The present invention concerns a method and a system with one or more reactor chambers (5) for photocatalytic reduction in connection with oxidation reactions for treatment of water with polychromatic light, preferably in the UV range, where the reactor chamber (5) is coated with a photocatalyst and to which may be added one or more oxidation chemicals, and where one or several types of lamps (2) can be adapted to the processes. Further is provided a positioning of an outlet channel (9) for extracting a water flow for the production of halogens, and the positioning of a dosage of halogens into the water system so as to reduce the formation of disinfection by-products.
Method and system for photocatalytic removal of organic halogens by reduction.

The present invention relates to a method and system with one or more reactor chambers for photocatalytic reduction using photooxidation reaction for treatment of water using ultraviolet light.

The water to be treated is preferably water being exposed to halogens as a disinfection agent in order to protect against micro organisms in the water. This is widely used for drinking water, coolant water, process water and bathing water in for example reservoirs or basins. This type of disinfection results in the formation of halogenic disinfection by-products.

By the use of halogens, for example chlorine as an oxidation/disinfection agent in water systems it is a drawback that the halogen (the chlorine) is reacting with inorganic or organic material thus producing disinfection by-products (DBP) such as organic and inorganic halogenamines, which are measured as combined chlorine, and organic chlorine compounds, which are measured as THM (Trihalomethanes) and AOX (Adsorbable Organic Halogen). These compounds constitute a health risk and combined chlorine can cause corrosion of metal constructions.

European patent EP 1 042 237 B1 describes a method for removing water dissolved substances such as combined chlorine, THM and AOX from chlorinated water in swimming pools. The method consists of exposing a partial flow of the water to intensive radiation of ultraviolet light. The employment of a sufficient number of lamps and a sufficient content of free chlorine in the water enables the photochemical processes to remove chloramines, THM and AOX through a combination of primary photolytic reactions and secondary photooxidation. These reactions also decompose dissolved organic material, whereby the formation of DBP in the water after the treatment is reduced. During primary photolysis the chemical compound is absorbed which breaks down the energy in the photon thus initiating a reaction occurring in the form of a cascade until the compound is completely oxidized. The secondary photooxidation consists of halogen (hypohalogenic acid) or water being photolized into oxidizing radicals which react with the chemical compound being decomposed.
This method of removing the chloramines, THM and AOX can obtain a satisfactory level of purification. However, in practice, the treatment process is not as energy-efficient as could be desired for two reasons: Firstly, part of the photons emitted by such a polychromatic medium/high pressure lamp as is typically used in a system according to EP 1 042 237 is not emitted at wavelengths, which are absorbed by the oxidation means or the DBP's, and therefore they do not participate in driving the photochemical conversion. Accordingly, these photons will be lost in reactions, which do not lead to photochemical transformations. Due to the inability of these ineffective photons to be absorbed by dissolved compounds, these photons will penetrate the reactor chamber and be absorbed or reflected from the chamber walls.

The second reason that the purification process may be considered to be energy inefficient is the fact that the treatment capacity must be designed so as to reduce all DBP to tolerable levels whereas the treatment efficiency varies considerably between different chemical groups of DBP's. Certain relevant organic halogen compounds react slower with oxidizing radicals than do organic compounds containing less electronegative atoms. Therefore, the decomposition rate will therefore be slower than with many other organic contamination components. It is desirable to obtain very low concentrations of AOX and THM in bathing water and drinking water, since these compounds are suspected of causing cancer and asthma. Many other organic compounds in the water are not as harmful as AOX’s and therefore it is not necessary to remove them to the same extent in order to use the water. Due to the AOX’s slowness of reaction with oxidative mechanisms it is therefore necessary to treat the water very thoroughly so as to achieve a satisfactory water quality.

On this background, it is an object of the present invention to provide a method and a system for treatment of water, which will provide a satisfactory water quality in a more energy-efficient manner than with known systems.

