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# The application of three new technologies in water remediation: taking Pearl River Delta as an analysis sample

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**Abstract.** The problem of water pollution has always been a concern for people from all over the world. In recent years, due to the enhancement of people's awareness of environmental protection and the rapid development of science and technology, the solution to water pollution has been put on the agenda. More and more water remediation technologies are constantly being discovered and applied in solving pollution. In this article, the author will give an introduction to three popular water remediation technologies which are Nanofibrous membrane, Biofiltration, and Electrodialysis remediation, discuss the advantages and disadvantages of them, as well as give suggestions to the real application of the three technologies taking Pearl River Delta as a sample.

## 1. Introduction

With the development of the global economy and the advancement of living standard, many measures have been taken in water protection. A lot of skills and technologies are discovered to deal with pollution and water remediation. However, the problems of poor quality and low standard of emission, severe pollution and damage to water ecology as well as potential hazards regionally still exist. These problems have caused adverse negative social impacts and significant economic losses, which seriously threaten the sustainable development of society and economics of the world, as well as the survival of human beings in some less developed regions.

This article will focus on three cutting-edge methods on water remediation which are extensively used throughout the world, namely Nanofibrous membrane, Biofiltration, and Electrodialysis remediation. The author will give an introduction to these three technologies, analyze and give suggestions to the application of them taking Pearl River Delta as a sample regarding two main causes of water pollution which are industrial wastewater and living sewage. As one of the most densely urbanized regions in the world, Pearl River Delta is now the wealthiest region in China. With about 120 million people and a developed economy, the Pearl River Delta is notoriously polluted by both industrial wastewater and living sewage.[1] Therefore, the proposed countermeasures are of great significance for not only the delta but also other metropolitan regions in both China and other countries of the world.

## 2. Three methods of water remediation

### 2.1. Nanofibrous membrane

Poly (acrylic acid) (PAA) modified poly (ether sulfone) Nanofibrous membrane (NFM) are made under the guidance of electrospinning and hyperacoustic. Driven by gravity, NFM shows a high capacity of super hydrophilicity and prewetted oleophobicity that can separate the pollutants of water



effectively. Due to the high porosity and large contact area, the NFM shows a fast adsorption rate of water-soluble and dispersive pollutants. The contaminants could be separated quickly when the pollution water passes through the NFM, especially when separating the particular matter at around 5-10  $\mu\text{m}$ , heavy metal ions, water-soluble contaminants and a wide range of oil-water mixture. Additionally, by using silver and neptunium on the membranes, the NFM can work against *E. coli* and *S. aureus*, which is significant for domestic water purification.[2]

#### *2.1.1. Advantages*

Compared with the normal membrane, the NFM has the characteristic of high porosity, good pore connectivity and fiber diameter uniformity reflecting a broad application space and prospect. Based on the properties and composite of technology, various nanofibrous membrane materials are summarized. With the development of research, the nanofibrous membrane shows the critical value in the field of industrial water which most contain heavy metal, oil and dyes. Chromium ion is a typical heavy metal ion in industrial water, mainly in the form of  $\text{Cr}^{3+}$  and  $\text{Cr}^{6+}$ . The Poly (acrylic acid) (PAA) modified poly (ether sulfone) nanofibrous membrane has a larger area and porosity, which has a significant adsorption capacity and efficiency for chromium ions. With the deepening of the research, the new high performance materials are being developed, the field of wastewater treatment of nanofibrous membrane will have a broad application prospect.

#### *2.1.2. Disadvantages*

However, the NFM requires a high initial cost, and therefore cannot be applied extensively in general sewage treatment. Besides, the problems of low output, small intensity, and instability restrict its production and application.

