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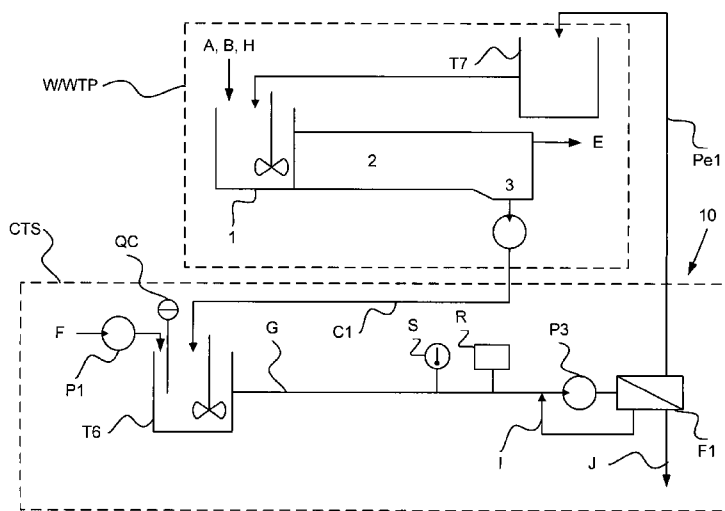
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(54) Title: METHOD FOR TREATMENT OF SLUDGE FROM WATER AND WASTEWATER TREATMENT PLANTS WITH CHEMICAL TREATMENT



(57) Abstract: Method and construction for treatment of sludge from (A) in waterworks and wastewater treatment plants, resulting in sludge (C1) and pure water (E). The method comprises adding an acid (F) to sludge (C1) in such way that a first sludge mixture (G), with low pH, is received. The first sludge mixture (G), which includes said inorganic chemical coagulants in solution and organic substances, is fed to at least one membrane filtration process (F1), in which a concentrate (I, J) and a permeate (Pe1, Pe2) are obtained. Temperature of said sludge (C1), said first sludge mixture (G), said concentrate (I, J) and said permeate (Pe1, Pe2) is below the boiling point of water at atmospheric pressure. If the used coagulant in the treatment process contains Fe, the method also comprises adding oxidizing agent (H) to the flocculation process..

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METHOD FOR TREATMENT OF SLUDGE FROM WATER AND WASTEWATER TREATMENT PLANTS WITH CHEMICAL TREATMENT

TECHNICAL FIELD

5 The invention refers to treatment of sludge, which comprises chemical coagulants, such as sludge from water and waste water treatment plants. More specifically the invention refers to a method and a construction for treatment of sludge in connection to waterworks and wastewater treatment plants for purifying of water, whereby chemical coagulants are recovered from the sludge and recycled back and
10 reused in the flocculation process. The resulting material is an organic concentrate which can be treated separately, such as by incineration, giving a low ash content.

BACKGROUND

 Sludge, such as sludge obtained from waterworks and wastewater treatment
15 plants, is often formed by addition of chemical coagulants into a polluted water mass. The coagulants bring about a flocculation of suspended substances, which makes it easier to separate these from the water mass, thus cleaning it.

 To be able to bring about this separation it is common to add inorganic chemical coagulants, such as trivalent metallic salts of iron or aluminum. The metallic
20 ions hereby forms, under slow stirring, hydroxy flocs, which encase and adsorb the suspended matter and the organic substances, dissolved in water. Additionally the phosphor dissolved in water, together with iron or aluminum, form an insoluble compound, which can be separated.

 After a flocculation phase, the formed flocks are separated in different ways,
25 such as through flotation, sedimentation or sand filtration. In waterworks, it is common that separated sludge is as a thin sludge pumped directly from the plant back to the recipient, to a sludge pond. Alternatively the sludge is dewatered, for example in a centrifuge, to thereafter be deposited.

 Due to regulatory requirements, many industries are required to have installed
30 wastewater treatment plants. Thus, the production of sludge as a byproduct of wastewater treatment is a growing problem, since it is hard to dispose.

 Sludge from wastewater treatment plants is sometimes used as a soil improvement agent, but this method is often criticized, and even forbidden, as the sludge frequently contains unwanted substances, such as heavy metals.

35 Methods for treating sludge are known from prior art. US 5,304,309 discloses a method for selective recycling of inorganic chemical coagulants in sludge from

waterworks, whereby acid at first is added to the sludge in a first tank, a membrane with enclosed ion exchanger is immersed in the acidic sludge to adsorb metallic ions, and the membrane is transferred to a second tank to desorb metallic ions. Such a method is complicated and has very little efficiency in treating large amounts of thin sludge.

5 EP 1 507 745 discloses a method for treatment of sludge with acid and high pressure and filtration. While providing an effective way for separating as trivalent metallic salts of iron or aluminum, the high pressure makes the method costly and cumbersome.

10 SUMMARY OF THE INVENTION

Accordingly, the present invention deals with one or more of the above-identified deficiencies in the art singly or in any combination by providing a method and a construction according to the appended patent claims.

The general solution according to the invention is first to treat the sludge with acid using low temperatures, such as below the boiling point of water at atmospheric pressure. The acid will dissolve any iron and aluminum components in the sludge and in 15 a second step these components can be separated in a filtration process in the form of Al and Fe salts. The separated Al and Fe salts can then be recycled and reused as coagulants in the flocculation process.

20 If Fe ions are present in the coagulant, some of the Fe^{3+} will be reduced to Fe^{2+} . The divalent Fe will, like trivalent Fe, fixate impurities but not hydrolyze. This means that the outgoing water from the separation process will contain some iron (Fe^{2+}) and have an increased COD content. Fe ions are present both when Fe salts are used, but also when some types of Al salts are used (such as Kemira AVR).

25 By adding an equivalent dosage of hydrogen peroxide to the divalent content into the flocculation process the Fe^{2+} will be oxidized to Fe^{3+} , which enables hydrolysis at the more neutral pH level of the flocculation basin, typically with a pH between 5-7.

According to an aspect of the invention, a method for treatment of sludge from waterworks or wastewater treatment plant, comprising iron ions as inorganic chemical 30 coagulants is provided. The method comprising the steps of adding inorganic chemical coagulants, comprising iron ions, to a flocculation basin of the waterworks or wastewater treatment plant, leading to flocculation of particles which sediment to form a sludge in a flocculation basin, thus purifying the water, giving pure water. The method comprises adding an acid to said sludge, comprising precipitated inorganic chemical 35 coagulants and precipitated organic substances, in such way that a first sludge mixture

with pH below 3.5 is received, which includes said inorganic chemical coagulants in solution and said organic substances. The method further comprises feeding said obtained first sludge mixture to at least one membrane filtration process, in which a first concentrate and a first permeate are obtained and keeping a temperature of said sludge, 5 said first sludge mixture, said first concentrate and said first permeate which is below the boiling point of water at atmospheric pressure. The method further comprises adding an oxidizing agent to the flocculation basin.

