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Review Article

Pretreatment of Water before Application of Membrane Separation: Focus on NOM Removal

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ABSTRACT

Water reuse and recycle is becoming important for conservation of water resources. Primary, secondary and tertiary treatments with physical, biological and chemical techniques are conventionally used for treatment. The physico-chemical treatments are widely used for water treatment and removal of organic matter. Use of membrane separation can be done for water purification. Many investigators have explored possibility of use of membrane separation for wastewater and domestic water treatment. The membranes are prone to contaminate and undergo fouling. The presence of natural organic matter affects the membrane performance. The current review is aimed at reviewing research and studies on membrane separation for organic matter removal.

Key words: Natural organic matter (NOM), Membrane separation, microfiltration, ultrafiltration, fouling.

INTRODUCTION

Water scarcity is one of the major problems faced by the world. The purification of domestic and potable water is gaining importance as the water resources are contaminated by industrial activities and improper disposal practices. Water reuse and recycle is becoming important for conservation of water resources along with rainwater harvesting. [1-4] Primary, secondary and tertiary treatments with physical, biological and chemical techniques are conventionally used for treatment. The physic-chemical treatments are widely used for water treatment and removal of organic matter. [5-6] These methods include adsorption and ion exchange. Also electro dialysis, coagulation, flocculation are used according to the requirements and water composition. [7-10] Use of membrane separation can be done for water purification. Many investigators have explored possibility of use of membrane separation for wastewater and domestic water treatment. [11-15] Membrane separation method needs selection of proper membrane. The membranes are prone to contaminate and undergo fouling. The presence of natural organic matter affects the membrane performance. The current review is aimed at reviewing research and studies on membrane separation and pretreatment for natural organic matter removal.

REVIEW ON MEMBRANE TREATMENT AND NOM REMOVAL

Padmaja et. al. reviewed various purification methods for drinking water purification. [16] The methods include conventional methods like activated carbon, activated alumina, silica, and diatomaceous earth. The new cutting age technologies like use of nano-materials, carbon nano-tubes

and nano-composites were also discussed by them. Also few breakthrough techniques like thin films, quantum dots and aero-gels were also cited by them. According to them Purification at the point of entry and point of use is more effective than centralized system. Silva-Medeiros et. al. used microfiltration membranes and activated carbon in a gravitational system for drinking water treatment. [17] Their focus was on removal of chlorine, trihalomethanes (THM) and natural organic matter. They used acetate cellulose microfiltration membrane in their experiments. They carried out experiments with membrane working alone and with GAC as a pretreatment. They observed that by using microfiltration membrane, brominated THM compounds were removed more significantly than chlorinated THM ones. Also it was seen that application of activated carbon as pretreatment increased the permeate flux and also increased the rejection efficiency.

Mijatovicet. al. investigated ultra-filtration and nano-filtration for removal of natural organic matter. [18] In their investigation, they used method including ozonation, flocculation and filtration. For this method, they observed that efficiency of the removal of natural organic matter was relatively low. In an alternative method, they used ultra-filtration (UF) and nano-filtration (NF) membranes. By using this combination, they were able to produce water of high quality. Moreover, they observed that process parameters remained stable over the entire period of investigation. Thekkedath studied fouling of ultrafltration membranes by natural organic matter. [19] According to their discussion, for low pressure UF/MF processes membrane fouling is a major problem. Fouling due to natural organic matter is major concern. Schafer et.al. studied the effect of chemical addition prior to the membrane separation. [20] Their focus was on removal of natural organic matter removal (NOM). In their investigation, they used ferric chloride prior to the MF. They obtained 95% removal of NOM with 25 mg/l dosage. Hematite dosages also were able remove NOM, with higher dosage though. They concluded that MF can be operated with chemical pretreatment when the NOM concentration is high. Halle employed biofilteration in drinking water pretreatment before membrane separation. [21] According to him, the presence of pharmaceutically active compounds (PHACs), personal care products (PCPs) and endocrine disrupting compounds (EDCs) in drinking water sources is increasingly becoming cause of concern. He explored the possibility of use of bio-filtration pretreatment without prior coagulation for controlling membrane fouling in natural waters. The bio-filtration can also bring about removal of trace organic matter. He found that bio-filtration reduced both reversible and irreversible fouling of ultra-filtration membranes. They also found that along with biopolymers, humic substances and low molecular weight acids are also rejected.

