only partially filtered. As previously mentioned, the characteristics of the water of these bodies are very different from swimming pools or tropical seas and their uses are limited.

[0134] Filtering large water volumes is technically complex and highly costly, and consequently this is a barrier for the scaling-up of crystalline water bodies. The suction device of the present invention removes suspended solids (turbidity) that flocculate together with the polymer in an efficient and economic way, thus replacing filtering.

[0135] In addition to the high costs, the traditional filtering system does not solve the cleaning of the bottom of the lagoon.

[0136] The technology described in this invention patent, i.e. the replacement of filtering by a suction device and skimmers plus the application of controlled oxidation pulses, which are essential parts of the process, allows breaking the barrier that hinders the construction of crystalline lagoons with unlimited extensions and volumes, thus opening a new field of tourist applications.

[0137] The main advantage of the implemented process is evidenced by comparing the regulations for recreational waters and the results obtained in the artificial lagoon of the example. Additionally, the level of transparency obtained in the water is highly important, being the clarity equal or higher than 35 meters, which is a result not found in any water body larger than 15,000 m<sup>3</sup> nor in the majority of swimming pools; in fact, the swimming pool regulation demand only 1.4 meters of clarity (see Table 3).

[0138] Other advantages of the disclosed process of the present invention are:

[0139] Low maintenance costs.

[0140] Established regulations for recreational waters with direct contact are widely fulfilled (see Table 2) and comparable parameters of the swimming pool and potable water regulations are also fulfilled (see Tables 3 and 4).

[0141] The water in the lagoon is always absolutely transparent, with no turbidity, with the characteristic turquoise color of swimming pools or tropical seas and with a clean bottom, which are optimal visual characteristics for the acceptance of the user public.

(temperature, solar radiation, wind). In practical terms, in the lagoon of the application example in summer, temperatures of more than 10° C. higher than those of the sea are obtained.

[0144] Flocculation and bottom cleaning by suction together with skimmers replace the filter system of conventional swimming pools, thus generating high transparency conditions at a very low cost. The removal of sediments prevents said sediments to consume oxidants and generate anoxic zones, and they allow the bottom membrane to give an attractive tonality to the lagoon's water.

[0145] Water bodies can be built with no size limit having optimal aesthetical, physicochemical and sanitary conditions, which generates large tourist attraction poles.

[0146] In order to make more evident the surprising effect of the process disclosed in the present invention, Table 5 is shown, which illustrates the costs for both cleaning methods in the water body of the application example (250,000 m<sup>3</sup>).

TABLE 5

| Comparison of the traditional filtering method* and the suction device |                                                                                                                                                                                                                                                                                                                                                                                           |                                 |                    |                         |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------|-------------------------|
|                                                                        | Specifications                                                                                                                                                                                                                                                                                                                                                                            | Volume circulated through pumps | Installation costs | Monthly operation costs |
| Traditional filter                                                     | 120 15 HP Three-phase Aral-C 3000 pumps (Astral code 01206)<br>60 Praga 3000 filters (Astral code 15781)<br>714,000 kilograms of sand (Astral code 905000)<br>60 batteries of 250 mm valves (Astral code 19133)<br>Installation labor<br>Shed of 2,500 m <sup>2</sup><br>Total monthly energy required, 24 hours*30 days*1343.28 kW/hour (967,164.18 kW/hour)<br>Operators<br>Maintenance | 2,893 lts/sec                   | US\$ 2,686,648*    | US\$ 119,246            |
| Suction device                                                         | Windglider boat<br>Protected outboard 9.5 HP motor<br>Suction device<br>Suction pump 7.5 HP<br>Hoses, accessories<br>Fuel<br>Flocculant<br>Operator<br>Maintenance                                                                                                                                                                                                                        | 10 lts/sec                      | US\$ 25,166        | US\$ 2,242              |

\*Considering T = 2 (minimal rate for swimming pool filtration) according to regulation NCh 209

\*Does not consider the cost of the land for the 2,500 m<sup>2</sup> shed.

[0142] Use of oxidant, algicide and disinfectant concentrations up to 100 times lower than those recommended to be applied in conventional swimming pools; this advantage favors the users and is more environmentally-friendly.

[0143] As these water bodies are disconnected from the sea or near natural lakes, they are not affected by temperature variations produced by oceanographic currents, ice thawing, etc. but only by environmental variables

[0147] It is important to keep in mind that to obtain the desired final result of "color, transparency and cleanness characteristics similar to swimming pools or tropical seas at low cost", it is essential to have a water containing structure that have the required elements for water treatment and features that allow obtaining the desired results. The isolated application of the physicochemical process for water treatment would not be possible nor would it produce the desired results.

What is claimed is:

1. A process to obtain a large body of water comprising:
  - a. providing a structure to contain the large body of water;
  - b. treating the water periodically to establish oxidation-reduction potential (ORP) within a predetermined range;
  - c. adding an agent to precipitate impurities in the water to the bottom of the structure; and
  - d. removing the precipitated impurities and other suspended debris without filtration of the whole body of water.
2. The process of claim 1, wherein providing a structure further comprises:
  - providing a bottom and walls made of low permeability materials coated with a non porous material;
  - providing a system for removing impurities and superficial oils using skimmers;
  - providing a feeding pipe system for introduction of fresh water; and
  - providing a feed water intake system.
3. The process of claim 1, wherein the large body of water is larger than 15,000 m<sup>3</sup>.
4. The process of claim 1, wherein the large body of water is for recreational use.
5. The process of claim 1, wherein treating the water to maintain oxidation-reduction potential (ORP) comprises:
  - a. feeding the structure containing the large body of water with inlet water having iron and manganese levels lower than 1.5 ppm and turbidity lower than 5 NTU;
  - b. measuring the water pH; and
  - c. adding an oxidizing agent to the large body of water to maintain an ORP at a given level in the large body of water using a pulse of a given time over a given number of hours in a cycle.
6. The process of claim 5, wherein adding an oxidizing agent comprises adding an agent to water to maintain an ORP of at least 600 mV in the large body of water using a pulse of at least 4 hours in a 48 hour cycle.
7. The process of claim 5, wherein adding an oxidizing agent comprises adding an agent to water to maintain an ORP of at least 500 mV in the large body of water using a pulse of at least 4 hours in a 24 hour cycle.
8. The process of claim 1, wherein adding an agent to precipitate impurities comprises adding a flocculating agent to the large body of water contained in the structure.
9. The process of claim 8, wherein the flocculating agent is a cationic polymer added in concentrations from about 0.02 ppm to about 1 ppm over a time period no greater than 6 days.
10. The process of claim 8, wherein the flocculating agent is a cationic polymer added at a concentration of 0.05 ppm every 24 hours.
11. The process of claim 5, wherein bromine salts are added if the pH is higher than 7.8 are added.
12. The process of claim 11, wherein the bromine salt is sodium bromide, and wherein the bromide concentration is maintained at values higher than 0.6 ppm.
13. The process of claim 5, wherein adding an oxidizing agent comprises adding an agent from the group consisting of ozone, sodium persulfate, potassium persulfate, chlorine derivatives, hydrogen peroxide, bromine derivatives, and agents produced by electrochlorination.
14. The process of claim 5, wherein treating the water to maintain ORP further comprises adding algacides to the large body of water.
15. The process of claim 14, wherein the algacides are selected from the group consisting of quarternary ammonium salts and copper compounds.
16. The process of claim 15, wherein the copper compounds have copper levels between 1 ppb and 1.5 ppm, depending on temperature and sunlight.
17. The process of claim 15, wherein the copper compounds are added at copper levels of about 0.3 to about 1.5 ppm for temperatures between 10° C. and 30° C.
18. The process of claim 5, wherein feeding the structure with inlet water comprises feeding with inlet water selected from the group consisting of sea water, well water, spring water and water from other sources.
19. The process of claim 1, wherein removing the precipitated impurities and other suspended debris without filtration of the whole body of water further comprises:
  - (a) cleaning the bottom of the structure containing the large body of water with a movable suction device to remove precipitated impurities; and
  - (b) generating a displacement of surface water containing impurities and surface oils, comprising injecting inlet water into the large body of water; removing surface water with the skimmers on the structure containing the large body of water; and removing suspended debris with a movable suction device, wherein the combination of steps (a) and (b) replace filtration of the whole body of water.
20. A process to implement and maintain a large water body, wherein the process comprises:
  - (a) providing a structure with skimmers able to contain a large water body larger than 15,000 m<sup>3</sup>;
  - (b) feeding the structure of step (a) with inlet water having iron and manganese levels lower than 1.5 ppm and turbidity lower than 5 NTU;
  - (c) measuring water pH, wherein the pH is maintained no lower than 5 and no higher than 9;
  - (d) adding an oxidizing agent to the water body contained in the structure of step (a), to maintain an oxidation-reduction potential (ORP) of at least 600 mV in the water body using a pulse of at least 4 hours within a 48 hour cycle;
  - (e) adding a flocculating agent in concentrations within 0.02 and 1 ppm over a time period no greater than 6 days to precipitate impurities in the water to the bottom of the structure of step (a);
  - (f) cleaning the bottom of the structure of step (a) with a movable suction device to remove the precipitated impurities from the bottom of said structure, together with the additional flocculants; and
  - (g) generating a displacement of surface water containing impurities and surface oils by means of injection of inlet water according to step (b), which generates said displacement in such a way to remove said surface water using said skimmers provided in the structure of step (a), which together with step (f) replaces filtration to remove suspended debris from the water body.
21. The process of claim 20, wherein the large water body is for recreational use.

\* \* \* \* \*



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(19) **United States**(12) **Patent Application Publication**  
**FISCHMANN T.**(10) **Pub. No.: US 2013/0264261 A1**(43) **Pub. Date: Oct. 10, 2013**(54) **SYSTEM FOR PROVIDING HIGH  
MICROBIOLOGICAL QUALITY COOLING  
WATER TO AN INDUSTRIAL PROCESSES**(52) **U.S. Cl.**  
CPC ..... **C02F 1/5281** (2013.01)  
USPC ..... **210/182; 210/184**(71) Applicant: **Crystal Lagoons (Curacao) B.V., (US)**(72) Inventor: **Fernando FISCHMANN T., Santiago  
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B.V., Curacao (NL)**(21) Appl. No.: **13/861,262**(22) Filed: **Apr. 11, 2013****Related U.S. Application Data**(62) Division of application No. 13/195,695, filed on Aug.  
1, 2011, now Pat. No. 8,454,838.(60) Provisional application No. 61/469,526, filed on Mar.  
30, 2011.**Publication Classification**(51) **Int. Cl.**  
**C02F 1/52** (2006.01)(57) **ABSTRACT**

A method and system for treating water, and using the treated water for the cooling of industrial processes is disclosed. The water is treated and stored in a large container or artificial lagoon, has high clarity and high microbiological quality. A system of the invention generally includes a containing means, such as a large container or artificial lagoon, a coordination means, a chemical application means, a mobile suction means, and a filtration means. The coordination means monitors and controls the processes in order to adjust water quality parameters within specified limits. The large container or artificial lagoon can act as a heat sink, absorbing waste heat from the industrial cooling process, thus creating thermal energy reservoirs in a sustainable manner, which can be later used for other purposes. The method and system can be used in any industrial cooling system with any type of water available, including fresh water, brackish water, and seawater.

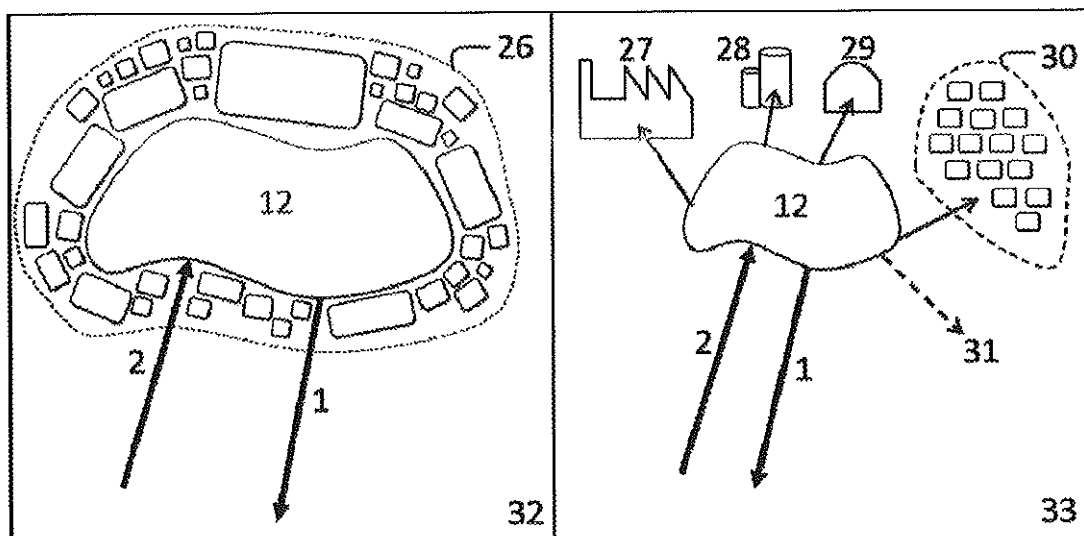


Figure 1

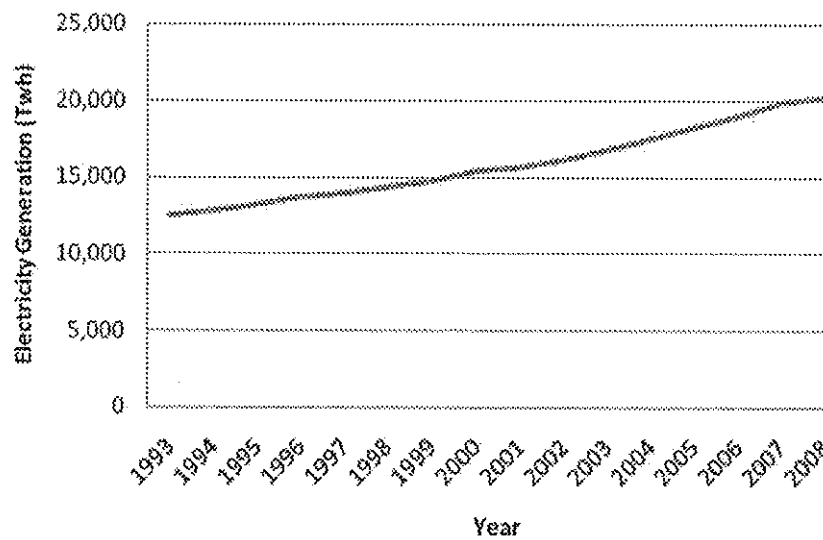


Figure 2

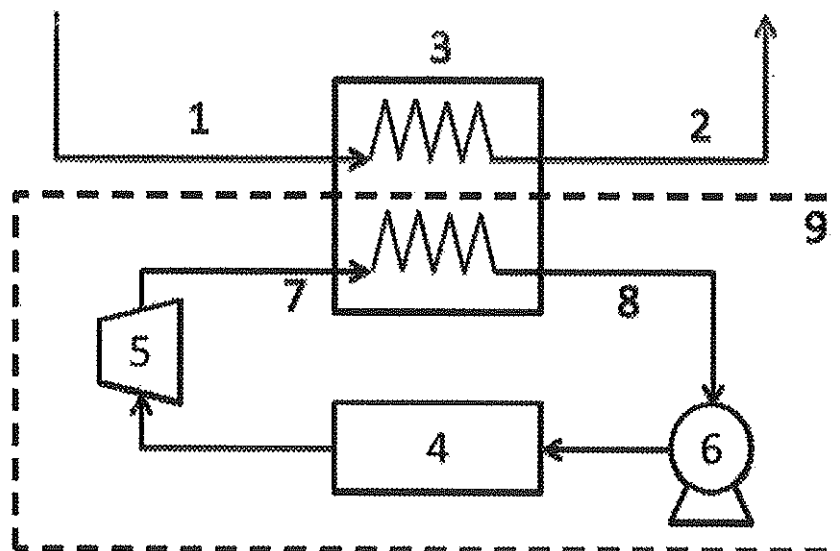


Figure 3

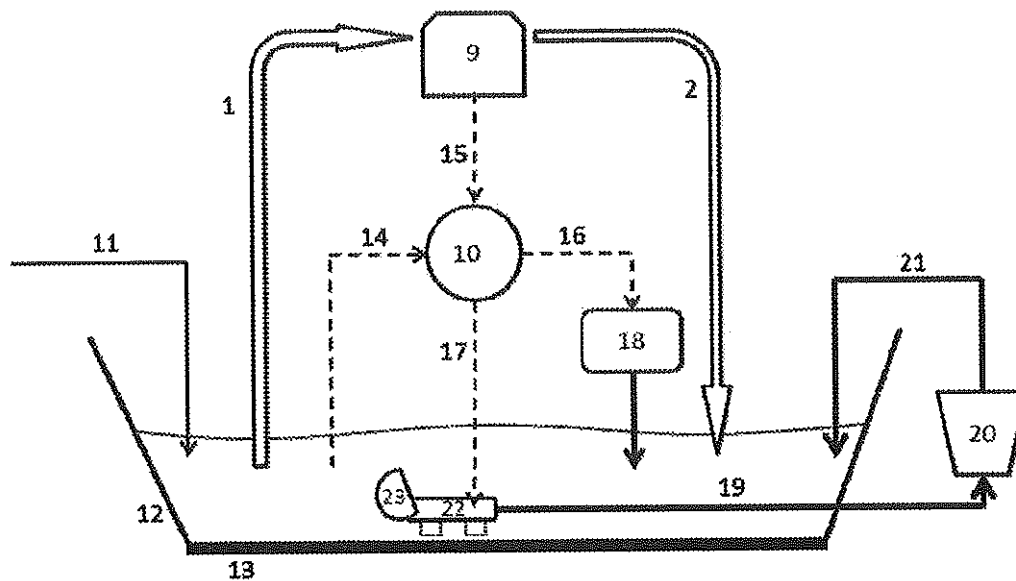


Figure 4

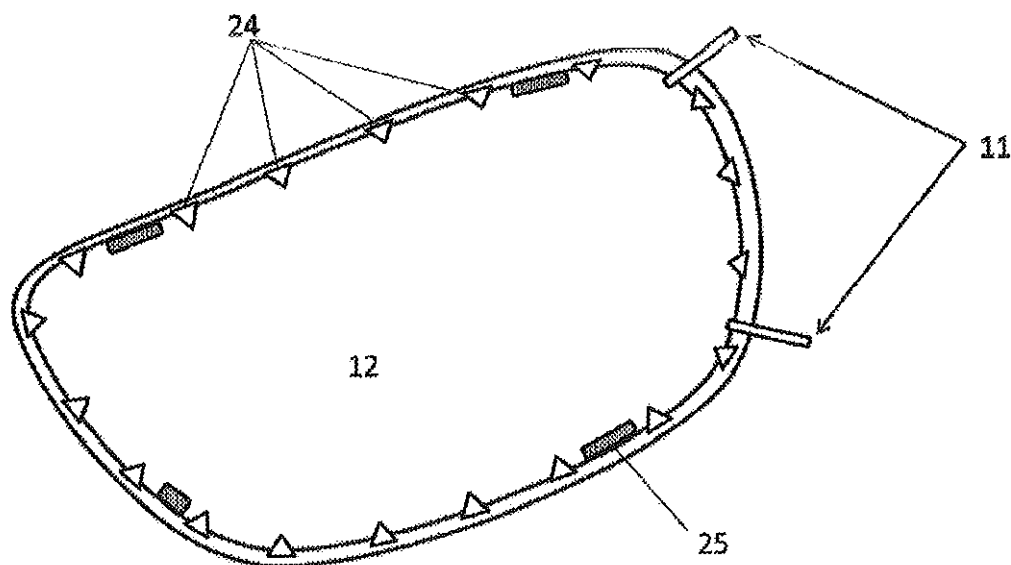
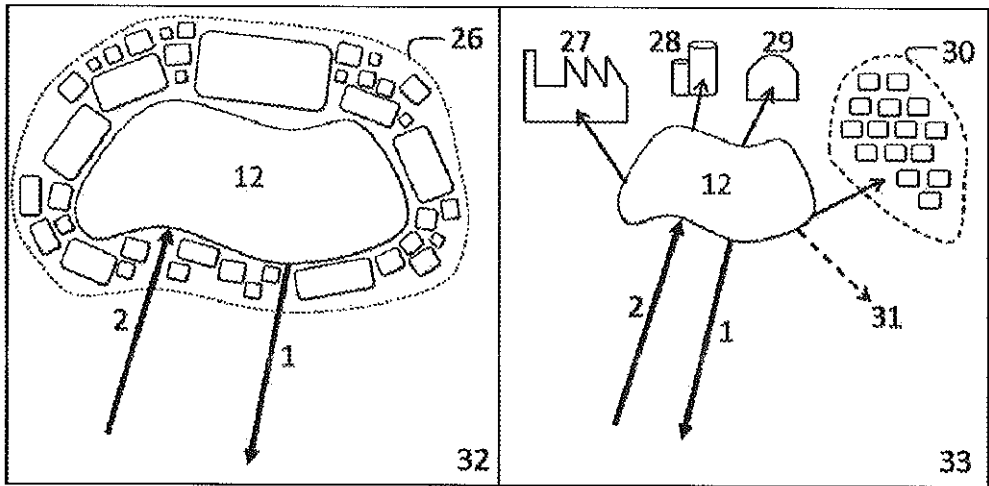


Figure 5



## SYSTEM FOR PROVIDING HIGH MICROBIOLOGICAL QUALITY COOLING WATER TO AN INDUSTRIAL PROCESSES

[0001] This application claims benefit of U.S. Provisional Ser. No. 61/469,526, filed 30 Mar. 2011 and which application is incorporated herein by reference. To the extent appropriate, a claim of priority is made to the above disclosed application.

### FIELD OF THE INVENTION

[0002] The present invention relates to a method and system for treating water, and using the treated water for the cooling of industrial processes. The water is treated and stored in a large container or artificial lagoon, has high clarity and high microbiological quality. The large container or artificial lagoon can act as a heat sink, absorbing waste heat from the industrial cooling process, thus creating thermal energy reservoirs in a sustainable manner, which can be later used for other purposes. The method and system can be used in any industrial cooling system with any type of water available, including fresh water, brackish water, and seawater.

### BACKGROUND

[0003] Industries worldwide have increased significantly in number and have improved their processes over the years. Many of these industries require systems that provide cooling for at least some of their processes. Many of the cooling systems utilize water as a heat sink or heat transfer fluid. However, water is a limited resource. Exploitation and contamination of underground aquifers, oceans, and surface waters has occurred, leading to a decrease in the quantity of suitable water, as well as the quality of the naturally available water. Thus, new ways of using water in a sustainable and economical way need to be found in order to utilize this resource in an efficient manner and without damaging the environment.

[0004] Current industrial cooling systems are often restricted to areas where large volumes of cooling water are available. For example, cooling systems are often located along an ocean coast line or near other natural sources of water, such as rivers and large lakes, where this resource exists abundantly. Accordingly, a significant drawback associated with water-based cooling systems is that they are often constrained to specific geographical areas. For example, for a 350 MW power plant using coal, nearly 45,000 cubic meters of water per hour may be needed for cooling purposes, such as in plant heat exchangers, equivalent to filling 18 Olympic swimming pools in just one hour.

[0005] Moreover, waste heat absorbed by the cooling water generally is lost into the environment by discharging the heated water back into a natural source of water, or by discharging water vapor into the atmosphere. Recoverable energy that is wasted throughout the world each day may be up to 80% of the total electricity consumed daily worldwide.

[0006] Specific representative environments which may benefit from improved industrial water-based cooling systems can include, but are not limited to, the following:

#### Thermal Power Plants

[0007] Increases in population and technological advances have resulted in a vast demand for additional energy. A significant use of worldwide energy is concentrated in the gen-

eration of electricity. The demand for electricity is growing at a pace set by the modernization of nations and their economic development. For example, electricity generation has increased nearly 40% in the last 10 years (see FIG. 1). This demand has led to an increase in the construction of new facilities for electricity generation worldwide.

[0008] Thermal power plants are currently the predominant type of power plants in operation. These plants employ a fuel to generate combustion, with the combustion heating a fluid which in turn drives a turbine in an electrical generation circuit. There are also a number of power plants using renewable resources—such as solar energy or geothermal energy—generating a driving fluid that in turn drives a turbine. Still other thermal power plants use nuclear fuels, such as uranium. However, available statistics show that of the total energy consumed in 2008, 80% to 90% was derived from the combustion of fossil fuels in thermal power plants. Most typically, these types of plants use coal, oil, or natural gas. In part, this large percentage of electricity production is due to the high availability of fossil fuels in the world. In 1973, the world energy matrix consisted of 78.4% thermal power plants (including nuclear plants), while in 2008 the percentage had increased to 81.5%. There is a continual need for these plants to improve their operational efficiency and reduce their environmental impact.