An advantage with this is that the method, run at atmospheric pressure, is safer than pressurized systems. Also, use of a temperature below the boiling point of water at 10 atmospheric pressure reduces wear on the equipment, and enables less costly equipment. Lower temperature also means that less trivalent Fe will be reduced, which in normal conditions results in that the Fe content of the pure water decreases.

By adding an oxidizing agent, such as hydrogen peroxide, to the flocculation process, Fe^{2+} will be oxidized to Fe^{3+} , thus increasing the amount of flocculated 15 material. This is advantageous, since the chemical oxygen demand (COD) and the Fe content of the pure water will then decrease. The oxidizing agent may be added to a concentration of 5 ppm to 60 ppm, such as 5 ppm to 10 ppm.

In an embodiment, the oxidizing agent is hydrogen peroxide (H_2O_2).

This is advantageous, since hydrogen peroxide will give oxidation of iron first 20 priority.

In an embodiment, the method further comprises the steps of re-circulating the permeate into the flocculation basin.

This is advantageous, because the Fe^{3+} will then precipitate, since the pH of the flocculation basin is more neutral, typically between pH 5-7. Also, Fe^{2+} present in the 25 permeate will be oxidized to Fe^{3+} , thus increasing the amount of flocculated material.

In an embodiment, the membrane filtration process is ultra filtration and/or micro filtration.

This is advantageous, since it provides an efficient separation of particulate matter and dissolved chemical coagulant.

30 In an embodiment, the method further comprises the step of feeding said first concentrate to a second membrane filtration process, so that a second concentrate and a second permeate are obtained.

This is advantageous, since it further reduces the volume of the concentrate exiting the system, which saves costs e.g. for transportation.

In an embodiment, the temperature of said sludge, said first sludge mixture, said first concentrate, said second concentrate and said first and second permeate is below 100°C, such as between about 40°C and about 90°C, such as between about 80°C and about 90°C. In an embodiment, said first membrane filtration process and/or said
5 second membrane filtration process are driven by a pressure higher than atmospheric pressure.

This is advantageous, since the process is more efficient at higher pressures.

In an embodiment, the pressure is between about 1 bar and about 4 bar.

In an embodiment, the method further comprises the steps of separating the
10 concentrate or the second concentrate and incinerating the concentrate. The method may optionally comprise the step of re-circulating the first and/or second permeate into the flocculation basin.

In an embodiment, the method further comprises the step of adding a base to said first concentrate or said second concentrate in a neutralization tank.

15 This is advantageous, because it makes the end concentrate more environmentally friendly and easier to handle.

In an embodiment, the inorganic chemical coagulants in solution are trivalent aluminum and/or iron ions.

According to a second aspect of the invention, a construction for treatment of
20 sludge from waterworks or wastewater treatment plants is provided. The construction comprises a first dissolution tank for addition of acid, connected in series with a membrane filtration unit and at least one sensor unit for monitoring a temperature of the sludge in the construction and a regulator unit for regulating the temperature of the
25 sludge in the construction, wherein the sensor and the regulator are connected to ensure that said temperature of said sludge within said construction is below the boiling point of water at atmospheric pressure.

In an embodiment, said temperature of said sludge within said construction is below 100°C, such as about 40°C and about 90°C, preferably between about 80°C and about 90°C.

30 In an embodiment, said membrane filtration unit is ultra filtration and/or a micro filtration.

In an embodiment, said construction further comprises a second membrane filtration unit arranged in series with said first membrane filtration unit.

In an embodiment, said construction further comprises a neutralization tank
35 (T8), arranged subsequent to said second membrane filtration unit.

In an embodiment, the construction further comprises a pH-meter/control.

The present invention has the advantage over the prior art that it is possible to acidify the sludge at atmospheric pressure, which is simpler and safer compared to a pressurized system. Another advantage is that the lower temperatures reduces wear on the equipment, and enables less costly equipment.

Furthermore, the hydrolysis of organic material in the permeate decreases.

Yet another advantage is that Iron is reduced in a lower extent, which makes it possible to run the process without the need for oxidizing iron, which makes the process less costly.

BRIEF DESCRIPTION OF DRAWINGS

These and other aspects, features and advantages of which the invention is capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which

Fig. 1 is a schematic illustration of a construction according to an embodiment; Fig. 2-4 are graphs showing process parameters; and Fig. 5 is a schematic illustration of a method according to an embodiment; and Fig. 6 is a schematic illustration of a construction according to an embodiment.

DESCRIPTION OF EMBODIMENTS

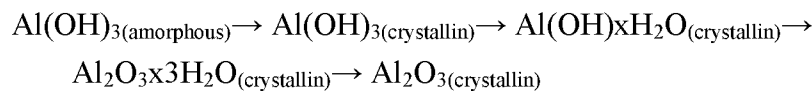
Several embodiments of the present invention will be described in more detail below with reference to the accompanying drawings in order for those skilled in the art to be able to carry out the invention. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The embodiments do not limit the invention, but the invention is only limited by the appended patent claims. Furthermore, the terminology used in the detailed description of the particular embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention.

Fig. 1 is a flowchart of an embodiment of a construction for treatment of sludge from waterworks or wastewater treatment plants. In all parts of the construction, the sludge has a temperature below the boiling point of water at atmospheric pressure,

such as below 100°C between about 40°C and about 90°C, such as between 40°C and 90°C, preferably between about 80°C and about 90°C, such as between 80°C and 90°C.

The present inventor has surprisingly found that when using fresh sludge, i.e. sludge younger than 7 days, dissolution of metal hydroxides, such as aluminum
5 hydroxide, is possible to obtain with acceptable rates, even in a process with a temperature below the boiling point of water at atmospheric pressure.

Sludge comprising metal hydroxides, such as typical sludge from waterworks or wastewater treatment plants, age in a process which, in the case with aluminum(III)hydroxide is:
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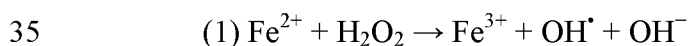
Each state is less soluble than the previous state, which makes it harder to
15 purify sludge which has aged, i.e. is older than 7 days. On the contrary, according to the present invention, $\text{Al(OH)}_{3(\text{amorphous})}$ may be dissolved in sulphuric acid without the need for high temperatures or pressures.

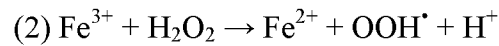
Returning to Fig. 1, incoming water A is supplied to waterworks or wastewater treatment plant W/WTP. The water in flocculation basin 1 is allowed under stirring to
20 react with a simultaneously incoming solution B of inorganic chemical coagulants. Usually, the chemical coagulants are aluminum or iron ions, which flocculate suspended substances in the water and organic substances and for wastewater treatment plants also phosphor. Thereafter the formed flocks are separated in a basin 2, where a thin sludge is formed on the base of the basin. Treated water in wastewater treatment plants is
25 separated as outgoing pure water E.