The invention relates to a method of photocatalytic removal of organic halogen compounds in water, said method comprising providing a water flow to a UV treatment system, said UV treatment system comprising at least one reactor chamber comprising one or more UV lamps arranged in at least said at least one reactor chamber, and where a photocatalytic material is provided in said reactor chamber, which photocatalytic material when exposed to light creates reductive and oxidative regions
upon said photocatalytic material, whereby halogenated organic compounds in the water are dehalogenated by reductive reactions to form halogenides and reactive radicals, which are subsequently decomposed in the water.

The invention further concerns a system for photocatalytic removal of organic halogen compounds in water from a basin or the like water reservoir, where a water flow is provided photochemical in a UV treatment system, which comprises at least one reactor chamber comprising one or more UV lamps arranged in said reaction chamber, where there said reactor chamber is provided a photocatalytic material for exposing said water flow to ultraviolet light at wave lengths between 150 - 550 nm in order to form reductive and oxidative areas on the photocatalytic material, whereby halogenated organic compounds in the water are reduced to reactive radicals, which can subsequently be decomposed in the water.

By placing the photocatalyst inside the reactor chamber for light treatment, preferably with ultraviolet light, this enables the formation of reductive and oxidative radicals upon the surface of the coating, where in particular compounds comprising electronegative atoms such as chlorine organic compounds are broken down by reductive reactions. Simultaneously, a part of the light is utilized for catalytic oxidation of water to hydroxyl radicals, thus increasing the oxidative effect of the UV treatment. A satisfactory water quality is thus attained in a more energy efficient manner.

The invention provides an improvement in a system for treating water from a swimming pool or the like, where chlorine, iodine or bromine is added as disinfection or oxidation agents, by treating the water with polychromatic UV light. In known systems the light of the UV lamps in the region of approx. 150 - 300 nm is utilized in the photochemical processes, whereas the benefit of UV light in the region of 300 - 550 nm is limited. By lining or in other ways providing a semiconductive photocatalytic material inside the reactor chamber, such as anatase titanium dioxide crystals, the latter lower energy UV light is absorbed. This exposure to light results in a displacement of electrons in the crystals, thus creating reductive and oxidative areas on the surfaces of the crystals. These charge displacements reduces halogenated organic compounds on the electron rich sections of the crystals to reactive radicals, which are subsequently decomposed very quickly in the water. Further, the charge displacement can be transferred to oxygen and water by formation of oxidising radicals.
By a method according to the invention there is provided reductive regions upon the photocatalytic material and dissolved reactive reductive intermediate products, whereby oxidized halogen compounds, such as \( \text{ClO}_3^- \), \( \text{ClO}_2^- \), \( \text{ClO}_2^- \), \( \text{ClO}_4^- \) and \( \text{BrO}_3^- \) in the water are reduced to halogen compounds at lower oxidation levels, which compounds are generally less toxic.

In the preferred embodiment of the invention the photocatalytic material is titanium dioxide, preferably anatase titanium dioxide crystals (\( \text{TiO}_2 \)). However, it has been realized that other semiconductor materials can be used for providing the advantages according to the present invention, such as \( \text{TiO}_2 \), CdS, ZnO, \( \text{WO}_3 \) and combinations thereof, and compounds which increase the output of the transference of the charge separations, such as \( \text{SnO}_2 \) and \( \text{RuO}_2 \) and any combination thereof, which leads to an efficient charge separation and high quantum yield from the light employed.

The reactor chamber is preferably constructed from an inlet section and an outlet section whereinbetween is arranged a substantially cylindrical reactor chamber, where at least said inlet section is provided with a substantially axially oriented lamp. It has by the invention been realized that the lamps alternatively may be transversally mounted. The outlet section can also be fitted with a substantially axially oriented lamp.

Preferably, the inlet section and the outlet section exhibit substantially radically orientated inlet and outlet channels, respectively. The inlet channel and preferably also the outlet channel in the preferred embodiment of the invention is provided with a dosage aperture for addition of chemicals for photochemical water treatment in the reaction chamber.

