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Brackish Water Desalination Using Moringa Oleifera Seed Powder, Coconut Shell Activated Charcoal And Vetiver Grass : A Review

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ABSTRACT

Desalination of water is generally expensive, requires more energy and specialized equipment. This work is to present an overview of desalination of brackish water by developing filter model using naturally available materials to produce fresh water for supplementing water supplies to the common people in smaller quantity. The bio filter model is constructed with Moringa oleifera seed powder, coconut shell activated charcoal and Chrysopogan zizanioides (vetiver grass – dried form) coupled with traditional sand filter. Moringa oleifera seeds are good in coagulation whereas activated charcoal prepared from coconut shell is a good adsorbent and these three materials are capable of reducing the amount of salts, pollutants present in water. This technique is a small-scale scheme and easily employed for intermittent use. As the filter is made from renewable materials found in abundance it provides a solution to environmental problems and offer an additional value to the agricultural economy. The potential of the materials used is determined by analyzing physical and chemical characteristics like pH, Conductivity, Turbidity, TDS, Hardness, Chloride, Sulphate, Nitrate, Fluoride, DO, BOD, COD and E. coli as per Indian Standards. The bio filter model improves the quality of water suggesting that the application of this bio filter containing natural products is effective to treat the polluted water in an economic and eco- friendly manner. This water treatment technology may offer a practical, cheap, appropriate and sustainable solution for producing potable water in some developing nations.

Keywords : Desalination, Brackish water, Coagulant, Adsorbent, Activated Charcoal, Energy Efficient

I. INTRODUCTION

In 2025 about 30-40% of the world will have water scarcity and according to the researches climate change can make it even worse. In undeveloped countries people living in extreme poverty are presently drinking highly turbid and contaminated water because they cannot afford to costly treated water using chemical coagulants. Many countries are

using natural coagulants to purify river, lake and brackish water and seawater in the form of coagulants, disinfectants and also as filter media in desalination process. The method of adopting bio filter with the products obtained from natural materials for desalination is discussed.

Fresh and clean water is essential and basic need for healthy life and healthy environment. Ecosystem depend on the availability and quality of water to thrive. We human are also dependent on water for drinking, cleaning, cooking, goods production and other uses. Most of the world's fresh water is not easily accessible to humans. Nearly 69% of the fresh water is locked up in polar caps and glaciers, 30% is present as ground water and only 1% of freshwater that remains is all that's available for all the ways we use water [a]. The main source of freshwater is precipitation in the form of rain, mist and snow. The precipitation leads to the formation of water bodies like pond, lake, river, stream and groundwater contained in the aquifers which can be used as sources of freshwater. It is estimated that more than half of the freshwater has been used.

The demand for water originates from four main uses- agriculture, energy production, industrial uses and human consumption. Global water scarcity is growing severe in recent years. Recent research has demonstrated that two-third of the world's population currently live in area that experience water scarcity for at least 1 month in a year. About 50% of the people living in China, Pakistan, Saudi Arabia and India facing this level of water scarcity.

1.1 Desalination

The sea water contains minerals and salts like sodium, chloride, calcium, magnesium, fluoride dissolved in it. Desalination process removes or reduces the salts dissolved in sea water and convert it into clean potable water. Desalination process of saline water is more efficient, economical and sustainable technique when compared to other fresh water harvesting methods as sea water is found in abundance throughout the earth. The feed water for desalination process can be seawater or brackish water. Seawater is much saltier but brackish water contains more salt than fresh water but less than seawater. Brackish water is commonly found in estuaries. The salt and other impurities removed from the sea water is then returned to the ocean via diffusers, which ensures it mixes quickly and prevents impacted the marine environment. The desalinated water is then subject to further treatment to meet drinking water standards before it reaches our customers.