[0009] Over time, thermal power plants have undergone diverse changes associated with their operation. For example, changes have been implemented relating to emissions and the efficient use of fuel. However, a remaining drawback of these plants is the use of water cooling systems. These systems have several disadvantages which restrict the use to certain geographical locations. Additionally, the use of the water and attendant heating of the water produce a potentially damaging impact to the environment, raise energy costs, result in an intensive use of water, waste the residual heat, and/or have high installation and operation costs. Accordingly, improved cooling systems are needed to keep up with the growing demand for energy and electricity.

[0010] The current cooling systems used in thermal power plants and other industries are: once through cooling systems, wet cooling towers, and cooling ponds.

#### Once Through Cooling Systems

[0011] One of the main types of cooling systems used today is the "once through" cooling system, which refers to an open-cycle system (i.e., not employing water recirculation). This type of system consists of a water intake structure to collect the water from a natural source and a discharge structure to return the water back to the natural source (e.g., often the ocean or sea). Collected cooling water is circulated through heat exchangers functioning as part of the industrial process. In heat exchangers, the water acts as a heat sink whereby the water temperature increases as it flows through the exchanger. The heated water is then discharged back into the natural source. In the U.S. alone, approximately 5,500 power plants use a once through cooling system. These plants use more than 180,000 million gallons of water per day for cooling purposes. This amount is, for example, more than 13 times the irrigation water used in Australia daily. Once through cooling systems have many drawbacks including environmental damage due to suction and death of marine organisms; thermal pollution from the returned, heated water;

restricted location of the plants to a coastline (or on the border of large water sources); poor quality water; and waste of residual heat.

**[0012]** The once through cooling system uses large volumes of water at relatively low cost, but often leads to large-scale adverse effects on the marine ecosystem. For example, this system creates a temperature increase in the discharged water. In the ocean, the sharp increase in temperature can cause serious problems, even resulting in death of living organisms. This affects the marine ecosystem and human activity that takes place on the coast, such as fisheries and other economic activity. The once through cooling system can also cause the death of marine organisms due to suction produced in the water inlet. This may affect millions of fish, larvae and other aquatic organisms each year worldwide because they are sucked into the conduits leading to the heat exchangers. Death can occur because of the filters or screens (e.g., collisions with filters/screens or retention by the filters or screens), because of the driving pumps (e.g., by passing inside structures at high pressures and/or flows that cause collisions with the walls), due to chemicals that may be added, and in the heat exchangers due to the abrupt change of temperature. The laws of some countries and states ban the use of once through cooling systems. Therefore, there is a need to seek new ways of cooling that are sustainable over time and allow better performance and efficiency.

**[0013]** Another major limitation of the once through cooling system is its restricted location. As noted above, these types of plants must typically be located on the coast bordering the sea or inland along rivers, in order to better capture large amounts of water. These locations can create significant land use problems. These industries are thereby limited due to the large volumes of water to be captured and the effect of thermal pollution in such places. Because of this, plants have various problems related to location which results in higher costs and potential rejection by the residents of the community.

**[0014]** Another problem with the once through cooling system is the poor quality of water used for cooling. Once through cooling systems typically use seawater, which has a large organic content. This adversely affects the heat transfer systems of cooling processes. For example, reduced heat transfer occurs due to living or dead organisms which adhere to or clog the pipes. Biofouling is produced and begins to adhere to the inner surface of the pipes, reducing heat transfer and thus generating greater inefficiencies. In addition, new environmental standards recommend (and some require) that plants operate at a high efficiency to maximize the amount of energy produced per unit of fuel. One study estimates that fouling in heat exchangers produces monetary losses in industrialized countries at a level of about 0.25% of Gross Domestic Product (GDP).

**[0015]** Another constraint of once through cooling systems is that all the heat absorbed is discharged back into the natural water source without using the thermal energy in the water. In some instances, the thermal energy that is wasted can approach two thirds of the total generated heat, while the amount of electric energy produced by a power plant is only one third of the total generated heat. It would be advantageous to use this wasted, valuable energy for other beneficial purposes.

## Wet Cooling Towers

**[0016]** Another cooling system currently used is a wet cooling tower. These systems cool water through heat exchange with air inside evaporation chimneys. The chimneys contain a cold water reservoir at the base which feeds the plant by pumps that circulate through the condenser of the plant (chillers), thereby transferring the heat of the working fluid of the plant into the water. When the high temperature effluent water reaches the top of the tower, it begins to descend in fine jets to maximize contact area for heat transfer. Some plants have fans, either on the top or bottom of the tower, to circulate air upwards so as to achieve a counter-flow contact with water. As the water falls, it cools and heat loss occurs through evaporation. When water evaporates, dissolved salts fall back into the water tank, thereby increasing its concentration. Therefore, a certain amount of water must be purged from time-to-time and the reservoir must be fed with fresh water. Wet cooling towers have various problems associated with their operation, including high withdrawal rates and evaporation of water, high costs, deterioration of the urban aesthetic or landscape, and loss of the captured residual heat.

**[0017]** A significant problem of wet cooling towers is the high rate of water use. According to the Electric Power Research Institute (EPRI), for a steam driven power station operating on coal, water withdrawal rates are about 2,082 liters/MWh, and water consumption due to evaporation is about 1,817 liters/MWh. Moreover, wet cooling towers require frequent replenishment due to heavy water consumption caused by high evaporation rates. All the evaporated water must be replaced and also from time to time a certain amount of water must be purged due to the increase in mineral concentration in the tank, which also must be replenished. Generally, wet cooling towers work with fresh water, resulting in higher operating costs.

**[0018]** Another major problem of wet cooling towers is that they have high installation, operation, and maintenance costs. For example, for a plant of 2,245 MW, the capital cost may rise to 600 million dollars.

**[0019]** Further, wet cooling towers cause a deterioration of urban aesthetics and landscape. This is due to both the structure of the tower and the steam discharged from the tower into the atmosphere. The steam interferes with the landscape view and can cause wet pavements, roads, and other adjacent surfaces. A further limitation of wet cooling towers is that they do not exploit the residual energy, since they discharge virtually all the residual heat into the atmosphere as water vapor. Accordingly, the overall energy efficiency of the process is reduced.

## Cooling Ponds

**[0020]** Many current cooling systems used in industrial processes employ cooling ponds. Cooling ponds generally consist of large volumes of water contained in a pond from which cooling water is extracted. After going through a heat exchange process in the plant, the water (with a higher temperature) is discharged back into the pond. The area of the pond typically depends on the capacity and efficiency of the plant. These types of ponds are used by almost fifteen percent (15%) of thermal power generation plants in the U.S. that use coal, other fossil fuels, a combined cycle, and nuclear plants. The main disadvantages of cooling ponds are the large physical areas required for implementation and the poor quality of water contained within the pond.

[0021] The requirement of a large area for cooling pond implementation is based on the low temperatures to be maintained—generally below 22° C. This is because once the water temperature begins to rise, the pond water is more prone to the growth and proliferation of algae and other organisms that cause problems in the cooling system and the pond itself. So to maintain low temperatures, cooling ponds have very large areas of up to 2,500 hectares. Considering that land use is increasingly scarce, this solution is becoming less viable.

[0022] Another limitation of cooling ponds is the poor quality of water in the pond. In some plants, the cooling water from the pond must be subjected to additional treatments such as filtration and removal of compounds that damage machinery. The poor quality is due to the proliferation of microorganisms, algae, and sediment particles. Water quality in these ponds makes them unattractive for use in recreational purposes, and they may pose health hazards to people who use the pond.

[0023] Also, since the water temperature in the cooling pond is not permitted to increase to 25-30° C. or more, the heated water cannot be used for other purposes, therefore wasting valuable thermal energy.

#### Casting Industries

[0024] Other industries, such as foundry and cast industries, may use a cooling water system. The foundry industry is of high importance, especially for mining where metals are melted to produce other products. In the casting process, gases are generated at extremely high temperatures, which must be cooled for later discharge or use. Currently, most foundry industries use water cooling systems, either by recycling or by once through cooling systems.

[0025] Based on the cooling needs of many industries and the drawbacks of existing cooling systems, there is a need for improved cooling systems which operate at a lower cost, avoid thermal pollution and associated thermal damage to marine ecosystems, use less water, allow for flexibility in geographic locations, and/or take advantage of the thermal energy generated by the cooling process (e.g. heat exchanger) for useful purposes.

#### PREVIOUS ART

[0026] U.S. Pat. No. 4,254,818 generally describes preventing corrosion in the cooling system of an industrial operation through the use of aqueous brine with a concentration of 20-35% by weight. The brine circulates in a closed circuit between a heat exchanger for the operation and a cooling pond to maintain the desired brine concentration, which must be between 20 and 35% by weight. The cooling method requires a metal or alloy cooling system resistant to corrosion by water and by aqueous salt solution, and also requires a cooling tank containing an aqueous salt solution with a concentration of 20 to 35% by weight, and a closed circuit between said tank and the cooling system through which the brine circulates. In order to keep the desired concentration of the brine, the method contemplates replenishment of water to replace losses and maintain the salt concentration. There is also the option of using an auxiliary vessel or tank for the precipitation of calcium carbonate and calcium sulfate from effluent water from the cooling of the industrial operation, and transferring the water without those salts to the cooling pond, with the option of recovering the salts.

[0027] U.S. Pat. No. 4,254,818 requires the use of water with a certain concentration of salt, in the range of 20-35% by weight, therefore restricting the type of water that can be used. Also, this patent does not disclose the use of oxidizing agents and flocculants or coagulants, nor does the patent disclose the removal of suspended solids, algae, bacteria, metals, and organic matter. In addition, this patent does not provide an economical filtration system. Instead, the patent discloses the use of auxiliary tanks for the purpose of precipitating calcium carbonate and calcium sulfate, resulting in higher installation and maintenance costs.

#### SUMMARY

[0028] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify required or essential features of the claimed subject matter. Nor is this summary intended to be used to limit the scope of the claimed subject matter. The present invention can be employed in diverse industries and cooling systems. Although the present application refers to specific environments in which the principles of the present invention may be employed, such environments are representative and are not limiting.

[0029] Methods and systems in accordance with the principles of the present invention provide an industrial process with high quality cooling water, often comparable to the water quality of swimming pools, at a very low cost. In some embodiments, a coordinated cooling method and system comprising a large container to store water used to feed an industrial process are described, wherein the water is initially conditioned and maintained at a high quality, and is then recycled to achieve a sustainable cooling system over time. Additionally, the water heated by the industrial process optionally may be used for other purposes, such as for residential heating, producing hot water, thermal desalination, and heating greenhouses, as well as various other industrial and residential purposes. In thermal desalination, the water to be desalinated needs to be heated before passing through the distillation processes. Therefore, the heated water from the container can be used for heating purposes in the thermal desalination process.

[0030] Also, industries that use water or other fluids at high temperatures can employ this "pre-heated" water for producing water vapor or steam or for increasing the temperature of another fluid via heat exchange, thereby improving energy and cost efficiency.

[0031] In the case of cooling systems used in electricity generating plants, the present invention provides a coordinated cooling method which has several advantages over existing systems, such as being low cost, eco-friendly, and sustainable over time. The present invention uses less water than other systems, thereby allowing industries to locate in places before unimagined. Moreover, as the lagoon absorbs heat from the cooling process, a large temperate lagoon (e.g., a thermal energy reservoir) can be created that can be used for many industrial and recreational purposes. For example, if all thermal power plants used the present invention for cooling purposes, which allows for the use of the otherwise-wasted thermal energy, CO<sub>2</sub> emissions could be reduced by up to 50% in the world.

[0032] Unlike current once through cooling technology, the present invention provides a coordinated cooling method and system including a tempered lagoon operating in closed cir-

cuit, in an economical, sustainable and eco-friendly manner. The method and system avoid the adverse effects of thermal pollution associated with water discharge at high temperatures into the sea and its impact on marine organisms. Ultimately, the present invention will help prevent the high mortality of aquatic organisms that can occur due to the suction systems of prior art devices and passage through industrial cooling systems. In addition, it will allow locating plants in a diverse variety of geographical locations. In some instances, plant relocation may be possible to provide energy savings (e.g., since the plant can be located close to where energy is used or close to demand centers without having large distances between generation and consumption).

[0033] Still further, the present invention may increase the efficiency of heat exchangers though the use of very high quality water (e.g., comparable to swimming pool water) at a low cost. For example, seawater on average has a transparency of 2 meters horizontally, while the water of the present invention has a horizontal transparency of up to 40 meters. Sea water also contains a large amount of bacteria, while the water of the present invention contains significantly reduced amounts of organic matter, preferably little to no organic matter, after treatment. Thus, water from the present invention will minimize biofouling and prevent the formation of undesirable build-up in the pipes that reduce heat transfer. The cooling water of the present invention is recycled with minimal replacement, with replacement of water in the present invention necessitated mainly by evaporation from the lagoon.

[0034] Finally, the present invention may allow use of the residual thermal energy discarded by the industrial process. For example, the elevated temperature of the water returning to the cooling lagoon may be used for other purposes, such as for residential heating, producing hot water, thermal desalinization, or other industrial and residential uses.

[0035] Compared to wet cooling towers, the present invention provides a coordinated cooling method applied to a system that replenishes about 20% less water compared to cooling towers and evaporates about 20% less water to the atmosphere (based on current estimates and ambient temperatures and humidity). Thus, the present invention is better for the environment and natural resources. The large lagoons described herein also bring benefits in terms of cost reduction, achieving savings estimated at up to 50% with respect to the construction and operation of wet cooling towers. In addition, the present invention creates a lagoon that can be used for recreation and as a tourist attraction. For example, very large, tempered lagoons can be created which may be used for recreation throughout the year. And, as noted above, residual heat in the lagoon can be used for other industrial and residential purposes. The lagoons with recreational or industrial purposes can be organized in different configurations in order to allow several artificial cooling lagoons at the same time. Such lagoons can be configured in series, in parallel, and by coupling one lagoon to another.

[0036] Also, the present invention provides a method and system with several advantages over cooling ponds. First of all, treated water herein may reach a temperature of as high as 30° C., or as high as 50° C., or more, and still maintain excellent quality, comparable to conventional swimming pool water. Thus, the exposed surface area of the lagoons disclosed herein can be at least 3 to 10 times smaller than the exposed surface area of traditional cooling ponds. Also, if the water is maintained at higher temperatures, e.g., 40° C., fur-

ther area reductions can be achieved, thus making the lagoons disclosed herein even more beneficial. By reducing the necessary surface area of the container or artificial lagoon, industrial plants can be constructed and operated in areas that were not possible before. Furthermore, the quality of water provided by the present invention exceeds by far the current quality of many artificial lakes, with high clarity water at temperatures that can fall within a range from about 20° C. to about 50° C., or higher.

[0037] Generally, the present invention discloses methods and systems for providing water of high purity and clarity from a constructed artificial lagoon or other artificial large body of water (e.g., container). This water can be used as a heat transfer fluid for cooling various industrial processes. Embodiments of the present invention are directed to the use of large amounts of water for the cooling of industrial processes in an economical and sustainable manner. The container or artificial lagoon supplying the water can act as a heat sink, absorbing the waste heat from the industrial process through the transfer of heat to the circulating cooling water.

[0038] In an embodiment, a method for providing high microbiological quality cooling water to an industrial process comprises the following:

- a. Collecting inlet water from a water source;
- b. Storing the inlet water in a container, wherein the container has a bottom capable of being cleaned by a mobile suction means;
- c. Within periods of 7 days:

[0039] i. For a container water temperature up to and including 35° C., maintaining an ORP of the container water above 500 mV for a minimum period of 1 hour for each ° C. of the container water temperature, by adding a disinfectant agent to the container water;

[0040] ii. For a container water temperature greater than 35° C. and less than 70° C., maintaining an ORP of the container water above 500 mV for a minimum period of hours by adding a disinfectant agent to the container water, wherein the minimum period of hours is calculated by the following equation:

$$[35 \text{ hours}] - [\text{Temperature of the water in } ^\circ \text{C.} - 35] \\ = \text{minimum period of hours; or}$$

[0041] iii. For a container water temperature of 70° C. or more, maintaining an ORP of the container water above 500 mV for a minimum period of 1 hour, by adding a disinfectant agent to the container water;

d. Activating the following processes through a coordination means:

[0042] i. Applying an oxidizing agent to the container water to prevent the iron and manganese concentrations of the container water from exceeding 1.5 ppm;

[0043] ii. Applying a coagulant and/or flocculant to the container water to prevent the turbidity of the container water from exceeding 7 NTU;

[0044] iii. Suctioning the container water with a mobile suction means to prevent a thickness of settled material from exceeding an average 100 mm;

[0045] iv. Filtering the container water suctioned by the mobile suction means; and

[0046] v. Returning the filtered water to the container; and

e. Supplying high microbiological quality cooling water from the container to an industrial process at a flow rate such that a

difference in temperature between cooling water entering the industrial process and cooling water exiting the industrial process is at least 3° C.

[0047] In an embodiment, a system of the present invention for supplying cooling water to an industrial process comprises the following:

[0048] a container for storing cooling water, the container comprising a bottom for receiving settled particles;

[0049] a feeding line of inlet water to the container;

[0050] a coordination means for timely activating processes necessary to adjust parameters of the cooling water within predetermined limits;

[0051] a chemical application means activated by the coordination means;

[0052] a mobile suction means for moving along the bottom of the container and suctioning cooling water containing settled particles;

[0053] a propelling means for moving the mobile suction means along the bottom of the container;

[0054] a filtration means for filtering the cooling water containing settled particles;

[0055] a collecting line coupled between the mobile suction means and the filtration means;

[0056] a return line from the filtration means to the container;

[0057] a heat exchanger inlet line from the container to the industrial process; and

[0058] a return water line from the industrial process to the container.

[0059] In the system, the bottom of the container generally comprises membranes, geo-membranes, geotextile membranes, plastic liners, concrete, coated concrete, or combinations thereof. The coordination means is capable of receiving information, processing that information, and activating other processes, such as the chemical application means, mobile suction means, and the filtration means. The chemical application means generally comprises injectors, sprinklers, manual application, dispensers by weight, pipes, or combinations thereof. The propelling means drives the mobile suction means and typically comprises a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine, a floating device with an engine, or a combination thereof. The filtration means often comprises cartridge filters, sand filters, micro-filters, ultra-filters, nano-filters, or a combination thereof, and is generally connected to the mobile suction means by a collecting line comprising a flexible hose, a rigid hose, a pipe, or a combination thereof.

[0060] The present invention addresses diverse environmental problems arising from industrial cooling processes, including thermal pollution and the negative impact on the environment caused by such thermal pollution. The inventor of the novel technology disclosed herein, Mr. Fernando Fischmann, has developed many new advances in water treatment technology that are rapidly being adopted throughout the world. In a short period of time, the inventor's technologies related to recreational crystalline lagoons have been incorporated into more than 180 projects throughout the world. The inventor and his advancements in water treatment technology have been the subject of more than 2,000 articles, as can be seen at <http://press.crystal-lagoons.com/>. The inventor has also received important international awards for innovation and entrepreneurship related to these advances in

water treatment technology and has been the subject of interviews by major media outlets including CNN, BBC, FUJI, and Bloomberg's Businessweek.

[0061] Both the foregoing summary and the following detailed description provide examples and are explanatory only. Accordingly, the foregoing summary and the following detailed description should not be considered to be restrictive. Further, features or variations may be provided in addition to those set forth herein. For example, certain embodiments may be directed to various feature combinations and sub-combinations described in the detailed description.

#### BRIEF DESCRIPTION OF THE FIGURES

[0062] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate various embodiments of the present invention. In the drawings:

[0063] FIG. 1 is a graph illustrating the power generation increase in the world, in TWh, from 1993 to 2008.

[0064] FIG. 2 is a process flow schematic diagram illustrating a heat exchange system of an embodiment of the present invention.

[0065] FIG. 3 is a process flow schematic diagram illustrating the use of water from a water containing structure, such as a lagoon, as a heat transfer fluid in an embodiment of the present invention.

[0066] FIG. 4 shows a top view of a water containing structure, such as a lagoon, in an embodiment of the invention.

[0067] FIG. 5 is a schematic diagram illustrating possible recreational and industrial uses of a water containing structure, such as lagoon, in embodiments of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

[0068] The following detailed description refers to the accompanying drawings. While embodiments of the invention may be described, modifications, adaptations, and other implementations are possible. For example, substitutions, additions, or modifications may be made to the elements illustrated in the drawings, and the methods described herein may be modified by substituting, reordering, or adding stages to the disclosed methods. Accordingly, the following detailed description does not limit the scope of the invention. While systems and methods are described in terms of "comprising" various apparatus or steps, the systems and methods can also "consist essentially of" or "consist of" the various apparatus or steps, unless stated otherwise. Additionally, the terms "a," "an," and "the" are intended to include plural alternatives, e.g., at least one, unless stated otherwise. For instance, the disclosure of "a disinfectant agent," "an inlet line," "a mobile suction means," etc., is meant to encompass one, or more than one, disinfectant agent, inlet line, mobile suction means, etc., unless otherwise specified.

#### DEFINITIONS

[0069] In the light of the present disclosure, the following terms or phrases should be understood with the meanings described below.

[0070] The terms "container" or "containing means" or "water containing structure" are used generically herein to describe any artificial large body of water, including artificial lagoons, artificial lakes, artificial ponds, pools, and the like.

[0071] The term "coordination means" is used generically herein to describe an automated system that is able to receive

information, process it, and make a decision according to it. In one embodiment of the invention, this could be done by a person, while in another embodiment this could be done with a computer connected to sensors.

[0072] The term "chemical application means" is used generically herein to describe any system that can add or apply chemicals, e.g., to the water in the container or lagoon.

[0073] The term "mobile suction means" is used generically herein to describe any suctioning device that is able to travel across the bottom surface of the container and suction any settled material or particles.

[0074] The term "propelling means" is used generically herein to describe any propelling device that provides movement, either by pushing or pulling another device.

[0075] The term "filtration means" is used generically herein to describe any filtration system, inclusive of systems comprising filters, strainers, and/or separators, and the like.

[0076] As used herein, the general types of water and their respective Total Dissolved Solids (TDS) concentration (in mg/L) are Fresh, with  $TDS \leq 1,500$ ; Brackish, with  $1,500 < TDS \leq 10,000$ ; and Seawater, with  $TDS > 10,000$ .

[0077] As used herein, the term "high microbiological water quality" comprises a preferred aerobic bacteria count of less than 200 colony forming units "CFU"/ml, more preferably of less than 100 CFU/ml, and most preferably of less than 50 CFU/ml.

[0078] As used herein, the term "high clarity" comprises a preferred turbidity level of less than 12 Nephelometer Turbidity Units "NTU", more preferably of less than 10 NTU, and most preferably of less than 7 NTU.

[0079] As used herein, the term "small fraction" corresponding to the filtered water volume comprises a flow of up to 200 times less than the flow filtered in traditionally configured swimming pool water filtration systems.

[0080] As used herein, the term "traditional swimming pool water filtration system" or "conventional swimming pool water filtration system" or "conventional swimming pool filtration system" comprises a filtration system that filters the entire water volume that has to be treated, from 1 to 6 times per day, typically with a centralized filtration unit.

#### MODES FOR CARRYING OUT THE INVENTION

[0081] As discussed above, industrial cooling systems typically require large volumes of water of high quality and at low costs to feed heat exchangers for the condensing or cooling processes in many industries. In general, water is used in heat exchangers, as it has a heat capacity about 4 times greater than air, allowing greater efficiencies of heat transfer. In the heat exchange process, cooling water enters the exchanger at an initial temperature, absorbs heat increasing the temperature of the cooling water, for example, at least  $3^{\circ}\text{C}$ ., or between  $3^{\circ}\text{C}$ . and  $20^{\circ}\text{C}$ ., or about  $10^{\circ}\text{C}$ . Then, the cooling water at a higher temperature leaves the heat exchanger and is discharged, recycled back to the lagoon, or employed in some other downstream process. For instance, the artificial lagoon can be used to decrease the temperature of the water that exits the industrial cooling process, but before the water is discharged into a water source.

[0082] Furthermore, the cooling water quality is also very important, because depending on its quality, heat transfer in heat exchangers will have a greater or lesser efficiency, thus affecting the operation and maintenance costs of the plant. The quality of cooling water used today relies heavily on the

water source from which the water has been extracted, either from the sea, rivers, lakes, etc.

[0083] The present invention relates to a method and system for providing an industrial process with high microbiological quality cooling water, comparable to the water quality of swimming pools, at a very low cost. By recirculating the cooling water, a sustainable process can be achieved, and at the same time, large volumes of water will be heated, thus creating reservoirs of thermal energy for other uses such as residential heating, producing hot water, thermal desalinization, heating greenhouses, and the like, as well as other industrial and residential uses.

[0084] Large volumes of treated water can be supplied from a large container or artificial lagoon. The surface area of the container or lagoon can be defined in some embodiments by the amount of energy that needs to be dissipated in the industrial process. Typically, the surface area can range from about  $50\text{ m}^2$  to about  $30,000\text{ m}^2$  per MW of cooling required by the industrial process. In some embodiments, the surface area can be in a range from about  $50\text{ m}^2$  to about  $20,000\text{ m}^2$ , from about  $50\text{ m}^2$  to about  $10,000\text{ m}^2$ , or from about  $50\text{ m}^2$  to about  $5,000\text{ m}^2$ , per MW of cooling required by the industrial process. The container or lagoon can be used for recreational or industrial purposes and can be organized in different configurations in order to allow the use several artificial cooling lagoons or containers at the same time. Such lagoons or containers can be configured in series, in parallel, and by coupling one lagoon or container to another.