In a first preferred embodiment of the invention, the photocatalyst means are provided using an anode oxidation or coating of photocatalytic material, for example \( \text{TiO}_2 \) as a covering on the inside surface of the reactor chamber.

In a second preferred embodiment of the invention, the photocatalyst means are one or more rotating photocatalytic elements inside the reaction chamber, which one or more photocatalytic elements are coated with photocatalytic material, either as an alternative or as a supplement to the above mentioned first embodiment of the invention.
The photocatalytic elements can be formed as helical plates or substantially star shaped photocatalytic elements, i.e. radially orientated plates coated with photocatalytic material. Thus, the elements are formed like paddle wheels, whereby a large volume of water is being exposed. In the preferred embodiment a plurality of rotating photocatalytic elements, e.g. 2 - 8 elements, are arranged, which are axially oriented substantially parallel to the lamp or the lamps.

In one embodiment of the invention, the UV system comprises a plurality of reactor chambers for UV treatment, which are arranged in series and where oxidation means may be added before each of the reactor chambers. Further, the reactor chambers in series can be combined in parallel. Thus, the UV system can be adapted to an exact treatment of water and the purification can be performed with accurate dosage of chemicals, such as oxidizing agents like hydrogen peroxide, chlorine etc., just before treatment in a given reactor chamber. The lamps and the lamp types can be adapted to suit the chemical dosage and be adapted individually in each reaction chamber, so that UV light is irradiated having intensities at different wavelengths in the different chambers so that the water may be sequentially treated for different impurities in each chamber. The types of lamps adapted the dosage can be vacuum UV lamps and/or low pressure UV lamps and/or medium pressure UV lamps and/or high pressure UV lamps and/or ultra high pressure UV lamps and/or xenon lamps and/or excimer UV lamps and/or halogen high pressure UV lamps (see e.g. EP 1 463 091 A2) and/or UV light diodes. By adding chemicals to each chamber individually it is possible to ensure that no greater dosage than necessary is applied, thus avoiding residual chemical matter that will interrupt water purification downstream the system.

In one embodiment of the invention, the water flow, which is extracted for UV treatment, is the entire water flow from the basin. Alternatively, the system can be adapted in such a way that the water flow, which is extracted for UV treatment, is only a partial water flow from the basin.

By the invention, it has been realized that a method and system according to the invention may also be utilized for purifying water from halogenic chemical compounds resulting from other processes than the above mentioned examples, where the compounds in question chemically resemble disinfection bi-products.
The invention is described in more detail in the following with reference to the appended drawing, in which:

Fig. 1 shows a container with a reactor chamber for a system according to a first embodiment of the invention,

Fig. 2 shows a container with a reactor chamber for a system according to a second embodiment of the invention,

Fig. 3 shows an UV system according to a third embodiment of the invention,

Fig. 4 shows a container with a reactor chamber for a system according to a fourth embodiment of the invention,

Fig. 5 shows a container with a reactor chamber for a system according to a fifth embodiment of the invention, and

Fig. 6A, 6B show cross sections of a container with a reactor chamber in fig. 4.

Fig. 1 shows a container with a reactor chamber 5 for a UV system for water treatment. The container 1 is formed by an inlet section 4 and an outlet section 6, which are arranged on either side of a substantially cylindrical reactor chamber 5, which in this first embodiment is provided with a photocatalytic coating 3 on the inside of the chamber for water treatment. In the inlet section 4 a UV lamp 2 is mounted, which is substantially axially orientated inside the container 1, where said UV lamp can be a medium or high pressure lamp, which is adapted in such a way as to concentrate the wavelengths of the UV light at selected intervals. The inlet and outlet sections 4, 6, which preferably are made of stainless steel, are mounted to the chamber 5 by means of corresponding flanges with sealing gaskets 7 between the inlet and outlet sections and the cylindrical chamber 5, respectively. These gaskets 7 are designed as to prevent corrosion as a result of the different materials used in the three sections, i.e. the coating in the UV chamber 5 and the steel sections 4, 6 on either side of the chamber 5, when water flows in through the inlet section 4, through the chamber 5 and out through the outlet section 6.
The inlet section 4 is provided with an inlet channel 8, which preferably is radially orientated in relation to the cylindrical container 1. This inlet channel 8 is provided with a dosage aperture 10 through which chemicals, in particular oxidizing agents for use in the UV process in the UV reactor chamber 5, can be added. Correspondingly, the outlet section 6 is provided with an outlet channel 9, which is provided with a dosage aperture 11 through which chemicals can be added in order to regulate the water quality.