If Fe^{2+} is present in the water, it will fixate impurities just like Fe^{3+} but it will not hydrolyze. This means that the outgoing water from the separation process will contain some iron (Fe^{2+}) and have an increased COD. Fe^{2+} may be present both when
30 when Fe salts are used as chemical coagulants, but also when some types of Al salts are used (such as the product AVR from Kemira).

Hydrogen peroxide (H_2O_2 , denoted H) is added to the process, such as into the flocculation basin (1).

The hydrogen peroxide oxidizes iron ions according to Fenton's reaction:





Since Fe^{3+} hydrolyze in the system and precipitate, reaction 2 above will be less likely to occur than reaction 1, which will shift the balance and effectively reduce the content of Fe^{2+} in the system. This is advantageous, because it increases the amount of flocculated material. Thus, the chemical oxygen demand (COD) and divalent Fe in the pure water (E) will then decrease.

Ideally, the concentration of hydrogen peroxide is regulated to match the content of iron ions, so that no excess hydrogen peroxide remains in the system. This hydrogen peroxide might otherwise decompose polymers if they are used in the process.

The inventors conducted experiments with addition of hydrogen peroxide (10, 20, 40 or 60 ppm, respectively) to a system comprising iron ions as inorganic chemical coagulants.

The results are shown in Table 1 below. It was noted that addition of a small amount of hydrogen peroxide (H_2O_2), such as between 5 ppm and 10 ppm, to the process will decrease the COD of the product.

Table 1. COD, and iron ion content in different samples.

	COD mg/l	Fe2+ mg/l	Fe3+ mg/l	Total iron ions mg/l
Fe sulfate virgin	59,5			0,82
Fe permeate	74			6
Fe permeate + 10 ppm H2O2	56	0,87	0,125	0,995
Fe permeate +20 ppm H2O2	60,3	1,23	0,206	1,43
Fe permeate + 40 ppm H2O2	47,1	0,924	0,254	1,18
Fe permeate + 60 ppm H2O2	40,8	0,767	0,232	0,999

As can be seen in Table 1, the COD of virgin product (commercially available Fe sulfate) is less than the COD in permeate from the process. However, by adding 10 ppm hydrogen peroxide to the flocculation basin (1), the COD of the permeate can be lowered.

Settled sludge is scraped or in another way transported to a sludge hopper 3. In an embodiment, a received sludge C1, from the waterworks or wastewater treatment plant W/WTP, or coming directly from an industrial process, is led to a dissolution-tank T6, for treatment of sludge in connection to waterworks or wastewater treatment plant W/WTP, or in connection with an industrial process, for purifying water. Sludge from

other waterworks or wastewater treatment plants may also be treated in the dissolution-tank T6 according to the invention, which for example is transported thereto by lorry.

The sludge mixture C1 is led; irrespective which type of sludge, to the first dissolution-tank T6 with simultaneous supply of an acid F. Preferably, the acid is
5 sulphuric acid.

In the first dissolution-tank T6, which functions as a dissolver, the acid is stirred so that the metallic hydroxide in the obtained mixture is dissolved, i.e. free metallic ions (substantially Fe^{3+} and Al^{3+}) are formed. The addition of acid is controlled via a pH-meter/control QC, which controls a pump P1 for addition of acid. That
10 metallic hydroxide is dissolved and metallic ions are set free when pH is decreased is well known. The first dissolution-tank T6 may also comprise a level gauge, for measuring the level and controlling the amount of sludge mixture C1 entering the first dissolution-tank T6, such that the first dissolution-tank T6 comprises a constant volume of sludge.

Thus, in an embodiment, the amount of sludge in the first dissolution-tank T6
15 is regulated, e.g. by regulating the amount of sludge mixture C1 entering the first dissolution-tank T6, such that the first dissolution-tank T6 comprises a constant volume of sludge.

This is advantageous, since it makes it easier to regulate the process and
20 coordinate addition of acid.

Thus, when the metal hydroxide has been dissolved, a sludge mixture G, with acidic pH, is received, which includes suspended substances, organic substances and inorganic ions, including Fe^{3+} or Al^{3+} .

In an embodiment, the acidic pH is below 3.5, preferably below 3.

According to the invention this acidic feed sludge C1 is subjected to at least
25 one membrane filtration process, so that a first concentrate J and a first permeate Pe1 are received. As a result, said first permeate Pe1 substantially includes the inorganic chemical coagulants in solution.

A feed G of acidic sludge is pumped by the pump P3 to a construction of
30 MF/UF F1 and a part I of the first concentrate J is led back in a feedback loop and the first concentrate J is separated from the process directly so that the process is run as a continuous process. The first concentrate J may then optionally be subject to a separate dewatering step, to increase the level of dry substance. The feed G of acidic sludge is regulated to compensate for the amount of first concentrate J and first permeate Pe1
35 exiting the system.

This is advantageous, since it obliterate the need for stopping the process, which means drop of the capacity.

In an embodiment (not shown), the first concentrate J is recycled to tank T6. The process may thus be run in a discontinuous fashion, i.e. until the sludge in T6 is so
5 thick that it cannot be pumped to the construction of MF/UF F1. The tank T6 is then emptied and the process may restart.

In an embodiment (not shown), the first concentrate J is subject to washing, by adding water, before being transferred to the construction of MF/UF F1. If several filters are present, the washing step is conducted just before the sludge is transferred to
10 the last filter. Typically, the ratio of water added is 1:1 in relation to the amount of first concentrate J.

The washing step is advantageous, since it increases the amount of coagulant that can be re-circulated in the process. Thus, the resulting first concentrate J is cleaner than the first concentrate J and the yield of recovered Fe or Al can exceed 90%.

15 As will be appreciate by a person skilled in the art, a number of filtration units may be connected in series.

In an embodiment (not shown), the process may be run as a batch process, i.e. by re-circulating all I of the concentrate until the desired thickness has been obtained and the first concentrate J may be taken from the construction of MF/UF F1.

20 To this end the term "membrane filtration process" designates a separation process where the driving force is constituted of a difference in chemical potential over the membrane. The driving force –the chemical potential- may however be achieved in different ways in different membrane processes; it may be an applied pressure, a difference in concentration or temperature, or a difference in electric potential. The
25 mechanism of separation is based on solution theory, at which the solubility and diffusivity of the dissolved substances in the membrane are decisive. In one embodiment, ceramic filters are used.

In an embodiment, the pressure is above atmospheric pressure, such as between about 1 bar and about 4 bar, preferably between 3 bar and 4 bar.