[0085] Consistent with embodiments disclosed herein, the methods and systems can treat large volumes of water at low cost. Generally, this involves purifying the water and eliminating suspended solids from the water without filtering the totality of the water volume, but only filtering a small fraction, corresponding to a volume up to 200 times smaller than for traditional swimming pool water filtration methods. Treated water produced by these methods and systems can be used as cooling water for industrial purposes, such as inlet water to an industrial heat exchange process.

[0086] FIG. 2 illustrates an embodiment of the present invention directed to a heat exchange system. The system of FIG. 2 is shown for a simplified thermal power generation process (9). However, the general heat exchange concept of FIG. 2 can apply to any industrial process where cooling of a material or apparatus may be required. In FIG. 2, a vapor passes through one or more turbines (5), and then flows to a heat exchanger (3) where the vapor is condensed. Heated vapor (7) enters the heat exchanger, where heat is absorbed, and the material exits as a condensate (8). The condensate (8) can pass through a pumping system (6), where it is driven to a boiler (4) to be again transformed into vapor to pass through the turbines (5). In the heat exchanger (3), the fluid absorbing the heat can be inlet cooling water (1), which enters at a predetermined temperature, passes through the heat exchanger and absorbs heat from the vapor (7), and then exits (2) at a higher temperature.

[0087] A system of the invention generally includes a containing means, a coordination means, a chemical application means, a mobile suction means, and a filtration means. FIG. 3 illustrates an embodiment of a system of the invention, where water from a container or artificial lagoon is used as a heat transfer fluid in an industrial process. This system can comprise an inlet water line (11) to a container or artificial lagoon (12). The size of the container or artificial lagoon is not particularly limited, however, in many embodiments, the con-

tainer or lagoon can have a volume of at least 10,000 m<sup>3</sup>, or alternatively, at least 50,000 m<sup>3</sup>. It is contemplated that the container or lagoon can have a volume of 1 million m<sup>3</sup>, 50 million m<sup>3</sup>, 500 million m<sup>3</sup>, or more. The container or artificial lagoon (12) can have a bottom (13) which can receive settled material, such as bacteria, algae, suspended solids, metals, and other particles that settle from the water. There is also a controlling device or means (10) which monitors and controls the processes in order to adjust water quality parameters (14) within their respective limits. Such processes can include activation (16) of a chemical application means (18) and the activation (17) of a mobile suction means (22). The mobile suction means (22) moves along the bottom of the lagoon, suctioning water containing settled particles produced by any of the processes disclosed herein that may affect water quality. There is also a propelling means (23) that provides movement to the mobile suction means, such that the mobile suction means can traverse the bottom of the lagoon. The suctioned water can be sent to a filtration means (20) that filters the water containing the settled particles, thus eliminating the need to filter the totality of the water volume (e.g., only filtering a small fraction of the water in the lagoon over the same time period as a typical filtration system for a pool). The suctioned water can be sent to the filtration means by a collecting line (19) connected to the suction means. Also, there is a return line (21) from the filtration means back to the lagoon to return the filtered water. A cooling water inlet line (1) provides cooling water from the lagoon to an industrial process (9), such as a heat exchanger, and a return line (2) is provided for the water having a higher temperature coming from the industrial cooling process back to the lagoon. In some embodiments, this water coming from the industrial cooling process back to the lagoon does not add more than 10 ppm of iron to the water in the container or lagoon. The coordination means (10) can vary the flow of treated cooling water to the industrial process (9). The industrial process (9) can send information (15) to the coordination means (10) for establishing the predetermined limits of water quality.

[0088] The inlet water line (11) can comprise treated water, freshwater, brackish water, or seawater to be treated in accordance with a method and system of the invention. The method and system can include a coordination means (10) that allows the timely activation of the processes required to adjust the controlled parameters (e.g., water quality parameters) within limits specified by the operator or predetermined. In embodiments, the industrial process (9) can send information (15) to the coordination means (10) for establishing the predetermined limits of water quality. The present invention uses far less chemicals than traditional swimming pool water treatment systems, since chemicals are applied according to the systems' needs by the use of an algorithm that depends on water temperature, thus avoiding having to maintain permanent concentrations of chemicals in the water, which results in higher operational costs. Thus, there can be a considerable reduction in the amount of chemicals used, of up to 100 times as compared to conventional swimming pool water treatments, highly decreasing operating costs.

[0089] The water returned to the lagoon begins to slowly circulate and mix with the entire volume of water in the lagoon to achieve a lower temperature. The heat may be lost due to a heat exchange with the environment by conduction, convection, and/or evaporation. There is at least one extraction point (1) of the water from the lagoon to the industrial process and at least one return point (2) of water at higher

temperatures from the industrial process to the lagoon, and they beneficially can be separated by a distance such that the temperature of water at the extraction point is not affected by the temperature of the water at the return point. Moreover, lagoon area/volume reductions can be realized if the temperature of the water at the return point and/or the temperature of the lagoon water are higher.

[0090] Information received by coordinating means can be obtained by visual inspection, empirical methods, algorithms based on experience, by electronic detectors, or combinations thereof.

[0091] Coordinating means can comprise one or more people, electronic devices, any means capable of receiving information, processing that information, and activating other processes, and this includes combinations thereof. One example of a controller means is computing device, such as a personal computer. Coordinating means can also include sensors utilized to receive information regarding the water quality parameters.

[0092] The chemical application means can be activated by the coordination means, and applies or dispenses chemicals into the water. Chemical application means can include, but are not limited to, injectors, sprinklers, manual application, dispensers by weight, pipes, and combinations thereof.

[0093] The bottom of the container or lagoon generally comprises or is covered with a non-porous material. The non-porous materials can be membranes, geo-membranes, geotextile membranes, plastic liners, concrete, coated concrete, or combinations thereof. In a preferred embodiment of the invention, the bottom of the container or artificial lagoon can comprise a plastic liner.

[0094] The mobile suction means moves along the bottom of the container or lagoon, suctioning water containing settled particles and materials produced by any of the processes disclosed herein. A propelling means can be coupled to the mobile suction means, allowing the mobile suction means to travel across the bottom of the container or lagoon. The propelling means drives the mobile suction means by using a system such as a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine or a floating device with an engine, or combinations thereof. In a preferred embodiment of the invention, the propelling means comprises a boat with an engine.

[0095] The water suctioned by the mobile suction means can be sent to a filtration means. The filtration means receives the flow of water suctioned by the mobile suction means and filters the suctioned water containing the settled particles and materials, thus eliminating the need to filter the totality of the water volume (e.g., only filtering a small fraction). The filtration means can include, but is not limited to, cartridge filters, sand filters, micro-filters, ultra-filters, nano-filters, and combinations thereof. The suctioned water can be sent to the filtration means by a collecting line connected to the mobile suction means. The collecting line can be selected from flexible hoses, rigid hoses, pipes of any material, and combinations thereof. The system can include a line from the filtration means back to the container or lagoon for returning filtered water.

[0096] FIG. 4 shows a top view of a system of the invention. The container or artificial lagoon (12) can include an inlet feeding pipe system (11) for refilling the container or lagoon due to evaporation or other loss of water (e.g., purges or infiltration). The system can also include injectors (24)

arranged along the perimeter of the container or artificial lagoon for applying or dispensing chemicals into the water. Skimmers (25) also can be used for removing surface oils and particles.

[0097] In an embodiment, a system for providing high microbiological quality cooling water to an industrial process comprises the following elements:

- [0098] a container for storing cooling water, the container comprising a bottom for receiving settled particles;
- [0099] a feeding line of inlet water to the container;
- [0100] a coordination means for timely activating processes necessary to adjust parameters of the cooling water within predetermined limits;
- [0101] a chemical application means activated by the coordination means;
- [0102] a mobile suction means for moving along the bottom of the container and suctioning cooling water containing settled particles;
- [0103] a propelling means for moving the mobile suction means along the bottom of the container;
- [0104] a filtration means for filtering the cooling water containing settled particles;
- [0105] a collecting line coupled between the mobile suction means and the filtration means;
- [0106] a return line from the filtration means to the container;
- [0107] a heat exchanger inlet line from the container to the industrial process; and
- [0108] a return water line from the industrial process to the container.

[0109] This same system allows for the elimination of compounds or materials that are susceptible to settling by the addition of a chemical agent, since the mobile suction means can suction all the settled particles from the bottom of the container.

[0110] The method of the invention for treating water can be performed at low costs compared to traditional swimming pool water treatment systems, due to the fact that the present invention uses less chemicals and consumes less energy than traditional swimming pool water treatment systems. In one aspect, the present method uses far less chemicals because it applies an algorithm to maintain an ORP (oxidation reduction potential) of at least 500 mV for a certain period of time depending on the temperature of the water, thereby maintaining a high microbiological quality according to the water's real needs. The present method is carried out on a system as described herein that comprises a coordination means, which determines when to apply the needed chemicals in order to adjust the controlled parameters within their limits, based on the information received from the system. Since a coordination means is used, the chemicals are applied only when they are needed, avoiding the need to maintain a permanent concentration of the chemicals in the water. Thus, there is a considerable reduction in the amount of chemicals, of up to 100 times less than traditional swimming pool water treatment systems, resulting in decreased operating and maintaining costs.

[0111] In another embodiment, the method and system of the invention filters only a small fraction of the total volume of water within a particular time frame, as compared to conventional swimming pool water filtration systems that filter a much larger volume of water in the same time frame. In an embodiment, the small fraction of the total volume of water is

up to 200 times smaller than the flow processed in traditional swimming pool water filtration systems, which filter the totality of the water volume. The filtering means in the method and system of the invention operates at shorter periods of time due to the orders received from the coordination means. Thus the filtering means has a very small capacity, resulting in up to 50 times lower capital costs and energy consumption compared to the centralized filtering unit required in the conventional swimming pool water filtration system.

[0112] A method for providing high microbiological quality cooling water to an industrial process, consistent with embodiments of this invention, can include the following steps:

- a. Collecting inlet water from a water source;
- b. Storing the inlet water in a container, wherein the container has a bottom capable of being cleaned by a mobile suction means;
- c. Within periods of 7 days:

[0113] i. For a container water temperature up to and including 35° C., maintaining an ORP of the container water above 500 mV for a minimum period of 1 hour for each ° C. of the container water temperature, by adding a disinfectant agent to the container water;

[0114] ii. For a container water temperature greater than 35° C. and less than 70° C., maintaining an ORP of the container water above 500 mV for a minimum period of hours by adding a disinfectant agent to the container water, wherein the minimum period of hours is calculated by the following equation:

$$[35 \text{ hours}] - [\text{Temperature of the water in } ^\circ \text{C.} - 35] \\ = \text{minimum period of hours; or}$$

[0115] iii. For a container water temperature of 70° C. or more, maintaining an ORP of the container water above 500 mV for a minimum period of 1 hour, by adding a disinfectant agent to the container water;

- d. Activating the following processes through a coordination means:

[0116] i. Applying an oxidizing agent to the container water to prevent the iron and manganese concentrations of the container water from exceeding 1.5 ppm;

[0117] ii. Applying a coagulant and/or flocculant to the container water to prevent the turbidity of the container water from exceeding 7 NTU;

[0118] iii. Suctioning the container water with a mobile suction means to prevent a thickness of settled material from exceeding an average 100 mm;

[0119] iv. Filtering the container water suctioned by the mobile suction means; and

[0120] v. Returning the filtered water to the container; and

- e. Supplying high microbiological quality cooling water from the container to an industrial process at a flow rate such that a difference in temperature between cooling water entering the industrial process and cooling water exiting the industrial process is at least 3° C.

[0121] Water treated by the method of the invention can be provided by a natural water source, such as oceans, ground-water, lakes, rivers, treated water, or combinations thereof.

[0122] Disinfectant agents can be applied to the water by a chemical application means, in order to maintain an ORP level of at least 500 mV for a minimum period of time according to the temperature of the water, within periods of 7 days at a time. The disinfectant agents include, but are not limited to, ozone, biguanide products, algaecide and antibacterial agents

such as copper products; iron salts; alcohols; chlorine and chlorine compounds; peroxides; phenolic compounds; iodophors; quaternary amines (polyquats) in general, such as benzalkonium chloride and S-Triazine; peracetic acid; halogen-based compounds; bromine based compounds, and combinations thereof.

**[0123]** If the water temperature is up to and including 35° C., an ORP level of at least 500 mV is maintained for a minimum period of 1 hour for each ° C. of water temperature. For example, if the water temperature is 25° C., an ORP level of at least 500 mV is maintained for a minimum period of 25 hours, which can be distributed over the 7 day period.

**[0124]** If the water temperature is greater than 35° C. and less than 70° C., an ORP level of at least 500 mV is maintained for a minimum period of hours which is calculated by the following equation:

$$[35 \text{ hours}] - [\text{Temperature of the water in } ^\circ \text{C.} - 35] \\ = \text{minimum period of hours.}$$

**[0125]** For example, if the water temperature is 50° C., an ORP level of at least 500 mV is maintained for a minimum period of 20 hours ([35]-[50-35]), which can be distributed over the 7 day period.

**[0126]** Finally, if the water temperature is 70° C. or more, an ORP level of at least 500 mV is maintained for a minimum period of 1 hour over the 7 day period.

**[0127]** Oxidizing agents can be applied or dispersed into the water to maintain and/or prevent the iron and manganese concentrations from exceeding 1.5 ppm. Suitable oxidizing agents include, but are not limited to, permanganate salts; peroxides; ozone; sodium persulfate; potassium persulfate; oxidants produced by electrolytic methods; halogen based compounds; and combinations thereof. Generally, the oxidizing agents are applied to and/or dispersed in the water by a chemical application means.

**[0128]** Antiscalant agents can be applied to or dispersed into the water to reduce or prevent scaling, for example, of a heat exchanger of the industrial process. Non-limiting examples of antiscalant agents include, but are not limited to, phosphonate-based compounds, such as phosphonic acid, PBTC (phosphobutan-tricarboxylic acid), chromates, zinc polyphosphates, nitrites, silicates, organic substances, caustic soda, malic acid-based polymers, sodium polyacrylate, ethylene diamine tetracetic acid sodium salts, corrosion inhibitors such as benzotriazole, and combinations thereof.

**[0129]** A flocculant or coagulant agent can be applied or dispersed into the water to aggregate, agglomerate, coalesce, and/or coagulate suspected particles in the water, which then settle to the bottom of the containing means. Generally, flocculant or coagulant agents are applied or dispersed into the water by a chemical application means. Suitable flocculant or coagulant agents include, but are not limited to, polymers such as cationic polymers and anionic polymers; aluminum salts, such as aluminum chlorhydrate, alum, and aluminum sulfate; quats and polyquats; calcium oxide; calcium hydroxide; ferrous sulphate; ferric chloride; polyacrylamide; sodium aluminate; sodium silicate; natural products, such as chitosan, gelatin, guar gum, alginates, moringa seeds; starch derivatives; and combinations thereof. The fraction of water

in which the floccules collect or settle is generally the layer of water along the bottom of the container. The floccules form sediment at the bottom of the container that can then be removed by the mobile suction means without requiring that all of the water in the containing means be filtered, e.g., only a small fraction is filtered.

**[0130]** The chemical application means and mobile suction means in the method and system of the invention are timely activated by coordination means, in order to adjust the controlled parameters within their respective limits. The chemical application means and mobile suction means are activated according to the system's needs, resulting in the application of far less chemicals compared to conventional swimming pool water treatment systems, and the filtering of a small fraction of the total volume of water, up to 200 times smaller compared to conventional swimming pool water filtration systems that filter the totality of the water volume within the same time frame. In some embodiments contemplated herein, the "small fraction" of water being filtered can be less than about 30%, less than about 25%, less than about 20%, less than about 15%, less than about 10%, less than about 9%, less than about 8%, less than about 7%, less than about 6%, less than about 5%, less than about 4%, less than about 3%, less than about 2%, less than about 1%, less than about 0.9%, less than about 0.8%, less than about 0.7%, less than about 0.6%, or less than about 0.5%, per day of the total volume of water.

**[0131]** In the method and system disclosed herein, the coordination means can receive information regarding the water quality parameters and their respective limits. The information received by the coordination means can be obtained by empirical methods. The coordination means is also capable of receiving information, processing that information, and activating the required processes according to that information, including combinations thereof. One example of a coordination means is a computing device, such as a personal computer, connected to sensors which measures the parameters and activates the processes according to such information.

**[0132]** Representative processes that may be activated by the coordination means include:

**[0133]** Timely activation of the chemical application means, providing information about the dosage and addition of the suitable chemicals to maintain the controlled water quality parameters within their respective limits.

**[0134]** Timely activation of the mobile suction means, which can simultaneously activate the filtration means for filtering the water suctioned by the mobile suction means, thus filtering only a small fraction of the container or artificial lagoon water, as compared to traditionally configured centralized swimming pool filtration systems.

**[0135]** The coordination means also provides information to the mobile suction means to activate the mobile suction means. The coordination means can simultaneously activate the filtration means in order to filter the flow suctioned by the mobile suction means, i.e., filtering only a small fraction of the entire volume of water. The mobile suction means is activated by the coordination means to prevent the thickness of settled material, generally, from exceeding 100 mm. The filtration means and mobile suction means operate only as

needed to maintain the parameters of the water within their limits, for instance, only a few hours a day, as opposed to conventional filtration systems which operate substantially continuously. In further embodiments, the mobile suction means can prevent the thickness of the settled material from exceeding 50 mm, or 25 mm, or 15 mm. In some circumstances, the container or artificial lagoon can be used for recreational purposes in addition to being a source of cooling water for industrial processes.

**[0136]** In some embodiments, the mobile suction means can travel along the bottom of the artificial lagoon, thoroughly suctioning the water flow containing the settled particles, thereby allowing the bottom of the lagoon to be easily visible thru the water. Moreover, the bottom of the lagoon can be any color, including white, yellow, or light blue, often providing the water body with an attractive color. In an embodiment, horizontal visibility through the lagoon water can be at least 4 meters, at least 6 meters, at least 10 meters, or at least 15 meters, and in some cases up to 40 meters.

**[0137]** In addition to its use for cooling purposes, the water in the artificial lagoon may be of sufficient quality and purity to comply with governmental regulations for recreational water with direct contact and/or governmental regulations for swimming pool water quality. For instance, the water contained in the artificial lagoon can comply with the bacteriological requirements for recreational water with direct contact from the Environmental Protection Agency [EPA Criteria for Bathing (Full Body Contact) Recreational Waters, 1986].

**[0138]** FIG. 5 illustrates embodiments of various recreational and industrial uses of a container or artificial lagoon (12) disclosed herein. The container or artificial lagoon (12) comprises an inlet line (2) and outlet line (1) for water. In one embodiment (33), various uses of a lagoon containing heated water (a thermal energy reservoir) are illustrated: residential heating (30), supplying hot water for thermal desalinization purposes (28), for greenhouse heating (29), or preheating process fluids or supplying preheated water to diverse industrial processes (27), as well as other miscellaneous industrial and residential uses (31). In another embodiment (32), the use of a lagoon (12) containing heated water (a thermal energy reservoir) is illustrated for commercial/recreational purposes, such as surrounding the lagoon with real estate developments (26).

#### EXAMPLES

**[0139]** For the following examples, the terms "a/an/the" include plural alternatives (at least one). The disclosed information is illustrative, and other embodiments exist and are within the scope of the present invention.

##### Example 1

**[0140]** A method and system of the present invention was employed in the cooling process of an oil generator. A container having a volume of 200 m<sup>3</sup> and surface area of approximately 285 m<sup>2</sup> was filled with seawater having a TDS concentration of about 35,000 ppm. The temperature of the water in the container was 35° C. Based on this temperature, an ORP of at least 500 mV was maintained for a period of (35×1) 35 hours during the week. On Monday, to maintain the ORP for a period of 12 hours, sodium hypochlorite was added to the water in order to reach a concentration of 0.16 ppm in the

water. Later in the week on Wednesday, the ORP was maintained for a period of 9 hours by maintaining the same sodium hypochlorite concentration. Finally, on Friday a concentration of 0.16 ppm of sodium hypochlorite in the water was maintained for the remaining (35-12-9) 14 hours to complete the 35 hours in the week. There was no need to perform an additional oxidation process to adjust the iron and manganese levels, since the sodium hypochlorite had the sufficient redox potential to oxidize the iron and magnesium. A flocculant was added before the turbidity of the water reached a value of 7 NTU, and Crystal Clear® was injected until a concentration of 0.09 ppm was achieved in the container.

**[0141]** Based on the information received from the system, the coordination means activated the suctioning means before the thickness of the settled material exceeded 100 mm. The settled material, a product of the coordinated method, was suctioned by a device that traveled the surface of the container and the collected flow was filtered through a sand filter at a rate of 5 L/sec. It was not necessary to filter the entire volume of water. The suction device extracted only a small fraction of the entire volume of water containing the sediments, and delivered this water to the sand filter. The filtered water was then returned back to the container from the sand filter via a return line.

**[0142]** The conditioned water was used to cool one Hyundai Diesel Engine, model D6CA. The type of engine is a 6 cylinder, vertical engine, cooled by water. The generator was a Stanford of 125 kVA. The heat exchanger of the Diesel Engine was fed with filtered water from the container. The temperature of feed water to the exchanger was 35° C., and the temperature of discharge water back to the container was of 39.3° C., thus, the cooling water temperature increased approximately 4.3° C. The recycling water flow of each generator was 3.45 L/sec. In this way, the generator was cooled and at the same time the residual heat was used to heat the water of the container, which is maintained at high temperatures because of this heat exchange. Cooled thermal power was approximately 62 kW, resulting in a surface/MW rate of:

$$\frac{265 \text{ m}^2}{0.062 \text{ MW}} = 4,596 \frac{\text{m}^2}{\text{MW}} \quad \frac{265 \text{ m}^2}{0.062 \text{ MW}} = 4,596 \frac{\text{m}^2}{\text{MW}}$$

⑦ indicates text missing or illegible when filed

**[0143]** The heated water was used in a tempered swimming pool for recreational purposes, therefore representing high energy savings compared to heating the water with traditional methods (such as boilers).

##### Example 2

**[0144]** The method and system of the present invention can be used to treat and maintain water for cooling a 420 MW thermal power station. An artificial lagoon can be built, with a surface area of 360,000 m<sup>2</sup>, a volume of approximately 540,000 m<sup>3</sup>, and a water temperature of around 45° C. The following table shows the estimated surface areas (hectare=ha) that may be required for cooling a 420 MW power plant, based on the lagoon water temperature:

TABLE 1

|           | T° Lagoon (° C.) |     |     |     |     |     |    |    |    |    |    |    |    |    |    |
|-----------|------------------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|
|           | 25               | 28  | 29  | 30  | 32  | 33  | 35 | 36 | 38 | 39 | 41 | 43 | 45 | 47 | 49 |
| Area (ha) | 555              | 229 | 190 | 161 | 122 | 107 | 86 | 77 | 64 | 59 | 49 | 42 | 36 | 31 | 25 |

[0145] The lagoon can be fed by an inlet water line with water from the sea having a total dissolved solid's concentration of approximately 35,000 ppm, until the lagoon is full.

[0146] The temperature of the water is 45° C., which is more than 35° C., so an ORP of at least 500 mV is maintained for a total of 25 hours (35-[45-35]=25) distributed within a 7-day period. For example, on a Tuesday, sodium bromide can be added in order to maintain a concentration of 0.134 ppm in the water for 12 hours, and then on Friday of the same week, the chemical addition can be repeated in the same manner for 13 hours, thus completing the total of 25 hours for the 7-day period.

[0147] The coordination means, which can be a person, receives information regarding the controlled parameters of the method and system (e.g., various water quality parameters). It may not be necessary to add an oxidizing agent to the water, since sodium bromide generally has sufficient redox potential to oxidize iron and manganese.

[0148] For the flocculating step, Crystal Clear® can be injected before the turbidity reaches a value of 7 NTU, to obtain a concentration of 0.08 ppm in the water. The flocculant addition can be repeated every 48 hours.

[0149] After settling of bacteria, metals, algae and other solids, and before the thickness of the settled material layer reaches 15 mm, the coordination means can activate the mobile suction means, which can comprise 9 suctioning devices that move along the bottom of the lagoon, suctioning the water containing any settled particles. Each of the 9 suctioning devices can be coupled to a propelling means, in this case, a boat with an engine. The water flow containing the settled particles, for each suctioning device, can be pumped by means of a 5.5 kW pump to a filtering means through flexible hoses.

[0150] The suctioned flow for each suction device can be filtered by sand filters at a rate of 21 L/sec. Thus, there is no need to filter the whole volume of water—instead only filtering the water fraction that contains the settled particles suctioned by the suction devices, which is up to 200 times less than volume of water filtered by conventional swimming pool filtration systems. The filtered water can be returned back to the lagoon by means of a return line, which can be a flexible hose.

