DOI: https://doi.org/10.54393/mjz.v3i1.36

MARKHOR
THE JOURNAL OF ZOOLOGY
https://www.markhorjournal.com/index.php/mjz
Volume 3, Issue 1 (Jan-Jun 2022)

Review Article

Desalination of Saline Water: A Review

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ARTICLE INFO

Key Words:
saline water, desalination, graphene oxide, halophilic microbes

How to cite:
Ahsan, Y. ., Waheed Qurashi, A. ., & Yasmeen, R. . (2022). Desalination of Saline Water: A Review: Desalination of Saline Water. MARKHOR (The Journal of Zoology), 3(1). https://doi.org/10.54393/mjz.v3i1.36

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Received Date: 25th April, 2022
Acceptance Date: 13th May, 2022
Published Date: 30th June, 2022

ABSTRACT

Water is the most important requirement for life that is used for different purposes such as drinking, bathing, laundry and for many other various industrial applications. Clean water is the basic need of every human being. But the fresh water availability is limited now a days. Scarcity of water and untrustworthy water quality are the most important and major problems, so to attain the best water quality, desalinization of saline water is the alternate way to get the pure water and to improve the quality of life. Sea water covered almost the 94 % of the earth's surface and support the various commercial purposes. Saline water originates from different other sources as well such as agriculture, aquacultures and many other industries including chemical, pharmaceutical industries. Saline water contains high amount of salt concentration and other contaminants, which affects the terrestrial and aquatic both lives. Desalination of saline water, is done to eradicate minerals including salts, from saline water. Thus, the treatment of saline water for the removal of contaminants and salt from the water is the important task now a days in many countries. Many different conventional methods are used for the treating of saline water, but all these methods are costly and has limited applications for limited areas. Generally saline water is treated with the chemical and physical methods. Biological methods and nanobiotechnology are also used now a days. This review highlights the different conventional and non-conventional, nanobiotechnology based and biological based methods that are used for the water desalination.

INTRODUCTION

Water is the basic need for life, as population is increasing day by day, number of industries and urban areas are also increasing with the passage of time. Directly or indirectly human beings used water for numerous activities in daily life, in a large quantity. For industrial activities, water is used for different purposes in different industries, in agriculture, and for domestic purposes [1]. Increase in amount of sewage discharge, chemicals released from agriculture industry, and all anthropogenic activities that affects the underground water, leads to the damages the water quality. The one unlimited source of water, is the sea water which covers the 94 % of earth's surface. But this water having almost 4% salt concentration. Brackish water is completely unsuited for drinking purposes. But when, there is no other source is available, so the alternate method is to desalinate, the available saline water [2]. Salinity is the essential parameter during the water treatment. Waste water is well-defined as the high salinity, where salt ranges from 1-3.5% w/w, and sea water contains usually 3.5% w/w sodium chloride (NaCl). High salinity wastewater with high nutritional load was produced by several number of industrial methods [3], including aquacultures in costal arears, agriculture and food industry, nuclear industry, petroleum and natural gas extraction and leather manufacturing industry. Thus, the waste of all these industries may cause serious health and environmental problems that may cause pollution and affects the aquatic life, water potability and agriculture [4]. And it also can produce toxicity that influenced the marine environment and seagrass. There are various types of methods used to treat the saline wastewater including chemical, ecological, mechanical, physicochemical and biological methods. Physicochemical techniques e.g., reverse osmosis, electro dialysis are costly techniques. Due to high cost, biological

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treatments for saline wastewater treatment has been used the most due to its less cost [5]. Therefore, on the treatment of brackish water, the focus has developed in recent times. Many physicochemical, mechanical, chemical, ecological and biological methods have been researched for the treatment of industrial wastewater and saline or brackish water. Innovative hybrid approaches which combined different methods develops the interest in the treatment efficiency [6]. In biological treatment, for the effective biological treatment of saline wastewater, salt tolerant, halophilic microorganisms can be used separately [6]. This microbiological approach seems to be more effective and reasonable approach for the saline wastewater treatment. The biological removal of organics from industrial waste can easily minimized the toxicity without causing damage to the environment. The biological treatment also used for reducing the salt content [7].