According to Osterhus and Azrague, Natural organic matter (NOM) is a direct problem in drinking water. [22] It affects colour and taste. NOM has a tendency to react with most commonly used disinfectants. In the treatments such as ozonation, formation of byproducts is a concern. They suggested bio-filtration for the removal of NOM in drinking water. DiToro carried out work on use of ultra-filtration membranes for removing taste and odor causing compounds. [23] They found that negatively charged membranes were able to effectively remove taste (T) and odour(O). For maximum T and O compound, their study indicated that the pH value of 3.5 is desirable for maximum removal. Also it is envisaged to have minimum NOM and ionic strength. They found that modification of membrane by soaking in the 3-bromopropanesulfonate/ NaOH solution for 48 hours prior to use showed better results than unmodified membrane. Dual Membrane filtration along with conventional lime soda softening was used for NOM removal by Goss and

Gorczyca. [24] They investigated the removal of dissolved organic carbon (DOC) fractions by two water treatment plants. They found that since DOC concentrations were increasing after the GAC filter, the GAC filter was ineffective at removing DOC. They advocated a pre-treatment process be implemented prior to the micro/nano membranes.

Ostarcevic presented paper on removal of colour of water by using nanofiltration. [25] They carried out investigation without chemical addition. According to them, in the use of conventional methods like coagulation, flocculation, sedimentation, flotation, media or membrane filtration, the limitation is formation of disinfection byproducts due to limited removal of the NOM. They achieved a 40% reduction in DOC concentration. Garcia carried out investigation for removal of natural organic matter which further causes reduction of the presence of Trihalomethanes in drinking water. [26] He used aluminum sulphateand chitosan as coagulant. He also studied Adsorption with activated carbon and chitosan. His investigation suggested that chitosan could be a good option as a substitute for aluminum sulphate compounds. In dry season it is not available. Hence they expressed need to explore possibility of us of aluminumsulphate in combination with chitosan.

Ibrahim and Aziz reviewed trends on natural organic matter in drinking water. [27] They discussed adverse effects of NOM. According to them, High NOM content in water strongly impacts the water quality and treatment in several ways. It acts as the main precursor to disinfectant by products (DBPs) produce from the reaction of NOM and disinfectant. They discussed in detail the properties and available treatment techniques for NOM. According to them, none of the discussed treatment methods is successful in removing all NOM. They expressed need for research for improving the efficiency of existing methods and exploring new methods.

Kabsch-Korbutowicz and Urbanowska used polymeric and ceramic ultra-filtration membranes for separation of natural organic matter from water. [28] They conducted experiments for removing natural organic matter from water by ultra-filtration process. Their study indicated that the membrane material had significant effect on its transport and separation properties. Polymeric membranes showed highest permeate flux. Also they found that polymeric membranes are less prone to fouling. Kabsch-Korbutowicz and Urbanowska carried out investigation on use of ion-exchange process in NOM removal prior to water ultra-filtration. [29] They carried out comparative studies for the efficiency of natural organic matter removal achieved with various anion exchange resins. They found that ion exchange process was not effective to reduce membrane fouling. According to them, presence of NOM particles affects the performance and is the reason for fouling. The study carried out by Geluwe indicated that ozone is able to efficiently change the physico-chemical characteristics of natural organic matter. [30] In their review, they presented state-of-the-art knowledge of the reaction mechanisms between natural organic matter and molecular O_3 or _OH radicals.

CONCLUSION

The current review is aimed at reviewing research and studies on membrane separation for organic matter removal. Many investigators have explored possibility of use of membrane separation for wastewater and domestic water treatment. Membrane separation method needs selection of proper membrane. Primary, secondary and tertiary treatments with physical, biological and chemical techniques are conventionally used for treatment. The physico-chemical treatments are widely used for water treatment and removal of organic matter. These methods include adsorption and ion exchange. Also electro-dialysis, coagulation, flocculation

are used according to the requirements and water composition. Use of membrane separation can be done for water purification. The membranes are prone to contaminate and undergo fouling. The presence of natural organic matter affects the membrane performance.

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