[0151] The treated water can be used as cooling water for a 420 MW thermal power station. The power (or heat) to be dissipated, the water flow rate, and the temperature rise of the water are correlated by the equation:

$$[ \text{text missing or illegible when filed} ] \cdot c_p \cdot \Delta T,$$

where  $c_p$  is the specific heat of water at constant pressure, approximately:

$$4,000^b/\text{kg}=\text{K}.$$

[0152] Hence, for a 420 MW plant, the cooling water flow rate can be 54,000 m³/h with an increase in cooling water

temperature of about 7° C. The surface area of the lagoon is 36 hectares, which converts to 0.086 hectares for each MW of cooling required.

[0153] The cooling water portion of the heat exchanger of the thermal power plant can be fed with water from the lagoon, through various means. The water temperature of the lagoon, and thus the inlet cooling water temperature to the heat exchanger, is around 45° C. After exiting the heat exchanger, the water can be returned back to the lagoon at a temperature of around 52° C. Thus, the water used in the industrial cooling process increases in temperature by about 7° C.

[0154] The water returned back to the lagoon, which is at a higher temperature, begins to flow slowly throughout the lagoon, mixing with the entire water volume of the lagoon, thus reducing the temperature of the returned water. The lagoon's temperature stays at about 45° C. on average, and water can be extracted from the lagoon for use in the industrial cooling process again, or on a continuous basis. The treated water in the lagoon can have the following parameters:

| Parameter                          | Unit            | Treated Water | Drinking Water Norm-NCh409 |
|------------------------------------|-----------------|---------------|----------------------------|
| pH                                 | —               | 7.96          | 6.5 < pH < 8               |
| Odor                               | —               | Odorless      | Odorless                   |
| Turbidity                          | NTU             | 0.2           | <2                         |
| TDS                                | mg/L            | 35,000*       | 1,500                      |
| Iron                               | mg/L            | 0.1           | <0.3                       |
| Manganese                          | mg/L            | <0.01         | <0.1                       |
| Organic Matter                     |                 |               |                            |
| Tetrachloroethene                  | µg/l            | Not detected  | 40                         |
| Benzene                            | µg/l            | Not detected  | 10                         |
| Toluene                            | µg/l            | 0.01          | 700                        |
| Xylenes                            | µg/l            | Not detected  | 500                        |
| Pesticides                         |                 |               |                            |
| D.D.T + D.D.D + D.D.E              |                 | Not detected  | 2                          |
| 2,4 D                              | µg/l            | Not detected  | 30                         |
| Lindane                            | µg/l            | Not detected  | 2                          |
| Methoxychlor                       | µg/l            | Not detected  | 20                         |
| Pentachlorophenol                  | µg/l            | Not detected  | 9                          |
| Secondary Products of Disinfection |                 |               |                            |
| Monochloramines                    | mg/l            | <0.1          | 3                          |
| Dibromochloromethane               | mg/l            | <0.005        | 0.1                        |
| Dichloromethane                    | mg/l            | Not detected  | 0.06                       |
| Tribromomethane                    | mg/l            | 0.037         | 0.1                        |
| Trichloromethane                   | mg/l            | Not detected  | 0.2                        |
| Trihalomethanes                    | mg/l            | <1            | 1                          |
| Microbiological Analysis           |                 |               |                            |
| Total Coliforms                    | NMP/100 ml      | <2            | <2                         |
| <i>Escherichia coli</i>            | NMP/100 ml      | Absence       | Absence                    |
| Aerobic Bacteria                   | Colonies/100 ml | 2             | ≤200 <sup>2</sup>          |

\*Typical value of sea water before treatment in the lagoon

<sup>2</sup>(Not specified in NCh409) Swimming pool norm-NCh209

[0155] As can be seen from this example, the use of the present invention has several advantages over existing cooling systems, which include: avoiding the generation of a harmful environmental impact on the marine ecosystem due to either thermal pollution and the suction of aquatic organisms into the industrial process, since the illustrated system is a recirculating water system in a closed circuit that does not interact with the ocean or natural water sources; low installation and operating costs compared to cooling towers and other known cooling systems; the possibility to locate the industrial plant in places unimaginable before, due to the low consumption of water from a water source—it is not necessary that the industrial plant be located near the sea or other natural sources of water; and at the same time, creating a large reservoir of energy for many other uses, such as for residential heating, producing hot water, and thermal desalinization, as well as other industrial, residential, and/or recreational uses.

[0156] Due to the low cost filtering means, where only a small fraction of the total volume of water is filtered (up to 200 times less than conventional swimming pool filtration systems), and the reduced usage of chemicals (up to 100 times less than those used in conventional systems), it is possible to maintain these large bodies of high clarity water. Using conventional technologies of filtration and disinfection would not be economically feasible for containers or lagoons of these large dimensions.

[0157] A conventional pool filtration system often filters the entire volume of water up to 6 times a day, imposing high costs of installation and maintenance, in addition to consuming a large amount of energy in the process. For the 36 hectare lagoon illustrated above, in order to filter the entire volume of water up to 6 times a day, a building/area of about 1 hectare may be required to install the entire filtration system, making such construction and maintenance unviable, and thus, any associated cooling system would not be economically feasible. Furthermore, in terms of cost, for the example presented above, a comparison is provided below:

|                                                                                     | Description                                                                                                    | Installation costs | Monthly operating costs |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------|-------------------------|
| Traditional Filtration                                                              | 540 pumps<br>270 filters + sand                                                                                | US \$12,089,916    | US \$536,607            |
| A building of about 1 hectare to filter the entire water volume up to 6 times a day | 1 hectare of surface<br>Operators<br>Maintenance<br>270 valve<br>batteries<br>Energy consumption               |                    |                         |
| 9 Suctioning Means                                                                  | Boat<br>Motor                                                                                                  | US \$226,494       | US \$20,178             |
| Each one moves along the bottom of the lagoon, driven by engine propelled boats     | Suctioning Device<br>Suctioning pump<br>Hoses,<br>accessories<br>Fuel<br>Flocculant<br>Operator<br>Maintenance |                    |                         |

[0158] By using 9 suctioning devices and the system described herein, the installation costs are reduced by about 50 times and the operating costs reduce by about 25 times. Hence, the containers or lagoons represent viable and cost

effective options for providing cooling water to power plants and other industrial processes.

[0159] While certain embodiments of the invention have been described, other embodiments may exist. Further, any disclosed method steps or stages may be modified in any manner, including by reordering steps and/or inserting or deleting steps, without departing from the invention. While the specification includes a detailed description and associated drawings, the invention's scope is indicated by the following claims. Furthermore, while the specification has been described in language specific to structural features and/or methodological acts, the claims are not limited to the features or acts described above. Rather, the specific features and acts described above are disclosed as illustrative aspects and embodiments of the invention. Various other aspects, embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to one of ordinary skill in the art without departing from the spirit of the present invention or the scope of the claimed subject matter.

#### 1.-13. (canceled)

14. A system for providing high microbiological quality cooling water to an industrial process, the system comprising: a container for storing cooling water, the container comprising a bottom for receiving settled particles; a feeding line of inlet water to the container; a coordination means for timely activating processes necessary to adjust parameters of the cooling water within predetermined limits; a chemical application means activated by the coordination means; a mobile suction means for moving along the bottom of the container and suctioning cooling water containing settled particles; a propelling means for moving the mobile suction means along the bottom of the container; a filtration means for filtering the cooling water containing settled particles; a collecting line coupled between the mobile suction means and the filtration means; a return line from the filtration means to the container; a heat exchanger inlet line from the container to the industrial process; and a return water line from the industrial process to the container.

15. The system of claim 14, wherein the bottom of the container comprises a membrane, geomembrane, geotextile membrane, plastic liner, concrete, coated concrete, or a combination thereof.

16. The system of claim 14, wherein the coordination means is capable of receiving information, processing that information, and activating other processes.

17. The system of claim 14, wherein the chemical application means comprises an injector, a sprinkler, manual application, a weight dispenser, or combinations thereof.

18. The system of claim 14, wherein the propelling means comprises a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine, a floating device with an engine, or a combination thereof.

19. The system of claim 14, wherein the filtration means comprises a cartridge filter, a sand filter, a micro-filter, an ultra-filter, a nano-filter, or a combination thereof.

20. The system of claim 14, wherein the collecting line comprises a flexible hose, a rigid hose, a pipe comprising any material, or a combination thereof.

\* \* \* \* \*



US 20120024796A1

(19) **United States**(12) **Patent Application Publication**  
**Fischmann T.**(10) **Pub. No.: US 2012/0024796 A1**(43) **Pub. Date: Feb. 2, 2012**(54) **SUSTAINABLE METHOD AND SYSTEM FOR  
TREATING WATER BODIES AFFECTED BY  
BACTERIA AND MICROALGAE AT LOW  
COST**(75) **Inventor: Fernando Benjamin Fischmann  
T., Santiago (CL)**(73) **Assignee: Crystal Lagoons Corporation  
LLC, Lewes (DE)**(21) **Appl. No.: 13/136,458**(22) **Filed: Aug. 1, 2011****Related U.S. Application Data**(60) **Provisional application No. 61/469,548, filed on Mar.  
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**C02F 5/00** (2006.01)  
**C02F 1/76** (2006.01)(52) **U.S. Cl. .... 210/697; 210/696; 210/739; 210/753;  
210/754; 210/760; 210/764; 210/203; 210/141**(57) **ABSTRACT**

A sustainable method and system for treating and maintaining bodies of water at low cost for low density recreational use is disclosed. A system of the invention generally includes at least one containing means, at least one coordination means, at least one chemical application means, at least one non-intrusive mobile suction means, and at least one filtration means. The coordinating means can receive information regarding water quality parameters that are controlled, and can timely activate the processes necessary to adjust the water quality parameters within their respective limits. The disclosed methods and system filter only a small fraction of the total water volume, up to 200 times less per day than the flow filtered by conventional swimming pool filtration systems. The disclosed methods and system also use less chemicals, up to 100 times less than conventional swimming pool water treatment systems. The methods and system of the present invention can be used to treat recreational water bodies affected by bacteria and microalgae and provide sustainable methods for producing water that complies with bacteriological and physicochemical requirements for recreational water, as set forth by governmental regulatory agencies such as the Environmental Protection Agency (EPA), for bathing with full body contact.

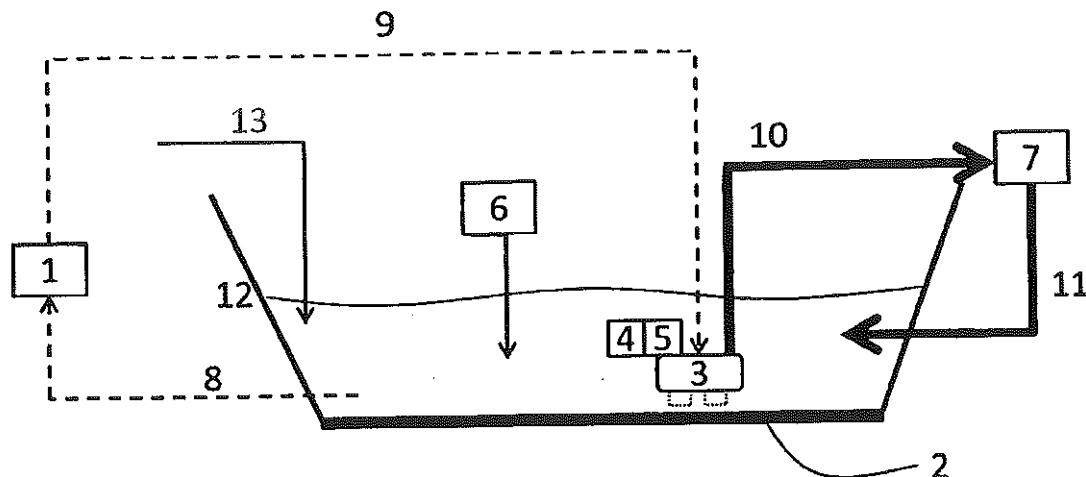


**Figure 1**

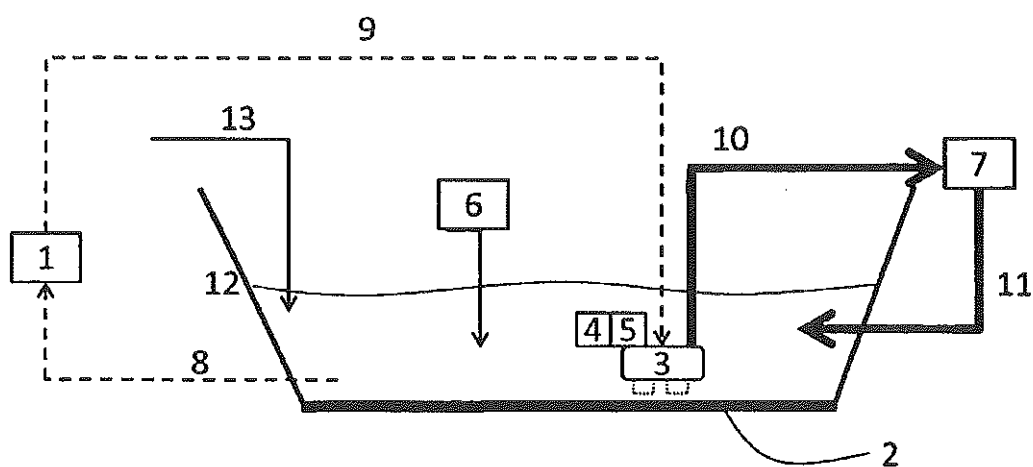
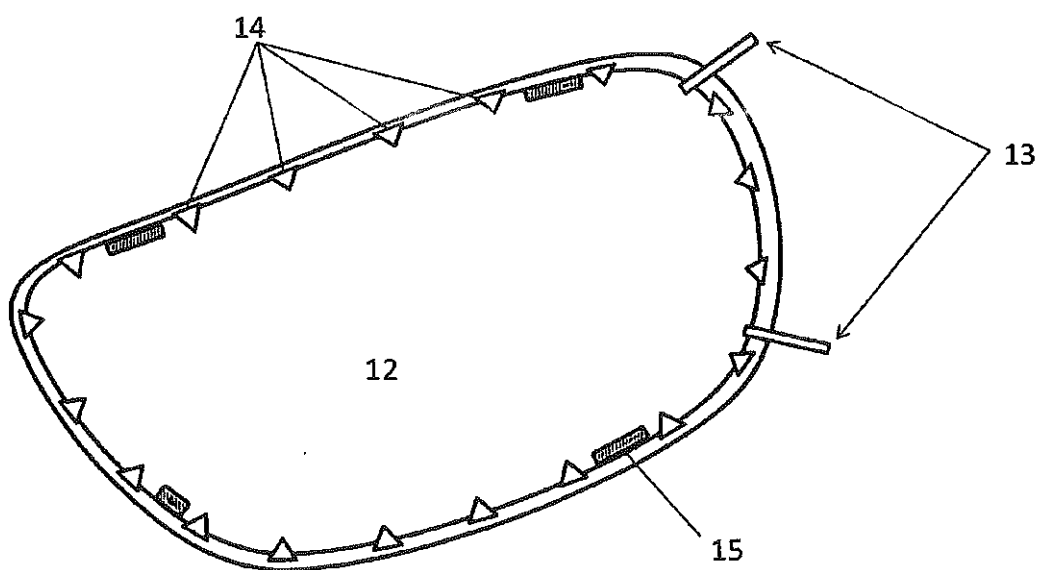


**Figure 2**



**SUSTAINABLE METHOD AND SYSTEM FOR  
TREATING WATER BODIES AFFECTED BY  
BACTERIA AND MICROALGAE AT LOW  
COST**

[0001] This application claims benefit of U.S. Provisional Ser. No. 61/469,548, filed 30 Mar. 2011 and which application is incorporated herein by reference. To the extent appropriate, a claim of priority is made to the above disclosed application.

**FIELD OF THE INVENTION**

[0002] The present invention is related to a sustainable method and system for treating and maintaining bodies of water at low cost for low density recreational use. Typically, the density of usage is up to 0.05 bathers per cubic meter of water volume. Unlike conventional swimming pool filtration systems in which all of the water volume is filtered up to 6 times per day, the methods and system disclosed herein filter only a small fraction of the total water volume, up to 200 times less per day than the flow filtered by conventional swimming pool filtration systems. The methods and system disclosed herein also use less chemicals, up to 100 times less than conventional swimming pool water treatment systems. The methods and system of the present invention can be used to treat recreational water bodies affected by bacteria and microalgae and provide sustainable methods for producing water that complies with bacteriological and physicochemical requirements for recreational water, as set forth by governmental regulatory agencies such as the Environmental Protection Agency (EPA), for bathing with full body contact.

**BACKGROUND**

[0003] Diverse recreational bodies of water are prone to be affected by bacteria and microalgae proliferation. In cases where the quality of water is of great importance, like swimming pools, high quality water suitable for swimming is achieved by adding large amounts of chemical agents. In swimming pools, for example, chemical agents are added to the water in the pool in order to maintain at least a 1.5 ppm permanent concentration of chlorine agents in the water. This concentration is required due to the strict swimming pool regulations regarding the water's bacteriological and physicochemical properties, and it is achieved by maintaining a permanent Oxidation Reduction Potential (ORP) on the water of at least 650 mV on a continuous basis.

[0004] Many countries throughout the world have regulations regarding recreational waters and there are generally two types of regulations regarding recreational use of such water bodies. The first type of regulation is directed to swimming pools, which essentially requires the maintenance of a high permanent chlorine buffer in order to avoid the contamination of the water when new bathers enter the swimming pool. The chlorine buffer neutralizes contaminants and kills microorganisms brought to the swimming pool water by bathers, thus maintaining a high water quality suitable for recreational purposes.

[0005] The second type of regulation applies to lakes and the sea, and is referred to as the criteria for bathing with full body contact for recreational waters. This regulation is based on the diluting power of water. When new bathers enter a body of water, the contaminants are diluted in such a way that

the contaminants do not attain a concentration in the body of water that causes significant effects. Therefore, in a large water body such as a lake or sea, a disinfectant buffer is not needed due to the high diluting power of the large water volume.

[0006] There is a global trend towards more sustainable and environmentally conscious systems in all aspects of life that can coexist with the environment leaving the smallest footprint behind. Nevertheless, when it comes to the treatment of recreational bodies of water, there have not been substantial advances towards environmentally responsible methods and systems. Usual treatments regarding the proliferation of bacteria and microalgae in swimming pools require high amounts of chemicals and energy, which does not fulfill today's sustainable necessities.

[0007] In order to comply with the first regulation, a chlorine buffer in swimming pools must be maintained on a continuous basis to neutralize the contaminants brought into the pool by new bathers. Maintaining a permanent chlorine buffer in the traditional treatment of swimming pools is related to maintaining an ORP level of at least 650 mV on a continual basis. Once demand for chlorine disinfecting has been satisfied, the free chlorine concentration remaining in the water, i.e. the residual chlorine, acts as a buffer in order to provide disinfection when new organic matter or microorganisms enter the body of water, for example, when new bathers enter into the water. The amount of chemicals used to permanently maintain an ORP level of at least 650 mV is very high, significantly increases the operational costs of the pool, involves the use of chemicals in amounts that are not environmentally friendly and can generate undesirable disinfection by-products (DBP's), such as chloramines.

[0008] Additionally, a typically configured swimming pool requires the filtration of its entire volume of water usually from 1 to 6 times per day. This is achieved by using a traditionally configured centralized filtration unit. Thus, the filtration system of traditional swimming pools consumes large amounts of energy, and also imposes high demands in terms of installation, operation and maintenance costs.

[0009] In sum, traditional swimming pools depend on large amounts of chemicals to maintain a chlorine buffer in order to neutralize the contamination entering the water body and a centralized filtration system that filters the whole volume of water usually from 1 to 6 times per day. Thus, traditional swimming pool technology has high operational and maintenance costs due to the high disinfectant concentrations that have to be continuously maintained and the required centralized filtration system. There is a great need for a sustainable, low energy method and system for treating and maintaining large water volumes for recreational purposes using a small amount of chemicals.

**Swimming Pools**

[0010] The consumption of nutrients in water by aerobic microorganisms results in a high demand of oxygen. This in turn, lowers the levels of dissolved oxygen in the water, and thus, allows the development of anaerobic microorganisms. Further development of anaerobic microorganisms produces accumulation of organic compounds. This chain of events produces an accumulation of nutrients in water, which can serve as a culture broth for particular microorganisms. Among the microorganisms developed in these conditions, bacteria and microalgae are the most relevant in recreational water bodies.

[0011] The turbidity in recreational bodies of water is produced mainly by microalgae present in the water. These microorganisms grow in water with a determined concentration of nutrients. Depending on the availability of a light source and the concentration of nutrients, algal blooms can occur in a process called eutrophication in which the algae populates the whole volume of water turning the whole body of water into a huge source of biomass and increases the turbidity of the water. Different regulations indicate that values of up to 50 nephelometric turbidity units (NTU) would be safe for human health. In British Columbia, for example, water turbidity determined by the Environmental Protection Division of the Ministry of Environment for recreational bodies of water, establishes an upper limit of 50 NTU (Section 2(e) of the Environment Management Act, 1981 of British Columbia, Canada), whereas the South Australian government considers an upper value of 25 NTU. When dissolved nutrients required for the maintenance of microalgae are consumed, the microalgae die and settle to the bottom of the body of water. The available organic matter in this settled layer at the bottom of the body of water can again serve as basis for the development of anaerobic microorganisms in the water, which in general pose health threats for humans. In artificial bodies of water, the quality of water deteriorates progressively as a consequence of microalgae and bacteria growth. In typical methods or processes for water treatment of swimming pools with high density of bathers, large amounts of disinfectant agents, such as chlorine, together with the filtration of the entire volume of water are used to control the proliferation of bacteria and microalgae. For example, if chlorine is used, it will react with organic matter as well as with reducing agents such as hydrogen sulfide, ferrous ions, manganese ions, and nitrite ions. The chlorine consumed in these reactions is defined as the chlorine demand. To meet the chlorine demand, permanent ORP levels of at least 650 mV have to be maintained in the water.

[0012] Reaction of chlorine with the organic compounds present in the water can form several toxic by-products or disinfection by-products (DBP). For example, the reaction of chlorine with ammonia can produce chloramines as undesired by-products. Further reaction of chlorine or chloramines with organic matter can produce trihalomethanes, which have been implicated as potential carcinogens. Also, depending on the disinfection method, new DBPs have been identified, such as iodinated trihalomethanes, haloacetonitriles, halonitromethanes, haloacetaldehydes, and nitrosamines. Furthermore, exposure of bathers to chlorine and organic matter has been suggested as contributing to respiratory problems, including asthma, and several other health problems.

[0013] The use of chemical agents also poses an environmental problem related to the accumulation and the disposal of these chemicals and DBPs in the environment. Therefore, a reduction in the use of such chemicals and the resultant DBPs would be beneficial.

[0014] In addition to the high cost and health and environmental issues associated with chemical treatment, conventional filtration systems have high capital costs and energy consumption. Traditional treatments of standard sized swimming pools require the filtration of the whole volume of water, usually from 1 to 6 times a day using a traditionally configured centralized filtration unit. This type of system imposes a high demand on energy supply, as well as elevated capital

costs associated with the filtration system such as piping, pumps, filters, and facilities, among others.

#### STATE OF THE ART

[0015] U.S. Pat. No. 5,143,623 describes a nutrient removal method, wherein the descending particles are collected while descending in the body of water by a structure having funnel shaped collectors and the structure can have the size of 1 acre (4,046 square meters). Said structure must stay in place for a prolonged period of time of at least a "few hours" in order to receive the descending particles, and furthermore, comprises a surface equal to the surface of the structure containing the body of water. The structure disclosed in U.S. Pat. No. 5,143,623 is intrusive as it does not allow for the normal development of aquatic activities and does not allow cleaning the bottom of the structure, thus it cannot provide desired color properties. Moreover, the method does not include the use of disinfectant agents or a filtration system.

[0016] Another document, WO2009114206 describes a method for algal removal from eutrophic water by using a settling pond and dosing different coagulants. This method requires the construction of at least one settling pond, and preferentially, at least 2 settling ponds and the amount of cationic coagulants used is up to 150 ppm. WO2009114206 requires the construction of more than one pond for its method to work properly, which requires more land and presents higher costs. The method disclosed by WO2009114206 does not disclose coordinated operation of the system and applies high amounts of coagulants in a manner that is not environmentally friendly.

[0017] FR2785898 describes a purification system for swimming pool water, comprising filtration, sterilization and pH control. The amount of chemical agents and the energy supplied to the traditionally configured centralized filtration system and the ionization process are similar to the amounts and filtration used for standard swimming pool technology. FR2785898 uses a high amount of chemicals to maintain a continuous concentration of the chemicals in the water. The method in FR2785898 also comprises filtration over the whole water volume, therefore demanding high amounts of energy and requiring expensive filtration equipment.

