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(54) Title: WATER TREATMENT PROCESS

(57) Abstract: A process for the treatment of an aqueous fluid is disclosed, comprising combining an aqueous fluid with an effective amount of at least one polyaluminium coagulant and a coagulating effective amount of at least one alkali metal silicate for a sufficient time and under conditions suitable to coagulate particles in said fluid and allow flocculation of coagulated particles. The aqueous fluid is preferably water, including but not limited to ground water, bore water, domestic waste water and industrial waste water. The invention is suitable for production of potable water and may of course be used to produce water of lower purity such as that suitable for industrial process water. The invention also relates to the use of a predetermined quantity of at least one alkali metal silicate in conjunction with an amount of at least one polyaluminium coagulant in the treatment of an aqueous fluid, preferably water, the quantity of the alkali metal silicate being sufficient such that improved flocculation is achieved as compared with flocculation achieved by the use of the polyaluminium coagulant alone.

## WATER TREATMENT PROCESS

Field of the Invention

This invention relates to improvements in treatment of aqueous fluids, and in particular to processes for the treatment of water using chemical additives in order to coagulate contaminants in the water and promote flocculation of the coagulated solids.

There are many examples in existing practice of coagulant compositions for the treatment of water. These treatments sometimes utilise a single component, however are frequently multi-component systems.

For example, aluminium sulphate (alum), ferric sulphate or ferric chloride are commonly used as primary coagulants in potable water and wastewater clarification processes. These additives have become particularly widely used in the removal of suspended solids and organic colour from drinking water. Alum or ferric sulphate or ferric chloride treatment is usually accompanied by treatment with alkaline additives such as hydrated lime, sodium hydroxide or soda ash in order to correct the acidity caused by the hydrolysis of the coagulants which occurs when the metal hydroxide floc is formed.

More recently, polyaluminium coagulants, particularly aluminium chlorohydrate, or polyferric coagulants have been increasingly used for water and wastewater treatment, being often more effective as coagulants, and requiring less pH correction than alum or non-hydroxylated ferric salts, owing to the pre-hydrolysed nature of the polyaluminium or polyferric compounds.

There have been related improvements in coagulant aids which act as enhancers for the process and they are effectively used in conjunction with primary coagulants such as aluminium sulphate in order to produce a better flocculation process. For example, activated silica, usually prepared from sodium silicate solution, is added in conjunction with a primary coagulant in order to enhance the floc formation. This has been effective in obtaining larger more readily separated flocs than produced by primary coagulant alone. The surface of activated silica is also known to be effective in the removal of certain organic contaminants from water and wastewater, and activated silica is also useful for stabilisation of certain inorganic contaminants such as manganese and iron. Several procedures for the prior preparation of activated silica from sodium silicate in water treatment plants

are known, and usually involve addition of acidic or alkaline additives to the silicate in a reaction tank, followed by ageing to yield the activated species.

Sodium silicate can be used as a corrosion inhibitor for cast iron pipes, service lines and fixtures. Sodium silicate inhibits corrosion by forming a protective film on metal surfaces that isolates the metal from further corrosive attack. Sodium silicate can also be used as a sequestrant for iron and manganese at acidic pH to prevent water discolouration.

There have been deficiencies in prior water treatment practice, particularly in certain critical water conditions, requiring large coagulant dosages to achieve an acceptable floc size and structure to enable separation of contaminants in clarifiers and filters. Installation of facilities for preparation of activated silica has partially addressed this problem, the activated silica typically being used in conjunction with alum as a two stage coagulation process, however these preparation facilities add a relatively complex step to the process, and have failed to overcome many difficult coagulation conditions.

#### Summary of the Invention

It is desirable therefore to lower the coagulant dosage, improve the floc size, structure, shear resistance and separation rate, simplify the operation of the water treatment process and provide more effective coagulation in difficult water conditions.

