WATER PURIFICATION WITH NANOTECHNOLOGY MEMBRANES

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Abstract- **The report has been undertaken for the purpose of identification of the importance of nanotechnology on treatment of wastewater. Moreover, the report has highlighted certain advantages and limitations that are associated with the use of nanotechnology for the purpose of cleaning and purifying water. The discussion has indicated that some of the advantages that are associated with the use of nanotechnology are effective discharge of hazardous chemicals from water along with effectively carrying out the process of filtration. On the other hand it has been argued that some of the limitations that are related to the application of nanotechnology are hazardous impact of technology on the environment. Different membranes that have been taken up for discussion are nanostructure membrane along with membrane filtration technology and bio mimetic membrane etc. The discussion has revealed that biomimetic membrane is of greater importance as compared to other membranes that were taken into consideration in this report.**
Index Terms **– Catalytic membrane, Biometric membrane, Ceramic membrane.**

I. INTRODUCTION

The discussion in the current assessment has been made to introduce the concept of nanotechnology and evaluate the importance of applying nanotechnology in wastewater treatment. Moreover, the argument will also be related to the advantages and the limitations of the technology along with its application in undertaking wastewater treatment. Furthermore, the discussion will also include different factors and the benefits that are associated with different membranes of nanotechnology. The concluding part will include the analysis regarding the membrane which can be of greater use for the individuals in different parts of the world. The analysis of the importance will be made on the basis of scale parameters of the different membranes that have been highlighted in this report.

II. Advantages and Limitations of Nanotechnology in Wastewater Treatment

In the view nanotechnology which is also referred to as molecular monitoring refers to the branch of engineering which is related to the designing and manufacturing of tiny electronic circuits along with mechanical devices. The devices through the use of nanotechnology are developed at the molecule level of matter. The application of nanotechnology in the modern times has been on a rise especially in the commercial products. Along with that, this technology is also being applied for the purpose of treating various kinds of diseases and preventing other health related issues. According to Alfadul and Elneshwy nanotechnology is used in the food industry for the purpose of undertaking environmental friendly methods of packaging and maintaining the taste and safety of food items for a longer period of time.

As stated by Qu, Alvarez the importance of nanotechnology has witnessed a dramatic rise for undertaking different programs of wastewater treatment. According to Lu, Yang, the treatment of wastewater is the process through which harmful and contaminated particles are removed from water through the application of different physical, chemical and biological processes. In the view of Cloete the application of nanotechnology is the cost effective method of treating wastewater and is an effective tool to purify it for the purpose of further use. As stated by Westerhoff, Kiser

and Hristovski; the use of nanotechnology for the treatment of wastewater is involved in the modification of the nature of water in the form of changing its biological oxygen demand and chemical oxygen demand. According to the findings of C. Mehta different categories of nanomaterials have the ability to perform efficiently for undertaking different processes of water treatment. Nanotechnology was instrumental in treating different elements of wastewater on small as well as on large scale. Moreover, it has been highlighted in the literature that nanotechnology is helpful in cleaning wastewater through removing pathogenic bacteria, different kinds of viruses along with harmful chemicals and insecticides, pesticides etc. The application of nanotechnology in this manner has been of considerable importance for the protection of environment.

However, it has been argued by Shatkin that there are certain limitations as well that are linked with the use of nanotechnology. One of the limitations that are involved in this case is risks to the human health as a result of using nanotechnology for purifying water. As stated by Ali that the application of nanotechnology is for purification of waste water as it absorbs valuable nutrients from the water and increase the level of toxicity in the water. On the other hand, it has been argued by Mueller, Braun, Bruns, Černík, Rissing that the use of nanotechnology can also have a negative impact on the environment. Extensive use of technology can result in the spreading of radiation in the environment which is considered as hazardous for human health.

Furthermore, it has been argued by Pérez-González that extensive use of information technology for the process of water purification is expected to have a negative impact as many experts believe that too much application of information can reduce the natural components that are involved in water and make it harmful for health. Therefore, careful evaluation needs to be taken to make sure that desirable advantages from the use of nanotechnology can be obtained.

On the contrary, in the view of Jiang, Kish, Fauth one of the major advantages that are associated with the application of nanotechnology is the effective application of environmental measures. Along with that, use of protection along with the removal of different kinds of greenhouse gases from the environment is also some of the benefits that can be gained with the help of nanotechnology. In the view of Pendergast and Hoek there are different kinds of membrane that are used through the application of nanotechnology for the purpose of treatment of water. Different membranes have different uses and applications that can be applied to achieve the desired objectives. Similarly it has been analysed by Li, Xu and Pinnau that the use of membrane has been instrumental in undertaking different projects that are concerned with the treatment of waste water. However, it has been argued by Perry, Madsen, Jørgensen, Braekevelt that there are various challenges that are involved in the effectively putting into use these membranes. One of the major issues that are related to the execution of these membranes is the technicalities and the complexities involved in their use. Some of the examples of these issues are production of membranes along with the development of effective methods of testing these membranes.

