CLAIMS

1. A process for removing a dissolved species from an aqueous inflow stream, the dissolved species comprising a dissolved nitrogen and/or a dissolved phosphorous and/or a dissolved potassium species, the process comprising:

segregating the aqueous inflow stream into a plurality of reactor inflow streams, and directing the plurality of reactor inflow streams upwardly into a base of a reaction conduit segment in a reactor vessel so as to create a turbulent upward flow in the reaction conduit segment;

injecting a precipitating agent into the base of the reaction conduit segment under conditions maintained in the reaction conduit segment so as to provide a supersaturated concentration of a reaction product of the precipitating agent reacting with the dissolved species, providing a saturation index of at least 2 for the reaction product, the reaction product forming a solid precipitant species entrained in an upward reaction conduit fluid flow;

directing the upward reaction conduit fluid flow to a contiguous clarifier segment of the reactor vessel, the clarifier segment of the reactor vessel being dimensioned to reduce the upward flow rate of the upward reaction conduit fluid flow, and maintaining an upward clarified fluid flow rate in the clarifier segment so as to permit entrained solid precipitant species to descend in the clarifier segment of the reactor vessel and return to the reaction conduit segment while a clarified discharge fluid flow continues to flow upwardly out of the clarifier segment of the reactor vessel;

maintaining conditions in the reactor vessel to permit the progressive agglomeration of the precipitant species to form agglomerated granules of a size and density sufficient to cause the agglomerated granules to settle towards the base of the reaction conduit segment in the presence of the turbulent upward reaction conduit fluid flow;

injecting an upward channeled fluid flow through a channel in fluid communication with the base of the reaction conduit segment, the channel being dimensioned to permit metering of the upward channeled fluid flow so as to permit agglomerated granules of a selected size and density to descend through the channel

while returning un-selected precipitant species upwardly to the reaction conduit segment, thereby segregating a sized solid granule product by elutriation that descends through the channel into a contiguous pellet hopper sized to accommodate a settled volume of the sized solid granule product.

2. The process of claim 1, further comprising periodically restricting the upward channeled fluid flow in the channel and downwardly releasing the contents of the hopper, to collect the solid granule product.

3. The process of claim 2, further comprising recirculating a portion of the clarified fluid flow from the clarifier segment to the hopper to mediate the upward channeled fluid flow through the channel.

4. The process of claim 3, further comprising providing an upward hopper fluid flow in the hopper that mediates the upward channeled fluid flow in the channel, and sizing the hopper so that the upward hopper fluid flow is less than the upward channeled fluid flow.

5. The process of claim 4, further comprising segregating the aqueous inflow stream into the plurality of reactor inflow streams in a manifold in fluid communication with the reaction conduit segment.

6. The process of claim 5, wherein the precipitating agent comprises an alkali, a magnesium salt, $MgCl_2$, $MgSO_4$, MgO, $Mg(OH)_2$, magnesite, brucite, a combustion bottom ash or a fly ash.

7. The process of claim 6, wherein the solid granule product comprises one or more of: struvite, K-struvite, calcium ammonium phosphate $CaNH_4PO_4$, and/or hydroxyapatite $Ca_5(PO_4)_3(OH)$, brushite $CaHPO_4 \cdot 2H_2O$, newberyite $MgHPO_4 \cdot 3H_2O$, and/or magnesium phosphate $Mg_3(PO_4)_2$.

8. The process of claim 7, wherein the aqueous inflow stream comprises up to 5% by weight suspended solids, and wherein 50-95% of the suspended solids in the aqueous inflow stream pass through the reactor vessel to the clarified discharge fluid flow.

9. The process of claim 8, wherein the channel has an average channel cross-sectional area C_{Xarea}, the pellet hopper has an average pellet hopper cross sectional area PH_{Xarea} and the reaction conduit segment has an average conduit cross sectional area RC_{Xarea}, wherein $C_{Xarea} < PH_{Xarea}$, and $C_{Xarea} < RC_{Xarea}$.

10. The process of claim 9, further comprising collecting the sized solid granule product on a sieve; and further washing and drying the sized solid granule product on the sieve.

