physical entrapment of particles in filtration processes, such as in waste water treatment.

However, diatomaceous earth is usually contaminated with varying quantities of clay, quartz, other minerals, and organic materials. Thus, raw diatomaceous earth usually contains a low amount of diatom cells. The adsorption capability of raw diatomaceous earth is therefore limited. As a result, high dosages of diatomaceous earth are required for effective waste water treatment.

In some instances, a refined version of diatomite is used for waste water treatment. Refined diatomite is typically processed from crude diatomite via known beneficiation processes to achieve a relatively high degree of purity, e.g., greater than 80% diatomite by weight. However, additional flocculants and/or additional coagulants must still be used in concert with refined diatomite in order to achieve satisfactory results of waste water treatment or for satisfactory recovery of the sludge during dehydration/dewatering processes.

Commonly used coagulants include metal-based coagulants, such as aluminum or iron sulfate, hydrated lime and magnesium carbonate. Commonly used flocculants include polyacrylamide. Such treatment processes remain less than ideal because even small, residual amounts of coagulant and flocculant remaining in the effluent after post-treatment may result in secondary contamination.

Accordingly, there is a need to provide a process or system to treat waste water that overcomes, or at least ameliorates, one or more of the disadvantages described above.

Summary of Invention

According to one ~~aspect~~ embodiment of the present disclosure, there is provided a waste water treatment process comprising the steps of: a) contacting microbes with a waste water stream to form a mixed liquor stream comprising activated sludge; b) dosing said mixed liquor stream with at least one diatomite treatment agent;

c) separating water from said mixed liquor stream to thereby provide a treated waste water effluent; and wherein said diatomite treatment agent comprises at least 90 to 99.9% of purified diatomite, wherein the purified diatomite comprises unbalanced surface charges. In particular, the diatomite cells of the purified diatomite may be substantially free of counter ions electrostatically coupled to its surface. More particularly, the diatomite cell may comprise a plurality of pores having an interior pore surface, and wherein the interior pore surface is substantially free of counter ions or charged impurities being electrostatically coupled thereto. Advantageously, the purified diatomite expresses a higher degree of unbalanced surface potential relative to crude (naturally occurring) diatomite.

In one aspect, there is provided a waste water treatment process comprising the steps of: a) contacting microbes with a waste water stream to form a mixed liquor stream comprising activated sludge; b) dosing said mixed liquor stream with at least one diatomite treatment agent; c) separating water from said mixed liquor stream to thereby provide a treated waste water effluent; and wherein said diatomite treatment agent comprises 98 to 99.9% by weight of diatomite particles, said diatomite particles comprising unbalanced surface charges, and wherein said diatomite treatment agent is obtained from a pre-treatment process comprising: contacting crude diatomite with a treatment solution to form a slurry, the treatment solution comprising, based on the weight of the crude diatomite, about 0.03 - 0.05 wt. % of at least one xanthine derivative, about 0.1 - 0.2 wt. % of at least one metal metasilicate, about 0.025 - 0.05 wt.% of at least one metal phosphate, about 0.01 - 0.025 wt. % of at least one base and about 0.015 - 0.035 wt. % of at least one metal carbonate.

The purified diatomite may consist essentially of siliceous frustules of diatomite cells that have been pre-treated to improve its purity and to increase its unbalanced surface charges. Hence, the terms “purified diatomite” and “pre-treated diatomite” are used interchangeably herein.

In the present disclosure, the transitional expression “consists essentially of” or its variants thereof, when used to describe the disclosed diatomite treatment agent means that the diatomite treatment agent may consist solely of diatomite or may optionally comprise in addition to purified diatomite, other component(s)

or material(s) that do not materially affect the characteristics and performance of the diatomite treatment agent.

In particular embodiments, the disclosed process advantageously excludes the addition of a flocculant or a coagulant to the waste water, the mixed liquor stream, the activated sludge or the discharged / recycled sludge. The diatomite treatment agent may be substantially free of any flocculant or coagulant and may be added solely into the activated sludge or the mixed liquor stream that has undergone or undergoing biological treatment.

