TECHNOLOGIES FOR PHYSICAL TREATMENT OF WATER CONTAINING SELENIUM: A REVIEW

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Abstract

This paper presents an overview of technologies for physical treatment of water containing selenium (Se) as a pollutant. Water with high content of selenium comes from the mining industry, production of pesticides and their use in agriculture, during coal combustion, etc. Physical treatment technologies include the reverse osmosis and nanofiltration. The reverse osmosis technology is applicable and the legal regulations can be met, as the concentration of Se in the final solution is less than 5 mg L^{-1}. The nanofiltration technology can be used to treat the mine wastewater that contains a low concentration of Se in the form of metals. As with the application of reverse osmosis, the legal regulations can be met.

Keywords: *selenium, wastewater, physical treatment technologies*

INTRODUCTION

Selenium in the environment is naturally present in rocks and soils in several oxidation states: as selenite, selenate, selenide, and elemental Se. It is a trace element in the natural ore deposits containing other minerals, such as heavy metal sulfides [1]. In addition to naturally occurring Se, its increase in concentration in the environment is caused by the human activities, especially mining, coal combustion, pesticide production, use in agriculture, etc. [2].

Nowadays, the industrial plants generate large amounts of various types of wastewaters that contain harmful chemicals and pollutants. Selenium is present in wastewater of the final stages of ore processing, mainly in the form of selenite (at low pH value) or selenate (at high pH value) [3].

The bio accumulative nature of Se in tissues, food and organisms has a dangerous impact and toxicity on human and animal life, so that the wastewater treatment with Se content makes it an urgent issue for the environment protection. However, the removal of Se from wastewater is a challenge because it is the result of its different solubilities, oxidation states, and the effect of other components. Thus, the identification of Se species in water systems, and adequate removal technology requires a deep understanding of its biogeochemistry and species[4].

TECHNOLOGIES FOR PHYSICAL TREATMENT

Technologies for physical treatment include the reverse osmosis (RO) and nanofiltration (NF). All these technologies are well understood and are applied to the wastewater treatment in other industries. However, with the exception of reverse osmosis, these selenium removal technologies have only been developed in the laboratory or pilot plant [4, 5].

The reverse osmosis is used to filter the contaminated water through a membrane that is impermeable to Se oxyions (Fig. 1). The process is applicable and easily adjustable, and it can be achieved that the concentration of Se in the final solution is less than <5 mg L^{-1}, which satisfies the legal regulations. The disadvantages of this process are high capital and operating costs, and the pre-treatment with coagulation/flocculation and/or ultrafiltration is required. The process requires frequent maintenance, control and cleaning of membranes, high working pressure. Also, in some cases, the treatment of solution is required before discharge[6].

Reverse osmosis achieved the removal of selenium from mine wastewater by 98%, for an initial concentration of 0.4 mg L^{-1} in 24 hours, with the concentration in wastewater after treatment being 0.002 mg L^{-1}[7].

The nanofiltration is a potential technology for water treatment with Se content, which is performed by filtering the contaminated water through a membrane that is impermeable to Se oxyanions (selenate and selenite). This technology can be used to treat the mine water that contains a low concentration of Se in the form of metals. The low working pressure on a membrane separates on the basis of molecular size and ionic charge, which allows water to pass through the membrane, and at the same time the pollutants are separated (Fig. 1). The advantage of this technology is that the concentration of Se in the final solution can be less than <5 mg L^{-1}, which satisfies the legal regulations. The disadvantages of this process are high capital and operating costs, testing related to the effect of presence other anionic species, suspended particles and etc. Process maintenance and control costs are small [6].

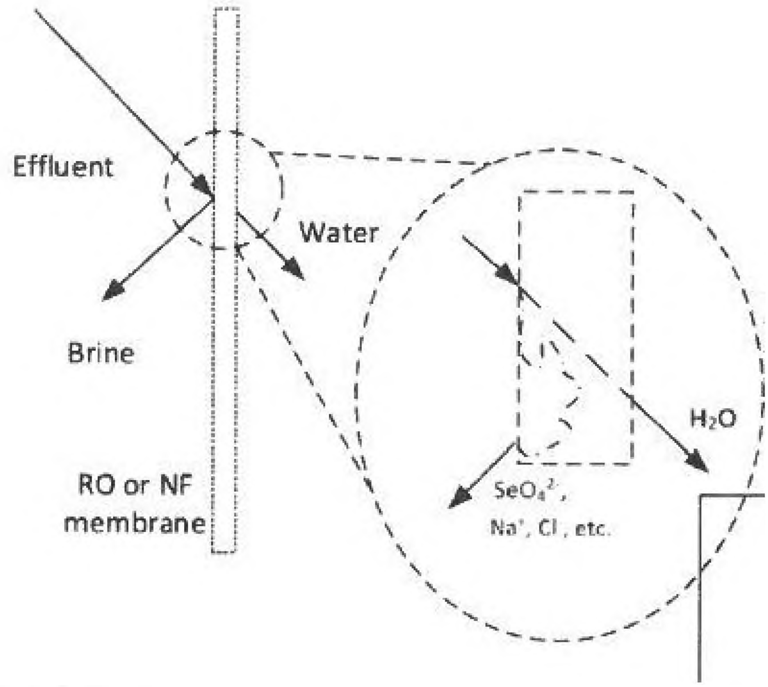

Fig. 1 *Process of membrane separation: reverse osmosis (RO) and nanofiltration (NF)*

Various types of composite membranes for nanofiltration have also been used to remove Se oxyanions. A new nanocomposite NF thin-plastic membrane containing a polyhedral oligometricsilsesquioxane in a selective layer (POSS) has been developed, which is in the form of such a thin-film [8]. For an initial selenite and selenate concentration of 1000 ppm, the removal percentage was 93.9% and 96.5% SeO_3^{2-} and SeO_4^{2-}, respectively. Also, a thin film composite membrane (TFC) consisting of zwitterionic water-soluble copolymer (P [MPC-co-AEMA]) was developed, which improved the removal efficiency to 98.2% and 99.1%, for SeO_3^{2-} and SeO_4^{2-}, respectively[9, 10, 11].

CONCLUSION

From the above results it can be concluded that NF is mainly applied only to synthetic waters, however, studies have shown that NF has the potential to remove both selenates and selenites above94%. RO and NF result in almost the same range of removal efficiencies, but RO achieved it in a significantly lower time interval (<24 h). Ceramic micropore filtration is a new technique that offers good low-cost removal efficiency, but a good assessment needs to be done for complex systems such as industrial water. This technique requires a longer removal time (> 48 h). Although RO and NF achieve high removal efficiencies, the number of studies to remove Se from wastewater has decreased significantly in recent decades. This could be due to the high operating costs and maintenance costs of the membranes, which forced the industry to focus on other treatments for effective removal. However, the potential replacement of membrane materials with natural organic fiber materials, as well as the reuse of NF membranes can help solve these problems, but operating and maintenance costs will not change significantly.

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