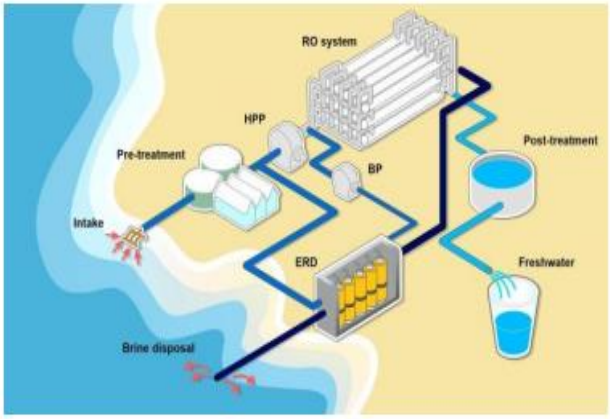

Fig 1. Desalination Process

1.2 Sand Filter

Filtration is a process that is widely used for removing fine particles from water. Sand filters are generally used as a step in treatment process of water purification. As the wastewater percolates slowly through the filter media, natural physical, biological, and chemical processes combine to provide treatment. Some of the organic matter breaks down in the filter. Particles stick to grain surfaces or get caught in crevices or voids on grains or in spaces between grains. So sand filters can provide high quality effluent. The advantages of the sand filters include energy-efficient and have relatively low maintenance requirements but should be serviced by trained technicians.

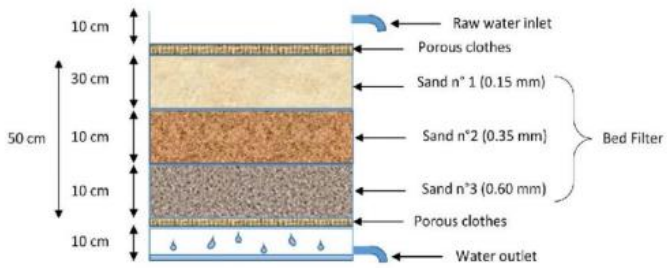

Fig 2. Slow Sand Filter

1.3 Role of Moringa Oleifera Seed Powder

Tree dried Moringa seeds were purchased from local market in Puducherry. The wings and coats of the seeds were removed and cleaned with distilled water to get rid of the impurities on its surface and dried in hot air oven at 50°C for 24 hours. The dried seeds were grinded using mortar and pestle, then sieved with 600 micrometre sieve. The prepared seed powder was stored in glass container for further use. The seed contains cationic proteins which attracts the negatively charged ions and settle at the bottom under gravity when left undisturbed. The seed protein is also effective in removal of micro-organisms as they are excellent antimicrobial agent.

Fig 3. Moringa oleifera Seed Powder

1.4 Role of Coconut Shell Activated Charcoal

Dried coconut shells were cleaned and placed in a muffle furnace at 350°C for 2 hours. This alters the shells into hydrocarbons and porous natured carbonaceous compounds. After cooling to the room temperature, it was cured with distilled water and then the activated charcoal were subjected to drying at 105°C. Then the charcoal was made into granules using a mortar and pestle and sieved with 6mm and 4.75 mm sieves. The prepared charcoal was stored in sealed polythene bags. The surface of the adsorbent is uniform and the existence of pores are greater. It adsorbs very small particles present in water when it comes into contact with the surface of the activated charcoal. The rate of adsorption will be more as the contact time of the charcoal surface with the water increases.

Fig 4. Coconut Shell Activated Charcoal

1.5 Role of Vetiver Grass (Dried)

Dried Vetiver grass was purchased from the local market and washed with distilled water to remove the impurities like dust and other suspended particles. The washed grass were sundried for 24 hours and stored for further use. The dried vetiver grass reduces the pollutants and improves the taste, odour and colour of the water. The grass also have excellent medicinal properties which reduces the impurities and reduces the temperature of the water.

Fig 5. Vetiver Grass (Dried)

II. RELATED WORKS

A. Carmalin Sophia, et.al, (2015) "Utilization of coconut shell carbon in the anode compartment of microbial desalination cell (MDC) for enhanced desalination and bioelectricity production" this study reports the bench-scale laboratory desalination using MDC loaded with granular coconut shell carbon, as a new electrode material in the anode compartment. Control experiments have been performed without granular coconut shell to evaluate the effect of carbon. The MDC with carbon showed 84.2% sodium and 58.25% chloride removal while MDC without carbon showed 68.2% sodium and 50.7% chloride removal. SEM analysis of the bio-film showed meager coverage of rod shaped microorganisms and molecular pili. This study suggests that coconut shell carbon has the tendency to desalinate water by removing sodium and chloride salts present in the water with more efficiency.

John Raymond Barajas, et.al, (2015) "Development of a low-cost water treatment technology using Moringa oleifera seeds" this research investigates the development of a bio filter using the seeds of MO, an indigenous tree in many low-income countries. The protein extract from the Moringa seeds was immobilized on adsorbents such as sand, activated carbon and rice husk and then tested the use of MO-functionalized adsorbents in E. coli disinfection. Results showed that the MO proteins binds strongly to all adsorbents and proteins are not released back to the solution. The MO adsorption is capacity was highest with carbon and highest E. coli reduction was observed in rice husk and activated carbon. It suggests to design low cost bio filter that uses MO immobilized adsorbents as packing material to purify water.

