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Description

Super Advanced Sewage Treatment Method and Device

Technical Field

The invention relates to a super advanced sewage treatment method and device, in particularly to a sewage endogenesis-based electro-osmosis and ion exchange method for the super advanced purification of the sewage, belonging to the technical field of sewage reclamation.

Background Art

In general, the urban sewage discharge accounts for 75-85% of the consumption and the industrial sewage discharge accounts for 80-90% of its consumption. And the sewage, which is actually utilized in a biological or chemical way and disappears in the form of vaporization loss, is less than 25%. Because of low rate of sewage treatment in our country, the majority of the surface water resources and the underground water resources are polluted to different extents, resulting in extra pressure, caused by the shortage of water resource, on the sound and sustainable development of economy and society. Sewage reclamation is not only favorable for enterprises to increase income and decrease expenditure as well as reduce consumption and improve efficiency, but is also an inevitable option for enhancing the supply capacity of urban water. It is more important to improve the revitalization environment of aquatic ecosystem, benefiting not only the present generation, but the future generations. Advanced sewage treatment means that, in order to cause urban sewage or industrial wastewater, which has been subjected to routine treatment, to reach a certain standard of recycled water and to be reused for production or living, treatment units are added in order to further remove the pollutants that cannot be removed by routine treatment, such as heavy metals, COD, TN, TP, TDS and the like. Electrochemical process has the prominent characteristics of wide adaptability, good cleaning property and easy control in the aspect of removing the pollutants in water. Combination of ion exchange and electrochemical technology research from the beginning that the ion exchange membrane i.e. the electrodialysis technology. With ion exchangers and selective ion exchange membranes having ion conduction capability are simultaneously used in, electrodeionization (EDI for short) and electrochemical ion exchange (EIX for short) to overcome the defects that electrolyte addition is required in the process of electrolytic reaction and chemical regeneration is required in the process of ion exchange. However, polarization and osmosis, caused by the verticality of membrane surface and flow field to electric field,



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as well as their impacts still exist as key factors that restrict the improvement of operation efficiency and the widening of applicable scope.

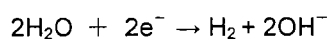
The objective of the invention is to provide an endogenesis-based new technology for sewage reclamation, particularly a technology for the super advanced purification of multiple sewages, which can remove the pollutant COD and the saline matters TN, TP and TDS in the sewage synchronously and kill pathogenic microorganisms. For high-salinity organic wastewater, the technology has the efficacy of improving its biodegradability significantly.

The technical solution of the invention is implemented in such a manner that:

A super advanced sewage treatment method is characterized in that electrochemical technology is skillfully combined with ion exchange technology and comprises the steps as follows:

A pump drive is adopted to input the sewage in the form of single stream from the bottom of an electrolytic bath to which a certain direct current voltage is applied, and the sewage is divided into a cathode effluent and an anode effluent through a filter cylinder electrode; the cathode effluent and the anode effluent respectively enter cation exchange columns filled with hydrogen and sodium cation exchangers so as to prepare a part of desalted water after the super advanced treatment and disinfection solution with disinfection function; and the scaling of the electrodes and the alternate regeneration and operation of the subsequent ion-exchangers can be controlled through electrode reverse operation.

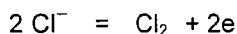
In the invention, the mechanism for the electro-osmosis ion exchange process is as follows: in the electro-osmosis ion exchange process, cations with high degree of hydration take their hydration layers to move towards the cathode direction under the action of DC electric field, and can drag a part of diffusion layers (hydration layers) on the micro-pore surface of resin to move together when passing through the anion exchange resin between the electrodes. In order to implement electro-osmosis, the discharge reaction of the cathode is as follows:



However, Na^+ , Ca^{2+} and other cations are not electrolyzed, instead, flow by the cathode under the driving of pressure and take out OH^- and H_2 which are generated by cathode reaction, thus avoiding that the surfaces of the electrodes are covered by gas generated in the process of electrolysis to further result in current reduction and mass transfer hindrance.

