Claims

1. A wastewater treatment reactor for use in electrochemical advanced oxidation processes, the reactor comprising:

a cathode;

an anode; and

a separator situated between the cathode and anode, wherein

the cathode comprises:

one or more fixed bed compartments, each of which has an inlet and an outlet for the passage of a wastewater;

a carbon brush situated in each of the one or more fixed bed compartments; and

activated carbon situated in each of the one or more fixed bed compartments,

where each carbon brush and activated carbon situated in each of the one or more fixed bed compartments are arranged within the compartment to contact a wastewater passing from the inlet to the outlet;

provided that, when there are two or more fixed bed compartments, the fixed bed compartments are arranged to operate in parallel to one another and not in series.

2. The reactor according to Claim 1, wherein each of the one or more fixed bed compartments has a height/diameter ratio of from 8 to 12, such as 10.

3. The reactor according to Claim 1 or Claim 2, wherein the activated carbon is provided in the form of granules.

4. The reactor according to any one of the preceding claims, wherein the activated carbon is provided in an amount of from 0.05 to 5 g (such as from 0.1 to 1 g, such as 0.2 g) per cubic centimetre of volume in each of the one or more fixed bed compartments.

5. The reactor according to any one of the preceding claims, wherein the separator fixes the carbon brushes and activated carbon in the one or more fixed bed compartments.

6. The reactor according to any one of the preceding claims, wherein the separator comprises a frame and a carbon cloth or a metal mesh (e.g. a stainless steel mesh) disposed within the frame, such that the carbon cloth or metal mesh contacts the cathode and anode.

~~7. The reactor according to any one of the preceding claims, wherein the anode is formed of boron doped diamond.~~

~~8. The reactor according to any one of the preceding claims, wherein each of the one or more fixed bed compartments of the cathode has a height of 20 cm, a width of 2.5 cm and a depth of 1 cm.~~

~~9. The reactor according to any one of the preceding claims, wherein the one or more fixed bed compartments of the cathode are three fixed bed compartments.~~

~~10. The reactor according to any one of the preceding claims, wherein the reactor comprises part of a wastewater treatment apparatus, the apparatus further comprising a wastewater source in fluid communication with each inlet of the one or more fixed bed compartments of the cathode, a power supply connected to the cathode and anode and a treated water receptacle in fluid communication with each outlet of the one or more fixed bed compartments of the cathode.~~

1~~1~~. A method of wastewater treatment comprising the steps of:

(a) a decontamination stage, where a wastewater comprising at least one contaminant is continuously supplied to a wastewater treatment apparatus, said wastewater treatment apparatus comprising:

(i) a wastewater treatment reactor for use in electrochemical advanced oxidation processes, the reactor comprising:

a cathode;

an anode; and

a separator situated between the cathode and anode, wherein

the cathode comprises:

one or more fixed bed compartments, each of which has an inlet and an outlet for the passage of a wastewater;

a carbon brush situated in each of the one or more fixed bed compartments; and

activated carbon situated in each of the one or more fixed bed compartments,

where each carbon brush and activated carbon situated in each of the one or more fixed bed compartments are arranged within the compartment to contact a wastewater passing from the inlet to the outlet;

provided that, when there are two or more fixed bed compartments, the fixed bed compartments are arranged to operate in parallel to one another and not in series; and

(ii) a wastewater source in fluid communication with each inlet of the one or more fixed bed compartments of the cathode,

(iii) a power supply connected to the cathode and anode; and

(iv) a treated water receptacle in fluid communication with each outlet of the one or more fixed bed compartments of the cathode,

~~as described in Claim 10, comprising a reactor according to any one of Claims 1 to 9,~~ such that the wastewater enters through an inlet of one of the one or more fixed bed compartments of the cathode and is subjected to an ~~electrochemical advanced oxidation~~adsorption process to remove the contaminant, such that the water passing through an outlet of the one or more fixed bed compartments of the cathode is a decontaminated water that has substantially none of the at least one contaminant present;

(b) an electrochemical advanced oxidation regeneration step comprising:

the electrochemical generation of H_2O_2;

the subsequent breakdown of H_2O_2 to form hydroxyl radicals and superoxide radical anions; and

the oxidative breakdown of contaminants by the hydroxyl radicals and superoxide radical anions to regenerate the activated carbon,

where the decontamination process of step (a) is stopped when a breakthrough amount of the at least one contaminant is detected and the reactor ~~of any one of Claims 1 to 9~~ is then placed into an electrochemical regeneration cycle; and

(c) repeating steps (a) and (b).

~~1~~2. The method according to Claim ~~1~~1, wherein the flow rate of the wastewater continuously supplied to the wastewater treatment apparatus is from 5 to 40 mL/min, such as from 8 to 14 ml/min, such as from 8 to 10 mL/min, optionally wherein these flow rates relate to a reactor as described in Claim 8 and the flow rate used in a reactor according to any one of Claims 1 to 7, Claim 9 as dependent upon any one of Claims 1 to 7 and Claim 10 as dependent upon Claims 1 to 7 and 9 as dependent upon any one of Claims 1 to 7 with a differing dimension is pro-rated accordingly.

~~1~~3. The method according to Claim ~~1~~1 or Claim ~~1~~2, wherein the current applied in the electrochemical advanced oxidation process is from 1 to 30 mA/g, such as from 10 to 25 mA/g, such as from 15 to 18 mA/g, such as 16.6 mA/g.

~~1~~4. The method according to any one of Claims ~~1~~1 to ~~1~~3, wherein the electrochemical advanced oxidation ~~process~~ regeneration step is an electro-Fenton process.

~~1~~5. The method according to any one of Claims ~~1~~1 to ~~1~~4, wherein the electrochemical regeneration cycle of the regeneration step is conducted for a period of from 10 to 180 minutes, such as from 30 to 140 minutes, such as from 60 to 130 minutes, such as 120 minutes.

~~1~~6. The method according to Claim ~~1~~5, wherein the electrochemical regeneration cycle of the regeneration step is conducted on activated carbon that has reached from 18 to 50% of its theoretical loading capacity, such as from 30 to 40% of its theoretical loading capacity, such as about 38% of its theoretical loading capacity.

~~1~~7. The method according to any one of Claims ~~1~~1 to ~~1~~6, wherein steps (a) and (b) can be conducted from 10 to 10,000 times, such as from 10 to 500 times, such as from 10 to 100 times, such as 10 times.

8. The method according to any one of the preceding claims, wherein each of the one or more fixed bed compartments has a height/diameter ratio of from 8 to 12, such as 10.

9. The method according to any one of the preceding claims, wherein the activated carbon is provided in the form of granules.

10. The method according to any one of the preceding claims, wherein the activated carbon is provided in an amount of from 0.05 to 5 g (such as from 0.1 to 1 g, such as 0.2 g) per cubic centimetre of volume in each of the one or more fixed bed compartments.

11. The method according to any one of the preceding claims, wherein the separator fixes the carbon brushes and activated carbon in the one or more fixed bed compartments.

12. The method according to any one of the preceding claims, wherein the separator comprises a frame and a carbon cloth or a metal mesh (e.g. a stainless steel mesh) disposed within the frame, such that the carbon cloth or metal mesh contacts the cathode and anode.

13. The reactor according to any one of the preceding claims, wherein the anode is formed of boron doped diamond.

14. The method according to any one of the preceding claims, wherein each of the one or more fixed bed compartments of the cathode has a height of 20 cm, a width of 2.5 cm and a depth of 1 cm.

15. The method according to any one of the preceding claims, wherein the one or more fixed bed compartments of the cathode are three fixed bed compartments.