[0018] U.S. Pat. No. 7,820,055 is directed to obtaining large bodies of water for recreational use, and describes a process for installing and maintaining large volumes or bodies of water for recreational purposes, such as lakes or artificial lagoons with excellent coloration, high transparency and clarity similar to those of pools or tropical seas at low cost, especially for bodies of water larger than 15,000 m<sup>3</sup>. U.S. Pat. No. 7,820,055 defines structural features such as skimmers for oil elimination, water collection systems, building details, types and colors of liners, circulation systems and additive injection, requirements for supplying water, pH measuring, addition of salts, use of flocculants, change of the rates of fresh water, additives and oxidation processes, and a suctioning vehicle driven by a boat. U.S. Pat. No. 7,820,055 describes an open system for water circulation but does not employ filtration or a coordinated method that applies an algorithm depending on the water's temperature to maintain water quality according to its real needs.

[0019] WO2010/074770A1 describes an efficient filtration process to maintain recreational and ornamental bodies of water. WO2010/074770A1 requires the application of ultrasound waves to the water, and application of flocculants.

WO2010/074770A1 does not disclose a coordination means that coordinates the method operation, and therefore imposes high energy demands.

#### SUMMARY

**[0020]** This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify required or essential features of the claimed subject matter. Nor is this summary intended to be used to limit the scope of the claimed subject matter.

**[0021]** The present invention provides a sustainable method and system for treating and maintaining large bodies of water for low density of bathers for recreational use. The density of bathers in the water body is up to 0.05 bathers or less per cubic meter, which is about 10 times lower than the density considered in the design of traditional swimming pools. By lowering the density of bathers, it is possible to use the diluting power of the water to maintain high quality water suitable for full contact bathing without the need to maintain a permanent chlorine buffer as in a conventional swimming pool. Thus, the present methods and system of the invention break the size barrier of conventional swimming pools and provide ecologic pools of very large dimensions, similar to high clarity lakes, that have high water quality associated with conventional swimming pools. These ecologic pools are not economically feasible using conventional swimming pool filtration technologies.

**[0022]** The methods and system described herein eliminate the chlorine buffer used in conventional swimming pool filtration systems. The amount of chemicals used is therefore very low compared to conventional swimming pool water treatment systems. Unlike current swimming pool water treatments, the methods and system of the invention do not require the ORP levels to be permanently maintained. In the methods and system described herein, ORP levels of at least 500 mV are maintained for a period of time determined by an algorithm that depends on the temperature of the water body. Thus, the present invention provides methods and a system capable of adjusting the amount and dosing of chemicals in response to environmental factors, such as water temperature, reducing the amount of chemicals by up to 100 times compared to traditional treatments of swimming pools.

**[0023]** In addition, the methods and system disclosed herein comprise a low cost filtration means, which allows the filtering of only a small fraction of the entire volume of water, up to 200 times smaller than for conventional swimming pools. Since a traditional centralized filtration unit is not employed, energy consumption and equipment costs may be up to 50 times less in the present invention than in traditionally configured swimming pool filtration systems.

**[0024]** Thus, the present invention may offer several advantages over traditional swimming pool filtration technology. The present invention employs an algorithm that adjusts the dosing and application of disinfectants to the water body in order to maintain an ORP level of at least 500 mV for a period of time that depends on the water's temperature, allowing a reduction in the amount of chemicals used of at least one order of magnitude compared to traditional swimming pool filtration systems. Advantages associated with decreasing the amount of chemicals include reduced operation costs and a reduction on the production of DBPs, which may be harmful to the environment and bathers. In addition, the use of a low cost filtration system that filters a small fraction of the total

volume of water reduces installation costs, operating costs, and energy usage compared to conventional swimming pool filtration systems.

**[0025]** The present invention addresses diverse environmental problems that arise in processes for treating water affected by bacteria and microalgae. The inventor of the novel technology disclosed herein, Mr. Fernando Fischmann, has developed many new advances in water treatment technology that are rapidly being adopted throughout the world. In a short period of time, the inventor's technologies related to recreational crystalline lagoons have been incorporated into more than 180 projects throughout the world. The inventor and his advancements in water treatment technology have been the subject of more than 2,000 articles, as can be seen at <http://press.crystal-lagoons.com/>. The inventor has also received important international awards for innovation and entrepreneurship related to these advances in water treatment technology and has been the subject of interviews by major media outlets including CNN, BBC, FUJI, and Bloomberg's Businessweek.

**[0026]** Both the foregoing summary and the following detailed description provide examples and are explanatory only. Accordingly, the foregoing summary and the following detailed description should not be considered to be restrictive. Further, features or variations may be provided in addition to those set forth herein. For example, certain embodiments may be directed to various feature combinations and sub-combinations described in the detailed description.

#### BRIEF DESCRIPTION OF THE FIGURES

**[0027]** The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate various embodiments of the present invention. In the drawings:

**[0028]** FIG. 1 is a process flow diagram illustrating a system for treating water in an embodiment of the invention.

**[0029]** FIG. 2 shows a top view of a containing structure in an embodiment of the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0030]** The following detailed description refers to the accompanying drawings. While embodiments of the invention may be described, modifications, adaptations, and other implementations are possible. For example, substitutions, additions, or modifications may be made to the elements illustrated in the drawings, and the methods described herein may be modified by substituting, reordering, or adding stages to the disclosed methods. Accordingly, the following detailed description does not limit the scope of the invention. While systems and methods are described in terms of "comprising" various apparatus or steps, the systems and methods can also "consist essentially of" or "consist of" the various apparatus or steps, unless stated otherwise.

#### DEFINITIONS

**[0031]** In the light of the present disclosure, the following terms or phrases should be understood with the meanings described below:

**[0032]** The term "swimming pool regulations" as used herein means regulations directed to swimming pools which require the maintenance of a permanent chlorine buffer in order to avoid the contamination of the water when new bathers enter the swimming pool. The chlorine buffer neu-

tralizes contaminants and kills microorganisms brought to the swimming pool water by bathers, thus maintaining a high water quality suitable for recreational purposes. These types of regulations are generally established by a governmental body or agency.

**[0033]** The term "chlorine buffer" as used herein means the residual chlorine concentration in a swimming pool or any other body of water required by the swimming pool regulations. The amount of active chlorine acts as a buffering mechanism when new microorganisms or organic matter enters the water, thus neutralizing the organic matter and killing the microorganisms in such a way that the organic matter can no longer be used as nutrients for other microorganisms to consume. The chlorine buffer can relate to the ORP levels in the water, which will be controlled according to the present invention. It is to be understood that another disinfectant could be used instead of chlorine, such as bromine, in order to maintain the required disinfectant levels.

**[0034]** The term "traditionally configured centralized filtration system" as used herein is to be understood as meaning a centralized filtration unit or system with a capacity designed to filter the whole volume of water of the swimming pool, usually from 1 to 6 times a day, in order to comply with the swimming pool regulations. The water sent to the centralized filtration system is collected from different sources, such as drains, skimmers, or by overflow, among others.

**[0035]** The terms "container" or "containing means" are used generically herein to describe any large artificial body of water, encompassing terminology such as artificial lagoons, artificial lakes, artificial ponds, pools, and the like, having large dimensions.

**[0036]** The term "non-intrusive cleaning system" as used herein includes a suction means which does not interfere with the normal development of recreational activities in the water. Generally, the suction means is able to travel across the bottom surface of the containing means and suction settled material. For example a boat pulling a suctioning cart is a non-intrusive system, given that the permanence of this system is temporal in a zone of the water body. A self-propelled suctioning cart would also be non-intrusive. Nevertheless, a system requiring fixed installations or fixed piping would be intrusive for the normal development of water sports or other activities.

**[0037]** The term "coordination means" is used generically herein to describe an automated system that is able to receive information, process it, and make a decision according to it. In a preferred embodiment of the invention, this could be done by a person, but more preferably with a computer connected to sensors.

**[0038]** The term "chemical application means" is used generically herein to describe a system that allows for the application or dispersion of chemicals into the water.

**[0039]** The term "mobile suction means" is used generically herein to describe a suctioning device that is able to travel across the bottom surface of the containing means and suction the settled material.

**[0040]** The term "propelling means" is used generically herein to describe a propelling device that allows providing movement, either by pushing or pulling another device.

**[0041]** The term "filtration means" is used generically herein to describe a filtration system that can include a filter, strainer, separator, and the like.

**[0042]** As used herein, the term "small fraction" corresponding to the filtered water volume means a flow of up to

200 times less than the flow filtered in a traditionally configured swimming pool filtration system.

#### MODES FOR CARRYING OUT THE INVENTION

**[0043]** Traditional swimming pool filtration methods and systems depend on the use of a chlorine buffer to neutralize contaminants and kill microorganisms entering the water body. These methods and systems require the application of chemicals in large amounts to maintain a permanent buffer independent of the real requirements of the water. In addition, these methods and systems generally require a traditionally configured centralized filtration system that filters the whole volume of water, usually from 1 to 6 times per day. Thus, traditional swimming pool technology uses a large amount of chemicals and has high capital costs and operating costs associated with the centralized filtering system.

**[0044]** The present invention relates to a low cost, sustainable method and system for treating and maintaining bodies of water affected by bacteria and microalgae for low density recreational use. The density of usage is up to 0.05 bathers per cubic meter. Unlike conventional swimming pool filtration systems in which the total volume of water is filtered one or more times per day, the methods and system of the present invention filter only a small fraction of the total volume of water, up to 200 times less per day compared to conventional filtration systems, providing treated water that complies with bacteriological and physicochemical regulations for recreational waters in full body contact.

**[0045]** The sustainable method for treating water can be performed at low costs compared to traditional water treatment systems, due to the fact that the present invention uses less chemicals and consumes less energy than traditional swimming pool water treatment systems. The methods and system of the invention do not require ORP levels of at least 650 mV to be maintained permanently as in conventional swimming pool water treatment systems. In contrast to conventional filtration systems, the methods and system described herein apply an algorithm that maintains ORP levels of at least 500 mV for a certain period of time dependent on the temperature of the water. Thus, the systems and methods of the invention provide a considerable reduction in the amount of chemicals compared to conventional swimming pool water treatments, up to 100 times less, which decreases operating and maintenance costs.

**[0046]** In addition, the methods and system of the invention filter only a small fraction of the total volume of water, up to 200 times less per day compared to conventional swimming pools that require a centralized filtration unit which generally filters the entire volume of water from 1 to 6 times per day. The filtering means of the methods and system of the invention comprises a smaller filtering means compared to the centralized filtration unit that operates for shorter periods of time, resulting in energy consumption and equipment costs up to 50 times less than in traditional swimming pool systems.

**[0047]** A system of the invention generally includes at least one containing means, at least one coordination means, at least one chemical application means, at least one mobile suction means, and at least one filtration means. FIG. 1 illustrates an embodiment of a system of the invention. The system includes a containing means (12). The size of the containing means is not particularly limited, however, in many embodiments the containing means can have a volume of at least 15,000 m<sup>3</sup>, or alternatively, at least 50,000 m<sup>3</sup>. It is

contemplated that the container or containing means can have a volume of 1 million m<sup>3</sup>, 50 million m<sup>3</sup>, 500 million m<sup>3</sup>, or more.

[0048] The containing means (12) has a bottom able to receive bacteria, algae, suspended solids, metals, and other particles that settle from the water. In an embodiment, the containing means (12) includes a receiving means (2) for receiving the settled particles or materials from the water being treated. A receiving means (2) is fixed to the bottom of the containing means (12) and preferably is constructed of a non-porous material capable of being cleaned. The bottom of the containing means (12) is generally covered with the non-porous material allowing the non-intrusive mobile suction means (3) to travel across the entire inferior surface of the containing means (12) and suction the settled particles produced by any of the processes disclosed herein. The non-porous materials can be membranes, geo-membranes, geotextile membranes, plastic liners, concrete, coated concrete, or combinations thereof. In a preferred embodiment of the invention, the bottom of the containing means (12) is covered with plastic liners. The containing means (12) can include an inlet line (13) for feeding water to the containing means (12). The inlet line (13) allows for the refilling of the containing means (12) due to evaporation and other losses of water.

[0049] The system includes at least one coordination means (1) which can control the necessary processes depending on the system needs (e.g., water quality). Such processes can include the activation (9) of a non-intrusive mobile suction means (3). The coordinating means (1) can receive information (8) regarding the water quality parameters that are controlled, and can timely activate the processes necessary to adjust said quality parameters within their respective limits. The information (8) received by coordinating means (1) can be obtained by visual inspection, empirical methods, algorithms based on experience, by electronic detectors, or combinations thereof. Coordinating means (1) can comprise one or more people, electronic devices, or any means capable of receiving information, processing that information, and activating other processes, and this includes combinations thereof. One example of a coordination means is a computing device, such as a personal computer. Coordinating means (1) can also include sensors utilized to receive information (8) regarding the water quality parameters.

[0050] Processes are timely activated by the coordination means (1) in order to adjust the controlled parameters within their limits. The processes are activated according to the system's needs, which allows for the filtering of a small fraction of the total volume of water per day, thus replacing the conventional swimming pool filtration systems which filter the totality of the water volume up to 6 times per day. The processes correspond to the timely activation (9) of the mobile suction means (3), which will simultaneously activate the filtration means (7) in order to filter the flow suctioned by the mobile suction means, filtering only a small fraction of the entire volume of water, up to 200 times less than conventional swimming pool filtration systems.

[0051] The chemical application means (6) applies or dispenses chemicals into the water. Chemical application means (6) include, but are not limited to, injectors, sprinklers, manual application, dispensers by weight, pipes, and combinations thereof.

[0052] The non-intrusive mobile suction means (3) moves along the bottom of the containing means (12), suctioning water containing settled particles and materials produced by

any of the processes disclosed herein. A propelling means (4) is coupled to the mobile suction means (3) with a coupling means (5) allowing the mobile suction means (3) to travel across the bottom of the containing means (12). The coupling means (5) can be flexible or rigid. Examples of coupling means include, but are not limited to, cords, ropes, lines, cables, strings, rods, bars, poles, shafts, and combinations thereof.

[0053] The mobile suction means should not be intrusive or alter the normal development of recreational activities in the water, such as swimming or the development of water sports. Preferably, the permanence of the suction means is temporal in a zone of the water body. Thus, a system requiring fixed installations or fixed piping would be intrusive to the normal development of water sports or other activities. The mobile suction means travels across the bottom of the containing means, thoroughly suctioning the flow of water with the settled particles, and allowing visualizing the color of the bottom. The propelling means (4) drives the mobile suction means (3) by using a system such as a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine or a floating device with an engine, or combinations thereof. In a preferred embodiment of the invention, the propelling means is a boat with an engine.

[0054] The water suctioned by the mobile suction means (3) is sent to a filtration means (7). The filtration means (7) receives the flow of water suctioned by the mobile suction means (3) and filters the suctioned water containing the settled particles and materials, thus eliminating the need to filter the totality of the water volume (e.g., only filtering a small fraction). The filtration means (7) includes, but is not limited to, cartridge filters, sand filters, micro-filters, nano-filters, ultra-filters, and combinations thereof. The suctioned water can be sent to the filtration means (7) by a collecting line (10) connected to the mobile suction means (3). The collecting line (10) can be selected from flexible hoses, rigid hoses, pipes of any material, and combinations thereof. The system can include a return line (11) from the filtration means (7) back to the containing means (12) to return the filtered water.

[0055] FIG. 2 shows a top view of a system of the invention. Containing means (12) can include a feeding pipe system (13) that allows for refilling of the containing means (12) due to evaporation or other loss of water from the containing means (12). The containing means (12) can also include injectors (14) arranged along the perimeter of the containing means (12) for applying or dispensing chemicals into the water. The containing means (12) can also include skimmers (15) for removing surface oils and particles.

[0056] In an embodiment, a system of the invention includes the following elements:

[0057] at least one inlet line (13) for feeding water to at least one containing means (12);

[0058] at least one containing means (12), which comprises a receiving means (2) for the settled particles produced by the method's processes, that is fixed to the bottom of said containing means;

[0059] at least one coordination means (1), where the coordination means timely activates the necessary processes to adjust the parameters within their limits;

[0060] at least one chemical application means (6), which allows adding the disinfectant agents to the water;

[0061] at least one non-intrusive mobile suction means (3), which moves through the bottom of said at least one containing means suctioning the water flow containing the settled particles produced by the method's processes;

[0062] at least one propelling means (4) that provides movement to said at least one non-intrusive mobile suction means so it can move through the bottom of said at least one containing means;

[0063] at least one coupling means (5), to connect said at least one propelling means and said at least one suction means;

[0064] at least one filtration means (7) that filters the water flow containing the settled particles;

[0065] at least one collecting line (10) coupled between said at least one mobile suction means and said at least one filtration means; and

[0066] at least one return line (11) from said at least one filtration means to said at least one containing means;

[0067] The method of the invention uses less chemicals and consumes less energy than traditional swimming pool treatment methods, and therefore can be performed at low costs compared to traditional treatment methods. In one aspect, the present method uses significantly less chemicals because it applies an algorithm that allows maintaining an ORP of at least 500 mV for a certain period of time depending on the temperature of the water. Thus, there is a considerable reduction on the amount of chemicals, of up to 100 times less than traditional swimming pool water treatment systems, which decreases operating and maintenance costs.

[0068] In another aspect, the methods of the invention filter only a small fraction of the total volume of water within a particular time frame compared to conventional swimming pool filtration systems which filter a much larger volume of water in the same time frame. In an embodiment, the small fraction of the total volume water is up to 200 times smaller than the flow processed in traditionally configured centralized filtration systems, which filter the totality of the water volume up to 6 times per day. The filtering means in the method and system of the invention operates at shorter periods of time due to the orders received from the coordination means. Thus the filtration means in the method and system of the invention has a very small capacity and up to 50 times lower capital costs and energy consumption compared to the centralized filtering unit used in conventional swimming pool filtration systems.

[0069] In an embodiment, the method includes the following stages:

[0070] a. Collecting water with a concentration of total dissolved solids (TDS) of up to 50,000 ppm;

[0071] b. Storing said water in at least one containing means (12), where said containing means has a bottom able to be thoroughly cleaned by a non-intrusive mobile suction means;

[0072] c. Limiting the density of bathers to be up to 0.05 bathers per cubic meter of water volume contained in said containing means.

[0073] d. Within periods of 7 days, for water temperatures up to 45 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour for each degree Celsius of water temperature, by adding disinfectant agents to the water;

[0074] e. Activating the following processes through a coordination means (1), where the processes purify the

water and eliminate the suspended solids by only filtering a small fraction of the total volume of water:

[0075] i. Suctioning the water flow that contains the settled particles, produced by the previous processes, with a non-intrusive mobile suction means (3) to prevent the thickness of the settled material from exceeding an average of 3 mm;

[0076] ii. Filtering the flow suctioned by the mobile suction means, with at least one filtration means (7); and

[0077] iii. Returning the filtered water to said at least one containing means, thus avoiding the filtering of the total volume of water, only filtering the flow containing the settled particles;

[0078] Disinfectant agents are applied to the water, by a chemical application means (6), in order to maintain an ORP level of at least 500 mV for a minimum period of time according to the temperature of the water, within periods of 7 days at a time. The disinfectant agents include, but are not limited to, ozone, biguanide products, algacide and antibacterial agents such as copper products; iron salts; alcohols; chlorine and chlorine compounds; peroxides; phenolic compounds; iodophors; quaternary amines (polyquats) in general, such as benzalkonium chloride and S-Triazine; peracetic acid; halogen-based compounds; bromine based compounds, chlorine base compounds, and combinations thereof. Preferred disinfectant agents include chlorine based compounds, ozone, biguanide products, bromine based compounds, halogen based compounds, or combinations thereof.

[0079] Control of bacteria and microalgae in the body of water is achieved by the chemical application means which applies the disinfectant agents to the water body. The amount of disinfectant agents used in the present invention is at least one order of magnitude lower than the usual amounts required by traditional swimming pool technology. Application of disinfectant agents results in the death of bacteria and other microorganisms, which collect or settle in the layer of water along the bottom of the containing means. Unlike traditional swimming pool technology, disinfectant agents in the present invention are applied without the need for maintaining a permanent concentration in the water volume. The sustainable method applies an algorithm that allows maintaining ORP levels only for a certain period of time determined according the water's temperature. If the water temperature is up to 45 degrees Celsius, an ORP level of at least 500 mV is maintained for a minimum period of 1 hour for each degree Celsius of water temperature. For example, if the water temperature is 25 degrees Celsius, then an ORP level of at least 500 mV is maintained for a minimum period of 25 hours, which can be distributed along the 7 day period. Water having a temperature greater than 45 degrees Celsius is not suitable for the recreational uses of the present invention as such temperatures could compromise the safety of the bathers.

[0080] The coordination means (1) can receive information (8) regarding the water quality parameters within their respective limits. The information received by the coordination means can be obtained by empirical methods. The coordination means (1) is also capable of receiving information, processing that information, and activating the required processes according to that information, including combinations thereof. One example of a coordination means is a computing device, such as a personal computer, connected to sensors which allow for the measuring of parameters and activation of processes according to such information.

[0081] The mobile suction means is designed to perform a thorough surface cleaning of the receiving means such that the surface color of the receiving means is visible, thereby providing the water body with an attractive color. The coordination means (1) provides information (9) to the mobile suction means (3) to activate the mobile suction means. The filtration means (7) is simultaneously activated in order to filter the flow suctioned by the mobile suction means (3), filtering only a small fraction of the entire volume of water. The filtered water is then returned to the containing means (12) by the return line (11). The mobile suction means (3) is activated (9) by the coordination means (1) to prevent the thickness of the settled material from exceeding 3 mm on average. The filtration means (7) and mobile suction means (3) operate only as needed to maintain the parameters of the water with their limits, for instance, only a few hours a day, as opposed to conventional filtration systems which operate continuously on a daily basis.

[0082] Water treated by the method of the invention can be provided by a natural water source, such as oceans, groundwater, lakes, rivers, treated water, or combinations thereof. The collected water can have a concentration up to 50,000 ppm of Total Dissolved Solids (TDS). When the concentration of TDS is less than or equal to 10,000 ppm, the Langelier Saturation Index of the water should be less than 3. For the present invention, the Langelier Saturation Index can be kept under 2 by pH adjustment, the addition of antiscalants, or a water softening process. When the concentration of TDS is higher than 10,000 ppm, the Stiff & Davis Saturation Index of the water should be less than 3. For the present invention, the Stiff & Davis Saturation Index can be maintained up to 2 by pH adjustment, the addition of antiscalants, or a water softening process. Antiscalants that can be used to maintain the Langelier Saturation Index or the Stiff & Davis Saturation Index under 2 include, but are not limited to, phosphonate based compounds, such as phosphonic acid, PBTC (phosphobutan-tricarboxylic acid), chromates, zinc polyphosphates, nitrites, silicates, organic substances, caustic soda, malic acid-based polymers, sodium polyacrylate, ethylene diamine tetracetic acid sodium salts, corrosion inhibitors such as benzotriazole, and combinations thereof.

#### EXAMPLES

[0083] For the following examples, the terms "a/an/the" include plural alternatives (at least one). The disclosed information is illustrative, and other embodiments exist and are within the scope of the present invention.

##### Example 1

[0084] The following table summarizes the amounts of chemicals used, energy consumed and associated costs considering a density of bathers of up to 0.05 bathers per cubic meter in A) a system according to the present invention and B) a traditional swimming pool configuration. The volume of water in both A) and B) is 90,000 m<sup>3</sup>.

|                                             | Case A  | Case B    |
|---------------------------------------------|---------|-----------|
| Total Volume (m <sup>3</sup> )              | 90,000  | 90,000    |
| Filtered flow in 24 hours (m <sup>3</sup> ) | 2.7     | 540       |
| Chemical agents (kg)                        | 1.5     | 135       |
| Energy used in filtration monthly (USD)     | USD 806 | USD 43000 |

[0085] As illustrated in the table, the operating cost of a pool configured with the system of the present invention will be at least one order of magnitude lower than a traditional configuration.

##### Example 2

[0086] A water body of 125,000 m<sup>3</sup> was treated with a method and system according to the present invention. The average depth of the body of water was 3.125 m. The system included spaced injectors as chemical application means at the border of the swimming pool and at the bottom of the structure. The cleaning system operated in cycles given the size of the water body. ORP levels were determined as follows: for water temperatures up to 45 degrees Celsius, an ORP level of at least 500 mV was maintained for a minimum period of 1 hour for each degree Celsius of water temperature. The temperature of the water was 20 degrees Celsius, so ORP levels of at least 500 mV were maintained during 20 hours during the week. On the first day of treatment, the chemical application means injected chlorine from 9:00 am to 7:00 pm to maintain chlorine concentrations of 0.15 ppm, thus completing 10 hours that day. The same procedure was repeated on the fourth day of treatment from 9:00 am to 7:00 pm, thus completing the 20 hours required for the 7 day treatment cycle.

[0087] Before the average thickness of the layer of settled material exceeded 3 mm, suctioning of the settled dead microalgae and microorganism debris was started by using a small boat with an engine as a propelling means to move a suctioning device along the bottom of the structure in a zone of the structure. The other zones were activated sequentially allowing the complete removal of dead microalgae and microorganism debris in a period of 4 hours.

[0088] The suctioned flow was sent to a small cartridge filter, since the volume filtered is a very small percentage (2.5%) of the whole volume of water per day. The filtering cartridge was located outside the swimming pool, and the filtered water was returned to the swimming pool by a flexible hose.