### *2.2. Biofiltration*

Biofiltration uses microorganisms which are fixed on the porous medium to break down pollutants. Biofiltration is a complicated process, where the effect of the biofiltration is determined by the cell surface structure, and the adsorption force is affected by environmental pH, temperature, initial concentration of metal ions and coexisting ions. In biofiltration system, the removal of biodegradable contaminants depends on biodegradation rather than physical strains as in normal filters. With the progress of biofiltration, the microorganism gradually develops on the surface of the filter medium and forms a biofilm. Some of the microorganisms have been proved capable to remove the heavy metals from the wastewater because they are small in size and density that can rapidly absorb the pollutants effectively.[3]

#### *2.2.1. Advantages*

For the traditional wastewater remediation, the technology is incomplete in the removal of pollutants, which lead to the occurrence of secondary pollution. Compared with traditional remediation, biofiltration is a fast, safe and low-cost technology to solve pollution especially the problem of heavy metal pollution. In a research made by Katsoyiannis and Zouboulis, it shows that the Biofiltration methods can remove 97.0% of Fe and Mn and 80.0% of As. It will play an increasingly important role in environmental engineering in the future.

#### *2.2.2. Disadvantages*

Although the Biofiltration method is one of the ways to solve the urban living pollution, it also faces with many problems, such as less matrix in water, little chance of biological contact with the substrate and lower levels of biological metabolism. So how to stabilize the biomass, activate the maintenance biological, and keep the operation of the system stable and efficient are also the problems to be solved.

### *2.3. Electrodialysis remediation*

Electrodialysis technology (ED) is a new green remediation technology which combines the Electrokinetic Remediation (EKR) and Permeable Reactive Barrier (PRB) with the principle of electrodynamics to restore the wastewater. The process is under the applied electric field in the water, anionic and cationic ions can be selectively transferred through the selectivity of exchange membranes, and then centralized treatment is carried out in the set processing area.[4]

#### *2.3.1. Advantages*

Centralized treatment can help to improve the efficiency and control the water pollution. Comparing with the traditional water remediation technology, the Electrodialysis technology not only has the advantages of continuous in-situ treatment and relatively low price but also reduces the surface treatment facilities that can decrease the exposure of environmental disturbance. It has the characteristics of environmental compatibility, multifunctional applicability, high selectivity, suitable for automatic control and low operating cost. Through several experimental pieces of research, the Electrodialysis technology shows great value in removing the nitrate in groundwater, it can not only remove 99% nitrate contained in the groundwater but also reduce the energy consumption, avoid secondary pollution caused by chemical recycling purposes. In conclusion, the Electrodialysis technology has excellent economic, environmental and social benefits and can achieve the reduction, harmless and management resources of Nitrate pollution in groundwater.

#### *2.3.2. Disadvantages*

Of course, electrodialysis has its drawbacks. The electrodialyzer is composed of dozens to hundreds of thin separators and membranes. The electrodialysis equipment is to make the water flow through the electric field. When a certain voltage is applied, the salt content of the electrolyte in the retaining layer near the membrane surface is less. At this time, the dissociation degree of water increases, and polarization scaling and neutral disturbance are easy to occur, which becomes a challenging and vital problem in electrodialysis water treatment technology.

### **3. The philosophy of application**

To sum up, the problem of water pollution could be solved through science and technology methods. Through the analysis of these three methods above, the philosophy and process of water remediation could be concluded as the following: 1) Define the region; 2) Analyze the specific situation of the polluted region; 3) Apply the specific technology methods according to the specific situation. Because there are usually multiple pollution sources in one region, the remediation solution is not unique in most cases.