In one aspect, the present invention consists in use of a predetermined quantity of at least one alkali metal silicate in conjunction with an amount of at least one polyaluminium coagulant in the treatment of an aqueous fluid, preferably water, the quantity of the alkali metal silicate being sufficient such that improved flocculation is achieved as compared with flocculation achieved by the use of polyaluminium coagulant alone.

The present inventors have surprisingly found that alkali metal silicate enhances the effect of the polyaluminium coagulant giving an increase in floc size, density and shear resistance. An improvement is also seen in the turbidity of the treated water.

Accordingly, another aspect of the present invention consists in use of a predetermined quantity of at least one alkali metal silicate in conjunction with an amount of at least one polyaluminium coagulant in the treatment of an aqueous fluid, preferably water, to produce a treated fluid, the quantity of said at least one alkali metal silicate being sufficient such that the turbidity of

the treated fluid is lower as compared with the turbidity of treated fluid produced by the use of said at least one polyaluminium coagulant alone.

A further aspect of the invention consists in a process for the treatment of an aqueous fluid, preferably water, comprising combining an aqueous fluid  
5 with an effective amount of at least one polyaluminium coagulant and a coagulating effective amount of at least one alkali metal silicate for a sufficient time and under conditions suitable to coagulate particles in said fluid and allow flocculation of coagulated particles.

Throughout this specification the word "comprise", or variations such  
10 as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The polyaluminium coagulant and alkali metal silicate may be  
15 combined with an aqueous fluid under conditions of rapid mixing suitable to coagulate particles in said fluid to give a partially treated fluid then subjected to slow mixing conditions suitable to promote flocculation of coagulated particles. The flocculated particles may then be separated to give a treated fluid.

20 The invention may be used for continuous treatment of fluid as well as batch treatment. Similarly, the polyaluminium coagulant and the alkali metal silicate may be added continuously or in unit doses as desired.

The present invention is suitable for the treatment of aqueous fluids from a wide range of sources. The aqueous fluid is preferably water,  
25 including but not limited to ground water, bore water, domestic waste water and industrial waste water. The invention is suitable for production of potable water and may of course be used to produce water of lower purity such as that suitable for industrial process water.

The polyaluminium coagulant and the alkali metal silicate are  
30 preferably added sequentially. To maximise the coagulating effectiveness of these components they are each thoroughly mixed with the water prior to addition of the next component. The polyaluminium coagulant may be added to the water before or after addition of the alkali metal silicate, but is preferably added beforehand. Each component may be thoroughly mixed  
35 with the water prior to addition of the next component using methods known in the art such as flash mixing and pre-dilution.

The term "flash mixing" as used herein refers to all types of rapid mixing known to those skilled in the art including, but not limited to, injection into a rapidly moving body of water (in-line mixing, both static and dynamic) and mixing in a mixing chamber with an electrically driven  
5 agitator.

The term "pre-dilution" refers to the practice of mixing additives with a quantity of raw water prior to addition to the main volume of water to be treated. In view of the large density difference between the polyaluminium coagulant and water, the relatively small amounts used of the coagulating  
10 components and the relatively short mixing times, prediluting the components with raw water facilitates thorough mixing.

The polyaluminium coagulant may be one or more polyaluminium compounds selected from the group consisting of chloride, sulphate, silicate sulphate, chlorosulphate and nitrate, preferably one or more polyaluminium  
15 compounds selected from the group consisting of chloride and sulphate, more preferably polyaluminium chloride. The polyaluminium chlorides (PACs) have a basicity of greater than zero, preferably a basicity of at least 35% and the more preferably a basicity of at least 83%.

As used herein, the term "basicity" refers to the extent of neutralisation  
20 of hydrated aluminium ions with basic anions, specifically hydroxide ions in this instance and is a measure of the number of hydroxide groups per aluminium group, in comparison with the 100% value of three hydroxide groups per aluminium group. For example, for the empirical formula  $\text{Al}(\text{OH})_a\text{Cl}_b$  in which  $(a+b=3)$ , the basicity (as a percentage) is the value  $(a/3)$   
25  $\times 100$ .