[0089] The energy consumed during 1 week using this configuration was 2,436 kW. In a traditional pool configuration, the calculated consumption of energy in one week would have been 124,306 kW. Therefore, the present invention consumes only a 2% of the energy and utilizes an amount of chemical agents up to 100 times lower than an equivalent swimming pool with traditional water treatment technology.

[0090] While certain embodiments of the invention have been described, other embodiments may exist. Further, any disclosed method steps or stages may be modified in any manner, including by reordering steps and/or inserting or deleting steps, without departing from the invention. While the specification includes a detailed description and associated drawings, the invention's scope is indicated by the following claims. Furthermore, while the specification has been described in language specific to structural features and/or methodological acts, the claims are not limited to the features or acts described above. Rather, the specific features and acts described above are disclosed as illustrative aspects and embodiments of the invention. Various other aspects, embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to one of ordinary skill in the art without departing from the spirit of the present invention or the scope of the claimed subject matter.

What is claimed is:

1. A sustainable method for treating and maintaining a body of water affected by bacteria and microalgae at low cost by filtering a small fraction of the total volume of the body of water, the method comprising:

- a. Collecting water with a concentration of total dissolved solids (TDS) of up to 50,000 ppm;
- b. Storing said water in at least one containing means, wherein said containing means has a bottom surface able to be thoroughly cleaned by a non-intrusive mobile suction means;
- c. Limiting the density of bathers up to 0.05 bathers per cubic meter in said water contained in the containing means.
- d. Within periods of 7 days, and for water temperatures up to 45 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour for each degree Celsius of water temperature, by adding disinfectant agents to the water;
- e. Activating the following processes through a coordination means, wherein the processes purify the water and eliminate suspended solids by filtering only a small fraction of the total volume of water:
  - i. Suctioning a portion of said water containing settled particles produced by the previous processes with a mobile suction means to prevent the thickness of settled material from exceeding an average of 3 mm;
  - ii. Filtering the portion of water suctioned by the mobile suction means; and
  - iii. Returning the filtered water to said at least one containing means.

2. The method of claim 1, wherein:

- a. if the water collected in stage a) has a total dissolved solids' concentration less than or equal to 10,000 ppm, the Langelier Saturation Index must be less than 3; or
- b. if the water collected in stage a) has a total dissolved solids' concentration higher than 10,000 ppm, the Stiff & Davis Saturation Index must be lower than 3.

3. The method of claim 2, wherein the Langelier Saturation Index is kept under 2 by a process selected from pH adjustment, the addition of antiscalants, or a water softening process.

4. The method of claim 2, wherein the Stiff & Davis Saturation Index is kept under 2 by a process selected from pH adjustment, the addition of antiscalants, or a water softening process.

5. The method of claim 3, wherein the antiscalants comprise phosphonate based compounds, phosphonic acid, PBTC (phosphobutan-tricarboxylic acid), chromates, zinc polyphosphates, nitrites, silicates, organic substances, caustic soda, malic acid-based polymers, sodium polyacrylate, ethylene diamine tetracetic acid sodium salts, benzotriazole, or a combination thereof.

6. The method of claim 1, wherein the coordination means receives information regarding the parameters that are controlled and timely activates the processes of step e) to adjust said parameters within their limits.

7. The method of claim 6, wherein the information received by the coordination means is obtained by empirical methods.

8. The method of claim 1, wherein the disinfectant agents are selected from chlorine and chlorine compounds; ozone; biguanide products; halogen-based compounds; bromine based compounds, or a combination thereof.

9. The method of claim 1, wherein the mobile suction means travels across the bottom of the containing means and suctions the portion of water containing the settled particles.

10. The method of claim 1, wherein the disinfectant agents are applied without the need of maintaining a permanent concentration in the water volume.

11. System for treating and maintaining a body of water affected by bacteria and microalgae at low cost by filtering a small fraction of the total volume of the body of water, the system comprising:

- at least one feeding line of affluent water to at least one containing means;
- at least one containing means comprising a receiving means for settled particles that is fixed to a bottom surface of said containing means;
- at least one coordination means, wherein the coordination means timely activates processes necessary to adjust parameters of the water within predetermined limits;
- at least one chemical application means;
- at least one non-intrusive mobile suction means for moving along the bottom of said at least one containing means and suctioning water containing settled particles;
- at least one propelling means for moving at least one non-intrusive mobile suction means along the bottom of said at least one containing means;
- at least one coupling means that connects said at least one propelling means to said at least one suction means;
- at least one filtration means for filtering water containing settled particles
- at least one collecting line coupled between said at least one mobile suction means and said at least one filtration means; and
- at least one return line from said at least one filtration means to said at least one containing means.

12. The system of claim 11, wherein the receiving means covering the bottom of the container comprises a membrane, geo-membrane, geotextile membrane, concrete, coated concrete, plastic liner, or a combination thereof.

13. The system of claim 11, wherein the coordination means is capable of receiving information, processing that information, and activating other processes.

14. The system of claim 11, wherein the chemical application means comprises an injector, a sprinkler, manual application, a dispenser by weight, piping, or a combination thereof.

15. The system of claim 11, wherein propelling means comprises a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine, a floating device with an engine, or a combination thereof.

16. The system of claim 11, wherein the non-intrusive suction means is coupled to the propelling means by the coupling means.

17. The system of claim 11, wherein the coupling means comprises a flexible cord, rope, line, cable, string, or a combination thereof.

18. The system of claim 11, wherein the coupling means comprises a rigid rod, bar, pole, shaft, or a combination thereof.

19. The system of claim 11, wherein the filtration means comprises a cartridge filter, sand filter, micro-filter, ultra-filter, nano-filter, or a combination thereof.

\* \* \* \* \*



Figure 1

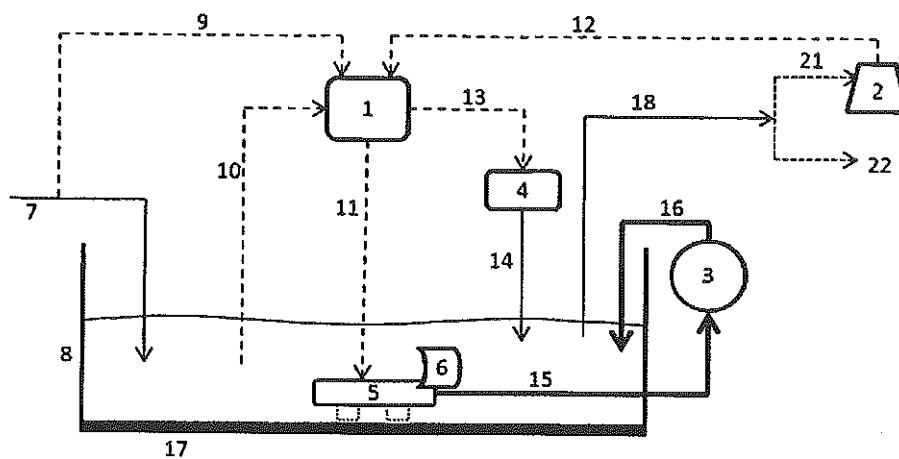
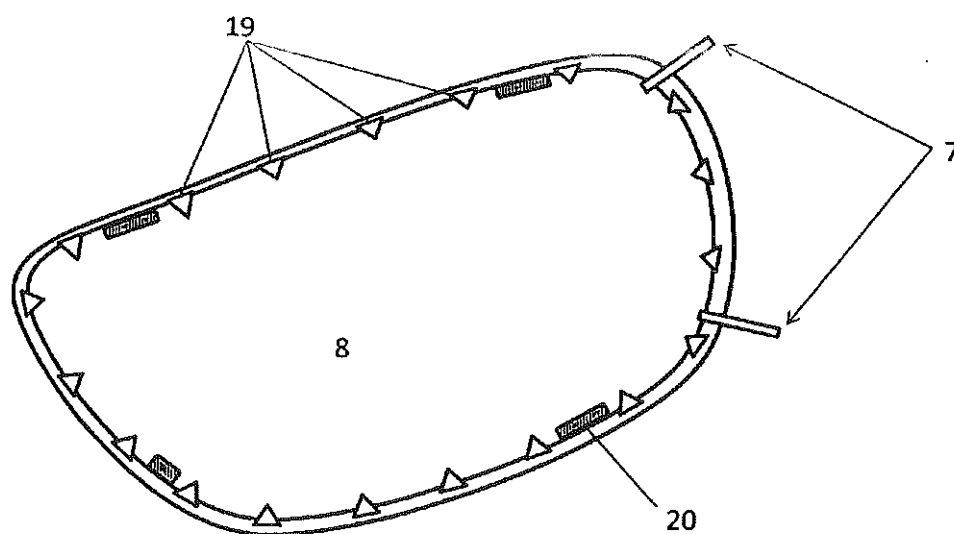


Figure 2



## METHOD AND SYSTEM FOR TREATING WATER USED FOR INDUSTRIAL PURPOSES

[0001] This application claims benefit of U.S. Provisional Ser. No. 61/469,537, filed 30 Mar. 2011 and which application is incorporated herein by reference. To the extent appropriate, a claim of priority is made to the above disclosed application.

### FIELD OF THE INVENTION

[0002] The present invention relates to a low cost method and system for treating water, which will be used in an industrial process. The method and system of the invention purifies the water and eliminates suspended solids without the need of filtering the totality of the water volume, but only filtering a small fraction of up to 200 times less than the flow filtered by a conventional water treatment filtration system.

### BACKGROUND

[0003] High microbiological quality water with high clarity is a scarce resource that is currently required for the processes of many industries. The treatment for obtaining such water entails large investment and operating costs, and the processes are complicated and present many problems that have not been effectively solved to the present day. Also, the processes consume large amounts of energy and chemicals, thus severely damaging the environment. Specifically, removing impurities that are contained in the water, such as suspended solids, metals, algae, and bacteria, among others, requires the installation of expensive and complex filtration systems that allow filtering the entire volume of water, thus presenting high energy consumption, high chemical and material requirements, and other resources that hinder this process.

[0004] High microbiological quality water is required for several important processes, such as the pretreatment of water for reverse osmosis desalination processes, for treating water used in aquaculture, for treating and maintaining water for the potable water industry, for treating industrial liquid residuals, or for mining industries, among others. The water of high microbiological quality and clarity at very low costs of the present invention can also be used in other industrial processes that require high physicochemical and microbiological quality water.

### Desalination

[0005] There are several reasons for addressing the improvement of current desalination processes, since this industry is growing exponentially and will be very important in the future. From the total water available in the world, 97% of it corresponds to seawater. From the remaining 3% of fresh water available, 2.1% is frozen in the poles and only a 0.9% is available for human consumption, which is found in rivers, lakes, or as groundwater. The limited availability of freshwater for human consumption is a problem that has been increasing along with global population growth and cultural change. About 40% of the world's population already suffers from problems caused by lack of access to sources of freshwater.

[0006] Thus, just as the United Nations Environment Programme (UNEP) has warned, it is expected that nearly 3 billion people will suffer from severe water shortages within the next 50 years. Also, in 1999, the UNEP identified the shortage of water along with global warming as the biggest

problems for the new millennium. The freshwater resources are being consumed at a rate greater than nature can replenish them, and also, pollution and exploitation of groundwater and surface water have led to a decrease in the quantity and/or quality of available natural resources. The combination of increasing population, the lack of new sources of freshwater, and the increasing of per capita water consumption, causes an aggravation of regional tensions among countries that are located near water resources. All of the above obligates to find a solution to the problem of water availability, not only to meet the future demands of humanity, but also to avoid the conflicts that water shortages can lead to.

[0007] Conveniently, seawater is the most abundant resource on earth, a virtually inexhaustible source of salt water which is always available for use. Therefore, to solve the immense problems associated with the short supply of fresh water, the best solution is to process sea water to provide fresh water for general consumption. The vast availability of sea water contained in the oceans has led to research and creation of technologies to remove the salts in the water by various processes, and produce fresh water. The best available technology in the world to achieve this objective is the desalination process. Currently, about 130 countries worldwide are implementing some type of desalination process, and it is expected that the installed capacity will be doubled by 2015.

[0008] The two most used desalination processes are:

[0009] Using water evaporation, as a distillation process, in such a way to evaporate only the water molecules, leaving behind all salts and dissolved minerals. This process is called thermal desalination.

[0010] Using special membranes which allow performing the reverse osmosis process, separating the water from salts through application of pressure on a semi-permeable membrane. This process is called reverse osmosis.

[0011] To decide between what process to use, energy consumption is an important factor to consider. It is estimated that the consumption of energy to produce 1 m<sup>3</sup> of water using thermal desalination is between 10 to 15 kWh/m<sup>3</sup>, while a process using reverse osmosis technology uses about 5 kWh/m<sup>3</sup>. This is because thermal desalination requires evaporation, so more energy is needed for the phase change process, making thermal desalination less efficient in terms of energy consumption. Current restrictions require improving the overall efficiency of processes, using technologies that meet the environmental requirements demanded by society, while minimizing the carbon footprint and the environmental impact.

[0012] In terms of the evolution of the mentioned technologies, since 2005 the global installed capacity of reverse osmosis desalination plants has exceeded the installed capacity of thermal plants. The projection is that by 2015 the world's desalination capacity will be distributed by 62% in reverse osmosis plants and 38% in thermal desalination plants. In fact, the global capacity to produce fresh water in desalination plants using reverse osmosis technologies has increased by over 300% in just 6 years.

[0013] Reverse osmosis is a process by which pressure is applied to a flow of water having a high concentration of salts, through a semi-permeable membrane that only lets water molecules to pass through. Because of this, the permeate leaving the other side of the membrane corresponds to high microbiological quality water with a low salt content. Within

the operation of desalination plants using reverse osmosis technology, there are 2 main stages:

[0014] 1. Water pretreatment

[0015] 2. Desalination Stage

[0016] The second stage, corresponding to the reverse osmosis process itself, has been extensively studied and efficiencies of up to 98% have been achieved (General Electric HERO Systems).

[0017] The first stage of the process of producing fresh water using reverse osmosis corresponds to the conditioning of salt water before reaching the semi-permeable membrane, also called water pretreatment. This pretreatment step experiences major problems related to water quality needed for efficient operation of reverse osmosis membranes. In fact, it is estimated that 51% of reverse osmosis membranes fail due to poor pretreatment, either due to poor design or poor operation, while 30% fail because of inadequate dosing of chemicals. Current methods, in addition to being inefficient due to high rate of failures, have very high costs thereby driving research to find new methods that solve these problems.

[0018] The problems arising in the membranes depend on the characteristics of feed water, which fouls the filters and membranes located prior to pretreatment and also the reverse osmosis membranes. These problems are reflected in a shorter life and higher frequencies of maintenance and cleaning of the membranes, leading to higher costs of operation and maintenance. Common problems that arise due to poor water pretreatment are divided into 2 types: damage of the membranes and blocking of the membranes.

[0019] The damage of reverse osmosis membranes is mainly caused by oxidation and hydrolysis of membrane material because of diverse compounds in the feed water. Most reverse osmosis membranes cannot withstand existing concentrations of residual chlorine, which is usually added in desalination processes to prevent biological growth. The membranes have high costs, so all possible precautions to maintain continuous operation and achieve the best possible performance should be taken; thus, the water must be often de-chlorinated before it passes through the membranes. Eventually, the pH of the feed water should also be adjusted for optimal operation of the membranes. In addition, dissolved oxygen and other oxidizing agents must be removed to prevent damage to the membranes. The gases also affect the proper operation of the membranes, so high concentrations should be avoided for optimal operation. Current methods to regulate the concentrations of gases and oxidizing agents are very expensive and inefficient.

[0020] On the other hand, blocking of reverse osmosis membranes is largely responsible for the large inefficiencies that arise because of various reasons, for example, higher pressures need to be applied on the feed water to pass through the membrane, major downtime is caused by the constant maintenance and washing that has to be performed, and the high replacement costs of supplies used in the process. The blocking of the membranes is caused by three major problems: biofouling, scaling and colloidal fouling.

[0021] Biofouling is caused by the growth of colonies of bacteria or algae on the surface of the membrane. Because chlorine cannot be used, the risk of developing a film of biomass exists, thus preventing the passage of water supply and reducing the efficiency of the system.

[0022] Another major problem that causes blockage of the membrane is scaling which finally causes their obstruction. Scaling refers to precipitation and deposits of moderately

soluble salt on the membranes. In fact, under certain operating conditions, the solubility limits of some of the components present in the feed water may be exceeded, allowing precipitation. These components include calcium carbonate, magnesium carbonate, calcium sulfate, silica, barium sulfate, strontium sulfate and calcium fluoride, among others. In reverse osmosis units, the final stage is subject to the highest concentration of dissolved salts, and this is where the first signs of scaling begin to appear. Scaling due to precipitation is amplified by the phenomenon of concentration gradient on the surface of the membranes.

[0023] Obstruction by particles or colloidal fouling occurs when the water supply contains a large amount of suspended particles and colloidal matter, requiring constant washing to clean the membranes. The concentration of particles in water can be measured and expressed in different ways. The most used parameter is the turbidity, which must be maintained at low levels for proper operation. The accumulation of particles on the surface of the membrane can adversely affect both the feed water flow and the rejection properties of reverse osmosis membrane. The colloidal fouling is caused by the accumulation of colloidal particles on the surface of the membrane and the formation of a layer with a cake form. The decrease in permeate flux is given on the one hand by the formation of a cake layer, and on the other hand, because of the high concentration of salt in the membrane surface caused by the obstructed diffusion of salt ions, causing an increased osmotic pressure which reduces the net force impulse. The monitored parameter to prevent colloidal fouling is the Silt Density Index (SDI), and membrane manufacturers suggest SDI's of up to 4. Blockage of the membranes can also occur due to fouling by Natural Organic Matter (NOM). The natural organic matter clogs the membrane either because: the narrowing of pores associated with the adsorption of natural organic matter on the walls of the pores, colloidal organic matter which acts as a stopper at the opening of the pores, or forming a continuous layer of gel that coats the surface of the membrane. This layer creates great inefficiencies and clogging of this layer should therefore be avoided at all costs.

[0024] Currently, the pretreatment of water before entering the desalination process generally includes the following steps:

[0025] 1. Chlorination to reduce organic and bacteriological load in raw water

[0026] 2. Sand filtration to reduce turbidity

[0027] 3. Acidification to reduce pH and reduce calcareous processes

[0028] 4. Inhibition of calcium and barium scales using antiscalants

[0029] 5. Dechlorination to remove residual chlorine

[0030] 6. Particle filtering cartridges required by membrane manufacturers

[0031] 7. Microfiltration (MF), Ultrafiltration (UF) and Nanofiltration (NF)

[0032] Among the pretreatment steps above, the costs of filtration steps, either with sand filters or more sophisticated filtration steps such as microfiltration, ultrafiltration or nanofiltration, leads to high costs along with a number of drawbacks. In particular, if the pretreatment is inadequate, the filters become clogged with organic matter, colloids, algae, microorganisms, and/or larvae. In addition, the requirement to filter the total volume of water to be processed in the plant to reduce turbidity and remove particles imposes severe restrictions in terms of energy, implementation and installa-

tion costs, as well as during the operation in terms of maintenance and replacement of filters. In addition, pretreatment systems today are very inefficient and have high costs due to the devices to be implemented, and the continuing operating and maintenance tasks that are costly and difficult to perform.

**[0033]** In summary, increasingly scarce freshwater resources has created a worldwide supply problem that has resulted in the design and implementation of various desalination technologies. Reverse osmosis desalination is a promising technology for addressing the increasing scarcity of freshwater resources, and this technology is projected to have significant growth in the future. However, a cost effective and energy efficient means of pretreating the feed water poses a significant problem for reverse osmosis desalination plants. An efficient technology that operates at low costs and is able to produce water of sufficient quality for its use as raw material in desalination processes is needed.

#### Aquaculture Industry

**[0034]** The aquaculture industry is focused on farming of aquatic species, plants and animals, from which raw materials for food, chemical, and pharmaceutical industries, among others, is obtained. The aquatic species are grown in fresh or sea water, where mainly fish, mollusks, crustaceans, macroalgae and microalgae are cultivated. Due to industry growth, development of new technologies, and environmental regulations imposed by the international community, there is a need to minimize the environmental impact of the aquaculture industry while at the same time maintaining adequate control of the operation conditions. To do this, the cultivation of aquatic species have migrated from being located in situ in natural water sources, such as the sea, to facilities built specifically for such purposes.

**[0035]** Besides the traditional culture of these species as raw material in food, pharmaceutical industries and general manufacturing, aquatic species are also used in the energy sector to generate energy from renewable non-conventional sources, in particular, for the production of biofuels such as biodiesel from microalgae.

**[0036]** With regard to biofuels, it should be noted that the global energy matrix is organized around fossil fuels (oil, gas and coal), which provide about 80% of global energy consumption. Biomass, hydroelectric, and other "non-conventional" energy sources, such as solar energy, are renewable energy sources. Within the latter group, and representing only 2.1% of the matrix, are comprised eolic energy, solar energy, and biofuels, which in turn include biogas, biodiesel and ethanol, mainly.

**[0037]** Because the sources of fossil and nuclear energy are finite, future demand may not be supplied. Accordingly, energy policy in developing countries is considering the introduction of alternative energies. Additionally, the abuse of conventional energy like oil and coal, among others, lead to problems such as pollution, increased greenhouse gases and the depletion of the ozone layer. Therefore, the production of clean, renewable, and alternative energies is an economic and environmental need. In some countries, the use biofuels blended with petroleum fuels, has forced massive and efficient production of biodiesel, which can be obtained from vegetable oil, animal fats and algae.

**[0038]** The production of biodiesel from algae does not require the extensive use of agricultural land. Thus, it does not affect food production worldwide, because the algae can grow in reduced spaces and have very fast growth rates, with biomass doubling times of 24 hours. Consequently, algae are a source of continuous and inexhaustible energy production,

and also absorb carbon dioxide for their growth, which can be captured from various sources such as thermal power stations.

**[0039]** The main systems for microalgae growth correspond to:

**[0040]** Lakes: Since algae require sun light, carbon dioxide, and water, they can be grown in lakes and open ponds.

**[0041]** Photo bioreactors: A photo bioreactor is a controlled and closed system including a source of light, which by being closed require the addition of carbon dioxide, water and light.

**[0042]** With respect to lakes, algae cultivation in open ponds has been extensively studied. This category of ponds are natural water bodies (lakes, lagoons, ponds, sea) and artificial ponds or containers. The most commonly used systems are large ponds, tanks, circular ponds and shallow raceway ponds. One of the main advantages of open ponds is that they are easier to construct and operate than most closed systems. However, the main constraints in natural open ponds are evaporation losses, requiring large surface of land, pollution from predators and other competitors in the pond, and the inefficiency of the agitation mechanisms resulting in low biomass productivity.

**[0043]** To this end, "raceway ponds" were created, which are operated continuously. In these ponds, the algae, water and nutrients are circulated in a type of racetrack, and are mixed with the aid of paddle wheels, to re-suspend the algae in the water, so that they are in constant movement and always receive sunlight. The ponds are shallow due to the need of algae for light, and that the penetration of sunlight reaches a limited depth.

**[0044]** Photo bioreactors allow the cultivation of a single species of microalgae for a long time and are ideal for producing a large biomass of algae. Photo bioreactors generally have a diameter less than or equal to 0.1 m, because a greater range would prevent light from entering the deeper zones, as the crop density is very high, in order to achieve a high yield. The photo bioreactors require cooling during daylight hours, and also need temperature control at night. For example, the loss of biomass produced at night can be reduced by lowering the temperature during these hours.

**[0045]** The biodiesel production process depends on the type of algae grown, which are selected based on performance and adaptation characteristics to environmental conditions. Microalgae biomass production is started in photo bioreactors, where CO<sub>2</sub> that generally comes from power plants is fed. Later, before entering the stationary growth phase, the microalgae are transported from photo bioreactors to tanks of greater volume, where they continue to develop and multiply, until the maximum biomass density is reached. The algae are then harvested by different separation processes, to obtain algal biomass, which is ultimately processed to extract bio-fuel products.

**[0046]** For the cultivation of microalgae, virtually sterile purified water is required, as productivity is affected by the contamination of other unwanted species of algae or micro-organisms. The water is conditioned according to specific culture medium, also depending on the needs of the system.

**[0047]** The key factors to control the rate of algal growth are:

**[0048]** Light: Needed for the photosynthesis process

**[0049]** Temperature: ideal range of temperature for each type of algae

- [0050] Medium: water composition is an important consideration, for example, salinity
- [0051] pH: usually algae require a pH between 7 and 9 to obtain an optimal growth rate
- [0052] Strain: each algae has a different growth rate
- [0053] Gases: Algae require CO<sub>2</sub> to perform photosynthesis
- [0054] Mixing: to avoid algae settling and warranty homogeneous exposition to light
- [0055] Photoperiod: cycles of light and darkness
- [0056] Algae are very tolerant to salinity, most of the species grow better with a salinity that is slightly inferior to the salinity found in the algae's natural environment, which is obtained by dilution of seawater with fresh water.