Saline wastewater and its impact on the environment: Saline waste cause serious damage to the aquatic and terrestrial ecosystem, directly or indirectly. The negative impact of saline waste, causes damage the aquatic life including, invertebrates, microbes, vertebrates, and plants. Salts interferes their cellular and internal ionic pressure that inhibits the plant growth and reduces the survival of seedling growth [8]. Saline waste also causes the evaporation in the water, for example the promotion of the water level of the Hunter River in Australia proved to be the incompletely associated with the waste of coal mine, de watering power plants and drainage that leads to the high salinity level and cause damage to the aquatic ecosystems [9]. In arid and semi-arid regions, with or without pre-treatment of waste having the salt concentration that can be an important irrigation resource. Clearing the saline waste into receiving waterbodies, and using the saline waste for the irrigation can also contributes towards the secondary salinization [8]. Saline wastewater also contains a heavy metal salt that is more harmful to the environment and for the ecosystem, because heavy metals are non-degradable and, tend to accumulate in the living bodies through their food chain, this can cause the carcinogenic effect [10]. Saline wastewater contains discharge of antibiotics that cause serious environmental problems around the world, due to the over-usage of antibiotics in costal aquaculture, especially in China [11]. Quinolone and flumequine are the antibiotics that are used in mariculture and can cause a major problem to the environment, and the human health. Antibiotics waste leads to increase in the antibiotics-resistant bacteria and transfer the resistance characteristics to the bacteria of terrestrial human pathogens and to the animals. All these contaminants in saline wastewater that could result in the pesticide ecotoxicity in the living organisms. So, there are various reasons that shown, that there is crucial necessity for the treatment of saline wastewater [12].

Treatment methods used for the desalination: There are different types of methods are used but most commonly used approaches, that are used for the desalination of saline wastewater into the fresh water are shown in the Figure 1.

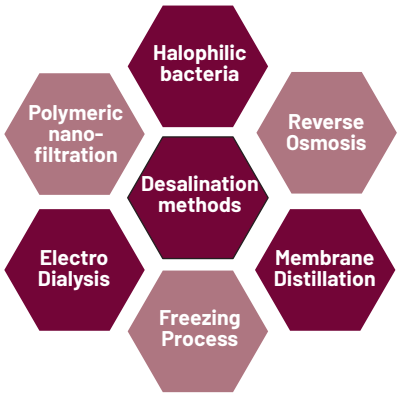

Figure 1: Treatment methods for desalination

Reverse osmosis: Reverse osmosis method is used to desalinate wastewater in the 90% of plants over the world. Reverse osmosis is the membrane process, in which a feed stream is flow through a semi permeable membrane, which are separating into the two aqueous streams; one in high salt concentration and other is in the low salt concentration. When the retained applied water will pass through the membrane. So, the lowest concentration of salt pervade stream is attained and a high salt concentration that remains at the feed side, where osmotic pressure is very high whereas salt is reserved. This is the effective process for the removal of total dissolved solid (TDS) concentrations of up to the 45,000 mg/L which is useful to desalinate the brackish or saline wastewater [13].

Membrane distillation: Membrane distillation is process that includes the phase conversion from liquid vapor from one side and vapor condensation to another side of liquid. Membrane distillation is the most promising technique used in the industrial level. Membrane distillation categorized into the four categories; direct contact membrane distillation air-gap membrane distillation vacuum-membrane distillation system and sweeping gas membrane distillation unit. Distillation method of solar power, with the thermal distillation method for water, that utilizes little heat energy. Solar energy is used for the conversion of saline water into the fresh water with the less cost and which is appropriate for all the small communities. Direct and indirect are the two systems of solar power membrane distillation systems; in the direct system desalination process can be done by solar stills naturally and by indirect method, it is categorized into two steps, solar collector and distillation unit [14].

Freezing process: This method is abundantly established by

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Dessouky *et al.*, (2000) [15], it is a method in which saline wastewater turned into the pure crystal form, which was then separated from brine and melted water. Freezing process can be categorized into the two steps; direct and indirect freezing processes. In indirect freezing, ice is formed by mechanical method by using mechanical refrigerators or other methods on the surface and saline wastewater do not come in-contact with the refrigerant directly. Firstly, seawater is pumped through the heat exchanger that helps to reduce the temperature, then, pass towards the freezing chamber, where it is chilled further more to reach the temperature at which ice crystal are produced. For the separation of ice and brine they are transferred to the wash pump where, both are separated. The ice then transferred to the Melter, where condensation process is occurred. Then the product's fresh water is pass through the wash column, and washed the ice crystals, to cool the feed seawater it is passed through the heat exchanger and then stored. In the indirect freezing process, the amount of energy is required in the high amount, because of the surface resistance of saline wastewater and refrigerant. For both, freezing and melting steps, larger metallic heat surface is essential. For this process the equipment used is very expensive, complex and difficult to maintain. Therefore, this process is not commonly used for the desalination of saline wastewater [16].