The polyaluminium coagulant is added in an amount effective to promote coagulation. A person skilled in the art will understand that the appropriate amount of coagulant will vary with raw water quality, a higher turbidity for example (greater amounts of colloidal matter) requiring greater  
30 amounts of coagulant. The polyaluminium coagulant may be added in amounts such as 1 to 500 mg/L, preferably 1 to 250 mg/L, more preferably 5 to 120 mg/L and most preferably 10 to 25 mg/L.

The alkali metal silicate is preferably one or more compounds selected from sodium and potassium silicates, more preferably sodium silicates. Of  
35 the sodium silicates the preferred compounds are those with a silicon (as

SiO<sub>2</sub>) to sodium (as Na<sub>2</sub>O) ratio of 0.5 to 4, more preferably 1.6 to 3.8, most preferably 2.5 to 3.5, such as 3.22.

The alkali metal silicate is added in a coagulating effective amount such as 0.5 to 100 mg/L, preferably 0.5 to 50 mg/L, more preferably 1 to 25  
5 mg/L and most preferably 2 to 10 mg/L.

In a preferred embodiment of the invention, a non-ionic or anionic polymeric flocculant is also added to the water and rapidly dispersed in the water. Suitable polymeric flocculants are polyacrylamides such as those supplied under the trade names Ciba Magnafloc LT20™ (Ciba Specialty  
10 Chemicals), Cytec Super floc N300™ (Cytec Industries Inc) and Hardman Multifloc N1900™ (Hardman Australia Pty Ltd). The polymeric flocculant may be added, for example, as an aqueous solution pre-blended with the sodium silicate or the sodium silicate may be added into a delivery line carrying diluted polymer.

15 The flash mixing stage is conventionally followed by a slow mixing stage to promote flocculation. Typically slow mixing is conducted in a separate chamber from the flash mixing, known as a flocculation chamber. A typical flocculation chamber consists of two-stage slow horizontally moving paddles in a concrete tank with a total retention time of about 20 minutes.  
20 The resulting floc is subsequently separated from the water by sedimentation/flotation and filtration. In some water treatment processes, the flocculation stage is omitted.

Sedimentation/flotation methods may include large gravity sedimentation basins, tube settlers, sludge blanket clarifiers and dissolved air  
25 flotation. Usually the filtration step consists of sand filters sometimes incorporating mixed-bed sand and anthracite for more efficient back-washing. Direct filtration is sometimes used on low-turbidity waters for which the suspended solids level is low and consists of flash mixing followed by sand filtration with no additional sedimentation basin.

30 In another preferred embodiment of the invention, a portion of the water from the flash mixing stage is used to pre-dilute the polyaluminium coagulant and/or the alkali metal silicate.

The treated water may be drawn directly from the flash mixer or from the outlet of the flash mixer and returned to the points of addition of the  
35 polyaluminium coagulant and alkali metal silicate at the front end of the flash

mixer. It has been found that pre-diluting with treated water rather than raw water further enhances the water treatment process.

Other additives may be included in the process. Other coagulants such as alum, ferric sulphate or ferric chloride may be added to the water to assist  
5 coagulation performance of the treatment process. Sodium carbonate, lime, sodium hydroxide or other known alkaline additives may be utilised for pH correction. The person skilled in the art will appreciate the need for pH correction to satisfy the Langelier Index requirement to control both corrosion and scale deposition and to conform to local regulatory requirements.

10

#### Detailed Description of the Invention

The invention provides an improvement in the floc size, structure and separation rate, and does not require more complex processes for prior conversion of sodium silicate to activated silica that have been traditionally  
15 carried out.

The invention enables a reduction in the total coagulant dosage requirement for effective coagulation of impurities especially in low turbidity or low alkalinity conditions during which it is often difficult to establish good coagulation. The invention is also less sensitive to variations in raw water  
20 quality so dosages need not be reset as often thereby reducing plant control time.