#### Drinking Water Industry

[0057] The water industry provides drinking water to residential, commercial, and industrial sectors of the economy. In order to provide potable water, the industry generally begins its operations with the collection of water from high microbiological quality and clarity natural sources, which is then stored in reservoirs for future use. The water can be stored for long periods of time in the reservoir without being used. The quality of water stored for long period of time begins to deteriorate as microorganisms and algae proliferate in the water, making the water unsuitable for human consumption.

[0058] Since the water is no longer suitable for consumption, it must be processed in a potable water treatment plant, where it passes through various stages of purification. In the purification plants, chlorine and other chemicals are added in order to produce high quality water. Reaction of chlorine with the organic compounds present in the water can produce several toxic by-products or disinfection by-products (DBP). For example, in the reaction of chlorine with ammonia, chloramines are undesired by-products. Further reaction of chlorine or chloramines with organic matter will produce trihalomethanes, which have been indicated as carcinogenic compounds. Also, depending on the disinfection method, new DBPs have been identified, such as iodinated trihalomethanes, haloacetonitriles, halonitromethanes, haloacetaldehydes, and nitrosamines. Furthermore, exposure of bathers to chlorine and organic matter has been mentioned as a factor contributing to potential respiratory problems, including asthma.

#### Wastewater Industries

[0059] Wastewater is treated every day to produce clean water used for different purposes. There is a need to treat wastewater producing small amounts of sludge and waste, and also using less chemicals and energy.

#### Mining Industry

[0060] Mining is a very important industry throughout the world, and highly collaborates to each nation's economy. Mining industries require water for many of their processes, a resource that is limited and that everyday becomes scarcer. Some mining industries have developed technologies for utilizing seawater in the majority of their processes, being able to operate only with this resource.

[0061] The mines themselves are generally located at great distances and heights from the coastal line, therefore the water has to travel many kilometers to reach the mines. To transport the large quantities of water, pumping stations have

been constructed, along with very long pipes, in order to pump the water from the sea to the mines.

[0062] The pumping stations consist on structures that comprise high power pumps, which send the collected seawater to the next pumping station, and so on. The pumping stations also comprise a containing structure to maintain seawater in case of any problems that could occur in the previous pumping stations. These containing structures eventually can develop diverse problems that affect the pumping process, like the biofouling of the walls and the inner surfaces of the pipes. Biofouling causes the deterioration of the materials as well as a reduction of the transversal area of the pipes, imposing higher operational and maintenance costs. Also, the water inside of the containing structures begins to deteriorate because of the microalgae growth, which negatively interferes with the station processes, and leads to diverse and important problems such as biofouling.

#### Industrial Liquid Residuals Treatment

[0063] Some industries have liquid residuals that may not comply with irrigation, infiltration, or discharging requirements imposed by local government. Also, some industries have settling tanks or other containment means to allow natural processes in the water to occur, such as the emission of gases or other substances that cause bad odor or color properties.

[0064] As discussed above, current methods and systems for treating water for industrial uses have high operating costs, require the use of large amounts of chemicals, are prone to fouling, produce undesirable by-products such as gases and other substances that cause bad odor or color properties, and require filtration of the entire volume of water. Improved methods and systems of treating water for industrial use that are low cost and more efficient than conventional water treatment filtration systems are desirable.

#### Previous Art

[0065] Patent JP2011005463A presents a control system for the injection of coagulants and flocculants in water purification plants. Said system is based in the use of a turbidity sensor that measures the quantity and quality of water before adding the coagulants and flocculants. The system uses a classifier that measures flocculant size after settling and classifies the treated water according to these measurements. According to the turbidity measurements, the control system calculates the coagulant and flocculants injection rate, which are applied by installations destined for this means. The calculations of the dosed compounds are corrected according to a function that determines a correction factor in accordance to the turbidity measured before and after the treatment. After the settling of the particles, there is a filtration stage that filters the whole treated water volume.

[0066] The disadvantages of patent JP2011005463A are that it does not control the organic content or the microorganisms present in the water, as the system does not comprise the use of disinfectant or oxidizing agents. Also, the system in JP2011005463A does not reduce the metal content in the water and relies on the constant measure of the parameters, therefore having high demands in terms of sensors and other measuring devices. Furthermore, patent JP2011005463A requires filtering the totality of the water volume that is

treated, which imposes high energy demands and high installation and maintenance costs regarding the system required for such filtration.

### SUMMARY

**[0067]** This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify required or essential features of the claimed subject matter. Nor is this summary intended to be used to limit the scope of the claimed subject matter.

**[0068]** The method and system constructed in accordance with the principles of the present invention purify water and remove suspended solids, metals, algae, bacteria, and other items from the water at very low costs, and without the need of filtering the totality of the water volume. Only a small fraction of the total volume of the water is filtered, up to 200 times less than the flow filtered by conventional water treatment filtration systems. The treated water can be used for industrial purposes such as treating water which will be used as a raw material in industrial purposes, or treating industrial liquid residuals for infiltration, irrigation, discharging, or other purposes.

**[0069]** Relating to reverse osmosis desalination, the present invention provides a method and system for the pretreatment and maintenance of feed water that uses fewer chemicals and consumes less energy than conventional pretreatment technologies.

**[0070]** Relating to the aquaculture industry, the water produced by the present invention achieves the characteristics required for algae inoculation using a filtering means that requires the filtering of only a fraction of the total volume of water. The present invention provides water of high microbiological quality that is used for the inoculation of microalgae and other microorganisms. The use of the treated water in, for example, raceway ponds, represents a high reduction in costs, since one of the main problems of this industry is preparing the water for the inoculation. Also, the present invention allows for the treatment of the water after the algae has grown and it has been harvested. Therefore, the water can be reused creating a sustainable method for the aquaculture industry.

**[0071]** By using the method and system of the present invention in drinking water industries, water stored in reservoirs can be maintained at very low costs without the proliferation of microorganisms and algae which can deteriorate the water quality. Thus, drinking water treated according to the method and system of the present invention does not need to be processed in a potable water treatment plant. The present invention therefore minimizes the generation of toxic by-products and disinfection by-products (DBPs) produced by the potable water treatment plant and reduces capital costs, amounts of chemicals used, operating costs and the environmental impact and footprint of a potable water treatment plant. The present invention maintains water from very pure natural sources in a high microbiological quality state at low costs in an environmentally friendly manner without deterioration or generation of toxic DBPs.

**[0072]** The present invention can be used for treating water that comes from wastewater treatment facilities at very low cost, removing odor and obtaining high clarity water with low turbidity levels. The amounts of waste and sludge are consid-

erably reduced compared to conventional wastewater treatments, thereby providing a sustainable method which is environmentally friendly.

**[0073]** Regarding mining industries, the present invention relates to a method and system for treating water that prevents biofouling in pumping stations, thus reducing operating and maintaining costs. The present invention can also be used for treating industrial liquid residuals coming from diverse industries, in order to comply with the irrigation, infiltration, or discharging requirements imposed by the local governments.

**[0074]** The method and system of the invention provides a low cost process for treating water for use in industrial processes that, unlike conventional water treatment filtration systems, purifies the water and eliminates suspended solids in the water by filtering a small fraction of the total volume of water. In an embodiment, the method of the invention comprises:

**[0075]** a. Collecting water with a concentration of total dissolved solids (TDS) of up to 60,000 ppm;

**[0076]** b. Storing said water in at least one containing means, where said containing means has a bottom able to be thoroughly cleaned by a mobile suction means;

**[0077]** c. Within periods of 7 days:

**[0078]** i. For water temperatures up to 35 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour for each degree Celsius of water temperature, by adding disinfectant agents to the water;

**[0079]** ii. For water temperatures greater than 35 degrees Celsius and up to 69 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of hours by adding disinfectant agents to the water, wherein the minimum period of hours is calculated by the following equation:

$$[35 \text{ hours}] - [\text{temperature of the water in degrees Celsius} - 35] = \text{minimum period of hours; and}$$

**[0080]** iii. For water temperatures of 70 degrees Celsius or more, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour.

**[0081]** d. Activating the following processes through a coordination means, where the processes purify the water and eliminate the suspended solids by only filtering a small fraction of the total volume of water:

**[0082]** i. Applying oxidant agents to avoid the iron and manganese concentrations to exceed 1 ppni;

**[0083]** ii. Applying coagulants, flocculants, or a mixture of them to avoid the turbidity to exceed 5 NTU;

**[0084]** iii. Suctioning the water flow that contains the settled particles, produced by the previous processes, with a mobile suction means to avoid the thickness of the settled material to exceed 100 mm in average;

**[0085]** iv. Filtering the flow suctioned by the mobile suction means, with at least one filtration means; and

**[0086]** v. Returning the filtered water to said at least one containing means;

**[0087]** e. Utilizing said treated water in a downstream process.

**[0088]** In an embodiment, the system of the invention comprises:

**[0089]** at least one feeding line of water (7) to at least one containing means (8);

**[0090]** at least one containing means (8), which comprises a receiving means for settled particles (17), that is fixed to the bottom of said containing means;

[0091] at least one coordination means (1), where the coordination means timely activates the necessary processes to adjust parameters of the water within limits specified by an operator or the coordination means;

[0092] at least one chemical application means (4), which is activated by said at least one coordination means

[0093] at least one mobile suction means (5), which moves through the bottom of said at least one containing means suctioning the water flow containing the settled particles;

[0094] at least one propelling means (6) that provides movement to said at least one mobile suction means so it can move through the bottom of said at least one containing means;

[0095] at least one filtration means (3) that filters the water flow containing the settled particles;

[0096] at least one collecting line (15) coupled between said at least one mobile suction means and said at least one filtration means;

[0097] at least one return line (16) from said at least one filtration means to said at least one containing means; and

[0098] at least one water feeding line (18) from said at least one containing means to at least one downstream process.

[0099] In the system, the receiving means is generally covered with a material comprising membranes, geo-membranes, geotextile membranes, plastic liners, concrete, or coated concrete, or a combination thereof. The coordination means is capable of receiving information, processing that information, and activating other processes, such as the chemical application means, mobile suction means, and the filtration means. The chemical application means generally includes injectors, sprinklers, manual application, dispensers by weight, pipes, or a combination thereof. The propelling means drives the mobile suction means and typically includes a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine, a floating device with an engine, or a combination thereof. The filtration means includes a cartridge filter, sand filter, micro-filter, ultra-filter, nano-filter, or a combination thereof and is generally connected to the mobile suction means by a collecting line comprising a flexible hose, rigid hose, pipe, or a combination thereof.

[0100] The present invention addresses diverse environmental problems arising from water treatment processes. The inventor of the novel technology disclosed herein, Mr. Fernando Fischmann, has developed many new advances in water treatment technology that are rapidly being adopted throughout the world. In a short period of time, the inventor's technologies related to recreational crystalline lagoons have been incorporated into more than 180 projects throughout the world. The inventor and his advancements in water treatment technology have been the subject of more than 2,000 articles, as can be seen at <http://press.crystal-lagoons.com/>. The inventor has also received important international awards for innovation and entrepreneurship related to these advances in water treatment technology and has been the subject of interviews by major media outlets including CNN, BBC, FUJI, and Bloomberg's Businessweek.

[0101] Both the foregoing summary and the following detailed description provide examples and are explanatory

only. Accordingly, the foregoing summary and the following detailed description should not be considered to be restrictive. Further, features or variations may be provided in addition to those set forth herein. For example, certain embodiments may be directed to various feature combinations and sub-combinations described in the detailed description.

#### BRIEF DESCRIPTION OF THE FIGURES

[0102] FIG. 1 is a process flow diagram illustrating water treatment in an embodiment of the invention.

[0103] FIG. 2 shows a top view of the water containing structure, such as a lagoon, in an embodiment of the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

[0104] The following detailed description refers to the accompanying drawings. While embodiments of the invention may be described, modifications, adaptations, and other implementations are possible. For example, substitutions, additions, or modifications may be made to the elements illustrated in the drawings, and the methods described herein may be modified by substituting, reordering, or adding stages to the disclosed methods. Accordingly, the following detailed description does not limit the scope of the invention. While systems and methods are described in terms of "comprising" various apparatus or steps, the systems and methods can also "consist essentially of" or "consist of" the various apparatus or steps, unless stated otherwise.

#### DEFINITIONS

[0105] In the light of the present disclosure, the following terms or phrases should be understood with the meanings described below.

[0106] The terms "container" or "containing means" are used generically herein to describe any artificial large body of water, including artificial lagoons, artificial lakes, artificial ponds, pools, and the like.

[0107] The term "coordination means" is used generically herein to describe an automated system that is able to receive information, process it, and make a decision according to it. In a preferred embodiment of the invention, this could be done by a person, but more preferably with a computer connected to sensors.

[0108] The term "chemical application means" is used generically herein to describe a system that applies chemicals into the water.

[0109] The term "mobile suction means" is used generically herein to describe a suctioning device that is able to travel across the bottom surface of the containing means and suction the settled material.

[0110] The term "propelling means" is used generically herein to describe a propelling device that provides movement, either by pushing or pulling another device.

[0111] The term "filtration means" is used generically herein to describe a filtration system, encompassing terminology such as filter, strainer, separator, and the like.

[0112] As used herein, the general types of water and their respective Total Dissolved Solids (TDS) concentration (in mg/L) are fresh water, with  $TDS \leq 1,500$ ; brackish water, with  $1,500 \leq TDS \leq 10,000$ ; and seawater, with  $TDS > 10,000$ .

[0113] As used herein, the term "high microbiological water quality" comprises a preferred aerobic bacteria count of

less than 200 CFU/ml, more preferably of less than 100 CFU/ml, and most preferably of less than 50 CFU/ml.

[0114] As used herein, the term "high clarity" comprises a preferred turbidity level of less than 10 Nephelometer Turbidity Units (NTU), more preferably of less than 7 NTU, and most preferably of less than 5 NTU.

[0115] As used herein, the term "low fouling levels" comprises a preferred SDI index of less than 6, more preferably of less than 5, and most preferably of less than 4.

[0116] As used herein, the term "small fraction" corresponding to the filtrated water volume comprises a flow of up to 200 times less than the flow filtrated in traditionally configured water treatment filtration systems.

[0117] As used herein, the term "traditional water treatment filtration systems" or "conventional water treatment filtration system" comprises a filtration system that filters the entire water volume that has to be treated, from 1 to 6 times per day.

#### MODES FOR CARRYING OUT THE INVENTION

[0118] The present invention relates to a method and system for treating water at low cost. The method and system of the invention purifies the water and eliminates suspended solids from the water without the need of filtering the totality of the water volume. The present invention filters only a small fraction of the entire volume of water, corresponding to a flow up to 200 times smaller than for traditional water treatment methods. Treated water produced by the method and system of the invention can be used for industrial purposes, such as a raw material in industrial purposes. The method and system of the invention can also be used to treat industrial liquid residuals in order to make the liquid residuals suitable for infiltration, irrigation, discharging, or other purposes.

[0119] Water treated by a method or system of the invention can be freshwater, brackish water, or seawater. The method and system includes a coordination means that allows the timely activation of the processes required to adjust the controlled parameters within limits specified by the operator. The present invention uses far less chemicals than traditional water treatment systems, since it applies the chemicals according to the systems' necessities by using an algorithm that depends on the water temperature, thus avoiding having to maintain permanent concentrations of chemicals in the water, which result in higher operational costs.

[0120] A system of the invention generally includes at least one containing means, at least one coordination means, at least one chemical application means, at least one mobile suction means, and at least one filtration means. FIG. 1 illustrates an embodiment of a system of the invention. The system includes a containing means (8). The size of the containing means is not particularly limited, however, in many embodiments the containing means can have a volume of at least 15,000 m<sup>3</sup>, or alternatively, at least 50,000 m<sup>3</sup>. It is contemplated that the container or containing means can have a volume of 1 million m<sup>3</sup>, 50 million m<sup>3</sup>, 500 million m<sup>3</sup>, or more.

[0121] The containing means (8) has a bottom able to receive bacteria, algae, suspended solids, metals, and other particles that settle from the water. In an embodiment, the containing means (8) includes a receiving means (17) for receiving the settled particles or materials from the water being treated. A receiving means (17) is affixed to the bottom of the containing means (8) and preferably is constructed of a non-porous material capable of being cleaned. The bottom of the containing means (8) is generally covered with the non-

porous material allowing the mobile suction means (5) to travel across the entire inferior surface of the containing means (8) and suction the settled particles produced by any of the processes disclosed herein. The non-porous materials can be membranes, geo-membranes, geotextile membranes, plastic liners, concrete, coated concrete, or combinations thereof. In a preferred embodiment of the invention, the bottom of the containing means (8) is covered with plastic liners.

[0122] The containing means (8) can include an inlet line (7) for feeding water to the containing means (8). The inlet line (7) allows for the refilling of the containing means (8) due to evaporation, consumption of water due to usage in an industrial process, and other losses of water.

[0123] The system includes at least one coordination means (1) which can control the necessary processes depending on the system needs (e.g., water quality or purity). Such processes can include activation (13) of a chemical application means (4) and the activation (11) of a mobile suction means (5). The coordination means (1) can vary the flow of treated water to the industrial process (2) based on information (12) such as output or production rate. The controlling means also may receive information (9) about the inlet line (7), as well as receiving information (10) about the water quality and settled material thickness at the bottom of the containing means (8).

[0124] The coordination means (1) allows for the addition of chemicals to the containing means (8) only when they are actually needed, avoiding the need to maintain a permanent concentration in the water by applying an algorithm that depends on water temperature. Thus, there can be a considerable reduction in the amount of chemicals used, of up to 100 times as compared to conventional water treatment protocols, which decreases operating costs. The coordinating means (1) can receive information (10) regarding the water quality parameters that are controlled, and can timely activate the processes necessary to adjust said quality parameters within their respective limits. The information (10) received by coordinating means (1) can be obtained by visual inspection, empirical methods, algorithms based on experience, by electronic detectors, or combinations thereof. Coordinating means (1) can comprise one or more people, electronic devices, any means capable of receiving information, processing that information, and activating other processes, and this includes combinations thereof. One example of a controller means is a computing device, such as a personal computer. Coordinating means (1) can also include sensors utilized to receive information (10) regarding the water quality parameters.

[0125] The chemical application means (4) is activated by the coordination means (1) and applies or dispenses chemicals (14) into the water. Chemical application means (4) include, but are not limited to, injectors, sprinklers, manual application, dispensers by weight, pipes, and combinations thereof.

[0126] The mobile suction means (5) moves along the bottom of the containing means (8), suctioning water containing settled particles and materials produced by any of the processes disclosed herein. A propelling means (6) is coupled to the mobile suction means (5) allowing the mobile suction means (5) to travel across the bottom of the containing means (8). The propelling means (6) drives the mobile suction means (5) by using a system selected from a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine or a floating device with an engine, or combi-

nations thereof. In a preferred embodiment of the invention, the propelling means is a boat with an engine.

[0127] The water suctioned by the mobile suction means (5) can be sent to a filtration means (3). The filtration means (3) receives the flow of water suctioned by the mobile suction means (5) and filters the suctioned water containing the settled particles and materials, thus eliminating the need to filter the totality of the water volume (e.g., only filtering a small fraction). The filtration means (3) includes, but is not limited, cartridge filters, sand filters, micro-filters, nano-filters, ultra-filters, and combinations thereof. The suctioned water can be sent to the filtration means (3) by a collecting line (15) connected to the mobile suction means (5). The collecting line (15) can be selected from flexible hoses, rigid hoses, pipes of any material, and combinations thereof. The system can include a return line (16) from the filtration means (3) back to the containing means (8) to return the filtered water.

[0128] The system can also include a water outlet line (18) that provides treated water from the containing means (8) to the industrial process (2). Examples of the industrial process include, but are not limited to, reverse osmosis, desalination, evaporation, purification, algae cultivation, an aquaculture process, a mining process, and combinations thereof. The industrial process can use the treated water as raw material (21) for its processes, or it can apply the method in order to treat residual water (22) for different purposes, such as maintenance purposes, irrigation, infiltration, or discharge purposes, among others. The predetermined parameter limits depend on the requirements of the industrial process (2). The industrial process (2) can in turn modify the limits (12) in order to adjust to its processes.

[0129] FIG. 2 shows a top view of a system of the invention. Containing means (8) can include a feeding pipe system (7) that allows for refilling of the containing means (8) due to evaporation, consumption of water in an industrial process, or other loss of water from the containing means (8). The containing means (8) can also include injectors (19) arranged along the perimeter of the containing means (8) for applying or dispensing chemicals into the water. The containing means (8) can also include skimmers (20) for removing surface oils and particles.

[0130] In an embodiment, a system of the invention includes the following elements:

[0131] at least one feeding line of water (7) to at least one containing means (8);

[0132] at least one containing means (8), which comprises a receiving means for the settled particles (17) produced by any of the processes disclosed herein, that is fixed to the bottom of said containing means;

[0133] at least one coordination means (1), where the coordination means timely activates the necessary processes to adjust the parameters within their limits;

[0134] at least one chemical application means (4), which is activated by said at least one coordination means

[0135] at least one mobile suction means (5), which moves through the bottom of said at least one containing means suctioning the water flow containing the settled particles produced by the any of the processes disclosed herein;

[0136] at least one propelling means (6) that provides movement to said at least one mobile suction means so it can move through the bottom of said at least one containing means;

[0137] at least one filtration means (3) that filtrates the water flow containing the settled particles, thus not needing to filter the totality of the water volume, but only filtering a small fraction;

[0138] at least one collecting line (15) coupled between said at least one mobile suction means and said at least one filtration means;

[0139] at least one return line (16) from said at least one filtration means to said at least one containing means; and

[0140] at least one water outlet line (18) from said at least one containing means to a downstream process.

[0141] This same system allows for the elimination of other compounds that are susceptible to settling by the addition of a chemical agent, since the mobile suction means (5) will suction all the settled particles from the bottom of the containing means (8).

[0142] The method of the invention for treating water can be performed at low costs compared to traditional water treatment systems, as the present invention uses less chemicals and consumes less energy than traditional water treatment systems. In one aspect, the present method uses significantly less chemicals compared to traditional water treatment systems because it applies an algorithm that allows maintaining an ORP of at least 500 mV for a certain period of time depending on the temperature of the water, which maintains water having high microbiological quality according to the needs of the process in which the water will be used. The present method is carried out on a system as described herein that includes a coordination means (1). The coordination means determines when to apply the chemicals to the water in order to adjust the controlled parameters within their limits, based on the information received from the system. Since a coordination means is used, the chemicals are applied only when they are needed, avoiding the need to maintain a permanent concentration of the chemicals in the water. Thus, there is a considerable reduction on the amount of chemicals, of up to 100 times less than traditional water treatment systems, which decreases operating and maintaining costs.

[0143] In another aspect, the method and system of the invention filters only a small fraction of the total volume of water within a particular time frame compared to conventional water treatment filtration systems that filter a much larger volume of water in the same time frame. In an embodiment, the small fraction of the total volume of water is up to 200 times smaller than the flow processed in traditionally configured centralized filtration systems, which filter the totality of the water volume within the same time frame. The filtering means in the method and system of the invention operates at shorter periods of time due to the orders received from the coordination means, thus the filtering means has a very small capacity, and up to 50 times lower capital costs and energy consumption compared to the centralized filtering unit required in the processing of water with traditional methods.

[0144] The method and system of the invention allow for the treatment of water at low costs. The method and system remove metals, bacteria, algae, and the like from the water and provide treated water having low fouling levels, measured as the Silt Density Index (SDI). Thus, the method and system provide high microbiological quality and clarity water that can be used for industrial purposes. In an embodiment, the method and system of the invention can treat water which will be used as raw material in industrial purposes. The method and system can also be used to treat industrial liquid residuals for infiltration, irrigation, discharging, or other purposes using less chemicals than conventional water treatment

systems and without filtering the entire volume of water as in conventional water treatment systems.

[0145] In an embodiment, the method of the invention includes the following stages:

[0146] a. Collecting water (7) with a concentration of total dissolved solids (TDS) of up to 60,000 ppm;

[0147] b. Storing said water in at least one containing means (8), where said containing means has a bottom (17) able to be thoroughly cleaned by a mobile suction means;

[0148] c. Within periods of 7 days:

[0149] i. For water temperatures up to 35 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour for each degree Celsius of water temperature, by adding disinfectant agents to the water;

[0150] ii. For water temperatures greater than 35 degrees Celsius and up to 69 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of hours by adding disinfectant agents to the water, wherein the minimum period of hours is calculated by the following equation:

$$[35 \text{ hours}] - [\text{Temperature of the water in degrees Celsius} - 35] = \text{minimum period of hours; and}$$

[0151] iii. For water temperatures of 70 degrees Celsius or more, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour.

[0152] d. Activating the following processes through a coordination means (1), where the processes eliminate the suspended solids by filtering only a small fraction of the total water volume, thus replacing the conventional water treatments that filter the totality of the water volume:

[0153] i. Applying oxidant agents to avoid the iron and manganese concentrations to exceed 1 ppm;

[0154] ii. Applying coagulants, flocculants, or a mixture of them to avoid the turbidity to exceed 5 NTU;

[0155] iii. Suctioning the water flow that contains the settled particles, produced by the previous processes, with a mobile suction means (5) to avoid the thickness of the settled material to exceed 100 mm in average;

[0156] iv. Filtering the flow suctioned by the mobile suction means (5), with at least one filtration means (3); and

[0157] v. Returning the filtered water to said at least one containing means (8);

[0158] e. Utilizing said treated water in a downstream process.