30 Different kinds of membranes were used in the different membrane processes, such as micro filtration (MF) or ultra filtration (UF). The membrane type is chosen so that Al^{3+} and Fe^{3+} may pass, and thereby be re-circulated.

During ultra filtration (UF), the size of the pores primarily decides what is separated and what passes through the membrane. The mechanism of sieving is
35 accordingly predominant; but the interaction between membrane and the dissolved

substances is also of importance. The separation during micro filtration (MF) is completely based on a mechanism of sieving, and the size is totally the determining factor for what will pass through the membrane.

In a MF-device suspended matter and colloids are mainly separated. When
5 using MF a higher flux (flow per membrane area) is often obtained. This alternative is preferably utilized for treatment of sludge, which does not require a high separation of dissolved organic substances, for example if the amount of humus is low. A concentrate is received, which substantially includes in water suspended matter.

MF/UF are membrane processes; where a driving pressure has to be present to
10 divide the feed into a permeate and a concentrate.

For sludge from waterworks, with a lot of humus matter, or for sludge from wastewater treatment plants, which contains a lot of organic matter, the membrane is preferably chosen in such way that also organic molecules are separated. This may be accomplished by choosing an ultra filtration membrane with low retention of spherical
15 ions, such as trivalent aluminum and iron ions, and a high retention of chain shaped molecules, for instance organic substances, such as humus. Accordingly, the filtration through a first construction of membrane filtration F1 results in a first concentrate J of suspended substances and organic compounds and a first permeate Pe1, substantially consisting of water with inorganic ions, such as Al^{3+} and Fe^{3+} , which pass through the
20 relevant membrane.

The first permeate Pe1, now substantially relieved from substances originally contaminating the water, contains Al^{3+} and Fe^{3+} ions, and may be re-circulated as a precipitation agent to the flocculation part of waterworks or wastewater treatment plants or be used as chemical coagulant in another purification plant.

25 The first permeate Pe1 may also be deposited in a storage tank T7. In an embodiment (not shown), the permeate may be subject to heat exchange with the sludge C1, which saves energy.

If the first permeate Pe1 is re-circulated, directly or by means of an intermittent storage tank T7, into the flocculation part of the waterworks or wastewater treatment
30 plant, the pH will increase so that the Al^{3+} and Fe^{3+} will hydrolyze and precipitate.

Thus, the precipitating effect of the permeate may be regulated by regulating pH. In the filtration process, pH is relatively low and the ions are dissolved. However, in the flocculation basin, pH is more neutral, typically between pH 5-7, which causes precipitation.

Fig. 2 is a graph showing the dependence of COD(Al), i.e. using Al^{3+} , of the permeate in mg/l O_2 in relation to temperature of the process, measured in °C. As can be seen, the COD(Al) decreases with decreasing temperature.

Fig. 3 is a graph showing the dependence of COD(Al), i.e. using Al^{3+} , of the permeate in mg/l O_2 in relation to pH of the sludge in T6. The temperature is 80°C. It can be noted that COD(Al) increases with decreasing pH.

Fig. 4 is a graph showing the flux of feed G in m^3 per hour, per area membrane of F1, in m^2 , using an ultra filtration, in relation to temperature of the sludge, measured in °C. As can be seen, the flux decreases with decreasing temperature, but is still acceptable at a temperature as low as 40°C.

Thus, low temperature and high pH is beneficial for the process, but requires a larger filter surface.

An advantage with the present invention, utilizing a process temperature below the boiling point of water at atmospheric pressure, is thus that the process can be run at conditions providing lower COD(Al) of the permeate.

In an embodiment according to Fig. 6, several filtration units are used. The more or less diluted permeate from the construction of MF/UF F1, obtained as described above, may then be led to a second construction of membrane filtration F2. This second type of membrane filtration F2 is designed in such a way that, except for a second permeate Pe2, a second concentrate K, L is received, which will substantially contain the inorganic chemical coagulants in solution. As with the first permeate Pe1, the second permeate Pe2 is re-circulated as a precipitation agent.

Thus, the precipitating effect of the permeate may be regulated by regulating pH. In the filtration process, pH is relatively low and the ions are dissolved. However, in the flocculation basin, pH is more neutral, typically between pH 5-7, which causes precipitation.

As previously described the second permeate Pe2 may also be deposited in a storage tank T7. In an embodiment (not shown), the permeate may be subject to heat exchange with the sludge C1, which saves energy.

In an embodiment (not shown), the second concentrate K, L is subject to washing, by adding water, and then subsequently pumped to an optional further filtration step, or discarded. Typically, the ratio of water added is 1:1 in relation to the amount of first concentrate J.

The washing step is advantageous, since it increases the amount of coagulant that can be re-circulated in the process. Thus, the resulting first concentrate J is cleaner than the first concentrate J and the yield of recovered Fe or Al can exceed 90%.

In an embodiment (not shown), the first concentrate J is subject to washing, by
5 adding water, before being transferred to the construction of MF/UF F2. If several filters are present, the washing step is conducted just before the sludge is transferred to the last filter. Typically, the ratio of water added is 1:1 in relation to the amount of first concentrate J.

The washing step is advantageous, since it increases the amount of coagulant
10 that can be re-circulated in the process. Thus, the resulting first concentrate J is cleaner than the first concentrate J and the yield of recovered Fe or Al can exceed 90%.

The first concentrate J is led to the construction of MF/UF F2. A pressure meter/regulator PI controls a control valve V1 on the outlet of a second concentrate K from the construction of MF/UF F2, such that a constant preset pressure on the feed is
15 obtained. The difference between this pressure and the pressure obtained by the pump P3 will at the same time constitute the differential pressure over the construction of MF/UF F1. A recirculation of the second concentrate K over the construction of MF/UF F2 is also possible by means of a pump P4. When the content of dry substance in the second concentrate K, L reaches a certain predetermined level, such as 15-20 % (by
20 weight) dry substance, it is separated from the process. Thus, in this embodiment, the process is run as a semi continuous batch process. This is advantageous, since it saves a separate dewatering step, which would have been needed if the level of dry substance in the concentrate would have been lower.

In another embodiment, the second concentrate K, L is separated from the
25 process directly. Thus, the process may be run as a continuous process. The second concentrate K, L may then optionally be subject to a separate dewatering step, to increase the level of dry substance.

This is advantageous, since it obliterates the need for stopping the process, which will reduce the capacity.

In an embodiment, the acidic second concentrate L, from the construction of MF/UF F2, is led to a neutralizing tank T8, which is provided with an agitator. A base P, preferably lime or sludge of lime is added to the neutralizing tank T8 until a neutral pH is obtained. A neutralized concentrate Q is thereafter tapped off or re-circulated.

