CLAIMS

What is claimed is:

1. A system for removing and recovering one or more contaminants from water, the system comprising:

one or more mobile carriers each comprising a core coated with a porous and non-reactive binding agent comprising one or more types of nanoparticles configured to become at least one of physically and chemically associated with the one or more contaminants;

a first reactor configured to:

receive contaminated water comprising one or more contaminants, wherein at least a portion of the one or more contaminants have net charges,

receive a solution comprising one or more acids or one or more bases configured to cause the contaminated water to have a first desired target pH,

receive the one or more mobile carriers, and

output a first reactor effluent comprising water, having the first desired pH, and the one or more mobile carriers being at least one of physically and chemically associated with the one or more contaminants;

a first solid-solid separation unit configured to separate the first reactor effluent into a first effluent and a second effluent, wherein:

the first effluent, of the first solid-solid separation unit, comprises water having the first desired pH, and is at least substantially free of the one or more mobile carriers and the one or more contaminants, and

the second effluent, of the first solid-solid separation unit, has the first desired pH and comprises the one or more mobile carriers being at least one of physically and chemically associated with the one or more contaminants;

a second reactor in fluidic communication with the first solid-solid separation unit, the second reactor configured to:

receive the second effluent of the first solid-solid separation unit,

receive a solution comprising at least one of one or more bases and one or more brines configured to cause the second effluent, of the first solid-solid separation unit, to have a second desired pH, and

output a second reactor effluent having the second desired pH and comprising the one or more contaminants separated from the one or more mobile carriers; and

a second solid-solid separation unit configured to separate the second reactor effluent into first and second effluents of the second solid-solid separation unit, wherein:

the first effluent, of the second solid-solid separation unit, comprises the one or more mobile carriers, and

the second effluent, of the second solid-solid separation unit, has the second desired pH and comprises the one or more contaminants.

2. The system of claim 1, wherein the one or more contaminants comprise one or more phosphates, one or more ammonium salts, or a combination of any two or more thereof, optionally, wherein the one or more phosphates comprise one or more of orthophosphate, di-phosphate, and tri-phosphate.

3. The system of claim 1, wherein the contaminated water is combined with the solution comprising one or more acids or one or more bases and the one or more mobile carriers prior to being input to the first reactor.

4. The system of claim 1, wherein: a) the first reactor is configured to mix the contaminated water, the solution comprising one or more acids or one or more bases, and the one or more mobile carriers to facilitate surface-based reactions between the one or more mobile carriers and the one or more contaminants,

b) at least a portion of the first effluent, of the first solid-solid separation unit, is input to the first reactor,

c) at least a portion of the first effluent, of the first solid-solid separation unit, is combined with the contaminated water prior to being input to the first reactor or

d) a solution comprising one or more bases or one or more acids is added to at least a portion of the first effluent, of the first solid-solid separation unit, to produce treated water,

optionally, further comprising a disinfection unit configured to receive the treated water, wherein the disinfection unit is configured to destroy residual organic compounds in the treated water.

5. The system of claim 1, wherein: a) the second reactor is configured to agitate the second effluent, of the first solid-solid separation unit, and the solution comprising at least one of one or more bases and one or more bases to cause the one or more contaminants to separate from the one or more mobile carriers,

b) at least a portion of the second effluent, of the second solid-solid separation unit, is input to the second reactor,

c) at least a portion of the second effluent, of the second solid-solid separation unit, is combined with the second effluent, of the first solid-solid separation unit, prior to being input to the second reactor, or

d) the solution comprising at least one of one or more bases and one or more brines is combined with the second effluent, of the first solid-solid separation unit, prior to being input to the second reactor.

6. The system of claim 1, wherein the first effluent, of the second solid-solid separation unit, is: input to the first reactor, or combined with the contaminated water prior to being input to the first reactor.

7. The system of claim 1, wherein: a) the first solid-solid separation unit is configured to use screening, hydrocyclone separation, sedimentation, clarification, membrane filtration, and cloth-disc type filtration, or a combination of any two or more thereof, or

b) the second solid-solid separation unit is configured to use screening, hydrocyclone separation, sedimentation, clarification, membrane filtration, classification, and cloth-disc type filtration, or a combination of any two or more thereof.

8. The system of claim 1, wherein the one or more mobile carriers: a) occupy up to 100% of a volume of the first reactor,

b) occupy up to 100% of a volume of the second reactor,

c) are 1% to 100% of total suspended solids in the first reactor, or

d) are 1% to 100% of total suspended solids in the second reactor.

