Claims

1. A system for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge comprising the following components that function in synergy:

(a) A central processor with artificial intelligence technology to continuously optimize system and method parameters with inbuilt algorithms based on various types of information on waste type and treatment parameters, and the processor analyzes information of freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge to classify the freshwater sludge into groups H, S, and T such that:

H is hard sludge that is brittle and comprises greater than 50% by volumetric basis slabs that are of dimensions 10 cm to 12.5 cm in length, 5 cm to 7.5 cm in width, and 0.5 cm to 1 cm in thickness;

S is soft sludge that is of muddy or clay texture and comprises less than 20% by volumetric basis slabs that are of dimensions 10 cm to 12.5 cm in length, 5 cm to 7.5 cm in width, and 0.5 cm to 1 cm in thickness; and

T is thickened sludge that contains >95% moisture content;

(b) A pulverization component that comprises:

A double-rotating shaft crusher with teeth; and

A paddle shredder that has mixing paddles distributed in spiraling manner about a central mixing axle; each mixing paddle is of length 10 cm to 14 cm, width 8 cm to 12 cm, and thickness 5 mm to 8 mm; length of paddle attachment to the central mixing axle is 1 cm to 2 cm; each paddle is free-rotating about its attachment to the central mixing axle, and degree of rotation is 60° to 80° from line of the central mixing axle;

(c) A bioreactor that is cylindrical in design with a thermal insulation jacket, a double ribbon mixing element, a mass sensor, a moisture meter, a temperature sensor, a water spraying device, and an outlet of 20 cm to 30 cm in diameter at bottom of the bioreactor;

(d) A coagulant recovery unit with a defoaming skimmer, a mixing device, a filtration device, a pH probe, a neutralization tank, a waste acid storage tank, and a metallic ion concentration sensor;

(e) A purification unit with a filtration device and an adjacent wastewater treatment unit; and

(f) A lightweight aggregate fabrication unit with a drying device, a horizontal ball mill, a mixing device that is a single ribbon mixer with a mass weighing sensor, a pan pelletizer, a water spraying apparatus, and a sintering device.

2. Method for resource recovery from freshwater sludge and similar solid wastes using the system of claim 1 wherein

Solid waste of group H enters the double-rotating shaft crusher of claim 1 (b), and solid waste of group S enters the paddle shredder of claim 1 (b), and in both cases of H and S waste material solid waste is crushed to lump size that is below 1 mm;

For solid waste of group S, lump size reduction to below 1 mm is aided by the free-rotating paddles in the paddle shredder of claim 1 (b) such that degree of rotation from the central mixing axle reduces from 80° to 60° until lump size is below 1 mm; and

For solid waste of group T the step of crushing using the double-rotating shaft crusher or the paddle shredder is bypassed.

3. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claim 2 wherein digestion inside the bioreactor of claim 1 (c) incorporates use of thermophilic aerobic digestion microorganisms consisting of fungal species that is selected from the group consisting of: *Aspergillus Terreus, Aspergillus Fumigatus, Fusarium verticillioides,* and *Eurotium rubrum* and bacteria species that is selected from the group consisting of: *Bacillus stearothermophilus*, *Bacillus brevis*, *Bacillus licheniformis*, and *Bacillus coagulans* and the bioreactor outlet opens at the end of digestion to allow internal contents to empty out by movement of the double ribbon mixing element of the bioreactor; the mass ratio of fungi to bacteria is 0.5 to 1.

4. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 3 wherein

For fresh batch of digestion, thermophilic aerobic digestion microorganism dosage is 0.5% to 2.5% by mass, digestion duration is 48 to 120 hours, operating temperature of digestion is controlled to be 40°C to 70°C by use of the temperature sensor of claim 1 (c), and moisture content is automatically maintained at 60% to 80% by use of the moisture meter of claim 1 (c) and the water spraying device of claim 1 (c); or

For continuing batch of digestion, 5% by mass previously digested sludge mixture material is used as recycling sludge for next round of digestion, digestion duration is 48 to 120 hours, operating temperature of digestion is controlled to be 40°C to 70°C by use of the temperature sensor of claim 1 (c), and moisture content is automatically maintained at 60% to 80% by use of the moisture meter of claim 1 (c) and the water spraying device of claim 1 (c).

5. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 4 wherein coagulant recovery is performed on material that has gone through the bioreactor of claim 1 (c) and concentrated acid that is selected from the group consisting of sulfuric acid, hydrochloric acid, nitric acid, hydrobromic acid, hydroiodic acid, perchloric acid, and chloric acid or with aqueous non-organic waste acid that has acid concentration 1% to 30% by volume from the waste acid storage tank of claim 1 (d), pH of coagulant recovery is automatically maintained at 1.5 to 3 using the pH probe, water is introduced into the mixture at a liquid:total solid waste ratio of 2:1 to 5:1 to facilitate mixing of solid waste and acid.

6. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 5 wherein the defoaming skimmer of claim 1 (d) removes

foam generated during coagulant recovery, sends collected foam to the neutralization tank with a mixing device where 0.5% by mass lime is used to break the foams.

7. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 6 wherein the metallic ion concentration sensor of claim 1 (d) monitors concentration of coagulant ions such as aluminum or iron (III) ions and stops coagulant recovery reaction if theoretical recovery rate based on past average metallic content in untreated freshwater sludge or other industrial solid wastes is 50% to 90%.

8. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 7 wherein:

If concentrated acid is used to adjust pH to 1.5 to 3 in coagulant recovery, liquid portion of coagulant recovery unit is separated by the filtration device of claim 1 (d) and 0.1% to 5% on wastewater volumetric basis of the liquid so obtained is used as liquid coagulant in wastewater treatment; or

If waste acid is used to adjust the pH to 1.5 to 3 in coagulant recovery, liquid portion of coagulant recovery unit that is separated by the filtration device of claim 1 (d) is sent to the purification unit of claim 1 (e) and a precipitant that is selected from the group consisting of ammonium hydroxide, calcium hydroxide, magnesium hydroxide, sodium carbonate, and sodium hydroxide is added in the purification unit to a pH of 7 to 7.5 and, furthermore:

Supernatant of purification reaction is sent to the wastewater treatment unit of claim 1 (e);

All precipitants thus formed are filtered out by the filtration device of claim 1 (e) to be used as precursor material in coagulant synthesis where precipitants thus formed are dissolved by sulfuric acid to be reused as coagulant; and

Filtrate from the filtration device of claim 1 (e) is sent to the wastewater treatment unit of claim 1 (e).

9. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 8 wherein the wastewater treatment unit of claim 1 (e) comprises a flocculating or coagulating step using a chemical that is selected from group consisting of aluminum sulfate, ferric chloride, ferric sulfate, ferrous sulfate, polyacrylamide, polyaluminum chloride, polyaluminum chlorosulfate, polyaluminum silicatesulfate, sodium alginates, polyelectrolytes, and combinations thereof.

10. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 9 wherein:

Remaining residual solid portion of freshwater sludge or other wastes after the coagulant recovery unit of claim 1 (d) is dried by rotary dryer at a temperature of 90°C to 105°C until moisture content is <1% and so dried sludge residual is milled by the horizontal ball mill to a particle size of <75μm;

Sludge residual so dried and milled is mixed with formulation consisting of 2% to 5% sludge residual so dried and milled, 10% to 12% binding agent that is selected from group consisting of sodium silicate and potassium silicate, 60% to 70% SiO_2, 20% to 25% Al_2O_3, and 3% to 5% flux, where flux is defined as sum of mass percentages of Fe_2O_3, K_2O, Na_2O, CaO, and MgO; and

The mass weighing sensor of claim 1 (f) measures and records the mass of mix.

11. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 10 wherein the pan pelletizer produces aggregate particles of diameter 10 mm to 20 mm, and the mass weighing sensor of claim 1 (f) sends mass information of mix to the water spraying apparatus of claim 1 (f) to control mass of water sprayed such that moisture content of resulting mix is 30% to 35%.

12. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 11 wherein the pan pelletizer that is a rotating circular pan rotates at a speed that is 30 rpm to 60 rpm and operates at an angle that is 34.5° to 55.5° from vertical position.

13. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 12 wherein the sintering device heats particles produced from the pan pelletizer to a temperature of 1,000 °C to 1,200 °C.

14. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 13 wherein produced lightweight aggregates that have simultaneously particle density <2 g/cm^3 and loose bulk density 0.65 g/cm^3 to 2 g/cm^3 are incorporated into 1% to 75% by volume of coarse aggregates in concrete formulation, and lightweight aggregates that have loose bulk density 0.75 g/cm^3 to 1.2 g/cm^3 are used for growth medium in gardening.

15. The method for resource recovery from freshwater sludge and similar solid wastes such as industrial wastewater treatment sludge of claims 2 to 14 wherein the central processor of claim 1 (a) utilizes artificial intelligence technology to collect and analyze information and optimize operational parameters in future resource recovery and minimize prediction error through feedback loop, and furthermore:

Analyzes waste information and automatically adjusts angle of rotation of the mixing paddles of the paddle shredder of claim 1 (b);

Monitors mass information from the mass sensor of claim 1 (c) on digestion sludge mass and stops digestion when overall mass loss is >30%;

Collects information from the moisture meter of claim 1 (c) on digestion sludge moisture content and automatically adjusts digestion sludge moisture content to 60% to 80% by

controlling the water spraying device of claim 1 (c), saves all treatment and waste type information, and determines future system parameters based on waste type;

Accumulates information of waste acid received in the waste acid storage tank on acid type, factory source of waste acid, and waste acid pH, and automatically adjusts dosage of waste acid used inside the coagulant recovery unit of claim 1 (d) such that pH is 1.5 to 3;

Monitors information from the metallic ion concentration sensor of claim 1 (d) and automatically controls coagulant recovery duration such that 70% to 90% of coagulant metal ions such as aluminum or iron (III) ions based on average past metallic content in untreated freshwater sludge or other industrial solid wastes are dissolved by acid inside the coagulant recovery unit; and

Collects information from the mass weighing sensor of claim 1 (f) and automatically controls the water spraying apparatus of claim 1 (f) to produce mix moisture content of 30% to 35% at the pan pelletizer of claim 1 (f).