As the permeate Pe1, Pe2, containing aluminum and iron ions, is separated and
35 re-circulated and new acidified sludge is fed from the tank T6, the concentrate I, which

is re-circulated, will contain more and more of suspended and dissolved substances. This will imply that the flux, i.e. the flow of concentrate J, will decrease. When the flux has reached a critical level, such as 15-20 % (by weight) dry substance, the process is stopped and the concentrate I may have to be separated from the process.

5 To increase the concentration of Al^{3+} and Fe^{3+} , the first concentrate J, from the device F1 of micro filtration (MF)/ultra filtration (UF), is preferably subjected to subsequent micro filtration (MF)/ultra filtration (UF) at device F2.

The membrane type is chosen so that Al^{3+} and Fe^{3+} may pass, and thereby be re-circulated.

10 In an embodiment (not shown), the part of the first concentrate I, or the second concentrate K, may be separated from the process, either semi-continuously or continuously, and incinerated.

The first concentrate J and the second concentrate K, L comprise less organic salts due to the filtration in F1 and/or F2.

15 This is advantageous, since the incineration will give less ash, compared to incinerating the sludge without prior filtration. Furthermore, without inorganic compounds the incineration will lead to less risk for incrustations.

Fig. 5 is a schematic illustration of a method 50 for treatment of sludge (C1) from waterworks or wastewater treatment plant (W/WTP), said sludge comprising precipitated inorganic chemical coagulants and precipitated organic substances.

The method 50 is suitably executed with a construction according to Fig. 1.

20 The method 50 comprises a step of adding 51 inorganic chemical coagulants, comprising iron ions, to a flocculation basin 1 of the waterworks or wastewater treatment plant W/WTP, leading to flocculation of particles which sediment to form a sludge C1 in a flocculation basin 2, thus purifying the water A, giving pure water E. The method 50 also comprises a step of adding 52 an acid F to said sludge C1, comprising precipitated inorganic chemical coagulants and precipitated organic substances, in such way that a first sludge mixture G with pH below 3.5 is received, which includes said inorganic chemical coagulants in solution and said organic substances.

30 The method also comprises a step of feeding 53 said obtained first sludge mixture G to at least one membrane filtration process F1, in which a first concentrate J and a first permeate Pe1 are obtained and a step of keeping 54 a temperature of said sludge C1, said first sludge mixture G, said first concentrate J and said first permeate Pe1 which is below the boiling point of water at atmospheric pressure. The method

further comprises a step of adding 55 an oxidizing agent H, such as hydrogen peroxide to the flocculation basin 1.

In an embodiment, the hydrogen peroxide is added to a concentration of 5 ppm to 60 ppm, such as 5 ppm to 10 ppm.

5 The temperature of the sludge C1, said first sludge mixture G, said first concentrate J, said second concentrate K, L and said first and second permeate Pe1, Pe2 is below 100°C, such as between about 40°C and about 90°C, such as between about 80°C and about 90°C.

10 In the invention, the above mentioned membrane processes are carried out at the same time as an effective hydrolysis of the organic matter in the sludge is obtained. Hydrolysis implies that water molecules are bound in polymeric organic substances, which then are split up into smaller pieces. The decomposition into smaller molecules facilitates subsequent biological decomposition. During normal conditions, a hydrolysis of an organic substance hardly ever occurs, when it gets in contact with water. At
15 addition of a strong acid or at an elevated temperature, which at the same time requires a pressurisation of the sludge, or a combination of the two, a hydrolysis of the organic substances, which usually can be found in sludge from waterworks and sludge from wastewater treatment plants, occur almost without exception. Hydrolysis of sludge is a method that, in recent times, is utilised more and more to increase the production of
20 biogas in digester constructions, which at the same time imply that the amount of residual sludge is decreased. The usual hydrolysis procedure, in this context, is thermal hydrolysis. Thermal hydrolysis in combination with addition of acid gives a more effective hydrolysis in a shorter period of time. Addition of acid and necessary subsequent neutralization is however often believed to be too costly. In the present
25 invention the addition of acid, the pressure that the recycling process requires, and the thermal energy that the elevation of pressure generates, is utilized.

Thus, the present invention brings with it that the greater part of the used chemical coagulants, trivalent iron or aluminum, is separated from the organic compounds and suspended substances bound in sludge at the same time as the organic
30 substances are effectively hydrolyzed. According to the invention the chemical coagulants may be recovered and the amount of sludge is decreased, since the iron or aluminum hydroxide formed by the chemical coagulant has been removed. The simultaneously accomplished hydrolysis of the organic substances increases the biological degradability, which partly improves the properties of the sludge as a soil
35 improvement agent, partly increases the production of biogas and further reduces the

residual amount of sludge in a subsequent digestion. By this procedure the invention simultaneously replaces a costly investment and operation of a conventional construction of dewatering. The treatment of the sludge additionally leads to the fact that the tapped off concentrate may be hygienic.

5 The term “hygienic” denotes that a bacterially contaminated solution is treated in such a way that the risk of transference of infection reaches an acceptable level. The object with the treatment is to kill off vegetative forms of disease generating microorganisms.

10 The invention has been described above with reference to an exemplary plant. However, the invention may be used in other types of plants and the respective parts and features of the invention may be combined in other ways than described and shown on the drawing. Such modifications appearing to a skilled person reading the present specification are intended to be within the scope of the invention which is merely limited by the appended patent claims.

15

CLAIMS

1. A method (50) for treatment of sludge from waterworks or wastewater treatment plant (W/WTP), comprising iron ions as inorganic chemical coagulants, said method comprising the steps of
- 5 adding (51) inorganic chemical coagulants, comprising iron ions, to a flocculation basin (1) of the waterworks or wastewater treatment plant (W/WTP), leading to flocculation of particles which sediment to form a sludge (C1) in a flocculation basin (2), thus purifying the water (A), giving pure water (E);
- 10 adding (52) an acid (F) to said sludge (C1), comprising precipitated inorganic chemical coagulants and precipitated organic substances, in such way that a first sludge mixture (G) with pH below 3.5 is received, which includes said inorganic chemical coagulants in solution and said organic substances,
- feeding (53) said obtained first sludge mixture (G) to at least one membrane filtration process (F1), in which a first concentrate (J) and a first permeate (Pe1) are
- 15 obtained; and
- keeping (54) a temperature of said sludge (C1), said first sludge mixture (G), said first concentrate (J) and said first permeate (Pe1) which is below the boiling point of water at atmospheric pressure; and
- 20 adding (55) an oxidizing agent (H) to the flocculation basin (1).
2. The method according to claim 1, wherein the oxidizing agent (H) is hydrogen peroxide.
- 25 3. The method according to claim 1 or 2, wherein the oxidizing agent is added to a concentration of 5 ppm to 60 ppm, such as 5 ppm to 10 ppm.
4. Method according to any of the preceding claims, further comprising the steps of
- 30 re-circulating the first permeate (Pe1) into the flocculation basin (1).
5. Method according to any of the preceding claims, wherein said first membrane filtration process (F1) is ultra filtration and/or micro filtration.

