

DESIGN, FABRICATION AND PROCESS OPTIMIZATION OF A BIO-BASED DESALINATION SETUP

Submitted in partial fulfillment of the requirements of the award of Bachelor of Engineering
degree in Mechanical Engineering

By

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of SANKARA NARAYANAN K (38150902), KIRAN KUMAR A (38150050) who carried out the project entitled "EFFECTS OF NANOCELLULOSE ON FILM PROPERTIES OF EDIBLE FILM" under our supervision from August 21 to March 22.

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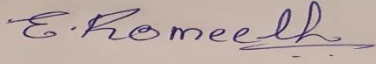
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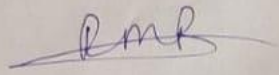
We, **ELAVARTHI ROMEETH (38150028)** and **RACHUMALLA MALLA REDDY (38150086)** hereby declare that the Project Report entitled “**DESIGN, FABRICATION AND PROCESS OPTIMIZATION OF A BIO-BASED DESALINATION SETUP**” done by us under the guidance of **Dr. JEYA JEEVAHAN**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

Desalination is the process of removing salt from the water, in these days due to the lack of rains or due to weather conditions we are facing water scarcity. The major cities like Chennai and states like Maharashtra, Karnataka, Jharkhand, Andhra Pradesh and Rajasthan had been facing serious water scarcity; the Indian union ministry of agriculture, the ground level of water has been fallen alarmingly over the years. So, we have chosen this project, there are different types of desalination methods like osmosis, reverse osmosis, electro dialysis, geothermal desalination and electrolysis. Electrolysis consist of two electrodes namely zinc (anode) and graphite (cathode). The Zinc electrode which attracts Cl^- and Graphite electrode which attracts Na^+ . In this electrolysis process, we had chosen this two electrodes because they are cheaply available in the market.

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CHAPTER 1

INTRODUCTION

1.1 IMPORTANCE OF WATER

Water is a vital component of our daily life. It's used for irrigation, cooking, cleaning, and drinking, among other things. Water is necessary for optimum health since it regulates body temperature, performs normal functions, promotes digestion, and eliminates toxins from the body.

Water is the source of all life. Epidemics are a real possibility without basic cleanliness.

- The goal is to maintain adequate sanitary standards in one's neighborhood and surrounding areas.
- Ensuring clean drinking water is crucial since many water-borne diseases (water-borne diseases account for 21% of all diseases in India) can harm residents, particularly children.

Water is an extremely important part of our lives. It is used for irrigation, cooking, washing, cleaning, drinking, etc. Water is essential for maintaining good health as it helps in regulating body temperature, carries out normal functioning, aids in digestion and removes toxins from the body. Water is life

1.2 CONSERVATION OF WATER

Water conservation is the practice of utilizing water efficiently in order to reduce waste. Water conservation is crucial, according to Fresh Water Watch, because fresh, clean water is a limited and expensive resource.

You're undoubtedly already aware of the financial penalties of poor water use as a homeowner. The ecosystem — and our wallets — both depend on the conservation of this natural resource.

1.3 HOW TO SAVE WATER

- Fill your toilet's water tank with a brick. Every day, you dump 70 liters of water down the toilet. If you don't have a high-efficiency toilet, try filling it with something like a brick to absorb some of the water.
- For each load of laundry, use the appropriate amount of water. Doing laundry accounts for 15-40% of all water used in the home. Make sure your machine's settings are adjusted to the right load size to save water.
- Make an informed decision when purchasing a washing machine. When comparing top-load vs. front-load washing machines, front-loading washers consume less water.
- Use caution when watering plants. Water your lawn or garden first thing in the morning or last thing at night.
- Replace your showerhead with a low-flow model. During a 10-minute shower, a low-flow showerhead can save 15 gallons of water.
- Look for and fix any leaks. Every year, household leaks waste an average of 10,000 gallons of water. Repairing leaky faucets and toilets is one of the most effective ways to reduce your water footprint.
- Put your dishes in the dishwasher. Dishwashing accounts for less than 2% of indoor water use, yet it is actually more water efficient to use a machine than to wash dishes by hand, especially if you run full loads. ENERGY Turn the water off.

- Teach your entire family to turn off the faucet when brushing their teeth or shaving. Every little thing counts when it comes to water conservation!
- Manage outdoor water use. Don't forget about water conservation outside as well. Equip all hoses with shut-off nozzles, which can prevent hose leaks.

1.4 INTRODUCTION OF WATER PURIFICATION

Water purification means the process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water. The goal is to produce water that is fit for specific purposes. Most water is purified and disinfected for human consumption (drinking water). However, water purification can be used for a range of additional applications, such as medicinal, pharmaceutical, chemical, and industrial ones. Water cleansing has been done in a variety of ways throughout history. Physical procedures like filtration, sedimentation, and distillation are utilized; biological processes like slow sand filters or biologically active carbon are used; chemical processes like flocculation and chlorination are used; and electromagnetic radiation like ultraviolet light is used.

Purification of water can reduce the quantity of suspended particles, parasites, bacteria, algae, viruses, and fungi, as well as a variety of dissolved and particulate materials. Governments or international standards are usually used to set drinking water quality requirements. These guidelines usually include minimum and maximum concentrations of contaminants, depending on the intended use of the water.

Visual inspection is ineffective in determining whether water meets quality criteria. Simple processes like boiling or using a household activated carbon filter aren't enough to remove all pollutants that could be present in water from an unknown source. Even natural spring water, which was always thought to be safe for all practical reasons, must now be tested to see what kind of treatment, if any, is required. Chemical and microbiological analysis, albeit costly, are the only ways to gather the information needed to choose the best purification process.

According to a 2007 World Health Organization (WHO) estimate, 1.1 billion people do not have access to safe drinking water, and 88 percent of the 4 billion diarrheal illness cases each year are caused.

According to the WHO, 94 percent of these diarrheal disease cases can be avoided by making environmental changes, such as providing access to clean water. Simple approaches for purifying and storing water in safe containers at home, such as chlorination, filtration, and sun disinfection, could save thousands of lives each year. In underdeveloped nations, reducing fatalities from waterborne illnesses is a key public health objective.

Chemical contaminants (pollutants, toxic metals), biological contaminants (algae, bacteria, fungus, parasites, viruses), suspended solids, and gases are all removed during water filtration for human use.

There are several methods used in the water purification process, which include: physical processes, such as filtration, sedimentation, or distillation; biological processes, such as sand filters, active carbon; chemical processes, such as flocculation, chlorination, the use of ultraviolet light.

The phenomena on which the procedures are based differ between the physical approaches utilized in water filtration. Filtration, for example, is based on the separation of solids from fluids by the use of a porous material (filter) that traps the solid particles while allowing the fluid to pass through. The sedimentation method, on the other hand, relies on gravity to cause solids to create a deposit at the bottom of a tube carrying contaminated water, whereas distillation entails the change of a liquid (water) into a vapor phase, a process that is reliant on the volatility of the compounds.

Slow sand filters are an example of biological approaches to water filtration that require 1–2 m deep tubes filled with sand, which retain the impurities present in the filtered water. Activated carbon (charcoal), another utilized approach, is a microporous carbon with high surface area and enhanced adsorption properties. In scientific terms, flocculation is the desalination of colloids in suspension with the addition of a clarifying

agent; in the context of water purification, the flocculation phenomenon can refer to the desalination and coagulation of pollutants in the water. Water chlorination is a widespread practice in the treatment of drinking water that involves adding chlorine or hypochlorite to kill germs and prevent the spread of waterborne diseases.

Electromagnetic light, particularly of short wavelength (in the ultraviolet range), is often utilized in disinfection because it causes holes in the structure of bacterial nucleic acids, rendering their biological processes inoperable. This approach is frequently employed in the purification of water.

This chapter focuses mainly on the most investigated physical methods which involve the filtration process. Compared to the other approaches used in water treatment, membrane water filtration presents some advantages, such as: the continuity of the operation; it does not require the use of any chemicals; it does not imply high energy consumption; the possibility of scaling up, be integrated/integrate other processes and possibility of automation (Street et al., 2014).

There are several parameters influencing the properties and efficiency of the membranes used in water filtration: the size of membrane pores/the size of the contaminant molecules/particles; the positive/negative charge of the membrane surface, respectively the polarity of the contaminant molecules; and the adsorbing capacity of the membrane surface (Street et al., 2014).

Contaminants of various sizes can be removed depending on the pore size of the used filters (membranes), and better purification can be achieved by reducing the pore size; thus, the available methods are: microfiltration (pore size about 0.1 m), which removes bacteria and suspended solids in the water; ultra filtration (pore size about 0.01 m), which removes viruses in addition to microfiltration; nano filtration (pore size about 0.001 m), which removes viruses.