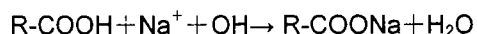
To maintain charge balance, Cl^- with negative charges and organic pollutants enriched on the anion exchange resin are firstly exchanged or adsorbed, and then move towards the anode direction under the

action of DC electric field while oxidization reaction is completed, or organic pollutants are directly oxidized into CO₂, or active intermediates with short life and extremely strong oxidizing property, such as solvated electrons, free radicals like OH, and Cl₂ generated by oxidization of Cl⁻ and its derivative HClO, are generated on the surface of the anode; the main reactions are as follows:

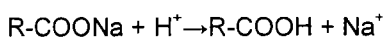


Similarly, these products, driven by pressure, flow by the anode, which not only avoids current reduction and mass transfer hindrance when they are separated from the electrodes owing to the generation of intermediates in the process of electrolysis, but also completely eliminating the adverse reaction in which they are reduced by the cathode, hence, the indirect oxidization action of these intermediates are fully exerted in anode filter element and subsequent applications. Therefore, the pH value of the anode effluent is lower than that of raw water, the concentrations of Cl⁻ and HClO are significantly higher than that of raw water and common flow-through-type electrochemical devices, so the anode effluent has the function of continuous disinfection and higher value in use.

The mechanism for the ion exchange process of the anode and cathode effluents in the invention are as follows: the cathode effluent is led into an exchange column filled with H-type resin, the following neutralization reaction occurs so that NaOH in the cathode effluent is removed to obtain a part of desalted water after the super advanced purification.



The anode effluent is led into an exchange column filled with Na-type resin, and the following reaction of the anode effluent with the resin occurs owing to its strong acidity:



The above exchange process is to convert the acidic product generated by electrode reaction into neutral salt, i.e. NaCl, in order to increase the pH value thereof and simultaneously finish resin regeneration. Because the main exchange reactions of the anode and cathode effluents are counter reactions to each other, switching can be performed through reverse operation so as to realize continuous operation.

Compared with the prior art, the invention has the positive effects that:

1. The electro-osmosis ion exchange method has wide adaptability in the aspect of the super advanced purification of sewage, no chemical agent is needed and no secondary pollution is caused.
2. The electro-osmosis unit is free from membrane, the cathode/anode-equivalent micro-pore

titanium filter element electrode array and the design that the flow field is parallel to the electric field are adopted, thus avoiding mutual interference between the cathode reaction and the anode reaction, and reducing current reduction and mass transfer hindrance, which are caused by gas coverage generated in the process of electrolysis. Furthermore, the elimination for the scaling of electrodes through electrode reverse operation and the regeneration and continuous operation of subsequent ion exchange resin are facilitated.

3. Filling resin between the electrodes results in an electrolyte supporting effect, so as to avoid the limitation on the electrical conductivity of influent. Electrolyte addition is not required when the sewage with low electrical conductivity is treated.

4. The invention provides a new way for pollution control and resource recycling, becomes an extremely promising technology as the recycling of H_2 is turned into another point for economic growth, and will bring wide prospect to ion exchange application technology in the field of sewage reclamation.

5. A wide space is provided for the application and development of the electro-osmosis ion exchange method due to diversified commercial ion exchangers.

Brief Description of the drawings

FIG.1 is a structural schematic diagram of the electro-osmosis unit;

FIG.2 is a schematic diagram of the electro-osmosis ion exchange process flow;

FIG.3 is a schematic diagram of the enrichment and conversion mechanisms of the components in sewage;

FIG.4 is a diagram of material balance in the embodiment;

In FIG.1, 1—anode, 2—cathode, 3—organic glass shell, and 4—water inlet.