Electrodialysis: Electrodialysis is a process used for the desalination of brackish water, it is most commonly used for the commercially to treat the water. This process involves the ions in the latent field; cations and anions exchange-membranes are used for this process. Between the anode and cathode cations and anions membrane chambers are positioned, the cations are transferred to the cathode and anions are transferred to the anode. The cations travel through the cation ion exchange chamber while anions that travel through the anion exchange membrane chamber. This movement produces increases in the ionic concentration from brine streams and decreases in the diluted streams from the purified water. The electric current also flows between the anode and cathode, therefore the charge balance is sustained.

Polymeric nanofiltration: The polymeric nanofiltration membrane technology used for the treatment of saline wastewater at low rate of pressure than the reverse osmosis. Nanofiltration membranes do not allow the particles and ions to pass through them, this is due to the selective permeability of the membrane. Suitable and selective nanomaterials integrate with polymer membrane, which is used to solve the problems such as biofouling, scaling, selectivity, low flux rate and degradation. Researchers has revealed that nano-porous single layer graphene and graphene oxide membranes with capable monovalent ions, that are promising material for the nanofiltration based desalination process. Graphene oxide membranes has the antifouling properties that are highly recommended for the improving of the membrane properties. Anand et al, (2018) has reported the basic understanding mechanism of graphene based nano filtration [17].

Biological method: Generally, saline wastewater is usually treated with different physical and chemical methods that are costly techniques and conventional methods. While, the biological treatment methods that are used to treat the salinewaste water, because they are eco-friendly, environment-friendly, and cost-effective techniques. Biological methods that remove pollutants and contaminants from the water through the imitation and metabolism of the microorganisms which are highly effective, stable and eco-friendly [18-20]. Microorganisms play important role for the exclusion of the COD and NH_4^+-N under the high salt concentration. Biological treatment methods used for the treatment of saline wastewater includes; aerobic sludge plants (such as traditional aerobic activated sludge process, the sequencing batch reaction, aerobic granular sludge, biofilters and biofilms), anaerobic sludge plants, cultivation and domestication of salt tolerant and halophilic bacteria from high saline wastewater [4,21,22].

Future perspectives: Available literature on the bio-treatment of high salinity waste water which, directs the cultivation and domestication of salt tolerant halophilic microbes can be a auspicious technique. It is eco-friendly and cost-effective technique. Synthetic saline wastewater has lower pollutants than actual saline wastewater. So, it is compulsory to characterize the halophilic microbes that are able to degrade the pollutants and contaminants from the actual saline wastewater. Many researches have already done on the treatment and removal of salts from saline wastewater of different industrial sectors like food processing industries, agriculture industries, petroleum and natural gas industries, nuclear industries. Many studies have also been done on the biodegradation of the high salt concentrations by using pure and mixed cultures of halotolerant microbes, the fully degradation pathway, microbial catabolic-enzymes that are involved in the process of degradation. Many salt-tolerant halotolerant microbes are unidentified. Development and identification of bacterial metabolic enzymes and their degradation pathways under the high salt concentration circumstances are highly suggested for the future studies and researches.

CONCLUSION

Biological technologies are the environment friendly and

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widely used for the treatment of saline wastewater treatment. Saline wastewater from different sources, that contains different types of pollutants and salt concentration, different organic and inorganic compounds pesticides, heavy metals, antibiotics and many others. These pollutants can be the reason damage to the environmental system and that can also the cause of land degradation and dilapidation water quality deterioration and causes many serious health problems. There are various methods used for the treatment of saline wastewater were reviewed in this review paper. Nevertheless, more studies are recommended to target the different pollutants and contaminants in saline wastewater. It is also suggested that the purified cultures of halophilic bacteria for the future studies and researches can be promising to further open the horizons

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