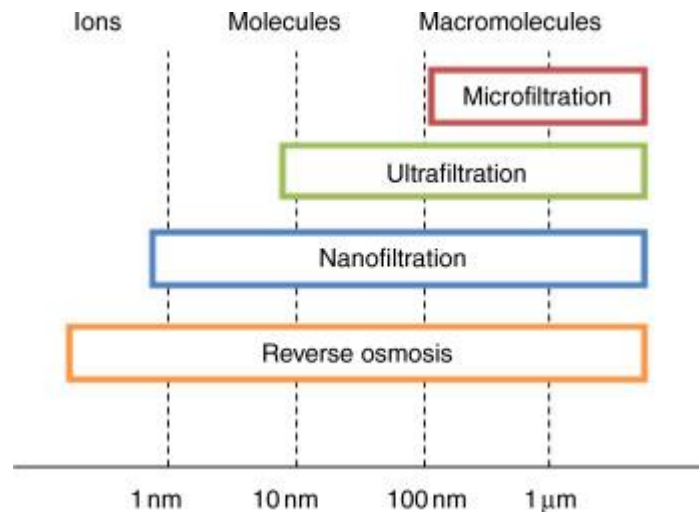


Fig: 1.1 : Different types of membranes and their filtering principles depending on the pore

When comparing the qualities of these membranes, it is evident that the ones with smaller pore sizes are the most favorable. However, when used in conjunction with other treatments, any of these filtering procedures can be employed to obtain drinkable water at a lower cost. When used in conjunction with disinfecting agents, micropore membranes can remove sand, silt, clays, *Guardia lambkin* and *Cryptosporidium* cysts, algae, and some bacterial species. Even while membranes intended for ultra filtration may remove the majority of bacteria and viruses in water, further disinfection is necessary. However, the following are some of the benefits of such membranes: filtration using size-exclusion mechanisms; consistent quality of the removal process; automation; compact installation including this type of filter and the filtering process. The biggest disadvantage could be related to the fouling problem. Because it removes all germs, viruses, and organic waste, nano filtration is the first step toward complete water filtration. Their capacity to remove alkalinity and hardness from water is another significant advantage. Reverse osmosis membranes provide the most advanced filtration, as they can also remove most inorganic pollutants, resulting in ultrapure water. The following are some of the benefits of this form of filtration: full contamination removal; filtering sensitivity is not adversely affected possibility of automation. Besides these advantages, the technique presents some limitations, which refer to the high

costs, the process management, and the need of a pretreatment and fouling predisposition.

The retention of contaminant molecules in membranes with adsorbing qualities is also dependent on electrostatic interactions: because the membrane surface is negatively charged, positively charged ions in water are adsorbed, generating an electrical double layer at the membrane's surface (Street et al., 2014). Contaminant adsorption ability is influenced by a number of elements, including the toxins' type, concentration, and mass distribution. Also, charged Ca^{2+} concentration influences the filtering properties because the interaction with the negatively surface of the membrane is preferentially favored, compared to the contaminant molecules, which are usually bigger in size and have different spatial conformations. Also, the physical and chemical properties of the membrane are important for the process (Street et al., 2014).

Depending on their structure and chemical composition, membranes can also be grouped as: (1) isotropic, having uniform physical nature and chemical composition in cross-section; and (2) anisotropic, which are non uniform in cross-section. Examples of anisotropic membranes for water filtration are given by layer-by-layer approaches (Wang et al., 2015, 2016a; Qin et al., 2016; Xu et al. 2015; Zhang et al., 2015a; Diep et al., 2015; Gu et al., 2015; Kaner et al., 2015). The main advantage of this type of membranes is given by the antifouling property determined by different approaches in surface modification (see Section 12.3 for details).

The scientific progress made in the detection of pathogens and other impurities in water, the implementation of new water quality rules, as well as the development of materials science, smart materials, and nano materials, have all influenced water purification advances. There are several commercial membranes for water purification available today; nevertheless, there is always room for improvement in terms of qualities such as (1) antifouling, (2) chemical stability, (3) mechanical stability, and (4) thermal stability.

The most common application of sorbent and ion exchange resins is water purification and softening, which provides high-quality water not only for the food sector, but also for a wide range of other industrial disciplines. This includes wastewater treatment as well.

This also covers wastewater treatment, which is becoming of increasing interest to reduce the organic loads of industrial effluents accruing in huge amounts. In addition, numerous biotechnological processes have been described making use of resin-based technologies for the enrichment and purification of valuable components, such as polyphenols, which may then be used in enriched foods, beverages, cosmetics, and pharmaceuticals (Kammerer *et al.*, 2011a; Soto *et al.*, 2011).

As well as phenolic compounds, which also contribute to cloud formation and brownish hues of the juices (Lyndon, 1996; Weinand, 1996). Apart from discoloration, off-tastes and off-flavors are frequent problems associated with juice production, which may arise immediately after processing or during storage. In this context, the most prominent example is the bitterness of grapefruits and navel oranges, which is observed pre-storage and caused by both limonin and either naringin or hesperidin, respectively (Chandler *et al.*, 1968; Johnson and Chandler, 1988; Shaw and Buslig, 1986). Such unwanted bitterness can be effectively mitigated by selective binding of the bitter compounds onto the surface of adsorbent resins as a final step of juice production. Consequently, off-tastes and off-flavors developed during storage remain in the past, the food industry's use of adsorbents and ion exchangers was dominated by methods designed to remove phenolic chemicals for a variety of reasons. Fruit juice technology is one of the most important application areas for such resins in the food industry, where they are primarily used for the stabilisation and decolorization of juices, as well as for reducing the bitterness of citrus juices, i.e., to overcome problems caused by phenolic compounds. In this context, adsorber technology is a viable alternative to traditional fining procedures involving, for example, bentonite, gelatin, and silica sol. Juices can be standardised, and light-colored, virtually water-clear juices can be made by combining the Maillard reaction products created during the thermal treatment of the fruit, unaffected by sportive treatment. Such phenomena may be observed when precursors, which themselves do not negatively affect the sensory properties of the products, are degraded or form undesired reaction products with other juice components. The

aforementioned precursor compounds may result from heating steps performed for thermal preservation of the juices or from degradation processes such as the Strecker reaction. This has been demonstrated for ferulic acid, a hydroxycinnamic acid frequently occurring in plant materials, which may give rise to an enhanced release of *para*-vinylguaiacol, the latter contributing to an “old fruit” or “rotten” flavor. Thus, strategies to cope with such problems have been developed, which are based on selective binding of the precursor compounds from juices using macromolecular resins. In such cases, resin-based technologies may significantly enhance the sensory quality of the juices without affecting their nutritional values, and at the same time extend the shelf life of the products (Ma and Lada, 2001a, b). Water purification and softening is by far the most important application of sorbent and ion exchange resins, thus providing high quality water, not only for the food industry, but also for a wide range of other industrial branches. This also covers wastewater treatment, which is becoming of increasing interest to reduce the organic loads of industrial effluents accruing in huge amounts. In addition, numerous biotechnological processes have been described making use of resin-based technologies for the enrichment and purification of valuable components, such as polyphenols, which may then be used in enriched foods, beverages, cosmetics, and pharmaceuticals. Moreover, a dual use may arise if organic loads of effluents are due to the occurrence of polyphenolic constituents. As an example, gallic acid is frequently found as a phenol micro pollutant in agro industrial wastewaters where adsorption and ion exchange technology may contribute on the one hand to overcome potential environmental problems due to high contents of such plant components. On the other hand, their recovery may be attractive from an economical point of view due to the promising health-related attributes of plant phenolics. Wastewaters of the artichoke canning industry are characterized by high organic loads and phenolic contents. To overcome this environmental issue and at the same time valorize this waste stream, a process was developed comprising three major steps. First, artichoke wastewaters were treated by ultrafiltration to remove macromolecular compounds and suspended solids. Subsequently, the resulting solution was further treated by nanofiltration to enrich phenolic compounds and sugars. Finally, this enriched fraction was applied to different adsorber resins to compare their potential regarding their recovery of phenolic

compounds, demonstrating that a combination of membrane and adsorption processes for treating industrial wastewaters may be an appropriate approach to overcome the aforementioned environmental problems. Olive oil production is also associated with large amounts of byproducts. Among these, olive oil wastewaters pose severe environmental problems due to their high loads of olive pulp, pectins, and oil. Furthermore, comparatively high polyphenol contents contribute to the poor biodegradability of such wastewaters. Thus, adsorption onto activated carbon has been suggested to reduce phenolic contents of the effluents, which can subsequently be used among others for bioethanol production. Under optimal process conditions, sorption capacities of around 36 mg phenolic compounds/g activated carbon were obtained, indicating this sorbent to be suitable for wastewater treatment.

The same problems apply to the wastewaters arising from the rose oil recovery process. Rose oil is obtained by steam distillation of fresh rose petals. This process goes along with large volumes of effluents characterized by high contents of phenolics. Consequently, a range of polymeric resins was assessed with regard to their potential to enrich these phenolic compounds and also the potential to elute those compounds bound onto the resin surface under mild conditions. Following filtration of the aqueous byproducts to remove suspended solids, phenolic compounds were adsorbed by the polymeric resins and finally eluted with hydroethanolic solutions. Thus, a waste stream depleted in phenolic compounds and an enriched polyphenol fraction was obtained.