In Fig. 2 is shown another embodiment of a container with a reactor chamber according to the invention, which as opposed to the container 1 in fig. 1 exhibit two lamps 2 in the container 1, which are mounted in inlet section 4 and outlet section 6, respectively.

Figure 3 shows an example of an assembly of serial reactor chambers 1, 1', 1" and V" and with addition of oxidizing agents in several steps in the course of the water treatment through dosage apertures 10, 11, 10', 11', 10", 11", 10"', and 11"'. The reactor chambers 1, 1', 1" and V" are in figure 3 shown as the reactor container shown in fig. 2, but it may of course be of other types, just as the reactor chambers shown assembled in series can also be equipped differently.

Figure 4 shows a container with a reactor chamber according to a fourth embodiment, where the container 1 is constructed of an inlet section 4 and an outlet section 6, which is mounted on either side of a substantially cylindrical reactor chamber 5, which in this embodiment is mounted with rotating elements 12 being coated with a photocatalytic coating 3 for water treatment. These rotating photovanes 12 function as a stirring or mixing mechanism and are mounted axially oriented inside the container 1, and are individually rotatably arranged on end wall 15 of the inlet section 4 and end wall 14 of the outlet section 6, respectively. Each of the elements 12 are provided with a gear wheel 13, which mesh together (see fig. 6a) and which are driven by a motor or the like arrangement. The rotating elements 12 are axially oriented in a ring shape around the lamp 2 or lamps. In the embodiment shown in fig. 4 there are eight rotating elements 12, see fig. 6A and 6B. In order to obtain an improved mixing effect the rotating elements 12 are formed like helical plates or substantially star shaped photocatalytic elements.
In the following, the mode of operation of the process of water treatment in a UV system according to the invention will be described in more detail:

**A - Removal of organic halogen compounds by reduction**

When a coating of a semiconductive material is applied to the inside of the reactor chamber with polychromatic UV lamps, the irradiation in the wavelength range of 170-550 nm causes a displacement of electrons in the material, which results the formation of oxidising and regions on the surfaces of the material. If the semiconductive material is e.g. anatase TiO₂ crystals, the reaction may be formulated thus:

\[ 2(TiO_2) \xrightarrow{\text{hv}} \{TiO^+\} + \{TiO^–\} \]

The halogenated organic compounds can be reduced on electron rich regions of the crystals into reactive radicals, which subsequently are quickly decomposed in the water. For initiating break down of chloroform the process may e.g. be formulated thus:

\[ (\text{TiO}_2)^+ + CHCl_3 \rightarrow (\text{TiO}_2)^+ + CHCl^\bullet + Cl^- \]

These charge displacements can also be transferred to oxygen and water during the formation of oxidising radicals, which can mostly be found adsorbed on the surface, but which may be dissolved in the water:

\[ (\text{TiO}_2)^+ + H_2O \rightarrow (\text{TiO}_2)^+HO^– \rightarrow H^+ \rightarrow (\text{TiO}_2)^+HO \rightarrow H^+ \]

\[ (\text{TiO}_2)^+ + O_2 \rightarrow (\text{TiO}_2)^+O_2^- \rightarrow (\text{TiO}_2)^+O_2^- \]

The oxidising radicals assist in the oxidising effect of the purification system in the same manner as do the radicals created by photolysis of water and hypohalogenic acid and hypohalogenide, whereby the total degree of effectiveness of the system in oxidative cleansing is improved. It may be seen, that reactions of the kinds exemplified by the chemical reactions marked II and IV compete for the formed reducing regions on the semiconductor.

