CLAIMS

1. A water treatment system comprising:

a first carbon stage comprising a first vessel containing at least a first amount of activated carbon effective to reduce a first amount of chemical oxygen demand (COD) from a wastewater stream and generate a first treated stream having a first reduced amount of COD;

an oxidation unit disposed downstream of the first carbon stage, the oxidation unit configured to oxidize a second amount of COD from the first treated stream and generate a second treated stream having a second reduced amount of COD;

a second carbon stage downstream of the oxidation unit comprising a second vessel containing at least a second amount of activated carbon effective to reduce a third amount of chemical oxygen demand (COD) from the second treated stream and generate a third treated stream having a third reduced amount of COD at or below a predetermined concentration limit;

wherein the first vessel comprises a first membrane bioreactor comprising the first amount of activated carbon, a first amount of biomass, and a plurality of membranes therein, the first membrane bioreactor configured to remove the first amount of COD from the wastewater stream, generate a first material comprising the first treated stream and a first solids portion comprising the first amount of activated carbon and biomass, and separate the first treated stream from the first solids portion;

wherein the second vessel is configured to remove the second amount of COD from the wastewater stream and generate a second material comprising the third treated stream and a second solids portion comprising the second amount of activated carbon; and

a second separator in fluid communication with the second vessel, the second separator configured to separate the third treated stream from the second solids portion.

2. The system of claim 1, wherein the first carbon stage, the second carbon stage, or both carbon stages further comprise an amount of a biomass therein for reducing the first amount and/or the third amount of COD.

3. The system of claim 1, wherein the oxidation unit comprises an oxidation unit configured for subjecting the first treated stream to at least one of an amount of ozone, hydrogen peroxide, and ultraviolet light effective to reduce the second amount of COD from the first treated stream.

4. The system of claim 1, wherein the first vessel is configured to remove the first amount of COD from the wastewater stream and generate a first material comprising the first treated stream and a first solids portion comprising the first amount of activated carbon; and

a first separator in fluid communication with the first vessel, the first separator configured to separate the first treated stream from the first solids portion.

5. The system of claim 1, wherein the first vessel comprises a first bioreactor, and wherein the first bioreactor comprises the first amount of activated carbon and a first amount of biomass therein, the first bioreactor configured to remove the first amount of COD from the wastewater stream and generate a first material comprising the first treated stream and a first solids portion comprising the first amount of activated carbon and biomass; and

a first separator in fluid communication with the first bioreactor, the first separator configured to separate the first treated stream from the solids portion.

~~6. The system of claim 1, wherein the first vessel comprises a first membrane bioreactor comprising the first amount of activated carbon, a first amount of biomass, and a plurality of membranes therein, the first membrane bioreactor configured to remove the first amount of COD from the wastewater stream, generate a first material comprising the first treated stream and a first solids portion comprising the first amount of activated carbon and biomass, and separate the first treated stream from the first solids portion.~~

67. The system of claim 1, wherein the second vessel comprises a second bioreactor, and wherein the second bioreactor comprises the second amount of activated carbon and a second amount of biomass therein, the second bioreactor configured to remove the third amount of COD from the wastewater stream and generate a second material comprising the third treated stream and a second solids portion comprising the second amount of activated carbon and biomass; and

a second separator in fluid communication with the second bioreactor, the second separator configured to separate third treated stream and the second solids portion.

78. The system of claim 1, wherein the second vessel comprises a second membrane bioreactor comprising the second amount of activated carbon, a second amount of biomass, and a plurality of membranes therein, the second membrane bioreactor configured to remove the third amount of COD from the second treated stream, generate the second third treated stream and the second material comprising the second amount of activated carbon and biomass, and separate the third treated stream from the second material.

89. The system of claim 1, further comprising:

a wet air oxidation unit configured to regenerate an amount of spent carbon input from the first carbon stage and/or second carbon stage; and

a recirculation line for recycling an amount of regenerated carbon from the wet air oxidation unit to the first carbon stage and/or second carbon stage.

910. The system of claim 1, wherein the second reduced amount of COD of the second treated stream further comprises at least one of an increased fraction of biodegradable COD and an overall decrease in COD relative to the first treated stream upon oxidation of the first treated stream in the oxidation unit.