Conversely, solid residues originating from plant food processing have frequently been proposed as low-cost adsorbents for various purposes. On the one hand, this also provides opportunities to establish sorption and ion exchange processes in food processing companies in countries with limited financial resources, because investment costs are comparatively high when applying state-of-the-art tailor-made resins. On the other hand, environmental problems associated with waste disposal may be overcome due to sustainable valorization of processing byproducts. To exemplify such valorization, spent coffee grounds were used after purification to enrich phenolic compounds from green tea extracts. This sorption appeared to be feasible, following a

pseudo-second-order kinetics, and equilibrium conditions could best be described by the Freundlich isotherm.

In the past, the application of adsorbents and ion exchangers in the food industry was dominated by processes established mainly for the removal of phenolic compounds for various reasons. In this context, fruit juice technology is one of the most important application areas of such resins in the food industry, where they are mainly applied for the stabilization and de-coloration of juices, and for reducing the bitterness of citrus juices, that is, to overcome problems often caused by phenolic compounds. In this regard, adsorber technology is an appropriate alternative to conventional fining methods using, for example, bentonite, gelatin, and silica sol, respectively. Thus, juices may be standardized, and light-colored almost water-clear juices may be obtained by binding both Maillard reaction products formed upon thermal treatment of the juices as well as phenolic compounds, which also contribute to cloud formation and brownish hues of the juices [30,31]. Kiwi fruit is another prominent example of a fruit matrix characterized by high polyphenol contents, which may cause problems upon juice processing with regard to objectionable browning and astringency of the juice. Among others, resin adsorption is a process allowing the reduction of polyphenol contents, thus overcoming the aforementioned problems. Statistical analyses were applied to systematically optimize process parameters, such as feed flow rate and feed volume, which may be treated with a certain amount of adsorption resin. At the same time, such tools allowed deduction of the optimal process conditions for polyphenol recovery from the resin upon desorption.

Moreover, proteins may also affect stability of processed foods, for example, by unwanted haze formation upon storage. For this reason, fining is a process step commonly performed during vinification, aiming at reduced protein contents, which may otherwise precipitate, also as a result of interaction with phenolic compounds. For that purpose, bentonite is frequently applied. Alternatively, ultrafiltration processes may be performed to diminish protein contents. More recent developments comprise the application of polymeric membranes with embedded micro- or nanosized particles, the latter responsible for protein adsorption. Consequently, such membranes allow

simultaneous adsorption and filtration in one single process step. In summary, wine fining with the aforementioned membranes was demonstrated to reduce processing times and to produce lower amounts of wastes. Polyphenols are the second major compound class significantly contributing to haze formation upon wine aging and are also responsible for browning reactions. Their contents are commonly reduced by treatment with PVPP. Unsurprisingly, color loss upon treatment of rosé wines with PVPP also indicates that desired compounds, that is, anthocyanins, are bound by this polymer. Detailed investigations revealed the degree of interaction with PVPP depended on the structure of the phenolic compounds. Fining mostly affected flavanols (64% reduction) with oligomeric flavanols showing higher adsorption rates compared with monomeric ones, followed by flavonols (42%), whereas only 12% of anthocyanins were bound onto the polymer surface. Computational methods calculating interaction energies were successful in interpreting the aforementioned differences in reduction rates.

The behavior of contaminants, such as polycyclic aromatic hydrocarbons (PAH), upon food contact with adsorbents has also been studied in detail. As an example, sesame oil was treated with clay and activated carbon, respectively, monitoring the effects of this treatment on PAH contents but also on genuine oil components. Expectedly, PAH significantly interacted with both sorbent materials, with activated carbons being more effective in lowering PAH contents than clay. Fatty acids, triacylglycerols, and tocopherol profiles were insignificantly affected by this measure. However, such treatment of edible oils also affects their contents of secondary metabolites, such as phenolics and phytosterols, thus also impairing the oxidative stability of the oils .

The membranes typically employed for water purification processes are classified according to their pore size dimensions as illustrated in fig. Even though these membranes do not have a dense thin layer, they do usually exhibit asymmetric structures with smaller pore dimensions at the separation surface layer. These membranes can be produced by the same nonsolvent-induced phase separation process discussed above for gas separation membranes, except that the polymer dope

solution is extruded directly into or closer to the coagulation bath. Pore size dimensions can be controlled by the air gap length, polymer solution concentration, addition of water-soluble polymers (such as poly(ethylene glycol) or poly(*N*-methyl pyrrolidone), or even addition of solvent-soluble salts .

The thermal phase inversion process is also employed for ultra- and microfiltration membranes. Crystalline polymers such as polyethylene and polypropylene are generally preferred as solutions; these can be prepared at temperatures above the melting point, but cooling below the melting point will yield rapid crystallization and phase separation. These membranes are often employed in microfiltration and dialysis applications.

For ultra- and microfiltration membranes, characterization of the pore size is of primary concern. One of the easier methods is commonly referred to as the 'bubble-point test'. A membrane is wetted with a liquid on one side of the membrane, and gas pressure is applied to the opposite side. The point at which bubbles appear on the liquid side determines the effective largest pore diameter as defined by the following relationship:

$$p = 4\gamma \cos\theta / d$$

where p is the bubble point pressure, γ is the surface tension of the liquid and θ is the liquid–solid contact angle. As the pore diameters have a size distribution, it is desirable to determine the range of diameters and the mean diameter. The method involves increasing the gas pressure until the gas flow is equivalent to the dry-membrane gas flow. This method is illustrated in Figure.

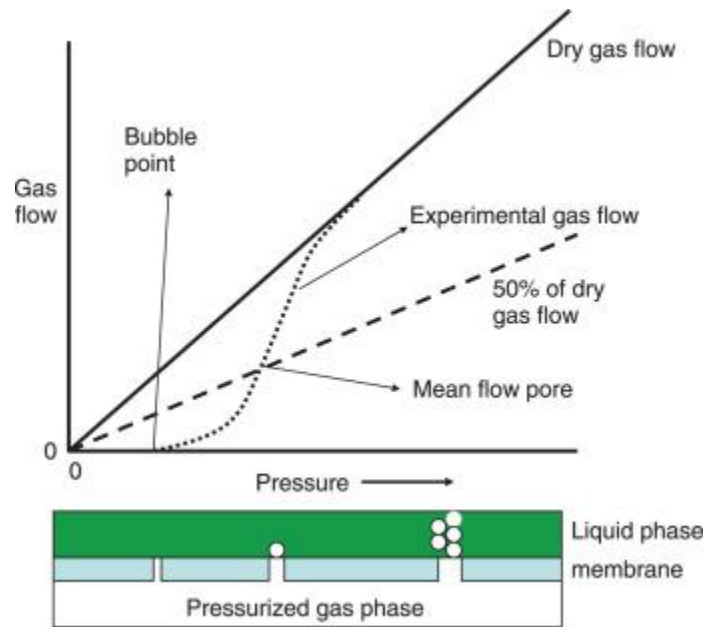


Fig 1.4.2 Pressurized gas phase

Nanotechnology for water purification: applications of nanotechnology methods in wastewater treatment

Konda Reddy Kunduru, ... Abraham J. Domb, in *Water Purification*, 2017

7 Conclusions

Water purification technologies that supply high-quality drinking water, eliminate micropollutants, and improve industrial processes are urgently needed today. The possibility is provided by nanotechnology; nanoparticles' special features make them a perfect choice for creating quick water-treatment technology. Metal ions, anions, organic chemicals, and microbes may be eliminated using nanoparticles. Because the

nanoparticle doses required for water purification are minimal, their use is reasonably cost-effective.

This chapter examines a variety of nanotechnologies. A few inventions are still in the laboratory, while others have progressed through pilot testing and are now available for purchase. Nano-adsorbents, nanomembranes, and nano-photocatalysts are the most promising of these technologies. Although these technologies have been marketed, their potential for large-scale wastewater treatment has yet to be realized.

The risk assessment of recovered contaminants and exhausted nanoparticles is still mostly unknown territory. To avoid risks and toxicities, environmentally friendly waste disposal procedures are essential. The future of nanoparticles in water treatment seems bright, but it will take the combined efforts of academic and industrial resources to develop a rapid, cost-effective, and practical water-treatment system. Working together to solve global water contamination will be achievable.

1.5 WATER PURIFICATION TECHNOLOGIES

We don't need to tell you that in a country where waterborne diseases cause over 10,000 fatalities each year, having a water filter in every home is critical. While higher authorities may try their utmost to supply us with clean and safe drinking water, we must also take responsibility for ourselves. For safe and clean water, we must ensure that our homes and workplaces are equipped with an electric water purifier. Although most people rely on a RO Filter or a RO UV Water Purifier for their drinking water needs, there are other options to consider.

Some of the most effective water purifying procedures that have lasted the test of time are as follows:

1.5 .1 Boiling

Boiling water for an extended period of time is the simplest way to purify it. Bacteria and viruses disintegrate at high temperatures, removing all contaminants from the water. Chemical additives also vanish from the water as a result of this process. Dead microorganisms and pollutants, on the other hand, settle at the bottom of the water, and boiling does not remove all of the impurities. To completely remove the contaminants, strain the water through a microporous sieve.

1.5.2 Water Purifier

An electric water purifier is the most trusted form of water purification that can be found in most houses today. A water purifier uses a multi-stage process that involves UV and UF filtration, carbon block, and modern water filtration technology that eliminates a majority of the chemicals and impurities making it the purest drinking water.