11. The process of claim 10, wherein the purity of the solid granule product is at least 90%.

12. The process of claim 11, wherein the upward channeled fluid flow rate is maintained in a range of 5-50% of the upward reaction conduit fluid flow rate.

13. The process of claim 12, wherein the initial saturation index SI at the base of the reaction conduit segment for the reaction product is maintained in the range of 2.0-3.0.

14. The process of claim 13, wherein the upward reaction conduit fluid flow rate is maintained between 20-80 cm/min.

15. The process of claim 14, wherein a hydraulic retention time in the reaction conduit segment is maintained between 1-10 min.

16. The process of claim 15, wherein the upward clarified fluid flow rate is maintained between 1-5 cm/min.

17. The process of claim 16, wherein the clarifier segment is a frustum shaped clarifier, where the frustum shaped clarifier comprises sloped walls having a slope angle of from 45-85°.

18. The process of claim 17, wherein the removal of one or more of the dissolved species from the aqueous inflow stream to provide the clarified discharge fluid flow is at least 60%.

19. The process of claim 18, wherein the sized solid granule product has an average product size, and the average product size is from 1-2 mm.

20. The process of claim 19, wherein the sized solid granule product has a product purity of at least 80%.

21. A reactor system operable to remove a dissolved species from an aqueous inflow stream, the dissolved species comprising a dissolved nitrogen and/or a dissolved phosphorous and/or a dissolved potassium species, the reactor system comprising:

a manifold segregating an aqueous inflow stream into a plurality of reactor inflow streams, and directing the plurality of reactor inflow streams upwardly into a base of a reaction conduit segment in a reactor vessel in fluid communication with the manifold, so as to create a turbulent upward flow in the reaction conduit segment;

an intake pump upstream of the manifold to provide a pressurized aqueous inflow stream;

injection nozzles directing the plurality of reactor inflow streams upwardly into the base of the reaction conduit segment; wherein the injection nozzles are elevated above a bottom portion of the reaction conduit segment; wherein a superficial upflow velocity is provided inside each nozzle of between 5-15 m/s;

a screen positioned in the aqueous inflow stream before the aqueous inflow stream enters the manifold; wherein the screen has a smaller mesh than the diameter of the injection nozzles;

a precipitating agent inlet port in fluid communication with the base of the reaction conduit segment, adapted for injecting a precipitating agent into the base of the reaction conduit segment under control of reactor system controls adapted to maintain conditions in the reaction conduit segment so as to provide a supersaturated concentration of a reaction product of the precipitating agent reacting with the dissolved species, providing a saturation index of at least 2 for the reaction product, the reaction product forming a solid precipitant species entrained in an upward reaction conduit fluid flow;

a clarifier segment of the reactor vessel, upwardly contiguous with the reaction conduit segment, the clarifier segment of the reactor vessel being dimensioned relative to the reaction segment so as to reduce an upward flow rate of an upward reaction conduit fluid flow directed into the clarifier segment from the reaction conduit segment, under the control of clarifier system controls operable to maintain an upward clarified fluid flow rate in the clarifier segment so as to permit entrained solid precipitant species to descend in the clarifier segment of the reactor vessel and return to the reaction conduit segment while a clarified discharge fluid flow continues to flow upwardly out of the clarifier segment of the reactor vessel;

a jacket on the clarifier segment configured to collect the clarified discharge fluid flow;

wherein the reactor system controls are operable to maintain conditions in the reactor vessel to permit progressive agglomeration of the precipitant species to form agglomerated granules of a size and density sufficient to cause the agglomerated granules to settle towards the base of the reaction conduit segment in the presence of turbulent upward reaction conduit fluid flow; and,

a channel in fluid communication with the base of the reaction conduit segment having a channel fluid source to provide an upward channeled fluid flow through the channel into the base of the reaction conduit segment, the channel being

dimensioned to permit metering of the upward channeled fluid flow so as to permit agglomerated granules of a selected size and density to descend through the channel while returning un-selected precipitant species upwardly to the reaction conduit segment, thereby segregating a sized solid granule product by elutriation that descends through the channel into a contiguous pellet hopper sized to accommodate a settled volume of sized solid granule product.