The discussion regarding the use and application of different membranes has been presented below in the following section

III. Nanostructured catalytic membrane

According to Marichy, Bechelany and Pinna nanostructured catalytic membrane is a kind of membrane that is largely employed for contamination of water treatment. In the view of He, Liu, some of the advantages that are associated with this membrane are standardization of catalytic sites along with undertaking different processes of water treatment in an effective manner. It is expected that further advances in the application of nanotechnology will improve the technology that is involved in this membrane along with improving its efficiency in obtaining fresh water from salty water. As stated by Lewis, Datta, S., Gui, Coker, Huggins, Daunert and Bhattacharyya nanostructured catalytic membrane is also helpful in the production of clean water with continuously high fluctuation which benefits the process of water purification.

According to C. Mehta there are different functions that are covered through the application of nanostructured catalytic membrane such as disintegration of organic pollutants along with physical separation of contaminations of water that were undertaken through the application of nanostructured films and membranes. The N-doped nanostructured particles forming the multifunctional membrane are considered effective in the removal of harmful

particles from water by increasing the process of photo degradation activity. Furthermore, it also helps in the production of clean water with constantly high level of fluctuation that benefits the process of water purification process. It has been highlighted in the findings of Stair, Marshall, Xiong, Feng, Pellin, Elam and Wang that the value of probability and the scale parameter for the nanostructured films and membrane is 20-400 nm.

IV. Membrane Filtration Technology

In the view of Malaeb and Ayoub one of nanofilteration technology refers to the process through which pesticides and other organic and other harmful particles are removed from the surface and ground water. The aim of this process is to ensure the safety of the supply of public drinking water. According to Ho and Sirkar the process of nanofilteration is the liquid separation membrane technology which is placed between reverse osmosis and ultrafiltration. It is further highlighted that nanofilteration is specifically suited for the treatment of well water and water from different lakes or rivers. According to the findings of the literature one of the most important uses of membrane filtration technology is that it transforms the water into usable condition once again. In accordance with the findings of C. Mehta nanofiltration removes the molecules at the range of 0.001.

In the view of Jaffrin membrane filtration technology is used primarily for treatment of water along with the treatment of equipment and different kinds of machine that are being operated in different organizations. Therefore, it can be stated that membrane filtrations can also be used for the purpose of maintenance of equipments within a factory. Nevertheless, in accordance to the findings of Shannon, Bohn, Elimelech, Georgiadis, Marinas, and Mayes there are certain drawbacks that can be associated with the process of membrane filtration. These drawbacks include high cost of implementation along with mechanical vulnerability of membrane filtration technology.

V. Biomimetic Membranes

Apart from the different types of membranes that have been discussed above, one of the other important membrane that is associated with the process of water purification is biomimetic membrane. In the view of Tang, Zhao, Wang, Hélix-Nielsen, and Fane biomimetic membranes are used for the purpose of purifying waste water with the usage of reverse osmosis technology which is helpful in removing impurities from the polluted water through the application of electrical energy. The main function of these types of membranes is that it removes salt and other harmful components from the water and makes it usable for different purposes. In addition to that, it has been analyzed that biomimetic membranes have the capability to create a noteworthy impact on the global market of water purification.

One of the major advantages that are associated with the execution of this membrane is that it reduces the cost of energy up to 80%. Furthermore, it has been evaluated that more than 15,000 desalination plants in different parts of the world through the usage of reverse osmosis technologies and the execution of biomimetic membranes at an extensive level can result in potential savings of millions of dollars with respect to cost of electrical energy. Therefore, it is believed that the execution of the biomimetic membranes on a large scale can result in savings of millions of dollars in terms of cost of electrical energy on a yearly basis. Biomimetic membranes can also be used for serving industrial purposes as they are useful in the process of separating liquid and gas for the purpose of variety of industrial applications. Additionally, the membrane can also be utilized for capturing carbon dioxide and storage of electrical energy applications for their applications for variety of industrial purposes.

In the view of Lee considering the benefits that are associated with the use of biomimetic applications, the users of this application has increases in the past few years. However, one major obstacle is related to understanding of the processes that are associated with biomimetic membranes. One of the major complications that are associated with the execution of biomimetic membrane is the level of understanding that is being gained regarding the benefits that are obtained through it. It is imperative to gain high level of understanding regarding the advantages that can be gained through it. It has been evaluated in the findings of Kaufman and Freger that thickness of the biometric membrane is greater than 5mn. Moreover, it has been analysed that the permeability of the water that is gone through biomimetic membrane does not expect to go down due to the involvement of the process of commercial nano-filtration in the water.

As opposed to the above presented discussion, in the view of Vockenroth, Fine one of the major drawbacks that are associated with the execution of biomimetic membrane is the widespread process of implementation of the membrane which undertakes extensive amount of them. Therefore, it is believed that effective implementation of these membranes is of considerable significance.