The diatomite agent may be substantially free or completely free of silica that is not of diatomite origin, e.g., silica sand or clay-based silica.

The disclosed diatomite treatment agent may also be substantially free or completely free of clay minerals, which are normally present as impurities in

As a result, the disclosed waste water treatment process may be substantially streamlined compared to existing processes. For instance, the disclosed process may not require an anaerobic stage or is able to substantially reduce the residence time of an anaerobic treatment stage. The disclosed process may also not require the use of PAOs (polyphosphate accumulating organisms). This is because the purified diatomite may provide sufficient phosphorus removal. This means that the biological treatment process may be simplified and lesser bio-reactors or tanks are required.

Also advantageously, the disclosed process may be able to substantially reduce the residence time of an anoxic treatment stage due to improved nitrogen removal by the purified diatomite.

The disclosed process may also shorten the time required for biological treatment, e.g., the disclosed process may shorten hydraulic residence time at an anoxic or aerobic stage of the disclosed process.

The disclosed process may reduce plant footprint due to improved separation and treatment efficiency.

The disclosed process may reduce costs as the amount of diatomite treatment agent required for effective waste water treatment is significantly reduced compared to known processes.

Another advantage of the disclosed diatomite treatment agent is that it improves concentration and porosity of the sludge, thereby facilitating ease of dehydration or dewatering of the sludge e.g., in a filter press. Surprisingly, the use of the disclosed diatomite treatment agent negates the need to add a coagulant to the discharged / waste activated sludge, which is normally essential in current sludge dewatering or dehydration procedures.

In another ~~aspect~~ embodiment of the present disclosure, there is provided a system for treatment of waste water, the system comprising: at least one biological treatment zone configured to receive and contact waste water influent with microbes to thereby form a mixed liquor stream comprising activated sludge; an upward clarifier in fluid communication with said biological treatment zone and configured to receive said mixed liquor stream from said biological treatment

zone; an inlet means disposed upstream of said clarifier operable to introduce a diatomite treatment agent to said mixed liquor stream; wherein said diatomite treatment agent comprises at least 90 to 99.9% of purified diatomite, wherein the purified diatomite comprises unbalanced surface charges; and an outlet means extending from said clarifier, being configured to discharge water that has been separated from the mixed liquor stream as treated waste water effluent.

In embodiments, the water treatment system employs a diatomite agent that has been pre-treated or purified in accordance with pre-treatment processes as disclosed herein.

In another aspect, there is provided a system for treatment of waste water, the system comprising: at least one biological treatment zone configured to receive and contact waste water with microbes to thereby form a mixed liquor stream comprising activated sludge; an upward clarifier in fluid communication with said biological treatment zone and configured to receive said mixed liquor stream from said biological treatment zone; an inlet means disposed upstream of said clarifier operable to introduce a diatomite treatment agent to said mixed liquor stream; wherein said diatomite treatment agent comprises 98 to 99.9% by weight of diatomite particles, said diatomite particles comprising unbalanced surface charges, and wherein said diatomite treatment agent is obtained from a pre-treatment process comprising: contacting crude diatomite with a treatment solution to form a slurry, the treatment solution comprising, based on the weight of the crude diatomite, about 0.03 - 0.05 wt. % of at least one xanthine derivative, about 0.1 - 0.2 wt. % of at least one metal metasilicate, about 0.025 - 0.05 wt.% of at least one metal phosphate, about 0.01 - 0.025 wt. % of at least one base and about 0.015 - 0.035 wt. % of at least one metal carbonate; and an outlet means extending from said clarifier, being configured to discharge water that has been separated from the mixed liquor stream as treated waste water effluent.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term "diatomite" as used herein refers to fossilized remains of diatom microorganisms. Diatom cells are enclosed within a porous cell wall, or "frustule", composed of silica. Upon death, the organic material of diatom cells decomposes, leaving behind the frustules. Diatomite includes various diatom species that may occur in a wide variety of shapes, such as cylindrical, rod-like, and star-shaped. The terms "diatomaceous earth", "diatomite" and "diatom" are used interchangeably herein.