In the process according to this invention, there is a surprising interaction between silicate species which gradually form in the water during the thorough mixing stage and the hydrolysed aluminium species which are  
25 formed from the polyaluminium coagulant. The improvement in coagulation has exceeded that achieved by adding activated silica formed by previous methods, and has given a surprising shear resistance to the flocs. This shear resistance has enabled floc that has been carried over from a sedimentation stage into a final filter stage to rapidly re-form in spite of turbulence, and to  
30 be effectively removed in the filter. This is a significant improvement for hydraulically overloaded water treatment plants.

The effect has been particularly noted in cases where the primary coagulant has mainly comprised an aqueous solution of aluminium chlorohydrate solution having a basicity preferably greater than 83 percent,  
35 with an aluminium content of 23.5 percent as  $Al_2O_3$ , and the sodium silicate has comprised an aqueous solution of 3.22 weight ratio of silicon dioxide to

sodium oxide, as exemplified by, but not limited to, N CLEAR™ Sodium Silicate Solution manufactured by The PQ Corporation.

The effect has also been particularly noted in cases where the sodium silicate solution is added after the primary coagulant, and both the primary  
5 coagulant and the sodium silicate solution are pre-diluted with a portion of the partially treated water already containing these additives and their reaction products. The partially treated water contains partially formed floc aggregates and other species which give a surprising improvement in the coagulation process when used as pre-dilution water with the above  
10 additives. The portion of the partially treated water that is returned as pre-dilution water is typically a very small proportion of the total flow of treated water, however it is preferable to maximise this flow as much as possible so as to maximise mixing of the coagulant and alkali metal silicate with the water. It enables significantly better coagulation compared to other sources  
15 of pre-dilution water.

Optionally, other known additives for disinfection, taste and odour removal, organics removal, polymer enhancement, correction of pH, hardness, alkalinity or metal content may be added to the treated water at selected stages in the process according to this invention.

20 In order to better understand the nature of the invention, examples will now be described.

#### Example 1

A potable water treatment plant treating 10 MLD (megalitres per day) of  
25 river water of very low alkalinity and variable turbidity (varying from 2 to 40 NTU ) in a conventional sedimentation clarifier / sand filter process was affected by problems in achieving optimum coagulation conditions when solid alum was used as the primary coagulant at a dosage of 30 to 50 milligrams per litre. The alum was added prior to a flash mixing stage located  
30 at the head of the plant, being dissolved in an inline mixer and injected into the raw water pipe twenty seconds prior to the flash mixer , being the point as far upstream as practically possible to ensure thorough mixing. As a consequence of the difficult and variable water conditions, the selection of a particular dosage, by means of prior laboratory jar tests, often led to either  
35 under-dosing and excessive carry-over of solids into the filters, or over-dosing causing excessive aluminium residuals and alkali demand. This posed a



difficult problem for plant operators, and required long periods of site attendance and loss of water production.

These problems were corrected by installing dosing systems for aluminium chlorohydrate solution having 83 percent basicity and an  
5 aluminium content of 23.5 percent as  $\text{Al}_2\text{O}_3$ , added at a constant dose of 10 milligrams per litre into the flash mixer, and for sodium silicate solution with a silicon dioxide content of 28.7% and a silicon dioxide to sodium oxide ratio of 3.22, dosed at a constant dose of 3.5 milligrams per litre into the flash mixer at a separate addition point after the aluminium chlorohydrate.

10 In an optimised treatment, a portion of the treated water was returned from the flow channel immediately after the flash mixer by installing a submersible pump in the flow channel and diverting 3000 litres per hour of treated water as inline dilution water for the aluminium chlorohydrate and the sodium silicate solutions, the dilution water being added after the  
15 metering pumps for each chemical. The diluted aluminium chlorohydrate and sodium silicate solutions were then injected into the incoming raw water in the flash mixer. The treated water underwent further mixing as it was transferred through the flow channels to a sedimentation clarifier, and then through a flocculation paddle stage, followed by a settling stage in the  
20 clarifier, then overflowed into the gravity sand filters for the final separation.