9. The system of claim 1, wherein the first reactor: a) is partitioned to perform two or more processes in series,

b) is partitioned to perform two or more processes in parallel,

c) has a hydraulic retention time of 0.1 to 100 hours, or

d) is mixed to have a velocity gradient of 1 to 1,000,000/s.

10. The system of claim 1, wherein the second reactor:

a) is partitioned to perform two more processes in series,

b) is partitioned to perform two more processes in parallel, or

c) has a hydraulic retention time of 0.1 to 100 hours.

11. The system of claim 1, further comprising:

a) a liquid-solid separation unit configured to receive the first effluent, of the first solid-solid separation unit, and separate one or more solids from water in the first effluent of the first solid-solid separation unit,

wherein the solution comprising one or more bases or one or more acids is added to the water output from the liquid-solid separation unit,

b) a disinfection unit configured to receive at least a portion of the second effluent of the second solid-solid separation unit, wherein the disinfection unit is configured to destroy residual organic compounds in the at least a portion of the second effluent of the second solid-solid separation unit,

c) an oxidation unit configured to receive at least a portion of the second effluent of the first solid-solid separation unit,

d) a liquid-solid separation unit configured to receive the second effluent, of the second solid-solid separation unit, and separate the one or more contaminants from water in the second effluent of the second solid-solid separation unit,

e) a concentrator unit configured to receive the second effluent, of the second solid-solid separation unit, or

f) a third reactor in fluidic communication with the second solid-solid separation unit, the third reactor configured to:

receive the second effluent of the second solid-solid separation unit,

receive a solution comprising at least one of one or more alkaline earth metal salts, one or more acids, and one or more bases, and

output a treated water comprising one or more contaminant particles.

optionally: i) wherein the one or more alkaline earth metal salts comprise one or more calcium salts, one or more magnesium salts, one or more potassium salts, one or more aluminum salts, one or more iron salts, one or more copper salts, or a combination of any two or more thereof,

ii) further comprising a liquid-solid separation unit configured to separate the treated water from the one or more contaminant particles, or

iii) further comprising a concentrator unit configured to separate the treated water from the one or more contaminant particles, or

g) further comprising at least one of a liquid-solid separation unit and a concentrator unit disposed in fluidic communication between the first reactor and the first solid-solid separation unit, wherein:

the at least one of the liquid-solid separation unit and the concentrator unit outputs a first effluent comprising water having the first desired pH, the first effluent being at least substantially free of the one or more mobile carriers and the one or more contaminants,

the at least one of the liquid-solid separation unit and the concentrator unit outputs a second effluent having the first desired pH and comprising the one or more mobile carriers having the one or more contaminants, and

the second effluent, of the liquid-solid separation unit is input to the first solid-solid separation unit.

12. The system of claim 1, wherein: the first desired pH is equal to or less than 8,or the second desired pH is equal to or greater than 7.

13. The system of claim 1, wherein the one or more mobile carriers comprise a first mobile carrier comprising a core coated with a porous and non-reactive binding agent comprising one or more types of nanoparticles, wherein at least one of:

the first mobile carrier has a density of 0.01 to 20 g/cm^3,

the first mobile carrier has a dimension of 1 to 12,500 microns, and

the porous and non-reactive binding agent has a thickness of 0.001 to 1,000 microns.

14. The system of claim 13, wherein: a) a shape of the first mobile carrier is formed through one or more physical processes, one or more chemical processes, one or more physical-chemical processes, or a combination of any two or more thereof,

b) the first mobile carrier has a naturally occurring shape,

c) a size of the first mobile carrier is formed through one or more physical processes, one or more chemical processes, one or more physical-chemical processes, or a combination of any two or more thereof,

d) a porosity of the first mobile carrier is formed through one or more physical processes, one or more chemical processes, one or more physical-chemical processes, or a combination of any two or more thereof,

e) the first mobile carrier has a net negative charge, or

f) the first mobile carrier has a net positive charge.

15. The system of claim 13, wherein: a) the core is formed through one or more physical processes, one or more chemical processes, one or more physical-chemical processes, or a combination of any two or more thereof,

b) the core is naturally occurring,

c) the core comprises one or more hydrophobic polymers, gypsum, lignocellulose, hemicellulose, basalt, bauxite, graphite, cera alba, bone, or a combination of any two or more thereof, or

d) the porous and non-reactive binding agent further comprises one or more magnetic nanoparticles, carbon, one or more carbon-containing compounds, one or more ceramics, one or more metals, one or more metal oxides, one or more polymers, one or more zeolites, one or more ion exchange resins, or a combination of any two or more thereof
optionally, wherein the porous and non-reactive binding agent comprises one or more magnetic nanoparticles and one or more ion exchange resins.