6. Method according to any of the preceding claims, further comprising the step of

feeding said first concentrate (J) to a second membrane filtration process (F2), so that a second concentrate (K, L) and a second permeate (Pe2) are obtained.

5

7. Method according to any of the preceding claims, wherein said temperature of said sludge (C1), said first sludge mixture (G), said first concentrate (J), said second concentrate (K, L) and said first and second permeate (Pe1, Pe2) is below 100°C, such as between about 40°C and about 90°C, such as between about 80°C and about 90°C.

10

8. Method according to any of the preceding claims, wherein said first membrane filtration process (F1) and/or said second membrane filtration process (F2) is/are driven by a pressure higher than atmospheric pressure.

15

9. Method according to claim 8, wherein said pressure is between about 1 bar and about 4 bar.

10. Method according to any of the preceding claims, further comprising the steps of re-circulating the first and/or second permeate (Pe1, Pe2) into the flocculation basin (1).

20

11. Method according to any of the preceding claims, further comprising the step of adding a base (P) to said first concentrate (J) or said second concentrate (K) in a neutralization tank (T8).

25

12. Method according to any of the preceding claims, wherein said inorganic chemical coagulants in solution are trivalent aluminum and/or iron ions.

30

13. A construction (CTS) for treatment of sludge (C1) from waterworks or wastewater treatment plants (W/WTP), comprising a first dissolution tank (T6) for addition of acid, connected in series with a membrane filtration unit (F1) and at least one sensor unit (S) for monitoring a temperature of the sludge in the construction (CTS)

35

and a regulator unit (R) for regulating the temperature of the sludge (C1) in the construction (CTS), wherein the sensor (S) and the regulator (R) are connected to ensure that said temperature of said sludge within said construction (CTS) is below the boiling point of water at atmospheric pressure.

5

14. Construction according to claim 13, wherein said temperature of said sludge within said construction is below 100°C, such as between about 40°C and about 90°C, such as between about 80°C and about 90°C.

10

15. Construction according to any of claims 13 to 14, wherein said membrane filtration unit (F1) is ultra filtration and/or a micro filtration.

15

16. Construction according to any of claims 13 to 15, further comprising a second membrane filtration unit (F2) arranged in series with said first membrane filtration unit (F1).