The benefits noted were that the coagulation process was improved, enabling faster settling and more solids removal in the clarifier. As a consequence, the sand filter run times were improved, with backwashes occurring on the basis of a pre-set timer rather than headloss. This led to a  
25 saving of more than 30 percent in backwash water. Plant control was improved by the new process, enabling operation at a constant coagulant dosage under varied incoming water conditions, and eliminating the need for excessive supervision by plant operators. High residual aluminium levels were avoided, being in a range from 0.01 to 0.04 milligrams per litre with the  
30 new process, compared to a range of 0.05 to > 0.2 milligrams per litre under the previous alum-treated conditions.

#### Example 2

35 A potable water plant having a conventional sedimentation clarifier / sand filter and treating 50 to 60 MLD of dam water having alkalinity of 15 mg per litre, turbidity ranging from 2 to 15 NTU, and colour ranging from 15 to

35 Hazen units required more than 65 mg per litre of liquid alum for coagulation, and more than 10 milligrams per litre of post-dosed hydrated lime for pH correction. The alum was added into a flash mixer located at the head of the plant, and lime was added as a slurry into the filtered water. A  
5 high molecular weight polymer, Ciba Magnafloc LT20™, was added at a dosage of 0.05 milligrams per litre in the final stage in the flash mixer in order to promote subsequent floc growth and settling in the clarifier. Problems were routinely experienced with pH control under varying contaminant loads, high sludge volume and sludge disposal costs, lime  
10 dosage control difficulties and deposits of lime-initiated particles in the clear water system after the post dosed lime was added.

These problems were corrected by installing dosing systems for aluminium chlorohydrate solution of 83 percent basicity and an aluminium content of 23.5 percent as Al<sub>2</sub>O<sub>3</sub>, added at a dose of 9 milligrams per litre into  
15 the flash mixer, and for sodium silicate solution of 28.7% silicon dioxide with a 3.22 weight ratio of silicon dioxide to sodium oxide, dosed at a constant dose of 2.5 milligrams per litre into the flash mixer at a separate addition point after the aluminium chlorohydrate. A portion of the treated water was returned from the flow channel immediately after the flash mixer by  
20 installing a submersible pump in the flow channel and diverting 10,000 litres per hour of treated water as inline dilution water for the aluminium chlorohydrate and the sodium silicate solutions, the dilution water being added after the metering pumps for each chemical. Further improvements were achieved by providing effective static and dynamic inline mixing  
25 facilities at the dilution point.

The diluted aluminium chlorohydrate and sodium silicate solutions were then injected into the incoming raw water in the flash mixer. High molecular weight polymer Magnafloc LT20™ was added in the final stage of the flash mixer at the same dosage and location as for alum treatment. The  
30 treated water underwent further mixing as it was transferred through the flow channels to the sedimentation clarifier, and subsequently in the flocculation stages of that clarifier. These stages were followed by a settling stage, then sand filtration.

The above improvements enabled alum and hydrated lime to be  
35 eliminated from the treatment process, while providing effective coagulation and removal of contaminants including colour and turbidity. The chlorine

demand for disinfection was also reduced by up to ten percent indicating that the removal of organics (which make a substantial contribution to total chlorine demand) had been improved. Sludge production was reduced by more than 38%, thereby having favourable disposal cost implications. Other  
 5 noted benefits included lower dissolved solids, and better filter operation, the filter runs being longer and head loss effects being reduced. The filtration improvements were primarily due to better shear resistance and re-growth of the flocs carried over from the sedimentation clarifier into the filters, and better filterability of these flocs. It was also noted that the use of high  
 10 molecular weight non-ionic polymer, Ciba Magnafloc LT20™, added for the purpose of floc augmentation, conferred better floc growth and dose response to the flocs in the new process, compared to the previous effect on alum flocs.