1.5.3 Reverse Osmosis

An RO Purifier proves to be one of the best methods of purifying water. Reverse Osmosis forces water through a semipermeable membrane and removes contaminants. The TDS Controller and Menileser Technology like the one found in an A. O. Smith **RO** UV Water Purifier help retain the necessary nutrients while doing away with harmful impurities.

1.5.4 Water Chlorination

This is an older technique used usually during an emergency, wherein a mild bleach with approximately 5% chlorine is added to the water. This mixture works as an oxidant and quickly kills microorganisms, making water safe for consumption.

1.5.5 Distillation

Distillation is a water purification process that involves collecting the condensed water after evaporation, which ensures that water is free of contaminants. However, this isn't as effective as an RO filter because it is time-consuming and eliminates minerals as well.

1.5.6 Iodine Addition

Iodine is a red chemical that is easily available as a tablet or a liquid. It is extremely powerful as it kills bacteria and viruses. However, it adds an unpleasant taste and can be fatal if taken in high doses. Therefore, it should only be used if you don't have access to a better method of purification like an electric water purifier.

1.5.7 Solar Purification

An alternative to the UV filtration is solar purification which involves treating water with the ultraviolet radiation of the sun. The process involves filling a plastic bottle with water, shaking it to activate the oxygen and leaving it horizontally in the sunlight. This effectively kills bacteria and viruses present in the water, making it safe for consumption.

1.5.8 Clay Vessel Filtration

Way before people had access to an RO or UV Purifier, they used clay pots which purified muddy water, by blocking out the mud and allowing pure, potable water to pass through. This method is still used in some rural regions.

1.5.9 UV Radiation

Water is exposed to a UV Light that kills microorganisms, thereby preventing it from breeding further. But if not coupled with an RO Filter, UV Radiation alone cannot remove impurities and heavy metals.

1.5.10 Desalination

This method is used when water with a certain level of salinity needs to be filtered. This process is helpful

Water can contain dirt, minerals and other impurities that can render it unfit for human consumption. Sometimes it can also be dangerous to your health, as impure water might contain harmful bacteria and other microscopic organisms. Purification of water ensures the removal of harmful organisms and other impurities from water, thereby

making it clean and safe for human consumption. In this article, let us understand some of the most common and different Water Purification Techniques.

Why should we purify water?

- Water is the elixir of life.
- More than 70 percent of our body is comprised of water.
- We should purify water to remove contaminants and other microbes.

Best Water Purification Methods

Water Purification methods can fit into three major buckets, viz.

- Large scale purification.
- Medium scale purification.
- Small scale or domestic purification.

Large Scale Water Purification Systems

The major techniques for large water bodies like lakes or ponds are as follows.

- Coagulation
- Sedimentation
- Filtration
- Disinfection

Medium Scale Water Purification System

For water sources like springs or wells, the following techniques can be used.

- Usage of chlorine bleach.
- Usage of Iodine.

Disinfection with Chlorine Bleach

Most often chlorine bleach is used in swimming pools to disinfect water. However, when used in moderate amounts, it can be used to eliminate bacteria and virus from water used for drinking. Chlorine is also used in the city or municipal water storage plants to disinfect water.

Home grade Chlorine or bleach contains 4% to 6% chlorine concentration and can be used to disinfect drinking water. According to Scientific American, it is ideal to use about 8 drops per gallon or 2 drops per liter of water. Allow it sit for thirty minutes before consumption, for the chlorine to work.

This technique is not only helpful at your home but can also be used when you are in the wild camping or trekking. Chlorine is effective against most bacteria and virus. However certain microbes like Norovirus and Giardia, are particularly resistant to chlorine and water needs to be treated for a longer duration to kill such organisms.

Filtration

Water filtration is the most common method of purification that is used in most homes. Water filtration systems come in many sizes and shapes, and are popular mainly due to their ease of use. Filtration systems use multi-level of purification methods. The first level would be a sedimentation filter of typically 0.2micron pore size. It will filter sediments, heavy metals like copper and lead and large parasites.

The next level would be a active carbon filter which easily filter most chemicals and smaller parasites. Additionally, it also removes odor from water. Some filters also have additional UV treatment layer to remove micro-organisms and other contaminants that escaped the previous level of filtration.

An advanced filtration system is the Reverse Osmosis or RO systems. These systems use a seven-level filtration and a reverse osmosis system to add required minerals and salts back to the water. Thus it ensures that the water coming out of the system is not only safe but is also healthy and tasty.

These days, portable water filters are available that are ideal for outdoor travel and camping. You may have access to fresh water features such as lakes or ponds if you go on treks frequently. Even if the water tastes good, sediments and germs must be removed by filtration. Fortunately, a portable water problem can quickly fix this issue and give clean, safe drinking water.

Treatment with iodine

Iodine is a potent disinfectant as well as a vital element that can help humans avoid thyroid disorders. It has the ability to eliminate bacteria, viruses, and other parasites at the molecular level. It comes in a variety of forms, including pills, crystals, and liquid.

However, we must exercise extreme caution when applying the correct amount of iodine. The use of iodine in higher dosages can be lethal. Hence, this technique must be used only when there is no other alternative. Usually, one crystal of iodine can be used to purify two thousand quarts of water.

Solar Purification

This method uses plastic water bottles and sunlight. Ensure that water bottles are scratch free. Fill the bottle with water up to three quarters full, shake it to activate the oxygen for half-minute, fill water to the brim, cover and then place it horizontally in sunlight.

It would be ideal to place the bottles in a location which has extended sun light exposure. The required exposure would be about six hours. If the day is dull and cloudy expose the bottles for about two days.

Boiling

Among all Water purification techniques, this method is the most ancient and popular method of purification till date. It is used in both urban and rural areas. Boiling technique can kill almost all types of microorganisms and make water safe and clean to drink.

However, it is ideal to filter the water initially using Alum or a cloth filter to remove sediments. Heat the water and allow it boil for at least three minutes. Allow the boiled water to cool and transfer it to a clean container. Cover and store the water to avoid recontamination.

Harmful effects of impure water



Consuming contaminated water can have dire effects on your health. Some of the most common water-borne diseases include diarrhea, cholera, typhoid, and guinea worms. These are rampant in the countryside as people there are less aware of purification techniques.

According to the World Health Organization, more than 3 million people die every year due to water contamination.

Importance of Water Purification

Water is an essential component of survival, as we mentioned before in this essay. Due to the myriad risks lying in it, the most of which are invisible to the naked eye, it is recommended to exercise extra caution and purify water using the most advanced procedures.

In this article, we've attempted to outline a few approaches that can be simply adopted at home. It's also a good idea to look into various water purifying methods in order to find the one that best fits your needs. For the most up-to-date information, keep an eye on our Water Softener Reviews.

1.6 DESALINATION

Desalination is a technique for removing minerals from saline water. Desalination, in a broader sense, refers to the process of removing salts and minerals from a target substance, such as soil desalination, which is a problem in agriculture. Desalination of saltwater (particularly seawater) produces water suitable for human consumption or irrigation. Brine is a by-product of the desalination process. Many seagoing ships and submarines employ desalination. The majority of present interest in desalination is centered on providing cost-effective fresh water for human consumption. It is one of the few rainfall-independent water resources, along with recovered wastewater.

Desalinating sea water is often more expensive than fresh water from surface water or groundwater, water recycling, and water conservation due to its energy consumption. However, these options are not always available, and reserve depletion is a major issue around the world. Thermal (in the case of distillation) or mechanical (in the case of reverse osmosis) energy types are typically used in desalination procedures.

Around 21,000 desalination units are presently operational around the world. The United Arab Emirates, Saudi Arabia, and Israel have the most. With a capacity of 1,401,000 cubic metres per day, Saudi Arabia's Ras Al-Khair Power and Desalination Plant is the world's largest desalination plant.

Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination. It is usually only economically practical for high-valued uses (such as household and industrial uses) in arid areas. However, there is growth in desalination for agricultural use, and

highly populated areas such as Singapore or California. The most extensive use is in the Persian Gulf.

While noting costs are falling, and generally positive about the technology for affluent areas in proximity to oceans, a 2004 study argued, "Desalinated water may be a solution for some water-stress regions, but not for places that are poor, deep in the interior of a continent, or at high elevation. Unfortunately, that includes some of the places with biggest water problems.", and, "Indeed, one needs to lift the water by 2000 m, or transport it over more than 1600 km to get transport costs equal to the desalination costs.

Thus, As a result, it may be more cost-effective to transfer fresh water from another location rather than desalinate it. Transport expenses could mirror desalination prices in cities far from the sea, such as New Delhi, or in high places, such as Mexico City. Desalinated water is especially expensive in areas like Riyadh and Harare, which are both far from the sea and high in elevation. Other places, such as Beijing, Bangkok, Zaragoza, Phoenix, and, of course, coastline cities like Tripoli, have substantially lower transportation costs." Water is pumped 320 kilometres inland to Riyadh after desalination in Jubail, Saudi Arabia. Desalination is becoming a more competitive option for coastal towns.

Some people are sceptical about whether desalination is or will be economically or environmentally viable.