VI. Ceramic membranes

Ceramic membrane refers to the filtration process of water treatment that is used for the generation of clean and usable tap water after the elimination of purities. It is a reliable technology through which pure water can be produced through removing different kinds of bacteria and other harmful elements that are generally involved in raw water such as surface water and ground water. Similarly, it has been stated by Huang, and Schwab that application of ceramic membrane in the form of filter is considered as a low-cost filtration system which is considered as a useful tool to fulfil the modern demands for purified water. Therefore, the use of ceramic membrane is considered as valuable in the fulfilment of the future needs of water for the individuals around the globe. According to Sondhi, Bhave and Jung ceramic membranes also include crossflow technologies along with different elements of membrane and the recent developments in the field of membrane technology. It is considered as one of the most cost-effective and economic methods that can be applied for the purpose of purification and filtration of water.

Flow of ceramic membranes are operated in the cross flow filtration mode. This mode has the benefit of maintaining a high filtration rate for membrane filters compared with the direct flow filtration mode of conventional filters. Cross flow filtration is a continuous process in which the feed stream flows parallel (tangential) to the membrane filtration surface and generates two outgoing streams. A small fraction of feed, called permeate or filtrate, separates out as purified liquid passing through the membrane. The remaining fraction of feed, called retentive or concentrate, contains particles rejected by the membrane. The separation is driven by the pressure difference across the membrane, or the trans-membrane pressure. The parallel flow of the feed stream, combined with the boundary layer turbulence created by the cross flow velocity, continually sweeps away particles and other material that would otherwise build up on the membrane surface.

It has been further analysed that ceramic membranes generally have an uneven structure which is primarily made up of two to three levels of void between them. Moreover, ceramic membranes are applied in different kinds of industries such pharmaceutical, food and beverage along with the industry of power generation. The use and the applicability of the ceramic membrane vary from one industry to another. It has been analysed that the module of the of the membrane can absorb extreme temperatures up to pH 0 to 14 along with bearing pressures up to 10 bar which is considered as equal to 145 psi. Due to these qualities, these applications are widely used for the benefits of businesses as well as for the purpose of providing individuals with the facility of pure water.

As the process of ceramic membrane is generally applied for the purpose of purification of water; therefore, they are also used in the clarification of fruit juices by technical experts of different organizations. One of the examples in this case is the filtration of sugar cane and different other stages for refining the production of sugar cane. Along with that, ceramic membranes can also be applied for the filtration of water streams that can be recycled for further use. On the contrary, it has been argued by Jegatheesan, Phong; de Oliveira, Docê that one of the major limitations of ceramic membrane is that they are light in nature and can be easily perished. Therefore, these kinds of membranes need greater degree of protection as compared to other membranes as their shape and size can be altered during the process of implementation. It has been analysed that ceramic membrane has the pore size of 0.01 m along with the unidentified channel diameter of 1.05. Total membrane of the area is 0.195 along with the magnetic flux of (L/M2/D/KPA) 36 +- 3 (CWI, 2016).

VII. Conclusion

With the help of the analysis that has been conducted above, it can be concluded that nanotechnology is an important process through which wastewater can be purified and used for further purpose. The effective use of nanotechnology has gained importance primarily due to shortage of water in different parts of the world. Apart from that, it has been analysed that application and use of different membranes of nanotechnology have been instrumental in the purification process of wastewater. The discussion in this assessment has taken into consideration different

membranes related to nanotechnology such as nanostructured catalytic membrane along with membrane filtration technology, biomimetic membranes and ceramic membranes. The analysis has been based on the advantages and limitation of these membranes along with their applications in different industries and their scale parameters.

On the basis of the discussion, it can be concluded that biomimetic membranes are of greater value and importance as compared to the other membranes that have been taken under consideration. The primary reason behind that is the fact that execution of biomimetic membranes does not vastly contribute towards the process of purification of water but it also plays it part in reduction of the cost of electricity up to 80%. The reduction of the electricity cost is an additional benefit that biomimetic membranes have the potential to provide to the individuals in various parts of the world. The other major reason due to which biomimetic membranes has been preferred over other membranes is the fact that they can be used in the process of desalination which can further result in reduction of electrical cost in the years to come.

Apart from that, the application of biomimetic membranes for the separation of liquid and gas gives it an edge over other membranes in the long run as in this way they can be termed as more versatile as their benefits are widespread in nature. The other advantage that biomimetic membranes have on other membranes is concerned with their thickness. It has been discussed that the parameters of thickness of biomimetic membranes is in excess of 5mn which indicates that it has the capacity to survive under tough circumstances as well. As a result of that, it can be concluded that biomimetic membranes can be more long lasting and it has greater amount of use than other membranes. As a result of that it has been considered as more important when being compared to other membranes included in the discussion.

VIII. References

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