### **4. The sample analysis of Pearl River Delta**

The Pearl River Delta region is one of the critical driving forces to the economic growth of China. In the process of economic growth, the region has also experienced the tortuous path which first polluted and then governed. Recently, through the implementation of many environmental protection plans, the quality of the water environment has been continuously improved. However, the long-term accumulated structural pollution is still difficult to be fundamentally solved in a short period. Water pollution is still a constraining factor for the sustainable development of regional economy, society, and environment.[5]

At present, the capacity of sewage treatment in the Pearl River Delta is still seriously inadequate compared with the increasing amount of wastewater discharged. From 1992 to 1998, the proportion of industrial wastewater discharged to the total wastewater discharged annually in the whole Pearl River Delta decreased from 48% to 25%, and the treatment rate of industrial wastewater increased to more than 70%, indicating that industrial wastewater is being gradually controlled. However, the proportion of domestic sewage discharged to the total wastewater discharged increased from 52% to 75%, and the treatment rate of domestic sewage is still relatively low. Domestic sewage treatment requires more

financial investments and higher technical skills. At present, the construction of centralized sewage treatment facilities as urban environmental infrastructures is slow when the shortage of funds is still a major problem, which results in a low level of the treatment rate and qualification rate of domestic sewage.[6]

#### *4.1. Industrial production wastewater*

##### *4.1.1. Situation*

In recent years, industrial enterprises in the Pearl River Delta have developed rapidly, with a wide range of pollutants, especially harmful heavy metals, which can cause severe damage to the residents' health. The petroleum industry, chemical plants, pharmaceutical factories, pesticide factories, paint factories, paper mills, coking plants, and garbage incinerators will produce harmful organic compounds difficult to be degraded.[6]

##### *4.1.2. Suggestions for solution*

The industrial wastewater contains heavy metals such as copper, zinc, nickel, and cyanide, which are discharged directly without treatment and will pollute the environment. At present, electrodialysis has been applied in many electroplating workshops to treat electroplating wastewater with good results, which not only recovers heavy metals, but also improves the reusability of water. So this method can be popularized in the industrial areas of the Pearl River Delta. Besides, electrodialysis can also be used to desalinate seawater and improve the utilization of seawater. It is strongly recommended to solve the pollution in the coastal area and to relieve the industrial water shortage by wastewater treatment and cycling. Besides, though costs high at first, the nanofiber membrane has an outstanding adsorption capacity, especially for heavy metals in water, and therefore can be adopted as a supplement of wastewater treatment containing heavy metals.

#### *4.2. Urban Living sewage*

##### *4.2.1. Situation*

According to the data of the Guangdong Environmental Quality Bulletin in 2003, only 55% of the Pearl River branches reach the standard. The other sections that fail to meet the standard mainly focus on the branches that flow through cities, mostly V-type and inferior V-type water which means highly polluted. The main pollution indicators are ammonia nitrogen, fecal coliform bacteria, oxygen-consuming organic matter, petroleum, total phosphorus, showing distinct types of organic pollution and bacterial pollution.[7]

##### *4.2.2. Suggestions for solution*

The method of biological filtration can be applied to the treatment of sewage in urban life. Fecal sewage can be treated by biological filtration, which can effectively discharge municipal sewage into rivers, lakes, and seas. Microbial remediation can effectively remove 80% of organic pollutants such as ammonia and nitrogen in rivers. It can be widely used in organic polluted river sections and urban polluted drinking water areas.[7] In this way, water quality can be effectively improved. This method can be used in densely populated areas due to its low cost and high efficiency. When treating urban drinking water and other high-demanding water, the nanofiber membrane can also be adopted because it can work against *E. coli* and *S. aureus* by using Ag and NPs on the membrane, so that the quality is guaranteed.

## **5. Conclusion**

Water remediation is a complicated and comprehensive system. Although technologies are potent and effective in water remediation, realities of the real situation in specific regions need to be considered and analyzed before application. Specific technologies and methods could maximize the impacts based

on different types of wastewater in different regions under different environments. Apart from pure technical factors, financial factors should also be considered in the real application. Good solution plans are those which could strike a balance between inputs and outputs, or in other words, financial funds and effective results. Except for all above, the philosophy of sustainability should be more mentioned and implemented in economic and social development, and the awareness of environmental protection needs to be improved among the public for an environmental-friendly future.

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