Debbie Cook wrote in 2011 that desalination plants can be energy intensive and costly. Therefore, water-stressed regions might do better to focus on conservation or other water supply solutions than to invest in desalination plants.

Technologies

Desalination is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis.

There are several methods. Each has advantages and disadvantages but all are useful. The methods can be divided into membrane-based (e.g., reverse osmosis) and thermal-

based (e.g., multistage flash distillation) methods. The traditional process of desalination is distillation, i.e. boiling and re-condensation of seawater to leave salt and impurities behind.

Currently there are two technologies with more desalination capacity in the world, multi-stage flash distillation and reverse osmosis.

1.6.1 Distillation

Solar distillation

Solar distillation imitates the natural water cycle, in which the sun heats seawater sufficiently to cause evaporation. The water vapour is condensed onto a cool surface after evaporation. Solar desalination can be divided into two categories. To power desalination, the first type employs photovoltaic cells to convert solar energy to electrical energy. Sun thermal powered desalination is the second form, which converts solar energy to heat.

Natural evaporation

Water can evaporate for a variety of reasons other than sun exposure. These effects have been included into a multidisciplinary desalination process in the IBTS Greenhouse. The IBTS is a greenhouse that utilises the natural water cycle on one side and a desalination (electricity) plant on the other (scaled down 1:10). The multiple evaporation and condensation processes are housed in low-tech utilities, which are partly subterranean, as well as the architectural shape of the structure. This integrated biotectural system is best suited for large-scale desert greening since it has a km² footprint for water distillation and the same for landscape change in desert greening, respectively the regeneration of natural fresh water cycles.

Vacuum distillation

In vacuum distillation atmospheric pressure is decreased, thus lowering the temperature required to evaporate the water. Liquids boil when the vapor pressure equals the ambient pressure and vapor pressure increases with temperature. Effectively, liquids boil at a lower temperature, when the ambient atmospheric pressure is less than usual atmospheric pressure. Thus, because of the reduced pressure, low-temperature "waste" heat from electrical power generation or industrial processes can be employed.

Multi-stage flash distillation

Multi-stage flash distillation, which is a sequence of flash evaporations, is used to evaporate and extract water from sea water. The energy released from the condensation of the water vapour in the preceding stage is used in each subsequent flash process.

Multiple-effect distillation

Multiple-effect distillation (MED) involves a number of "effects" processes. Water from the faucet is sprayed into pipes, which are subsequently heated to produce steam. The steam is then used to warm the next batch of sea water that arrives. The steam needed to heat the sea water can be obtained from local power plants to boost efficiency. Although this approach is the most thermodynamically efficient of the heat-powered ways, it does have some limits, such as a maximum temperature and maximum number of effects.

Vapor-compression distillation

Vapor-compression evaporation involves compressing the vapour present above the liquid using either a mechanical compressor or a jet stream. The compressed vapour is then used to produce the heat required for the rest of the sea water to evaporate. Because this device simply requires electricity, it is more cost effective to keep it small.

Wave-powered desalination

In most wave-powered desalination systems, mechanical wave motion is converted directly to hydraulic power for reverse osmosis. By avoiding conversion to electricity, eliminating excess pressurisation above the osmotic pressure, and innovating on hydraulic and wave power components, such systems attempt to maximise efficiency and save costs. [16] CETO, for example, is a wave power technique that uses submerged buoys to desalinate saltwater. In 2013, wave-powered desalination units were installed on Garden Island in Western Australia, and near 2015, they were installed in Perth.

Membrane distillation

Membrane distillation uses a temperature differential across a membrane to evaporate vapour from a brine solution on one side and condense clean water on the other. The membrane's design can have a big impact on its efficiency and durability. After 30 days of continuous use, a membrane made by co-axial electrospinning PVDF-HFP and silica aerogel was able to filter 99.99 percent of salt, according to a study.

Osmosis

Reverse osmosis

In terms of installed capacity and annual growth, reverse osmosis is the most used desalination method (RO). Semipermeable membranes and applied pressure (on the membrane feed side) are used in RO membrane processes to preferentially promote water penetration through the membrane while rejecting salts. Thermal desalination

technologies often consume more energy than reverse osmosis plant membrane systems. The cost of energy in desalination operations varies greatly depending on the salinity of the water, the size of the plant, and the kind of treatment. Seawater desalination, for example, is currently more expensive than traditional water sources, but costs are expected to continue to fall as technology advances, such as increased efficiency, reduced plant footprint, improved plant operation and optimization, more effective feed pretreatment, and lower operating costs.

The thin-film composite membrane used in reverse osmosis is made out of an ultra-thin, aromatic polyamide thin-film. The membrane's transport properties are provided by this polyamide film, while the rest of the thin-film composite membrane provides mechanical support. The polyamide film is made up of a dense, void-free polymer with a large surface area, which allows for excellent water permeability. According to a recent study, the internal nanoscale mass distribution of the polyamide active layer is the primary determinant of water permeability.

The reverse osmosis process does not require any maintenance. Ionic contamination (calcium, magnesium, etc.); dissolved organic carbon (DOC); bacteria; viruses; colloids and insoluble particles; biofouling and scaling are some of the causes that reduce efficiency. The RO membranes can be destroyed in extreme instances. Various pretreatment processes are used to reduce damage. rs polyacrylamide and polymaleic acid, phosphonates and polyphosphates. Inhibitors for fouling are biocides (as oxidants against bacteria and viruses), such as chlorine, ozone, sodium or calcium hypochlorite. At regular intervals, depending on the membrane contamination; fluctuating seawater conditions; or when prompted by monitoring processes, the membranes need to be cleaned, known as emergency or shock-flushing. Flushing is done with inhibitors in a fresh water solution and the system must go offline. Because contaminated water is discharged into the ocean without treatment, this technique is hazardous to the environment. Marine environments that are sensitive can be irreparably harmed.

Solar energy is used to fill a buffer tank atop a hill with seawater in off-grid solar-powered desalination systems. Without the use of fossil fuels, an energy grid, or batteries, the reverse osmosis process receives its pressured seawater supply by

gravity during non-sunlight hours, resulting in sustainable drinking water production. For the same purpose, nanotubes are also used (i.e., Reverse Osmosis).

Forward osmosis

Forward osmosis separates water from dissolved solutes using a semi-permeable membrane. An osmotic pressure gradient acts as the driving force for this separation, causing a high-concentration "pull" solution.

Freeze–thaw

Freeze–thaw desalination (also known as freezing desalination) removes fresh water from saline water by freezing it. During freezing temperatures, salt water is sprayed into a pad where an ice pile forms. Natural desalinated melt water is retrieved when the weather warms. This method relies on long durations of natural sub-freezing temperatures.

A alternative freeze–thaw technology, devised by Alexander Zarchin, freezes seawater in a vacuum and is not weather dependent. Desalinated ice is melted and diverted for collection under vacuum conditions, and the salt is recovered.

Electrodialysis membrane

Electrodialysis utilizes electric potential to move the salts through pairs of charged membranes, which trap salt in alternating channels. Several variances of electrodialysis exist such as conventional electrodialysis, electrodialysis reversal.

Design aspects

Energy consumption The amount of energy used in the desalination process is determined by the salinity of the water. Desalination of brackish water uses less energy than desalination of seawater. Seawater desalination uses as little as 3 kWh/m³ of energy, including pre-filtering and ancillaries, which is comparable to other fresh water supplies transported over long distances but significantly higher than local fresh water suppliers that require 0.2 kWh/m³ or less.]

A minimal energy consumption of roughly 1 kWh/m³ has been determined for seawater desalination, ignoring prefiltering and intake/outfall pumping. With reverse osmosis membrane technology, energy consumption has been reduced to under 2 kWh/m³, leaving little room for future energy savings, as reverse osmosis energy consumption in the 1970s was 16 kWh/m³.

Supplying all US domestic water by desalination would increase domestic energy consumption by around 10%, about the amount of energy used by domestic refrigerators.^[41] Domestic consumption is a relatively small fraction of the total water usage.

Energy consumption of seawater desalination methods.					
Desalination Method >>	Multi-stage Flash MSF	Multi-Effect Distillation MED	Mechanical Vapor Compression MVC	Reverse Osmosis RO	
Electrical energy (kWh/m ³)	4–6	1.5–2.5	7–12	3–5.5	
Thermal energy (kWh/m ³)	50–110	60–110	None	None	
Electrical equivalent of thermal energy (kWh/m ³)	9.5–19.5	5–8.5	None	None	

Total electrical energy (kWh/m ³)	13.5–25.5	6.5–11	7–12	3–5.5
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Note: "Electrical equivalent" refers to the amount of electrical energy that can be generated from a given amount of thermal energy and a suitable turbine generator. These figures do not take into account the energy used to build or renovate the goods used in the process.

Desalination is often regarded a last alternative after water conservation due to its energy intensive nature and accompanying economic and environmental implications. However, as costs continue to decline, this is changing.