The term "purified diatomite" as used herein refers to diatomite that has been pre-treated according to methods/processes disclosed herein to achieve superior adsorptive properties relative to crude or refined diatomite that has not been pre-treated similarly. Purified diatomite may refer to pre-treated diatomite expressing a greater unbalanced potential / unbalance charge on its surface relative to diatomite that has not been pre-treated in accordance with the present disclosure.

The term "net charge" as used herein in reference to the charge of a compound means that there is an imbalance in the number of active groups within the compound having a charge, i.e. either a positive or negative

Claims

1. A waste water treatment process comprising the steps of:

a) contacting microbes with a waste water stream to form a mixed liquor stream comprising activated sludge;

b) dosing said mixed liquor stream with at least one diatomite treatment agent;

c) separating water from said mixed liquor stream to thereby provide a treated waste water effluent; and

wherein said diatomite treatment agent comprises ~~at least 90~~ 98 to 99.9% by weight of diatomite particles~~of purified diatomite~~, said ~~purified~~ diatomite particles comprising unbalanced surface charges, and

wherein said diatomite treatment agent is obtained from a pre-treatment process comprising: contacting crude diatomite with a treatment solution to form a slurry, the treatment solution comprising, based on the weight of the crude diatomite, about 0.03 - 0.05 wt. % of at least one xanthine derivative, about 0.1 - 0.2 wt. % of at least one metal metasilicate, about 0.025 - 0.05 wt.% of at least one metal phosphate, about 0.01 - 0.025 wt. % of at least one base and about 0.015 - 0.035 wt. % of at least one metal carbonate.

2. The process of claim 1, wherein said diatomite treatment agent consists essentially of diatomite cells, said diatomite cells being substantially free of counter ions electrostatically coupled to its surface.

3. The process of claim 2, wherein each diatomite cell comprises a plurality of pores having an interior pore surface, the interior pore surface being substantially free of counter ions or charged impurities being electrostatically coupled thereto.

4. The process of any one of the preceding claims, wherein said diatomite treatment agent is dosed at about 10 milligrams to about 30 milligrams per liter of waste water.

5. The process of any one of the preceding claims, said diatomite treatment agent is substantially free of a flocculant or a coagulant.

~~6. The process of any one of the preceding claims, wherein said diatomite treatment agent comprises at least 92 to 98% of said purified diatomite.~~

~~7~~6. The process of any one of the preceding claims, wherein said separating step comprises conveying said mixed liquor stream to an upward clarifier; providing an upward velocity of said mixed liquor stream sufficient to dispose a layer of suspended solids at a vertical level of said clarifier; discharging waste water that has passed through said suspended solids layer as treated waste water effluent.

~~8~~7. The process of claim ~~7~~6, wherein said conveying step is actuated by gravitational potential energy.

~~9~~8. The process of claim ~~7~~6 or ~~8~~7, further comprising periodically discharging at least a fraction of suspended solids in the clarifier and optionally recycling said discharged suspended solids to step a).

~~10~~9. The process of any one of the preceding claims, wherein said contacting step and said dosing step are performed concurrently or sequentially.

~~11~~10. The process of any one of the preceding claims, wherein said diatomite treatment agent is added to said mixed liquor stream upstream of said separating step.

~~12~~11. The process of any one of the preceding claims, wherein ~~said diatomite treatment agent is obtained from a~~ the pre-treatment process further comprises~~comprising~~:

~~contacting crude diatomite with a treatment solution comprising at least one xanthine derivative, at least one metal silicate or metal phosphate, at least one metal hydroxide and at least one metal carbonate to form a slurry;~~

separating diatomite cells from said slurry by gravitational separation to form said diatomite treatment agent.

~~13~~12. The process of claim ~~12~~11, wherein said pre-treatment process further comprises a step of sonicating said slurry during the separation step.

~~14~~13. The process of claim ~~12~~ 11 or claim ~~13~~12, wherein said pre-treatment process further comprises a step of applying an electric field to said slurry during said separation step.