### Example 3

#### 15 Laboratory Jar tests

Seven 1 litre samples were taken from a raw water source. Each sample was stirred at a constant rate of 300 rpm. Aluminium chlorohydrate (where used) was added after 1 minute of stirring and sodium silicate solution (where used) was added after 3 minutes of stirring. Stirring was  
 20 continued for another 2 minutes and then the rate of stirring was reduced to 20 rpm and maintained at this slower rate for 20 minutes so as to promote flocculation. After 20 minutes the stirring was stopped and the paddles removed. The samples were allowed to stand for 20 minutes to allow the flocs to settle. 10ml samples were drawn from the supernatant water and  
 25 tested using a Hach 2100P turbidity meter. The results are shown in the table below.

ACH dosage (mg/L)	Sodium silicate solution dosage (mg/L)	Floc Size *	Settled NTU
0	0	-	2.7
15	0	C	0.75
10	0	A - B	0.93
7	0	A	0.98
15	3	D	0.6

10	3	C - D	0.56
7	3	C	0.69

\* A: 0.3-0.5 mm, B: 0.5-0.75 mm, C: 0.75-1.0 mm and D: 1.0-1.5 mm.

The samples treated with ACH and sodium silicate solution gave larger floc size and lower turbidity compared with samples treated with ACH only.

#### 5 Example 4

In a potable water treatment plant using a conventional sedimentation clarifier/sand filter process the dosages required to achieve target value of settled turbidity at the end of the clarifier were as follows:

- (a) Using untreated raw water for pre-dilution of ACH and sodium silicate:  
 10 14 mg per litre ACH, 2.8 mg per litre silicate
- (b) Using returned treated water from flow channel of the flash mixer after above additives were dosed and mixed:  
 9 mg per litre ACH, 2.8 mg per litre silicate.

A considerable reduction in the amount of ACH is achieved.

15

#### Example 5

In a potable water treatment plant using a conventional sedimentation clarifier/sand filter process, emulsion tests done by sampling from the flow channel after the flash mixer and performing jar tests as outlined above in

20 Example 3, commencing with the slow stirring step.

Raw Water turbidity = 2.3

Effect of dosing ACH with and without sodium silicate

(a) 9 mg per litre ACH, 2.5 mg per litre silicate: Settled turbidity = 0.47

(b) 9 mg per litre ACH: Settled turbidity = 0.92

25 The sample treated with ACH and sodium silicate solution gave lower turbidity compared with the sample treated with ACH only.

#### Example 6

A potable water plant having a conventional sedimentation clarifier / sand  
 30 filter and treating low turbidity (1.5 NTU) dam water at a rate of 250 litres per second using 55 mg per litre of liquid aluminium sulphate (alum), was experiencing problems with hydraulic overloading characterised by excessive carry-over of floc into the sand filters. This problem was most evident after 2 to 3 hours of continuous operation, when the sludge blanket had risen

sufficiently to contribute to the problem of carry-over of solids. The plant was routinely shut down at this stage to allow de-sludging operations to be conducted before resumption of normal operation. These stoppages led to reduced plant output and failure to meet design parameters for water  
5 production. Attempts to promote better settling and bed compaction using higher alum doses were ineffective and also led to higher aluminium residuals. High molecular weight organic polymer dosing was also evaluated as a means to augment the floc, however this treatment led to an additional problem caused by stickiness in the filter media.

10 Improved floc formation and sludge compaction was achieved by adding 10 mg per litre of aluminium chlorohydrate and 3.6 mg per litre of sodium silicate, while maintaining the alum dosage at the previous level of 55 mg per litre. The aluminium chlorohydrate and alum were added into the raw water pipe at separate points of good mixing prior to the flash mixer. Sodium  
15 silicate was dosed into the flash mixer. All the above additives were diluted after the metering pumps using treated water returned from the flash mixer.

It was found that the aluminium chlorohydrate and sodium silicate produced an improved coagulation mechanism in conjunction with the alum, enabling significantly enhanced floc size averaging 1.5 mm in jar test samples taken  
20 at the outlet of the flash mixer, compared to an average of 0.75 mm when alum was used alone. Enhanced settling was also observed, in the form of a dense cloud of floc that settled soon after the flocculation zone of the clarifier, whereas alum alone produced lighter flocs which partially carried over into the filters. Improved overflow turbidity, improved bed compaction  
25 and low solids carry-over were achieved with this water type, thus providing a means of correcting the hydraulic overloading conditions, and enabling the plant to run continually on demand without routine stoppages for de-sludging. It was also found that lower aluminium residuals were evident, despite the increase in total aluminium coagulant dosage.