Cogeneration

Cogeneration is the process of generating both extra heat and power from a same operation. In an integrated, or "dual-purpose" facility, where a power plant supplies the energy for desalination, cogeneration can supply useful heat for desalination. Alternatively, the plant's energy output might be focused to producing drinkable water (a stand-alone facility), or extra energy could be created and fed into the energy grid. Cogeneration can take several forms, and any type of energy production might theoretically be applied. The bulk of current and future cogeneration desalination facilities, on the other hand, use on either fossil fuels or nuclear power for their energy. The majority of plants are in the Middle East or North Africa, where petroleum resources are used to compensate for inadequate water resources. Dual-purpose facilities have the advantage of being more energy efficient, which makes desalination more feasible.

1.7 RECENT TRENDS IN DESALINATION

Nearly half of the world's desalination capacity is located in the Middle East, and demand for desalination continues to rise in the region. This rising tendency is fueled by

a growing population amplified by high water use per capita. The continuing drop in costs has also aided capacity expansion. Desalinated water can be had for as little as 0.5-1 USD/m³, which is comparable to many other types of water. Today, several Middle Eastern countries, notably Bahrain, Kuwait, and Qatar, rely exclusively on desalination.

Desalination has undergone a technological revolution as a result of the ongoing quest to cut costs. The old thermally-driven technologies of multistage flash (MSF) and multi-effect distillation (MED) have been replaced with an electrically-driven reverse osmosis process (RO). RO requires far less energy than MSF and MED, resulting in lower costs and emissions. Nonetheless, RO has severe environmental consequences, not just because of CO₂ emissions into the atmosphere, but also because of the vast amounts of brine released into the sea. Even the most advanced RO desalination facilities produce more than one kilo gram of CO₂ and one cubic meter of brine for every cubic meter of freshwater produced.

What does the future have in store for us?

Although the desalination industry has made great strides in lowering energy usage, it has paid relatively little attention to brine outflow to yet. Brine management not only decreases the impact on marine ecosystems, but it also opens the door to a new economy based on 'mining' the various components found in seawater. This prospect has piqued the interest of research funding organisations all over the world. The EU-funded sea4value project, for example, intends to extract nine metals from saltwater, including magnesium, lithium, and rubidium. The Sandoq Al Watan 'Think Brine Challenge' and the King Abdullah University of Science and Technology 'Brains for Brine' competition are two other recent initiatives.

Because RO is unable to handle the severe salinities observed, the final phases of brine concentration and mineral recovery are usually left to thermal technologies. Thermal technologies, on the other hand, have less work to do (and use less energy) if they are fed a feed that has already been preconcentrated in some way. This notion is now driving a number of innovations in high-recovery RO, ranging from the completely conceptual to the fully operating industrial plant. Yale University, for example, has proposed a method known as 'Low Salt Rejection Reverse Osmosis' (LSRRO), in which RO membranes are set to have imperfect salt rejection. The differential osmotic pressure across the membrane is reduced by a little amount of salt leakage, which would otherwise surpass 200 atmospheres (enough to crush even the most durable membranes).

The counter flow RO technique, in which the feed is diluted by water transported from the brine exiting the system to the point where it can be handled by a normal RO device, is a more established technology. The challenge, like with LSRRO, is to minimise a big concentration difference across the RO membrane while maintaining high absolute concentrations, avoiding the damaging pressures associated with high salinity RO. Western Saudi Arabia is currently implementing counter-flow RO.

It is completely free.

Solar evaporation can concentrate seawater and brine, as it does in traditional salt works, with the main disadvantage being the salt works' high land use and maintenance expenses. Wind-driven evaporation, on the other hand, can save a lot of land and money. In fact, as proved by Seawater Greenhouse technology in the Horn of Africa, a wind-driven evaporator can provide cooling benefits while lowering the cost below zero. At the water-energy-food nexus, an optimised system combining seawater desalination, brine concentration, greenhouse cultivation, and mineral recovery could deliver a winning solution.

His present research is to achieve long-term water resource treatment and utilisation in dry environments. Desalination and water reuse are among his scientific interests, as

are solar-powered saltwater cooling, seawater greenhouse technology, and negative emissions technologies. These categories help to meet the United Nations' Sustainable Development Goals.

CHAPTER 2

LITERATURE SURVEY

2.1 $\text{NaTi}_2(\text{PO}_4)_3$ (anode)& Ag(cathode)

PPyCl is a viable option for Cl storage in a desalination battery due to its high theoretical salt-removal capacity; nevertheless, the potential application suffers from rapid capacity fading. As a result, it is necessary to comprehend the fading mechanism of the PPyCl electrode, which will serve as a guideline for improving the cycle stability of the PPyCl electrode.

Redox-PSQ Film. As a novel Cl-storage material, Silambarasan et al. (YYYY) reported ferrocyanide molecule-immobilized poly(silsesquioxane) (redox-PSQ). Nickel hexacyanoferrate is used as the cation storage (Na^+ and K^+) electrode, and ferrocyanide immobilized poly(silsesquioxane) film is used as the Cl-storage electrode in a membrane-free desalination battery. Real seawater was used to test the desalination cell.

The energy consumption and desalination capacity, respectively, are 0.0184 mWh/L and 7.7 mg/L.⁶⁹

It's also been established that it is also confirmed that, during the oxidation process, Cl^- is inserted into the redox polymer film for charge compensation. During the reduction process, the inserted Cl^- is ejected from the film into the solution.

2.2 CuHCF (ANODE) & Bi (CATHODE)

The CuHCF/Bi cell's desalination capability was first tested in a neutral 0.6 M NaCl solution galvanostatically cycled at a constant current density of 1 mA cm⁻². To store Na⁺, Fe(III) in CuHCF was reduced to Fe(II) throughout the desalination process.

(cathode) at the same time To store Cl⁻, Bi was oxidised to BiOCl.(anode). As a result, electrons began to flow from the Bi the CuHCF electrode to the electrode Bi's potential grew significantly as the response progressed vs.Ag/AgCl, it grew from its open circuit potential and plateaued at -0.08 V, while the In comparison to Ag/AgCl, the CuHCF electrode's potential gradually reduced from 0.64 to 0.56 V.

2.3 HC@MnO₂ (ANODE) &PHC (CATHODE)

A low-cost, membrane-free HCDI system with high ion removal capacities and rates has been assembled in this study. For collecting sodium via redox reaction, hollow carbon@MnO₂ (HC@MnO₂) was utilised as an electrode material, whereas for adsorption of chloride, a hollow carbon sphere with net positive surface charges (PHC) was used. In situ grown MnO₂ nanowire on hollow carbon sphere was used to successfully construct the HC@MnO₂ composite (HC). At the same time, the HC was positively charged by PDDA, resulting in PHCs. During CDI operation, the unique structure and strong conductivity of HC@MnO₂ ensure faradaic interaction with Na⁺ ions. Furthermore, because to electrostatic repulsion, PHC may selectively adsorb Cl⁻ ions from the NaCl solution while preventing the adsorption of Na⁺ ions. As a result, a high ion concentration is required.

2.4 Graphite(ANODE) & Graphite(CATHODE)

The quantity of charge passed during ED operation must be proportional to the number of salt ions eliminated from the feed water in the desalination cell (i.e. one Na⁺ ion and one Cl⁻ ion per electron). Because current cannot flow through the ED cell without associated ion (Na⁺ and Cl⁻) movement from the feed water, this is the case. This was validated by measuring the salinity of the feed water as a function of charge passed with a salinity metre.

When 105 percent of the stoichiometric amount of charge was passed to remove all Na⁺ and Cl⁻ from the feed water, the salinity of the feed water became zero, exhibiting the desalination ED cell's expected behavior. The addition of salt ions to the feed water is also connected with the charge transferred through the salination cell. When the cell operation was completed, the NaCl concentration of the feed water in the salination cell was confirmed to be 1.2 M.

2.5 $2[\text{Fe}(\text{CN})_6]^{4-}$ (anode) & Zn(cathode)

The cell potential (+1.25 V) is 0.5 V higher than other reported desalination batteries, and the specific capacity (cathode: 81 mAh/g, anode: 828 mAh/g) is at least 2 times higher than any other desalination battery reported to date. It also avoids proton-coupled pH changes, which plague systems with the next-highest cell potential and capacity. 20 and 22 This permits revenue streams and cost savings normally associated with energy storage technology to balance the cost of desalination. It may be conceivable to enable low-cost seawater desalination through process intensification with electrical storage with enhancements to lower cell impedance.

More broadly, our findings introduce a new way of thinking about energy storage economics. In general, the field has concentrated on lowering cost per kilowatt-hour; different cost models that have been released to yet have backed up this strategy. It's also possible to create a cost-effective energy storage solution by using water revenue to offset energy storage expenditures.

CHAPTER 3

MATERIAL & METHODOLOGY

3.1 MATERIAL

- Battery
- Zink Electrode
- Graphite electrode
- Glass Container
- Water
- Electricity
- Salinity meter
- P. H. meter

3.2 FABRICATION OF EXPERIMENT SET UP

3.2.1. Battery

The nine-volt battery, sometimes known as a 9-volt battery, is a popular size of battery used in early transistor radios. It is shaped like a rectangular prism with rounded corners and a polarised snap connector on top. Smoke detectors, gas detectors, clocks, walkie-talkies, electric guitars, and effects units all employ this kind.

Primary carbon-zinc and alkaline chemistry, primary lithium iron disulfide, and rechargeable nickel-cadmium, nickel-metal hydride, and lithium-ion batteries are all typical nine-volt battery formats. Due of the mercury content, these types of mercury-oxide batteries haven't been manufactured in a long time.