[0159] Water treated by the method of the invention can be provided by a natural water source, such as oceans, groundwater, lakes, rivers, treated water, or combinations thereof. The water can also be provided by an industrial process in which liquid residuals from the industrial process are treated according to the method of the invention so that the treated liquid residuals can be used for infiltration, discharging, irrigation, or other purposes.

[0160] Disinfectant agents can be applied to the water by a chemical application means (4), in order to maintain an ORP level of at least 500 mV for a minimum period of time according to the temperature of the water, within periods of 7 days at a time. The disinfectant agents include, but are not limited to, ozone, biguanide products, algaecide and antibacterial agents such as copper products; iron salts; alcohols; chlorine and chlorine compounds; peroxides; phenolic compounds; iodophors; quaternary amines (polyquats) in general, such as

benzalkonium chloride and S-Triazine; peracetic acid; halogen-based compounds; bromine based compounds, and combinations thereof.

[0161] If the water temperature is up to 35 degrees Celsius, an ORP level of at least 500 mV is maintained for a minimum period of 1 hour for each degree Celsius of water temperature. For example, if the water temperature is 25 degrees Celsius, an ORP level of at least 500 mV is maintained for a minimum period of 25 hours, which can be distributed along the 7 day period.

[0162] If the water temperature is greater than 35 degrees Celsius and up to 69 degrees Celsius, an ORP level of at least 500 mV is maintained for a minimum period of hours which is calculated by the following equation:

$$[35 \text{ hours}] - [\text{Temperature of the water in degrees Celsius} - 35] = \text{minimum period of hours}$$

[0163] For example, if the water's temperature is 50 degrees Celsius, an ORP level of at least 500 mV is maintained for a minimum period of 20 hours  $[(35) - (50 - 35)]$ , which can be distributed along the 7 day period.

[0164] Finally, if the water temperature is 70 degrees Celsius or more, an ORP level of at least 500 mV is maintained for a minimum period of 1 hour.

[0165] Oxidant agents can be applied or dispersed into the water to maintain and/or prevent the iron and manganese concentrations from exceeding 1 ppm. Suitable oxidant agents include, but are not limited to, permanganate salts; peroxides; ozone; sodium persulfate; potassium persulfate; oxidants produced by electrolytic methods, halogen based compounds, and combinations thereof. Generally, the oxidant agents are applied or dispersed in to the water by a chemical application means (4).

[0166] A flocculant or coagulant agent can be applied or dispersed into the water to aggregate, agglomerate, coalesce, and/or coagulate suspected particles in the water, which then settle to the bottom of the containing means (8). Generally, flocculant or coagulant agents are applied or dispersed in to the water by a chemical application means (4). Suitable flocculant or coagulant agents include, but are not limited to polymers such as cationic polymers and anionic polymers; aluminum salts, such as aluminum chlorohydrate, alum, and aluminum sulfate; quats and polyquats; calcium oxide; calcium hydroxide; ferrous sulphate; ferric chloride; polyacrylamide; sodium aluminate; sodium silicate; natural products, such as chitosan, gelatin, guar gum, alginates, moring a seeds; starch derivatives; and combinations thereof. The fraction of water in which the floccules collect or settle is generally the layer of water along the bottom of the container. The floccules form a sediment at the bottom of the containing means (8) that can then be removed by the mobile suction means (5) without requiring that all of the water in the containing means (8) be filtered, e.g., only a small fraction is filtered.

[0167] The chemical application means (4) and mobile suction means (5) in the method and system of the invention are timely activated by a coordination means (1), in order to adjust the controlled parameters within their limits. The chemical application means (4) and mobile suction means (5) are activated according to the system's needs, which allows for the application of significantly less chemicals compared to conventional water treatment systems, and for the filtering of a small fraction of the total volume of water, up to 200 times smaller, compared to conventional water treatment filtration systems that filter the totality of the water volume within the same time frame.

[0168] In the method and system disclosed herein, the coordination means (1) can receive information (10) regarding the water quality parameters within their respective limits. The

information received by the coordination means can be obtained by empirical methods. The coordination means (1) is also capable of receiving information, processing that information, and activating the required processes according to that information, including combinations thereof. One example of a coordination means is computing device, such as a personal computer, connected to sensors which allow for measuring of the parameters and activation of the processes according to such information.

[0169] The coordination means (1) provides information (13) to the chemical application means (4) about the dosage and addition of the suitable chemicals and instructions for activating the chemical application means (4) to maintain the controlled parameters within their limits. The coordination means (1) also provides information (11) to activate the mobile suction means (5). The coordination means can simultaneously activate the filtration means (3) in order to filter the flow suctioned by the mobile suction means (5), filtering only a small fraction of the entire volume of water. The mobile suction means (5) is activated (11) by the coordination means (1) to avoid the thickness of the settled material to exceed 100 mm. When the method or system is used for producing water for desalinization purposes, the mobile suction means (5) is activated by the coordination means (1) to avoid the thickness of the settled material to exceed 10 mm. The filtration means (3) and mobile suction means (5) operate only as need to maintain the parameters of the water with their limits, for instance, only a few hours a day, as opposed to conventional filtration systems which operate substantially continuously.

[0170] The coordination means can also receive information about the collected water (9). When the concentration of TDS is less than or equal to 10,000 ppm, the Langelier Saturation Index of the water should be less than 3. For the present invention, the Langelier Saturation Index can be kept under 2 by pH adjustment, the addition of antiscalants, or a water softening process. When the concentration of TDS is higher than 10,000 ppm, the Stiff & Davis Saturation Index of the water should be less than 3. For the present invention, the Stiff & Davis Saturation Index can also be kept under 2 by pH adjustment, the addition of antiscalants, or a water softening process. Antiscalants that can be used to maintain the Langelier Saturation Index or the Stiff & Davis Saturation Index include, but are not limited to, phosphonate based compounds, such as phosphonic acid, PBTC (phosphobutan-tricarboxylic acid), chromates, zinc polyphosphates, nitrites, silicates, organic substances, caustic soda, malic acid-based polymers, sodium polyacrylate, ethylene diamine tetracetic acid sodium salts, corrosion inhibitors such as benzotriazole, and combinations thereof.

[0171] The method of the invention can optionally include a dechlorination step. Such a dechlorination step is desirable if an amount of residual chlorine which could interfere with the industrial process is detected in the water. The dechlorination can be carried out by adding chemicals including, but not limited to, reducing agents such as sodium bisulfite or sodium metabisulfite, using an active carbon filter, or a combination thereof.

#### EXAMPLES

[0172] For the following examples, the terms "a/an/the" include plural alternatives (at least one). The disclosed information is illustrative, and other embodiments exist and are within the scope of the present invention.

##### Example 1

[0173] The method and system of the present invention can be used as a pretreatment stage for reverse osmosis seawater desalination processes.

[0174] Seawater from the ocean, which had a total dissolved solid's concentration of approximately 35,000 ppm, was collected in a containing means according to the invention. The container had a volume of approximately 45 million m<sup>3</sup>, with an area of 22,000 m<sup>2</sup>.

[0175] The water temperature in the containing means was measured in April and had a temperature of about 18° C. As described herein, if the water temperature is 35° C. or less, then an ORP level of at least 500 mV is maintained for a minimum period of 1 hour for each °C. of water temperature. Utilizing this algorithm, an ORP of at least 500 mV was maintained for (18×1) 18 hours during the week. The distribution was 9 hours on Monday and 9 hours on Thursday, which added up to the total 18 hours. To maintain the ORP for a period of 9 hours, sodium hypochlorite was added to the water in order to reach a concentration of 0.16 ppm in the water.

[0176] It was not necessary to perform an additional oxidation process to adjust the iron and manganese levels since the sodium hypochlorite had sufficient redox potential to oxidize the iron and manganese. Crystal Clear®, a flocculant, was injected as a flocculant before the turbidity reached a value of 5 NTU, in concentrations of 0.08 ppm every 24 hours.

[0177] After allowing the bacteria, metals, algae and other solids to settle, a mobile suction means was activated before the thickness of the settled material layer reached 10 mm. The settled material, which was the product of the method's processes, was suctioned by a mobile suction means that moved along the bottom of the container. The suctioned water containing the settled particles was then pumped to a filter through a flexible hose, where it was filtered at a rate of 21 L/sec.

[0178] After treatment, the water had a pH of 7.96, a turbidity of 0.2 NTU, a Silt Density Index of 4, an iron concentration of less than 0.04 ppm and a manganese concentration of less than 0.01 ppm.

[0179] Pretreatment of water for reverse osmosis seawater desalination processes is important as the reverse osmosis desalination processes require high quality water to avoid clogging and fouling of the membranes. Column 2 in Table 1 below shows the water quality parameters required by membrane manufacturers. Column 3 in Table 1 shows the values for treated water obtained by the method of the present invention and demonstrates that the value for each parameter is within the range required by membrane manufacturers.

TABLE 1

| Parameters       | Value required by membrane manufacturers | Value obtained using the present invention |
|------------------|------------------------------------------|--------------------------------------------|
| SDI              | <4                                       | 3.8                                        |
| Turbidity (NTU)  | <1                                       | 0.2                                        |
| TDS (mg/L)       | Variable                                 | 35,000                                     |
| pH               | ~8                                       | 7.96                                       |
| Iron (mg/L)      | <0.05                                    | 0.04                                       |
| Manganese (mg/L) | <0.05                                    | <0.01                                      |

[0180] The amount of chemicals applied in the method and system of the invention to provide the treated water was significantly less than for conventional pretreatment technologies. The energy requirements were also lower compared to conventional pretreatment technologies as the present

invention only filters a small amount of the total volume of water within a given time frame and does not require micro-filtration, ultrafiltration or nanofiltration, which have very high energy consumptions.

#### Example 2

[0181] The method and system of the present invention can be used for treating water for use in the aquaculture industry, including use as conditioning water for the inoculation of microalgae.

[0182] A tank of 1 hectare of surface and a depth of 1.5 meters is used as the containing means for the water. The water is first treated in the tank and then sent to the raceways ponds where the microalgae is being cultured.

#### Example 3

[0183] The method and system of the present invention can be used for treating and maintaining water for the drinking water industry.

[0184] Water from meltwater or other natural water sources having the required properties of drinking water was collected. The collected water was maintained inside a containing means having a bottom capable of being thoroughly cleaned according to the method of the invention. Because the water complied with the drinking water requirements, there was no need to apply a post treatment in a drinking water plant, therefore reducing the amount of by-product produced by such a plant.

[0185] The temperature of the water in the containing means was 12° C. An ORP of at least 500 mV was maintained for (12×1) 12 hours within a period of 7 days. An ORP of 600 mV was maintained for 6 hours on Tuesday, and for 6 hours on Friday, thus completing the necessary 12 hours. To maintain such ORP, sodium bromide was added to the water in order to reach a concentration of 0.134 ppm in the water. An additional oxidation step was not needed, as the sodium bromide had sufficient redox potential to oxidize the iron and magnesium. Before the turbidity reached a value of 5 NTU, Crystal Clear®, a flocculant, was injected into the water in order to obtain a concentration of 0.08 ppm in the water. Addition of the flocculant was repeated every 48 hours.

[0186] The method and system of the invention minimized by-products and provided water having the following secondary disinfection products:

TABLE 2

| Product              | Unit | Value obtained using the present invention | Official 2005 NCh 409 |
|----------------------|------|--------------------------------------------|-----------------------|
| Monochloramines      | mg/l | <0.1                                       | 3                     |
| Dibromochloromethane | mg/l | <0.005                                     | 0.1                   |
| Dichlorobromomethane | mg/l | Not Detected                               | 0.06                  |
| Tribromomethane      | mg/l | 0.037                                      | 0.1                   |
| Trichloromethane     | mg/l | Not Detected                               | 0.2                   |
| Trihalomethanes      | mg/l | <1                                         | 1                     |

[0187] The data in Table 2 shows that water maintained by the method and system of the invention had drinking water properties, and did not have to be subjected to treatment in a drinking water plant.

#### Example 4

[0188] The method and system of the present invention can be used for wastewater industries.

[0189] Wastewater was maintained in a tank having a bottom covered with a plastic liner, in order to avoid leakage and

to allow thorough suctioning of the settled material by the mobile suctioning device that moved across the bottom of the tank.

[0190] As a disinfectant agent, sodium hypochlorite was added to the water in order to reach a concentration of 0.16 ppm. An additional oxidation step was not necessary as the sodium hypochlorite had sufficient redox potential to oxidize the iron and magnesium. Crystal Clear®, a flocculant, was injected into the water as the water had a high turbidity level of 25 NTU before the first treatment. The flocculant was injected into the water until a concentration of 0.09 ppm was achieved in the tank. The flocculant addition was repeated every 24 hours.

[0191] A suctioning cart was activated by the coordination means in order to suction the settled material in the bottom of the tank. The suctioning cart functioned for 12 hours on the first day. After the first day, the suctioning cart only functioned 8 hours a day.

[0192] The quality of the water before and after treatment according to the method and system of the invention is shown below in Table 3.

TABLE 3

| Parameter                             | Unit | Value before treatment | Value after treatment     |
|---------------------------------------|------|------------------------|---------------------------|
| Turbidity                             | NTU  | 25                     | 0.8                       |
| Smell                                 | —    | Noticeable, unpleasant | Odorless                  |
| Color                                 | —    | Light Brown            | Colorless - High Clarity  |
| Foam, grease, and suspended particles | —    | Some suspended foam    | No suspended foam or oils |

#### Example 5

[0193] The method and system of the present invention can be used for treating and maintaining water in pumping stations used for many purposes, such as mining purposes. A buffer tank in a pumping station contains seawater in case the pipes or the pumping systems are damaged or experience other problems. The water stored inside the tank begins to deteriorate after a length of time and microalgae and other microorganism being to growth begin to grow in the tank creating biofouling that adheres to the walls of the tank and pipes, reducing the transversal area and generating diverse problems that affect the water flow in the tank and pipes. The method from the present invention is applied to the buffer tank, treating the water stored in the buffer tank and maintaining the water by minimizing biofouling at low costs.

#### Example 6

[0194] The method and system of the present invention can be used for treating industrial liquid residuals that are produced as by-products of diverse processes. As a product of a mining process, an industrial liquid residual is generated. The liquid residual is treated in a plant that comprises a sedimentation process, sand filters, carbon filters, ultrafiltration and reverse osmosis. Two products, a permeate and rejected products, are created by this treatment. The permeate is then used for irrigation purposes, and the rejected products/water is sent to a Dissolved Air Flotation (DAF) Plant that reduces the sulfur content of the water from 500 ppm to 1 ppm. After DAF treatment, the water is sent to evaporation ponds.

[0195] A problem arose in an DAF plant where water with high sulfur content was reaching the evaporation ponds causing the ponds to have an unpleasant smell due to hydrogen sulfide in the water. Hydrogen sulfide in concentrations of less than 1 ppm is perceptible as a rotten egg smell, unpleasant to local neighbors of the evaporation pond. The method and system of the present invention was applied to the evaporation ponds in order to reduce the unpleasant smell produced by the hydrogen sulfide, by applying sodium bromide as an oxidant in order to reach concentration of 0.134 ppm in the water and maintaining an ORP level of 600 mV for a period of 20 hours within the week.

[0196] While certain embodiments of the invention have been described, other embodiments may exist. Further, any disclosed method steps or stages may be modified in any manner, including by reordering steps and/or inserting or deleting steps, without departing from the invention. While the specification includes a detailed description and associated drawings, the invention's scope is indicated by the following claims. Furthermore, while the specification has been described in language specific to structural features and/or methodological acts, the claims are not limited to the features or acts described above. Rather, the specific features and acts described above are disclosed as illustrative aspects and embodiments of the invention. Various other aspects, embodiments, modifications, and equivalents thereof which, after reading the description herein, may suggest themselves to one of ordinary skill in the art without departing from the spirit of the present invention or the scope of the claimed subject matter.

1. Method for treating water at low cost, which will be used in industrial processes, that purifies the water and eliminates suspended solids in the water by filtering a small fraction of the total volume of water, the method comprising:

- a. Collecting water with a concentration of total dissolved solids (TDS) of up to 60,000 ppm;
- b. Storing said water in at least one containing means, where said containing means has a bottom able to be thoroughly cleaned by a mobile suction means;
- c. Within periods of 7 days:
  - i. For water temperatures up to 35 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour for each degree Celsius of water temperature, by adding disinfectant agents to the water;
  - ii. For water temperatures greater than 35 degrees Celsius and up to 69 degrees Celsius, maintaining said water's ORP of at least 500 mV for a minimum period of hours by adding disinfectant agents to the water, wherein the minimum period of hours is calculated by the following equation:
 
$$[(35 \text{ hours}) - (\text{Temperature of the water in degrees Celsius} - 35)] = \text{minimum period of hours; and}$$
  - iii. For water temperatures of 70 degrees Celsius or more, maintaining said water's ORP of at least 500 mV for a minimum period of 1 hour.
- d. Activating the following processes through a coordination means, where the processes purify the water and eliminate the suspended solids by only filtering a small fraction of the total volume of water:
  - i. Applying oxidant agents to avoid the iron and manganese concentrations to exceed 1 ppm;
  - ii. Applying coagulants, flocculants, or a mixture of them to avoid the turbidity to exceed 5 NTU;

- iii. Suctioning the water flow that contains the settled particles, produced by the previous processes, with a mobile suction means to avoid the thickness of the settled material to exceed 100 mm in average;
- iv. Filtering the flow suctioned by the mobile suction means, with at least one filtration means; and
- v. Returning the filtered water to said at least one containing means;

e. Utilizing said treated water in a downstream process.

2. Method for treating water at low cost, according to claim 1, wherein:

- a. if the water collected in stage a) has a total dissolved solids' concentration less than or equal to 10,000 ppm, the Langelier Saturation Index must be less than 3; or
- b. if the water collected in stage a) has a total dissolved solids' concentration higher than 10,000 ppm, the Stiff & Davis Saturation Index must be lower than 3.

3. Method for treating water at low cost, according to claim 2, wherein the Langelier Saturation Index or Stiff & Davis Saturation index is kept under 2 by a process selected from pH adjustment, the addition of antiscalants, or a water softening process.

4. Method for treating water at low cost, according to claim 3, wherein the antiscalants comprise phosphonic acid, PBTC (phosphobutan-tricarboxylic acid), chromates, zinc polyphosphates, nitrites, silicates, organic substances, caustic soda, malic acid-based polymers, sodium polyacrylate, ethylene diamine tetracetic acid sodium salts, benzotriazole, or a combination thereof.

5. Method for treating water at low cost, according to claim 1, wherein the collected water can be a residual liquid from an industrial process or water collected from a natural water source and/or treated water.

6. Method for treating water at low cost, according to claim 1, wherein the disinfectant agents comprise ozone, biguanide products, bromine based compounds, halogen based compounds, or a combination thereof.

7. Method for treating water at low cost, according to claim 1, wherein the coordination means receives information regarding the parameters that are controlled, and timely activates the processes of step d) to adjust said parameters within their limits.

8. Method for treating water at low cost, according to claim 7, wherein the information received by the coordination means is obtained by empirical methods.

9. Method for treating water at low cost, according to claim 1, wherein the oxidizing agents comprise halogen based compounds; permanganate salts; peroxides; ozone; sodium persulfate; potassium persulfate; oxidants produced by electrolytic methods, or a combination thereof.

10. Method for treating water at low cost, according to claim 1, wherein the flocculant or coagulant agents comprise polymers, such as cationic polymers and anionic polymers; aluminum salts; quats and polyquats; calcium oxide; calcium hydroxide; ferrous sulphate; ferric chloride; polyacrylamide; sodium aluminate; sodium silicate; chitosan; gelatin; guar gum; alginates; moringa seeds; starch derivatives, or a combination thereof.

11. Method for treating water at low cost, according to claim 1, wherein if the method is used for treating water for desalinization purposes, the mobile suction means is activated by the coordination means to avoid the thickness of the settled material to exceed 10 mm.

12. Method for treating water at low cost, according to claim 1, wherein a dechlorination step is performed if residual chlorine is detected, the dechlorination step comprising an active carbon filter or chemicals comprising sodium bisulfite, sodium metabisulfite, or a combination thereof.

13. Method for treating water at low cost, according to claim 1, wherein the treated water is used:

- a. as raw material for an industrial process and circulates in an open cycle; or
- b. for discharging purposes, irrigation, infiltration, or a combination thereof.

14. System for treating water at low cost that eliminates suspended solids in the water by filtering a small fraction of the total volume of water, the system comprising:

- at least one feeding line of water to at least one containing means;
- at least one containing means, which comprises a receiving means for settled particles, that is fixed to the bottom of said containing means;
- at least one coordination means, where the coordination means timely activates the necessary processes to adjust parameters of the water within limits specified by an operator or the coordination means;
- at least one chemical application means, which is activated by said at least one coordination means
- at least one mobile suction means, which moves through the bottom of said at least one containing means suctioning the water flow containing the settled particles;
- at least one propelling means that provides movement to said at least one mobile suction means so it can move through the bottom of said at least one containing means;
- at least one filtration means that filters the water flow containing the settled particles;

at least one collecting line coupled between said at least one mobile suction means and said at least one filtration means;

at least one return line from said at least one filtration means to said at least one containing means; and  
at least one water outlet line from said at least one containing means to at least one downstream process.

15. System for treating water at low cost, according to claim 14, wherein the receiving means is covered with a material comprising membranes, geo-membranes, geotextile membranes, plastic liners, concrete, or coated concrete, or a combination thereof.

16. System for treating water at low cost, according to claim 14, wherein the coordination means is capable of receiving information, processing that information, and activating other processes.

17. System for treating water at low cost, according to claim 14, wherein the chemical application means comprises injectors, sprinklers, manual application, dispensers by weight, pipes, or a combination thereof.

18. System for treating water at low cost, according to claim 14, wherein the propelling means drives comprises a rail system, a cable system, a self-propelled system, a manually propelled system, a robotic system, a system guided from a distance, a boat with an engine, a floating device with an engine, or a combination thereof.

19. System for treating water at low cost, according to claim 14, wherein the filtration means comprises cartridge filters, sand filters, micro-filters, ultra-filters, nano-filters, or a combination thereof.

20. System for treating water at low cost, according to claim 14, wherein the collecting line comprises a flexible hose, rigid hose, pipe, or a combination thereof.

\* \* \* \* \*



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(57) Abstract: The present invention relates to floating lakes and to the treatment of the water in such lakes. The present invention further relates to large floating lakes that can be installed within a natural or artificial water body to improve water conditions that are unsuitable for recreational uses. The floating lake can be provided with a chemical application system; a filtration system including a mobile suctioning device and filters; a skimmer system, and optionally a coordination system.



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## CESION

El (la) abajo firmante (En adelante EL CEDENTE)

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en su carácter de inventor /diseñador con domicilio en:

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Santiago, CHILE

por el presente documento declara que cede todos y cada uno de los derechos que le corresponden o puedan corresponderle sobre la siguiente invención No. **PCT/IB2014/002991**

a: **CRYSTAL LAGOONS (CURACAO) B.V**

con domicilio en **Kaya W.F.G. (Jombi) Mensing, 14, Curacao, PAÍSES BAJOS**

En prueba de la mutua aceptación de esta cesión ambas partes CEDENTE y CESIONARIO firman el presente documento.

Dado y firmado en Santiago, Chile

A los 30 Días de MARZO De 2016

**1. FISCHMANN T., Fernando Benjamin**

X

El Cedente

X

El Cesionario

## ASSIGNMENT

The undersigned (Hereinafter THE ASSIGNOR)

**1. FISCHMANN T., Fernando Benjamin**

Inventor /designor of domiciled at :

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Santiago, CHILE

do hereby declares that it assigns all and each of his rights and privileges on the following invention No. **PCT/IB2014/002991**

to: **CRYSTAL LAGOONS (CURACAO) B.V**

with domicile in **Kaya W.F.G. (Jombi) Mensing, 14, Curacao, NETHERLANDS**

As a proof of the mutual acceptance of this assignment, both parties ASSIGNOR and ASSIGNEE sign the present document.

Granted and signed at Santiago, Chile

on this      day of      of

**1. FISCHMANN T., Fernando Benjamin**

The Assignor

The Assignee

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legal representative(s) of

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- 8) I (we) hereby appoint the afore mentioned attorneys with powers to receive notifications and to designate judicial and extrajudicial attorneys, substitute this Power of Attorney and to revoke such substitutions.

Dado y firmado en Santiago, Chile

a los 30 días de MARZO, 2016

Granted and signed at

on this day of

of

Firma / Signature

## **Resumen**

La presente invención se relaciona a lagos flotantes y al tratamiento de agua en tales lagos. La presente invención además se relaciona a grandes lagos flotantes que pueden ser instalados dentro de un cuerpo de agua natural o artificial para mejorar condiciones del agua que son inadecuados para usos recreacionales. El lago flotante puede ser proporcionado con un sistema de aplicación de químicos; un sistema de filtración incluyendo un dispositivo de succión móvil y filtros; un sistema de espumadera, y opcionalmente un sistema de coordinación.