30

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to  
35 be considered in all respects as illustrative and not restrictive.

## CLAIMS

1. Use of a predetermined quantity of at least one alkali metal silicate in conjunction with an amount of at least one polyaluminium coagulant in the  
5 treatment of an aqueous fluid, preferably water, the quantity of said at least one alkali metal silicate being sufficient such that improved flocculation is achieved in said fluid as compared with flocculation achieved by the use of said at least one polyaluminium coagulant alone.
2. Use according to claim 1, wherein the improvement in flocculation is in  
10 increased floc size, shear resistance and/or density.
3. Use of a predetermined quantity of at least one alkali metal silicate in conjunction with an amount of at least one polyaluminium coagulant in the treatment of an aqueous fluid, preferably water, to produce a treated fluid, the quantity of said at least one alkali metal silicate being sufficient such that the  
15 turbidity of the treated fluid is lower as compared with the turbidity of treated fluid produced by the use of said at least one polyaluminium coagulant alone.
4. Use according to any one of claims 1 to 3 wherein said polyaluminium coagulant is one or more polyaluminium compounds selected from the group consisting of chloride, sulphate, silicate sulphate, chlorosulphate and nitrate,  
20 preferably one or more polyaluminium compounds selected from the group consisting of chloride and sulphate, more preferably polyaluminium chloride.
5. Use according to any one of claims 1 to 4 wherein said polyaluminium coagulant is polyaluminium chloride having a basicity of greater than zero, preferably a basicity of at least 35% and the more preferably a basicity of at  
25 least 83%.
6. Use according to any one of claims 1 to 5 wherein the amount of polyaluminium coagulant is in the range of from 1 to 500 mg/L, preferably from 1 to 250 mg/L, more preferably from 5 to 120 mg/L and most preferably from 10 to 25 mg/L.
- 30 7. Use according to any one of claims 1 to 6 wherein said alkali metal silicate is selected from sodium and potassium silicate, preferably sodium silicate.
8. Use according to claim 7 wherein said alkali metal silicate is sodium silicate having a silicon (as SiO<sub>2</sub>) to sodium (as Na<sub>2</sub>O) ratio in the range of from 0.5 to 4, preferably from 1.6 to 3.8 and more preferably from 2.5 to 3.5,  
35 such as 3.22.

9. Use according to any one of claims 1 to 8 wherein the amount of alkali metal silicate is in the range of from 0.5 to 100 mg/L, preferably from 0.5 to 50 mg/L, more preferably from 1 to 25 mg/L and most preferably from 2 to 10 mg/L.
- 5 10. A process for the treatment of an aqueous fluid, preferably water, comprising combining an aqueous fluid with an effective amount of at least one polyaluminium coagulant and a coagulating effective amount of at least one alkali metal silicate for a sufficient time and under conditions suitable to coagulate particles in said fluid and allow flocculation of coagulated particles.
- 10 11. A process according to claim 10 comprising combining an effective amount of at least one polyaluminium coagulant and a coagulating effective amount of at least one alkali metal silicate with an aqueous fluid under conditions of rapid mixing suitable to coagulate particles in said fluid to give a partially treated fluid.
- 15 12. A process according claim 11, further comprising subjecting said partially treated fluid to slow mixing conditions suitable to promote flocculation of coagulated particles.
13. A process according to any one of claims 10 to 12 further comprising substantially removing flocculated particles to give a treated fluid.
- 20 14. A process according to any one of claims 10 to 13 further comprising removing a portion of said partially treated fluid and using said portion to dilute said polyaluminium coagulant and/or said alkali metal silicate prior to combining with said aqueous fluid.
15. A process according to any one of claims 10 to 14 wherein said at least one polyaluminium coagulant and said at least one alkali metal silicate are added sequentially to said aqueous fluid.
16. A process according to any one of claims 10 to 14 wherein said at least one polyaluminium coagulant is added to said aqueous fluid prior to addition of said at least one alkali metal silicate.
- 30 17. A process according to any one of claims 10 to 16 wherein said polyaluminium coagulant is one or more polyaluminium compounds selected from the group consisting of chloride, sulphate, silicate sulphate, chlorosulphate and nitrate, preferably one or more polyaluminium compounds selected from the group consisting of chloride and sulphate, more preferably polyaluminium chloride.
- 35