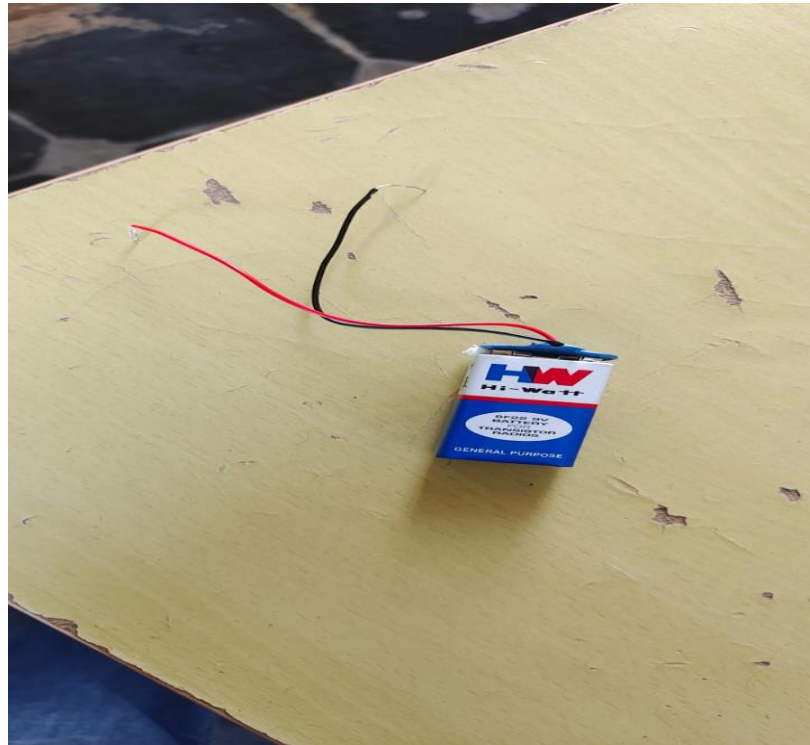


Fig 3.2.1 Battery

3.2.2. Graphite Electrode

In electric arc furnaces, Graphite electrodes are commonly utilized. They are currently the only goods on the market with great electrical conductivity and the ability to withstand the tremendous heat created by EAF. In addition to ladle furnaces and other smelting operations, graphite electrodes are used to refine steel. RP Graphite electrodes, HP Graphite electrodes, SHP Graphite electrodes, and UHP Graphite electrodes are the four types of graphite electrodes available.



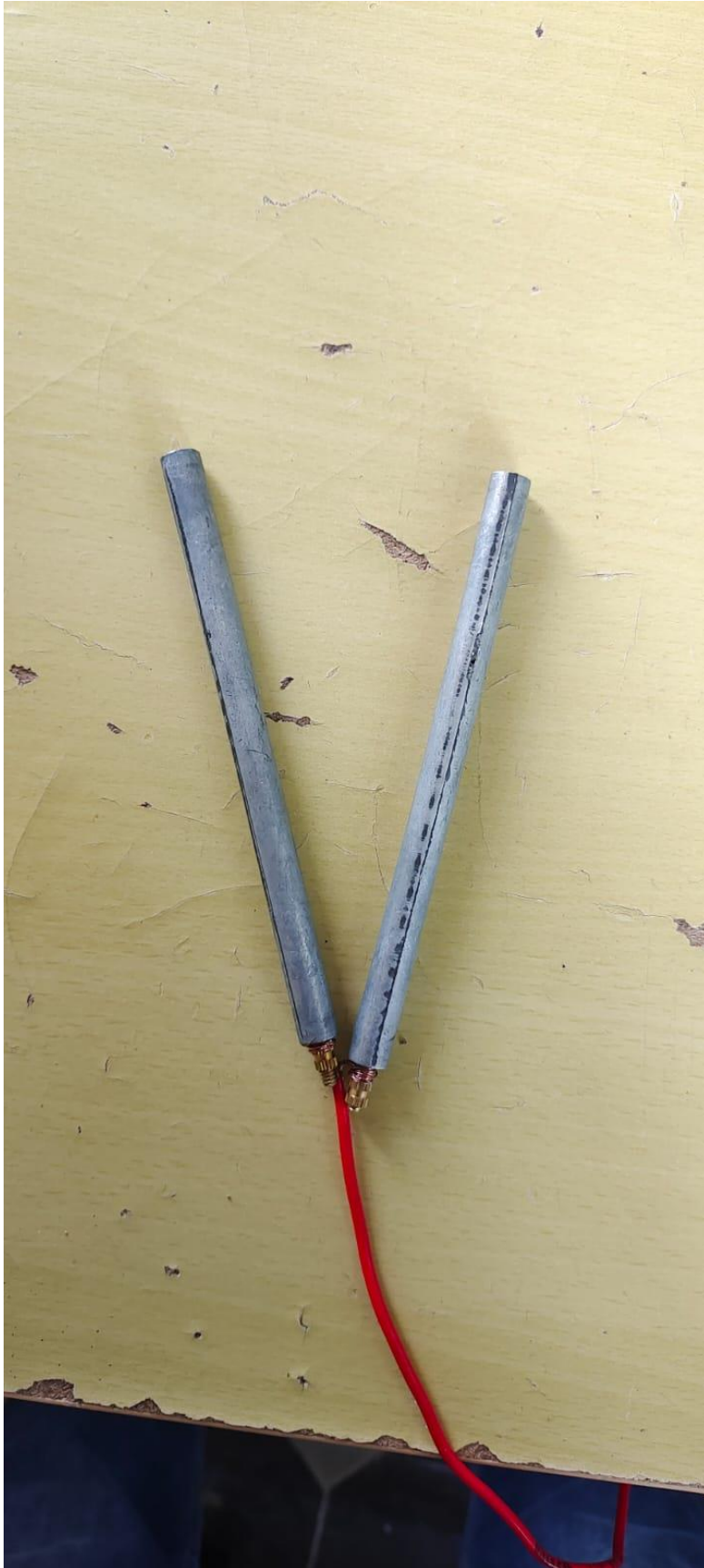
Fig 3.2.2 graphite electrode

3.2.3. Zinc Electrode

Continuous desalination with low energy usage is possible thanks to a unique dual zinc electrode electrochemical desalination technique. During a continuous batch mode operation, brackish water is immediately desalted from 2000 to 380.6 ppm. At a current density of 0.25 mA cm^2 , the energy consumption is as low as $35.30 \text{ kJ mol}^{-1}$, which is comparable to reverse osmosis.

Advanced water remediation necessitates technology that are both energy efficient and reliable. Reverse osmosis (RO), thermal distillation, and electrodialysis are examples of modern large-scale desalination techniques that can meet these goals and have been

used in many circumstances. 1 & 2 Capital expenditures, operating costs, and energy use, on the other hand, remain high. Capacitive deionization (CDI) has been proposed as a deionization method that is both energy efficient and cost effective.



3.2.3 Glass container

These airtight containers are available in a variety of sizes and have a lift-off cover for easy access. The contents can be quickly identified because to the clear glass. They're wonderful for exhibiting hand crafted storing essentials on the counter. An airtight seal is provided by a silicone gasket.



3.2.4 Water

The colorless, tasteless, very slightly compressible liquid oxide of hydrogen H₂O that appears bluish in thick layers, freezes at 0° C and boils at 100° C, has a maximum density at 4° C and a high specific heat, is feebly ionised to hydrogen and hydroxyl ions, and is a poor conductor of electricity and a good solvent, and is a major constituent of all living matter and that when pure is an colorless, tasteless.

3.2.5 Salinity Meter

Salinity meter are instruments that determine the quantity of salt in a substance. Salinity meter can be purchased alone or as a sensor in multiparameter meter that can also detect pH, conductivity, TDS, and other water quality parameters.

Electrical conductivity is the most frequent method for determining saline levels. The concentration of ions present in a substance or sample is measured by electrical conductivity.

The ability of a substance to transmit an electrical current across a specific region can be used to compute the number of ions present in a sample.

A current is transferred between two electrodes immersed in the substance you want to test during measurement. The more ions present, the more conductive the substance will be and the higher the electrical conductivity reading will be; the fewer ions present, the less conductive the substance will be and the lower the electrical conductivity reading will be.

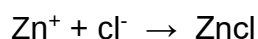
Siemens is the unit of measurement for electrical conductivity (S). Micro Siemens per centimeter mS/cm or Milli Siemens per centimeter mS/cm are displayed on the units.



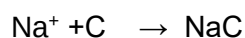
3.3 EXPERIMENT PROCEDURE

Bio desalination is carried through electrolysis process by using of electrodes,

- Zinc electrode as (anode) and Graphite electrode as (cathode)
- Zinc electrode attracts with chlorine and forms zinc chloride



- Sodium electrode attracts with graphite and forms sodium graphite



- Connecting both the electrode through the wire to the battery of 9v ,18v ,27v ,36v etc..
- While increasing the voltage by adding the battery, the rate of salinity increases, but the voltage can be taken as per the electrode acceptance.
- In this experiment only 18v is used because the experiment set is taken as per the electrodes size.
- These electrodes are placed in a glass container, in a glass container 500ml liter of water of salt water is added, electricity is passed through both the anode and cathode electrodes.
- After an certain period of time (20mim) the water is tested the percentage of salt removal is 45% and then later after 30mim again the water is tested with the salinity tester the rate of salt removal is 61%.
- The experiment is repeated with different time periods, but the removal rate of salt is 61%.
- Thus we had concluded the rate of salt percentage by using graphite electrode and zinc electrodes.