17. Construction according to claims 13 to 16, further comprising a pH-meter/control (QC).

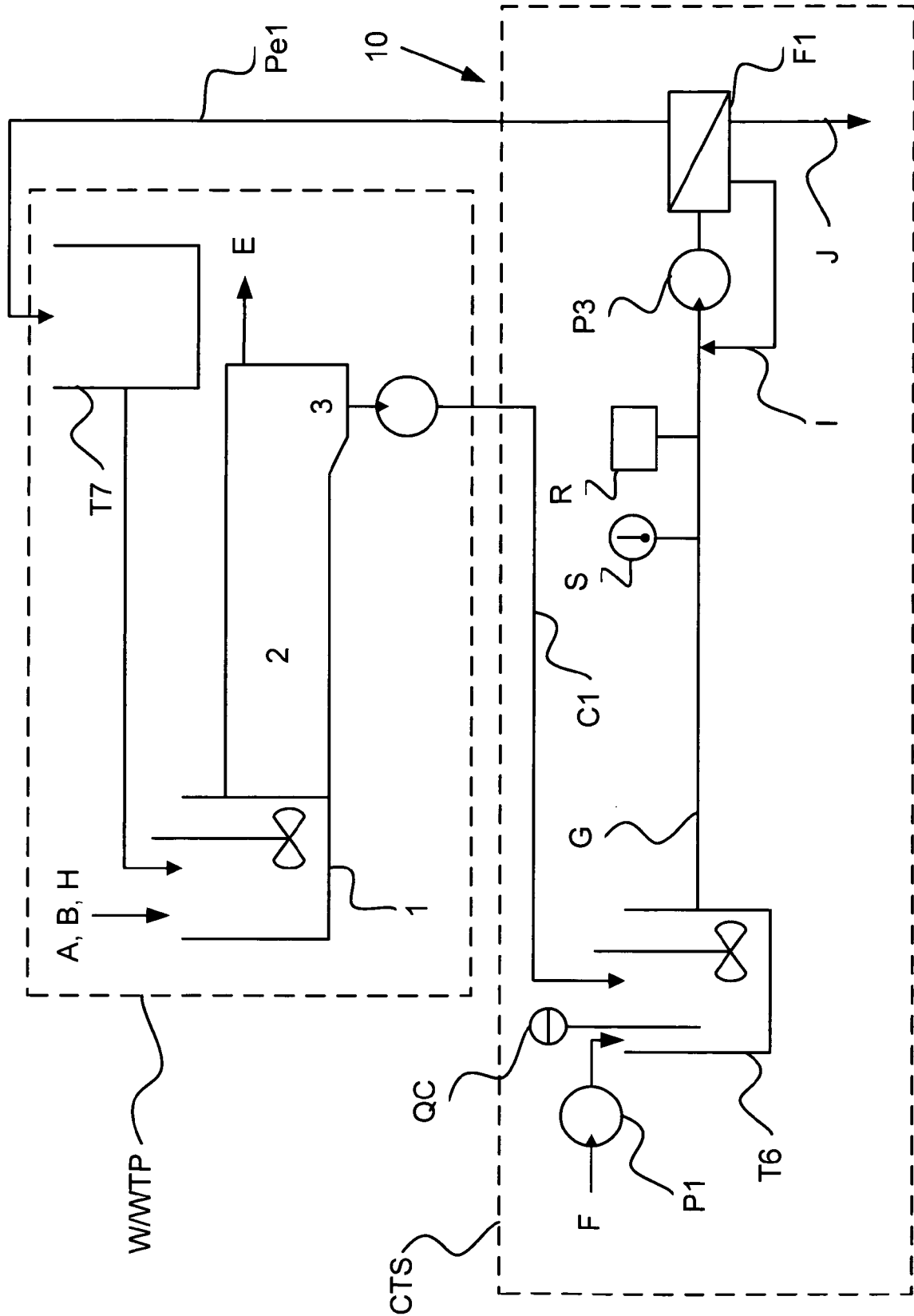


Fig. 1

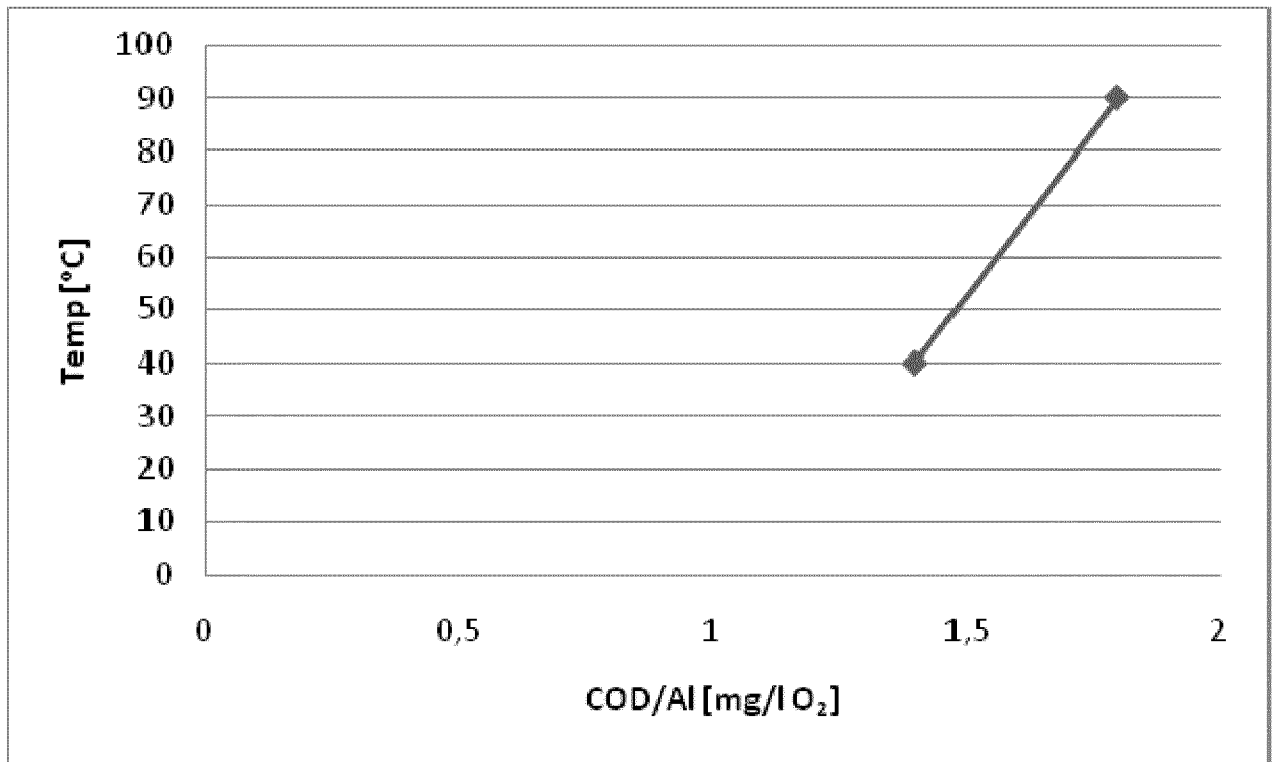


Fig. 2

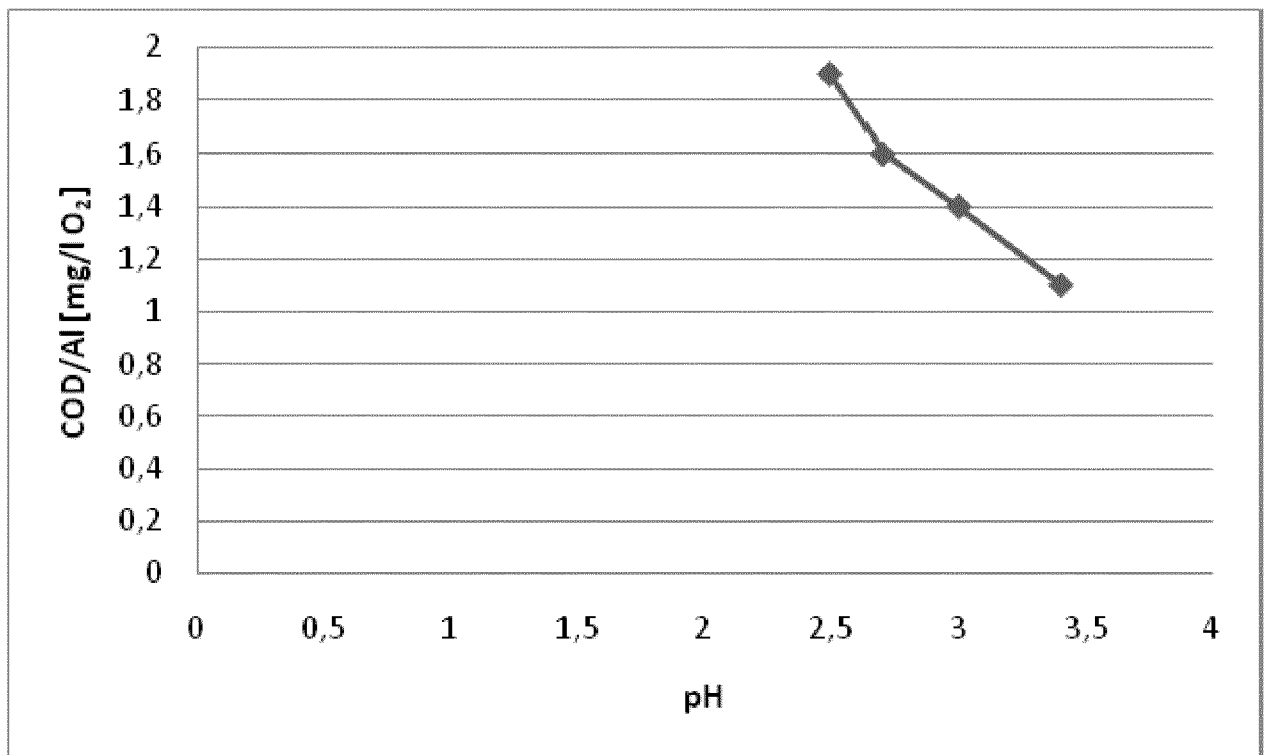


Fig. 3

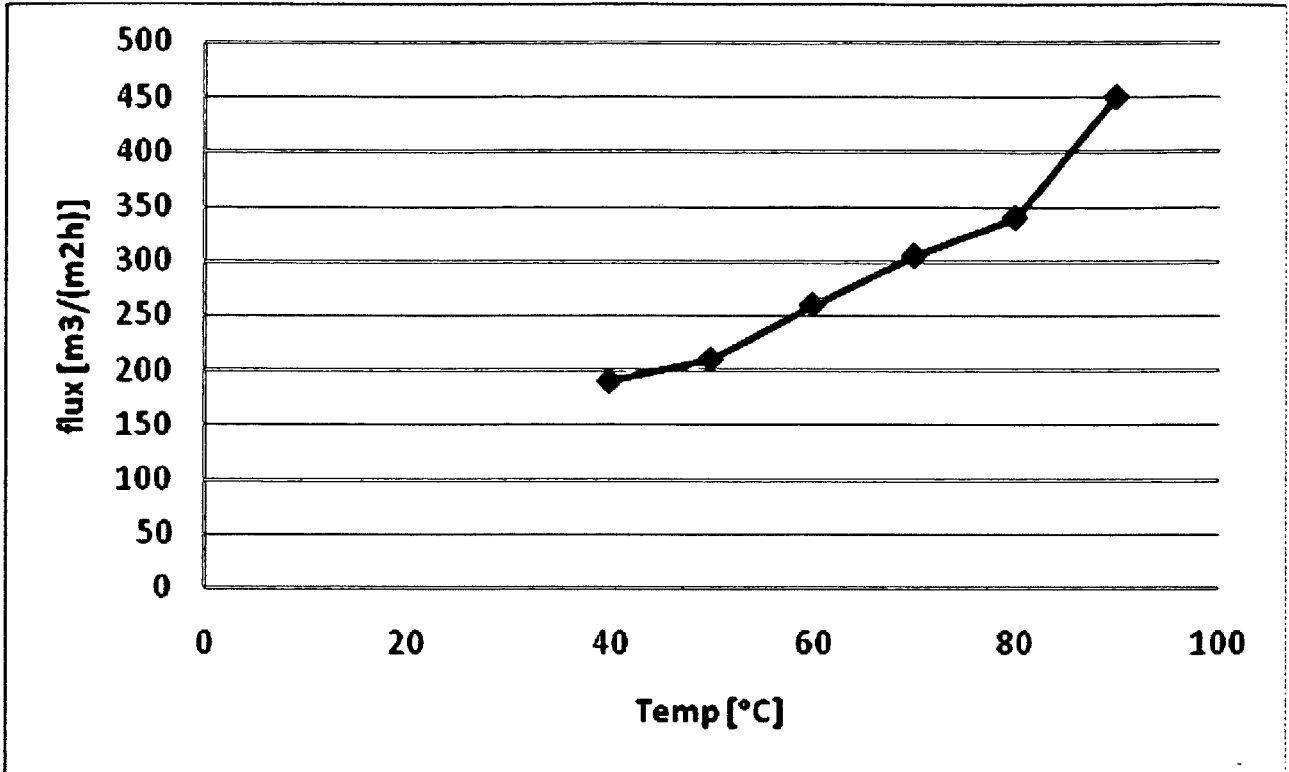


Fig. 4

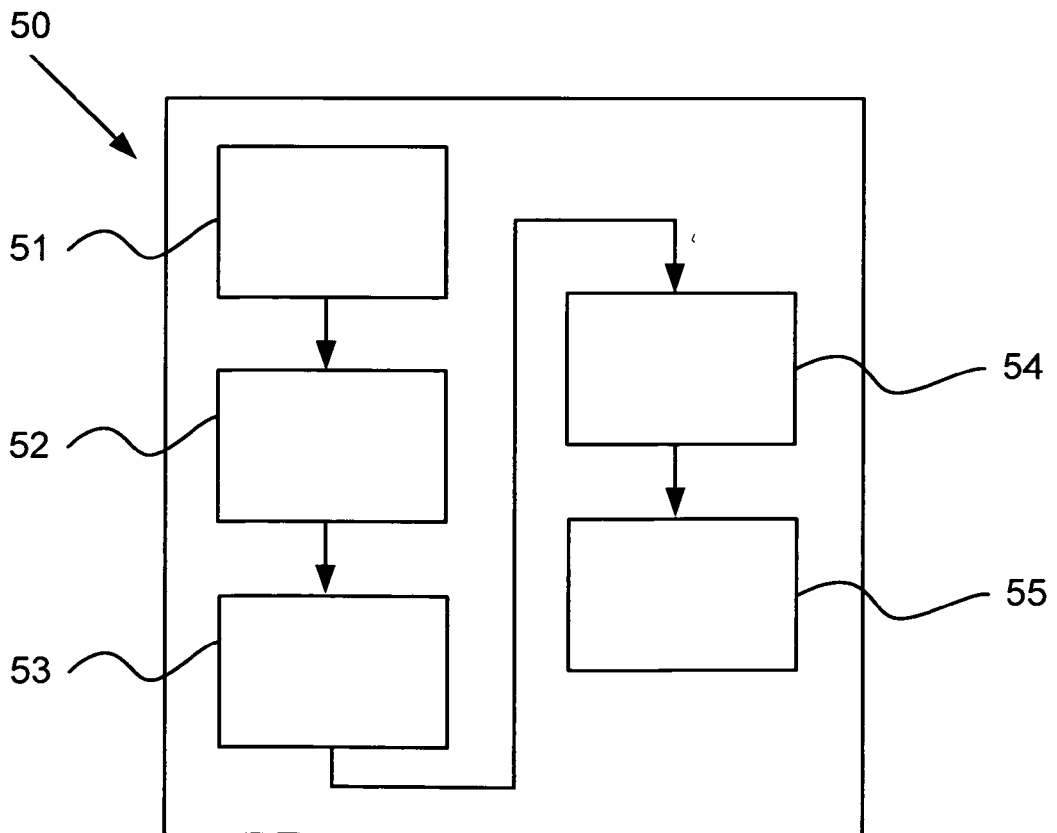


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/072738

A. CLASSIFICATION OF SUBJECT MATTER
 INV. B01D61/16 C02F9/00
 ADD. C02F1/52 C02F11/00

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)
 B01D 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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 507 745 A1 (ULMERT HANS DAVID [SE] FERALCO AB [SE]) 23 February 2005 (2005-02-23) figure 1 paragraph [0031] - paragraph [0065]	1-17
X	LINDSEY E E ET AL: "RECOVERY AND REUSE OF ALUM FROM WATER FILTRATION PLANT SLUDGE BY ULTRAFILTRATION", AICHE SYMPOSIUM SERIES, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, NEW YORK, NY, US, vol. 71, no. 151, 1 January 1975 (1975-01-01), pages 185-192, XP009072020, ISSN: 0065-8812 figure 1 tables 1,2 page 185 - page 187	1-17

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

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"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.

"&" document member of the same patent family

Date of the actual completion of the international search 16 March 2012	Date of mailing of the international search report 05/04/2012
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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 Châtellier, Xavier
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/072738

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0 371 187 A1 (GELSENWASSER AG [DE]) 6 June 1990 (1990-06-06) page 2, line 38 - line 50 page 3, line 43 - line 50 -----	1-3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2011/072738

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