In order to counteract too great a consumption of the reducing regions for transformation according to reaction IV instead of the desired reaction II, it is necessary that the amount of dissolved oxygen does not exceed the level, which corresponds to equilibrium with the atmosphere, but preferably remains at a lower level, which is typical in many systems with circulating water containing dissolved organic material.
The decomposition of organic halogenic materials in the system is incompatible with the use of ozone addition, as this result in a high partial pressure of dissolved oxygen in the water. Ozonisation of the water can be allowed where it is not required to apply UV light in order to remove chemical compounds in the water, but only required to increase the oxidising effect of the UV treatment.

**B - Increasing the available surface region for catalytic photoreactions** (see figs. 4 to 6)

The charge separation after reaction (I) is not stable. If the charge displacement is not immediately transferred to a substance placed on the surface the electron falls back into the positive range and the charge displacement is wasted. In order for the charge to be transferred to chemical compounds it is therefore necessary that a chemical substance is present, to and from which an electron can be transferred, on the surface of the crystal, before the charge separation occurs. For initiating the breakdown of chloroform, the process can e.g. be formulated as:

\[
\begin{align*}
(IA) \quad & 2(TiO_2) + CHCl_3 \rightarrow ((TiO_2)^{\circ}_2)^{-}CHCl_3 \\
(IB) \quad & ((TiO_2)^{\circ}_2)^{-}CHCl_3 \xrightarrow{\text{UV}, <450\text{nm}} (TiO_2^{+} - TiO_2^{2-}) - CHCl_3 \\
(IC) \quad & (TiO_2^{+} - TiO_2^{2-}) - CHCl_3 \rightarrow (TiO_2^{+} - TiO_2^{2-}) + CHCl_2^{\circ} + Cr \\
(II) \quad & (TiO_2^{+} - TiO_2^{2-}) + H_2O \rightarrow ((TiO_2)^{\circ}_2) + HO^{\circ} + H^+ 
\end{align*}
\]

On an intensely irradiated surface the process, in which the material is adsorbed onto the surface of the crystal (IA), could be slower than the formation rate of charge separation (IB). Therefore, the adsorption onto the surface will limit the rate of desired breakdown of DBP's.

A surface coated with photocatalyst and rotating in a light field in such a way that it is alternately irradiated and located in shadow can therefore increase the total breakdown effect of the UV reactor by increasing that area of the surface region, which is available for adsorption, in proportion to the amount of charge displacements being formed.

Therefore, the photocatalytic coating may be arranged on rotating vanes inside the photochamber, where the surfaces thereof are moved in and out of the radiation field of the UV lamps. By using rotating vanes the reactor chamber is provided with at least
one rotating vane, where the preferred embodiment with two lamps has got eight pieces of rotating vanes.

C - Connecting reactor chambers in series (see fig. 3)

In order to further increase the oxidation during treatment one may add one or more further oxidisation chemicals in addition to that added as a combined oxidisation and disinfectant agent in the pipe/bypass (parallel) inlet and/or before each reactor chamber in the form of e.g. chlorine (Cl2, HOCl), hydrogen peroxide (H2O2), iodine, peracetic acid or persulphate.

D - Dosage of chlorine in the water from the outlet of the UV process

The formation of disinfectant by-products increases proportionally to the concentrations of reactants in the reaction, that is to say the concentration of halogens and dissolved compounds, which are the precursors of disinfectant by-products. It has been observed, that the creation of DBP is much higher in water around the position in the water system where the halogen is dosed to the water and thus where the concentration of halogens is at its highest. It has been shown, that the formation of DBP can be minimized by dosing the halogen in the outlet after the photochemical process and after the extraction if connected to an electro chlorine system for maintaining the minimal level of free halogens in regard to the disinfection and before the water is conducted to the piping on the clean water side leading e.g. to the swimming pool/basin.