18. A process according to any one of claims 10 to 17 wherein said polyaluminium coagulant is polyaluminium chloride having a basicity of greater than zero, preferably a basicity of at least 35% and the more preferably a basicity of at least 83%.
- 5 19. A process according to any one of claims 10 to 18 wherein the amount of polyaluminium coagulant is in the range of from 500 mg/L, preferably from 1 to 250 mg/L, more preferably from 5 to 120 mg/L and most preferably from 10 to 25 mg/L.
20. A process according to any one of claims 10 to 19 wherein said alkali  
10 metal silicate is selected from sodium and potassium silicate, preferably sodium silicate.
21. A process according to any one of claims 10 to 20 wherein said alkali metal silicate is sodium silicate having a silicon (as  $\text{SiO}_2$ ) to sodium (as  $\text{Na}_2\text{O}$ ) ratio in the range of from 0.5 to 4, preferably from 1.6 to 3.8 and more  
15 preferably from 2.5 to 3.5, such as 3.22.
22. A process according to any one of claims 10 to 21 wherein the amount of alkali metal silicate is in the range of from 0.5 to 100 mg/L, preferably from 0.5 to 50 mg/L, more preferably from 1 to 25 mg/L and most preferably from 2 to 10 mg/L.
- 20 23. A process according to any one of claims 10 to 22 further comprising combining said aqueous fluid with an effective amount of at least one non-ionic or anionic polymeric flocculant, preferably with a flocculatingly effective amount of at least one polyacrylamide.
- 25 24. A process according to any one of claims 10 to 23 further comprising combining said aqueous fluid with an effective amount of at least one coagulant selected from the group consisting of aluminium sulphate, ferric sulphate and ferric chloride.



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/001790

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl.		
C02F 1/52 (2006.01)		
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)		
IPC: C02F 1/52, 1/54, 1/56		
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)		
DWPI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/025156 A1 (KEMIRA KEMI AB), 12 April 2001 Whole document	1-24
X	Derwent Abstract Accession No. 2000-368569/32, Class D15 JP 11-290612 A (HYMO CORP), 26 October 1999	1-24
X	CA 2174169 A1 (BETZ LABORATORIES INC.), 7 June 1997 Whole document	1-24
X	US 5614102 A (SAKURADA), 25 March 1997 Whole document	1-24
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> 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 "&" document member of the same patent family		
Date of the actual completion of the international search 20 December 2005		Date of mailing of the international search report 23 DEC 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustrialia.gov.au Facsimile No. (02) 6285 3929		Authorized officer  <b>Adrian Gillmore</b> Telephone No : (02) 6283 2125

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/001790

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Derwent Abstract Accession No. 74206 C/42, Class D15 JP 55-114388 A (HITACHI PLANT ENG CONST), 3 September 1980	1-24

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2005/001790

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2001/025156	AU	79787/00	CN	1384806	EP	1242316
		SE	9903594				
JP	11290612	NIL					
CA	2174169	NIL					
US	5614102	AU	70790/91	AU	70795/91	BR	9105966
		BR	9105968	CA	2074829	CA	2074840
		EP	0513352	EP	0514543	HU	62819
		HU	70672	OA	9597	OA	9709
		PL	293184	PL	293185	US	5350511
		WO	1991/011243	WO	1991/011392		
JP	55114388	NIL					
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							