Detailed description of the embodiments

FIG.1 to FIG.4 show a super advanced sewage treatment method and device. The treatment process comprises the steps as follows: (1) a pump drive is adopted to input sewage in the form of single stream from the bottom of an electrolytic bath to which a certain direct current voltage is applied, and the sewage is divided into a cathode effluent and an anode effluent through a filter element electrode, the cathode effluent and the anode effluent respectively enter cation exchange columns filled with hydrogen and sodium cation exchangers so as to prepare a part of desalted water after the super advanced treatment and disinfection solution with disinfection function, and the scaling of the electrodes and the alternate regeneration and operation of the subsequent ion-exchangers can be controlled through

electrode reverse operation. In the electrolytic bath for implementing the method, micro-pore titanium filter cylinder electrodes with the area of 0.0113m^2 , which are three anodes and three cathodes, are arranged uniformly in the form of regular hexagon, and the spacing between the centers of the adjacent anode and cathode is 25mm. 201x7 strongly alkaline styrene anion-exchange resin is filled between the electrodes. The power supply voltage is 25V, the flow of influent is 7.5L/h, and the ratio of the cathode effluent to the anode effluent is 1:1. The experimental results of a simulated water sample (Table 1) after the electro-osmosis ion exchange under the operation condition are shown as Table 2:

Table 1 Parameters of the Simulated Water Sample

Electrical Conductivity/ ($\mu\text{s}/\text{cm}$)	COD/ (mg/L)	Cl^- Concentration/(mg/L)	pH
2100	426	689.79	7.28

Table 2 Parameters of Cathode and Anode Effluents in the Electro-Osmosis Ion Exchange Process

	Cl^- Concentration(mg/L)	pH	Electrical Conductivity ($\mu\text{s}/\text{cm}$)
Anode Effluent	2899.10	2.24	---
Cathode Effluent	120.00	12.36	4500

Table 3 Parameters of Super Advanced Purified Water

Electrical Conductivity/ ($\mu\text{s}/\text{cm}$)	COD/ (mg/L)	Cl^- Concentration/(mg/L)	pH
350	32.6	120	7.28

The cathode effluent is led into the exchange column filled with H-type resin, the following neutralization reaction occurs so that NaOH in the cathode effluent is removed to obtain the super advanced purified water, which has the desalination rate up to 83% and the removal rate of COD up to 92%. Table 3 shows water quality parameters after the exchange of the cathode effluent. Under experimental conditions, material balance of the simulated water sample after the electro-osmosis ion exchange is shown as FIG.4.

Claims

1. A method for super advanced sewage treatment, characterized in that: the treatment process comprises the step that a pump drive is adopted to input sewage in the form of single stream from the bottom of an electrolytic bath to which a certain direct current voltage is applied, and the sewage is divided into a cathode effluent and an anode effluent through a filter cylinder electrode; the step that the cathode effluent and the anode effluent respectively enter cation exchange columns filled with hydrogen and sodium cation exchangers so as to prepare a part of desalted water after the super advanced treatment and disinfection solution with disinfection function; and the step of electrode reverse operation ,through which the scaling of the electrodes can be controlled, the alternate regeneration and operation of the subsequent ion-exchangers can be realized.

2. The method for super advanced sewage treatment according to claim 1, wherein the cation exchangers for the treatment of the cathode effluent and the anode effluent are equivalent, alkaline neutralization reaction occurs between the cathode effluent and the cation exchanger, and high-valence cations in the sewage is preferably removed to obtain demineralized water which is partially desalted; and regeneration reaction occurs between the anode effluent and the cation exchanger to obtain electrolyzed oxidizing water with disinfection function.

3. An electrolytic bath for implementing the method according to claim 1, characterized in that: (1) a cathode/anode-equivalent micro-pore titanium filter cylinder electrode array is adopted and a flow field and an electric field are enabled to be parallel to each other, and no membrane is needed; and (2) strongly alkaline anion-exchange resin is filled between the cathode and the anode to ensure that the external pressure of the filter cylinder electrode is larger than the internal pressure thereof, thus the effluent flowing by the cathode takes out OH^- , H_2 and sodium ions generated by reduction reaction, and the effluent flowing by the anode takes out Cl_2 , CO_2 , O_2 and chloride ions generated by oxidation reaction.

4. The electrolytic bath according to claim 3, wherein the electric field has the intensity from 1V/mm to 3V/mm and the average current density from 100A/m^2 to 500A/m^2 .

5. The electrolytic bath according to claim 4, wherein the cathode/anode-equivalent micro-pore titanium filter cylinder electrode array adopts a single-electrode structure, and through electrode reverse operation, the scaling of the electrodes can be controlled and the alternate regeneration and operation of the ion-exchangers can be realized.