This technique is employed when the disinfection and the described UV and advanced oxidisation treatment are applied to recirculated water so that the dosage with halogens and treatment of the water with UV light and the advanced oxidisation system are applied at the same place.

If the halogen is formed electrochemically from halogenides on site with or in the pool water, the DBP formation rate will be very high in the electrochemical reactor, in the piping and in potential storage tanks where the water has a high concentration of halogen. The same applies if concentrated chlorine - chlorine gas is added to reservoir water with organic load. The DBP formation rate is reduced by taking the water for the
reactor from an outlet channel on the outlet section from the UV treatment or dosage chlorine into this water from the outlet from the UV treatment, wherein the water content of organic materials it may react to in disinfection by-products is at its lowest level. This outlet channel is arranged upstream of said halogen dosage to the water flow from the UV treatment system.

If the halogen dosage employs water for an intermediate dilution of the halogen solution in order to ease dosage and handling then a high DBP formation rate also will occur in said intermediate dilution. This is countered by extracting the water for the intermediate dilution from the clean water side of the UV treatment plant.

By the invention, it has been realized, that other variants in the assembly or design of the reactor chamber may be provided than the ones described above without departing from the scope of the invention as defined in the attached patent claims.
Patent claims

1. A method for photocatalytic removal of organic halogen compounds in water, which method comprises providing a water flow to a UV treatment system, said UV treatment system comprising at least one reactor chamber comprising one or more UV lamps arranged in said at least one reactor chamber, and where a photocatalytic material is provided in said reactor chamber, which photocatalytic material when exposed to light creates reducing and oxidizing regions upon said photocatalytic material, whereby halogenated organic compounds in the water are dehalogenated by reductive reactions to form halogenides and reactive radicals, which are subsequently decomposed in the water.

2. A method according to claim 1, where there is provided reducing regions in the photocatalytic material and further dissolved reactive reducing intermediate products, whereby oxidized halogen compounds, such as ClO$_3^-$, ClO$_2^-$, ClO$_2^-$, and BrO$_3^-$, in the water are reduced to halogen compounds at lower oxidation levels, which compounds are generally less toxic.

3. A method according to claims 1 and 2, where the photocatalytic material is selected from a group of known catalytic materials such as for example TiO$_2$, CdS, ZnO, WO$_3$ and compounds which increase the output of the transfer of the charge separations, such as SnO$_2$ and RuO$_2$ and any combination thereof resulting in an efficient charge separation and high quantum yield from the applied light.

4. A method according to any of the previous claims, where the catalytic coating is preferably anatase TiO$_2$ crystals.

5. A method according to any of the previous claims, where the reactor chamber exhibit an inlet channel and an outlet channel, whereinbetween is arranged a reactor chamber and where at least the inlet channel is provided with a substantially axially orientated lamp.
6. A method according to claim 5, where at least the inlet channel is provided with a dosage aperture for addition of chemicals for photochemical water treatment in the reactor chamber.

7. A method according to any of the previous claims, where the photocatalytic material is a coating provided on the inside of the reactor chamber.

8. A method according to any of the previous claims, where one or more rotating photocatalytic elements are arranged in the reactor chamber, said one or more photocatalytic elements being coated with photocatalytic material.

9. A method according to claim 8, where said rotating photocatalytic elements are helical plates or substantially star shaped photocatalytic elements coated with a photocatalytic material.

10. A method according to claims 8 or 9, where a plurality of rotating photocatalytic elements is axially orientated, substantially parallel to at least one lamp.

11. A method according to any of the previous claims, where the UV system comprises a plurality of reactor chambers for UV treatment arranged in series, and where a chemical dosage, such as oxidising agents, may be added before each of the containers with reactor chambers.

12. A method according to claim 11, where the lamps are adapted to the chemical dosage and mounted in such a way inside each reactor chamber that UV light with intensities of different wavelengths are emitted inside the various chambers.