Chapter 4

RESULT & DISCUSSION

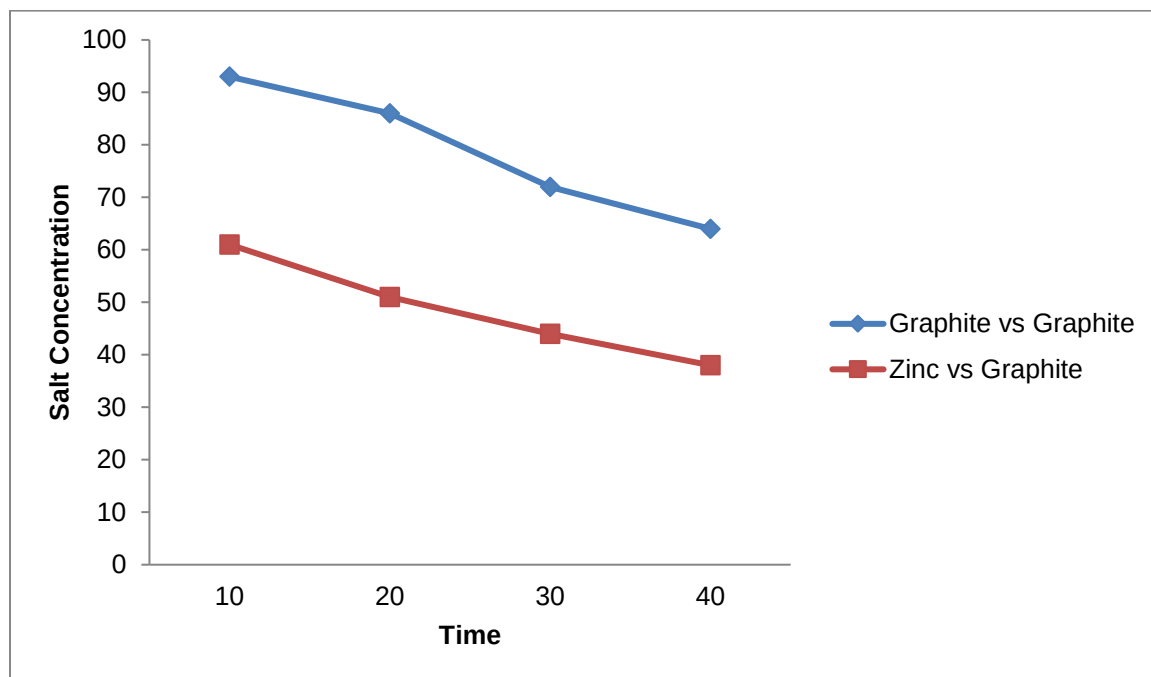


Fig: 4.1: Graph to describe the salt concentration

Time	Graphite VS Graphite	Zinc VS Graphite
10 min	93	61
20 min	86	51
30 min	72	44
40 min	64	38

Table: for the above fig: 4.1

In this graph, the salt concentration between graphite/graphite and zinc / graphite is shown

- In this graph x-axis represent the time and y-axis represent salt concentration.
- In first case Graphite (anode) and Graphite (cathode) this two electrodes are connected to a 18v battery and as per the timing wise reading is noted.
- In second case Zinc (anode) and Graphite (cathode) this two electrodes are connected to 18v battery and note timing wise readings is noted.
- First case, at the starting time of 10 minutes the concentration of salt is 93%, and the highest reduction of salt concentration is 64% at 40 minutes of time period.
- Second case, at the starting time of 10min the concentration of salt is 61%, and the highest reduction of salt concentration is 38% at 40 minutes of time period.
- Even the two electrodes are noted at the time of 50 minutes but the reduction of salt concentration is same.
- By this case we had chosen Zinc (anode) and Graphite (cathode) as the good removal of salt.

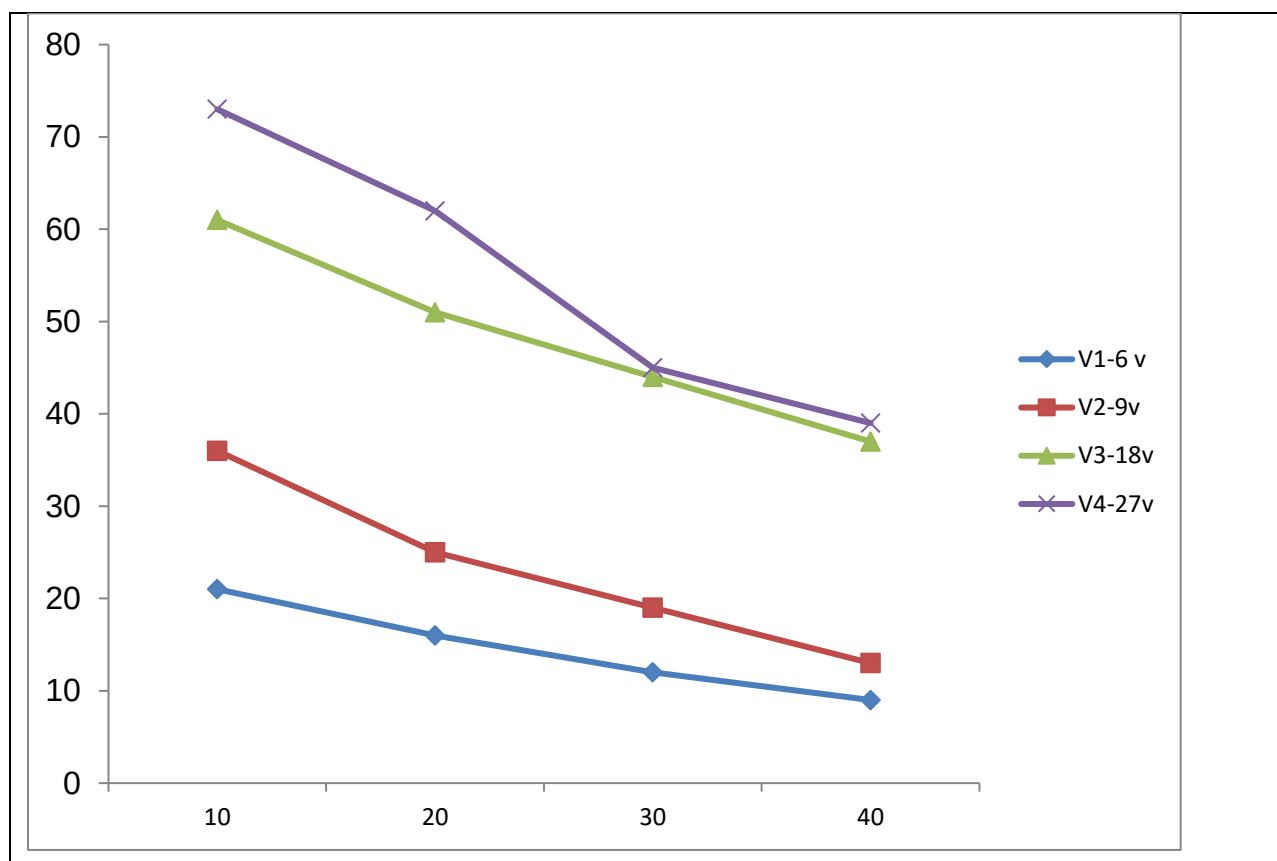


Fig 4.2 Increase of voltage

Fig:4.2: To describe the salt concentration reduction using different voltages.

Time	V ₁	V ₂	V ₃	V ₄
10	21%	36%	61%	73%
20	16%	25%	51%	62%
30	12%	19%	44%	45%
40	9%	13%	37%	39%

TABLE :- For the above fig:4.2

Fig 4.2 Increase of voltage

- Here four voltages are taken 6v, 9v, 18v and 27v batteries are used to conduct the experiment.

- $V_1 - 6V$

- $V_2 - 9V$

- $V_3 - 18V$

- $V_4 - 27V$

- In these graph the concentration of reduction of salt is shown as the the voltages increases.

CHAPTER 5

CONCLUSION

In these project a novel of bio-desalination method was developed, were discovered the effect of electrode type and voltage were investigated on desalination of salt water.

Experimental set-up was prepared with Zinc (anode) and Graphite (cathode) and 18V voltages. The salinity was tested before and after desalination. From the results the following conclusion are made,

- Among the two anode electrodes, Zinc electrode had shown the better results with salt removal rate of 61%, while Graphite electrode exhibited 7% of salt removal rate.
- As the voltage increases, there salt removal rate of desalination setup increases.
- As per the voltages 6v, 9V, 18V, 27V, 36V, 45V.

From the above findings the desalination kit Zinc anode and Graphite cathode proven to be an effective method for desalination.

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