~~15. The process of any one of claims 12-14, wherein said treatment solution comprises:~~

~~about 0.03 - 0.05 wt. % of a xanthine derivative;~~

~~about 0.1 - 0.2 wt. % of a metal metasilicate;~~

~~about 0.025 - 0.05 wt.% of a metal phosphate~~

~~about 0.01 - 0.025 wt. % of a base; and~~

~~about 0.015 - 0.035 wt. % of a metal carbonate.~~

~~16~~14. A system for treatment of waste water, the system comprising:

at least one biological treatment zone configured to receive and contact waste water with microbes to thereby form a mixed liquor stream comprising activated sludge;

an upward clarifier in fluid communication with said biological treatment zone and configured to receive said mixed liquor stream from said biological treatment zone;

an inlet means disposed upstream of said clarifier operable to introduce a diatomite treatment agent to said mixed liquor stream; wherein said diatomite treatment agent comprises ~~at least 90~~ 98 to 99.9% by weight of diatomite particles~~of purified diatomite~~, said ~~purified~~ diatomite particles comprising unbalanced surface charges, and wherein said diatomite treatment agent is obtained from a pre-treatment process comprising: contacting crude diatomite with a treatment solution to form a slurry, the treatment solution comprising, based on the weight of the crude diatomite, about 0.03 - 0.05 wt. % of at least one xanthine derivative, about 0.1 - 0.2 wt. % of at least one metal metasilicate, about 0.025 - 0.05 wt.% of at least one metal phosphate, about 0.01 - 0.025 wt. % of at least one base and about 0.015 - 0.035 wt. % of at least one metal carbonate; and

an outlet means extending from said clarifier, being configured to discharge water that has been separated from the mixed liquor stream as treated waste water effluent.

~~17~~15. The system of claim ~~16~~14, wherein said diatomite treatment agent consists essentially of diatomite cells, said diatomite cells being substantially free of counter ions electrostatically coupled to its surface.

~~18~~16. The system of claim ~~17~~15, wherein each diatomite cell comprises a plurality of pores having an interior pore surface, the interior pore surface being substantially free of counter ions or charged impurities being electrostatically coupled thereto.

~~19~~17. The system of any one of claims ~~16~~14-~~18~~16, wherein said inlet means is configured to provide said diatomite treatment agent at about 10 milligrams to about 30 milligrams per liter of waste water.

~~20~~18. The system of any one of claims ~~16~~14-~~19~~17, wherein said diatomite treatment agent is substantially free of a flocculant or a coagulant.

~~21. The system of any one of claims 16-20, wherein said diatomite treatment agent comprises at least 92 to 98% of said purified diatomite.~~

~~22~~19. The system of any one of claims ~~16~~14-~~21~~18, wherein said clarifier is operated to suspend a solids layer within said clarifier, said suspended solids layer comprising biomass supported on said diatomite treatment agent.

~~23~~20. The system of claim ~~22~~19, wherein said outlet means is configured to discharge water that has passed through said suspended solids layer as effluent.

~~24~~21. The system of any one of claims ~~16~~14-~~23~~20, further comprising at least one conduit fluidly communicating said clarifier with said biological treatment zone, said conduit being operable to discharge at least a fraction of said suspended solids.

~~25~~22. The system of any one of claims ~~16~~14-~~24~~21, wherein the biological treatment zone is arranged to discharge said mixed liquor stream having higher gravitational potential energy relative to a mixed liquor stream that has been conveyed to said clarifier.

~~26~~23. The system of any one of claims ~~16~~14-~~25~~22, further comprising a dehydration zone configured to receive the mixed liquor stream comprising activated sludge that has been discharged from said clarifier and being operable to dehydrate the activated sludge without addition of flocculant or coagulant.

~~27~~24. The system of any one of claims ~~16~~14-~~26~~23, wherein said ~~diatomite treatment agent has been obtained from a~~ pretreatment process is as defined in any one of claims ~~12~~11 to ~~15~~13.