13. A method according to claims 11 and 12, where a partial water flow is extracted just after the final reactor chamber and led to an electrolytic plant, where after a principal dosage of halogens is subsequently carried out into said partial flow, which is the purest water in the system, before being returned to the pool or the like.

14. A method according to any of the previous claims, where the water flow which is being extracted for UV treatment is the entire water flow from the basin.
15. A method according to any of the previous claims, where the water flow which is being extracted for UV treatment is a partial flow from the basin.

16. A method according to any of the previous claims, where the lamps are polychromatic UV lamps.

17. A system for photocatalytic removal of organic halogen compounds in water from a basin or the like water reservoir, where a water flow is led to photochemical in a UV treatment system, which UV treatment system comprises at least one reactor chamber comprising one or more UV lamps arranged in a reactor chamber; characterized in that a photocatalytic material is provided in the reactor chamber for an exposure to preferably ultraviolet light of wavelengths for the formation of reducing and oxidizing regions on the photocatalytic material, whereby halogenated organic compounds in the water are reduced to reactive radicals, which may subsequently be decomposed in the water.

18. A system according to claim 17, where the reactor chamber exhibit an inlet section and an outlet section, which are connected to a substantially cylindrical reactor chamber, where at least said inlet section is provided with an substantially axially oriented lamp.

19. A system according to claim 18, where also the outlet section is provided with a substantially axially oriented lamp.

20. A system according to claims 18 or 19, where the inlet section and the outlet section exhibit substantially radially orientated inlet and outlet channels, respectively.

21. A system according to any of the claims from 17 to 20, where at least the inlet channel is provided with a dosage aperture for the addition of chemicals for photochemical water treatment in the reactor chamber.

22. A system according to any of the claims from 17 to 21, where the photocatalytic material encompasses an anodic oxidation of said photocatalytic material on the inside of the reactor chamber.
23. A system according to any of the claims from 17 to 22, where the photocatalytic material is a coating on the inside of the reactor chamber.

24. A system according to any of the claims from 17 to 23, where there in the reactor chamber is provided one or more rotating photocatalytic elements, which are coated with photocatalytic material.

25. A system according to claim 24, where said photocatalytic elements are helically shaped plates or substantially star shaped photocatalytic elements coated with photocatalytic material.

26. A system according to claims 24 or 25, where a plurality of rotating photocatalytic elements is axially orientated substantially parallel to said at least one lamp.

27. A system according to any of the claims from 17 to 26, where the photocatalytic material is selected from a group of materials consisting of: TiO$_2$, CdS, ZnO, WO$_3$ and compounds, which increase the output of the transfer of the charge separations, such as SnO$_2$ and RuO$_2$ and any combination thereof, which results in an efficient charge separation and high quantum yield from the applied light.

28. A system according to claim 27, where the photocatalytic material is titanium dioxide, preferable anatase titanium dioxide crystals (TiO$_2$).

29. A system according to any of the claims from 17 to 28, where the UV system comprises a plurality of reactor chambers for UV treatment arranged in series and to which a dosage of chemicals such as oxidation agents may be added before each of the reactor containers.

30. A system according to claim 29, where the lamps are adapted to the chemical dosage and arranged in such a way in each individual reactor chamber so that UV light is irradiated having intensities at different wavelengths in the various chambers.

31. A system according to any of the claims from 17 to 30, where the water flow, which is extracted to the UV treatment system, is the entire water flow from the basin.
32. A system according to any of the claims from 17 to 31, where the water flow, which is extracted to the UV treatment system, is a partial water flow from the basin.

33. A system according to any of the claims from 17 to 32, where the lamps are polychromatic UV lamps.

34. A system according to any of the claims from 17 to 32, where the lamps are excimer lamps.

35. A system according to any of the claims from 17 to 32, where the lamps are UV light diodes.
A. CLASSIFICATION OF SUBJECT MATTER
INV. C02F1/32 C02F1/72

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

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Date of the actual completion of the international search
4 April 2007

Date of mailing of the international search report
13/04/2007

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