10~~11~~. A water treatment process comprising:

generating a first treated stream having a first reduced amount of COD via contacting a wastewater stream with a first amount of activated carbon;

generating a second treated stream having a second reduced amount of COD via subjecting the first treated stream to an oxidation process; and

generating a third treated stream having a third reduced amount of COD at or below a predetermined concentration limit via contacting the second treated stream with at least a second amount of activated carbon;

wherein, relative to a process without the oxidation step, the oxidation process reduces a total carbon consumption required to bring the COD to or below the predetermined concentration limit;

wherein the generating a third treated stream comprises:

treating the wastewater stream in a second vessel comprising a second amount of activated carbon effective to generate a second material comprising the third treated stream and a second solids portion comprising the second amount of activated carbon;

separating the second material into the third treated stream and the second solids portion, and~~.~~

~~12. The process of claim 11,~~ wherein the oxidation process comprises contacting the first treated stream with an amount of ~~at least one of ozone hydrogen peroxide, and~~ ultraviolet light effective to generate the second treated stream.

11~~13~~. The process of claim 10~~11~~, wherein the generating a first treated stream comprises:

treating the wastewater stream in a first vessel comprising a first amount of activated carbon effective to generate a first material comprising the first treated stream and a first solids portion comprising the first amount of activated carbon;

separating the first material into the first treated stream and the first solids portion.

12~~14~~. The process of claim 10~~12~~, wherein the generating a first treated stream further comprises:

contacting the wastewater stream with a first amount of biomass to generate the first treated stream, and wherein a first solids portion further comprises the first amount of biomass.

13~~15~~. The process of claim 10~~11~~, wherein a first solids portion comprises a first amount of spent carbon, and further comprising subjecting the first solids portion to a wet air oxidation process to regenerate the first amount of spent carbon and provide a first amount of regenerated carbon.

14~~16~~. The process of claim 10~~11~~, wherein the generating a third treated stream further comprises:

contacting the wastewater stream with a second amount of biomass to generate the second treated stream, and wherein the second solids portion further comprises the second amount of biomass.

15~~17~~. The process of claim 10~~11~~, wherein the second solids portion comprises an amount of spent carbon, and further comprising:

subjecting the second solids portion to a wet air oxidation process to provide a second amount of regenerated carbon material; and

utilizing the second amount of regenerated carbon to generate the first treated stream or the third treated stream.

16~~18~~. The process of claim 10~~11~~, wherein the predetermined concentration is 50 mg/L or less.

17~~19~~. The process of claim 10~~11~~, wherein the second reduced amount of COD of the second treated stream further comprises at least one of an increased fraction of biodegradable COD and an overall decrease in COD relative to the first treated stream upon the subjecting the first treated stream to an oxidation process.

20. A water treatment system comprising:

a first bioreactor comprising a first amount of activated carbon and a first amount of biomass, the first bioreactor configured to remove a first amount of chemical oxygen demand (COD) from a wastewater stream introduced thereto and to generate a first treated stream comprising a first reduced amount of COD along with a first solids portion comprising the first amount of activated carbon and biomass;

a first separator in fluid communication with the first bioreactor, the first separator configured to separate the first treated stream from the first solids portion;

an oxidation unit in fluid communication with the first separator, the oxidation unit configured to oxidize an amount of the COD in the first treated stream and generate a second treated stream comprising a second reduced amount of COD;

a second bioreactor comprising a second amount of activated carbon and a second amount of biomass in fluid communication with the oxidation unit, the second bioreactor configured to remove a third amount of COD from the second treated stream to generate a third treated stream comprising a reduced amount of COD along with a second solids portion comprising the second amount of activated carbon and biomass; and

a second separator in fluid communication with the second bioreactor, the second separator configured to separate the third treated stream from the second solids portion.

21. The system of claim 20, further comprising:

an activated carbon and biomass solids purge and storage system configured to remove and/or store a portion of the first solids portion and the second solids portion from the first and/or second separators; and

a wet air regeneration unit in fluid communication with the activated carbon and biomass purge and storage system configured to regenerate an amount of spent activated carbon and destroy biomass from the first and/or second solids portions.

~~22. The system of claim 20, wherein the wet air regeneration unit is in fluid communication with the first separator for regenerating an amount of spent carbon in the first solids fraction, and further comprising a first recirculation line from the wet air regeneration unit to the second bioreactor for delivery of regenerated activated carbon from the wet air regeneration unit to the second bioreactor.~~

~~23. The system of claim 20, wherein the oxidation unit comprises an oxidation unit configured to oxidize an amount of the COD in the first treated stream using at least one of ozone, hydrogen peroxide, and ultraviolet lights, and generate a second treated stream comprising at least one of second reduced amount of COD and an increase of biodegradable COD.~~