Sapna N. Nandeshwar, et.al, (2015) "Green activated carbons from different waste materials for the removal of iron from real wastewater samples of Nag River, India", the work is related with the preparation of green adsorbents using waste materials such as coconut shell, orange peel, sawdust and C. procera leaves so as to evaluate the cheapest and easiest means of iron removal from water. The materials were carbonized and activated using different agents such as HCl, HNO3 and H2SO4. The order of iron removal was orange peels, coconut shell, sawdust, C. procera leaves and it was found that charcoal activated with HCl can remove 77-90% iron.

Mini Mathew, et.al, (2016) "Effectiveness of Vetiver System for the Treatment of Wastewater from an Institutional Kitchen" this paper investigates the potential of vetiver system for the treatment of wastewater generated from an institutional kitchen. A pilot scale which includes 5 drums of 130 liters capacity with vetiver grass planted in the soil in it was made for the treatment of waste water. From the results it is observed that most of the water quality parameters tested is within the permissible limits. Vetiver system is able to remove 80-85% BOD, 85-90% COD, 85% total Coliform and it is very efficient and low cost method of water treatment.

Naji Raheem, et.al, (2018) "Role of Moringa oleifera and Tamarind Seed in Water Treatment" in this study an attempt has been made to evaluate the comparative effectiveness of chemical coagulant Alum and Natural Coagulant such as Moringa oleifera and Tamarind seed powder. The maximum turbidity removal of alum, Moringa oleifera, tamarind and combined use of natural coagulants were found as 97.5%, 98.12%, 98.12% and 98.75%. The other pH, alkalinity, acidity and chlorides was reduced effectively with combined use of natural coagulants. The utilization of these natural coagulants was found to be suitable, easier, cost effective and environmental friendly for water treatment.

R. Priyanka, et.al, (2018) "Water quality maintenance by developing a biofilter model using coconut shell

activated carbon and rice husk as adsorbents" this study made an attempt to design and evaluate a cost effective bio filter model from locally available materials such as coconut shell activated carbon, rice husk carbon, sand and pebble. The work was aimed at determining the efficiency of filter in removing the contaminants. From the results it is observed that there is substantial reduction in Total Hardness, Chlorides, Sulphates, and TDS after subjecting to the filter. The filter is efficient in pollution reduction, cost effective and ecofriendly.

Jayaprakash M C, et.al, (2018) "Desalination Approach of Seawater and Brackish Water by Coconut Shell Activated Carbon as a Natural Filter Method" this study aimed to develop a cheaper, cleaner, easy and more energy efficient way of desalinating seawater technique by using natural filters. The desalination system is developed by selecting coconut shell charcoal as the substrate material. As per the results there is a reduction of 60% chloride, 75% sodium, 100% iron, 53% sulphate, 20% TDS, 12% hardness which clearly indicates that the selected filter media with activated carbon charcoal could be used for effective desalination of saline water. This study states that coconut shell charcoal should be prepared by heating half splitted coconut shell at a temperature of 900°C for 4 hours using a muffle furnace for better results.

L. Chandana, et.al, (2019) "Low-cost adsorbent derived from the coconut shell for the removal of hexavalent chromium from aqueous medium" in this work a bio-adsorbent based on coconut shell has been developed and explored for the elimination of toxic heavy metals like Cr(VI) from the industrial overflows. Physical activation with CO2, O3 and H20 has been performed. The consequence of physical activation on the physicochemical properties was analyzed by N2 adsorption, thermogravimetric analysis (TGA) and temperature programmed decomposition (TPD). Results indicated that the physical activation of carbon is an efficient approach for the removal of heavy metal Cr(VI) from the aqueous solution and best adsorption was achieved at pH 2. This study highlights the potential off an eco-friendly, low cost bio-sorbent for the elimination of Cr(VI) from the industrial wastewater.

Aziz Qannaf Aziz Zaid, et.al, (2019) "Preliminary investigation of water treatment using Moringa oleifera seed powder as natural coagulant: A case study of Belat river, Malaysia" in this study the experimental procedure was conducted and operated at 200 rpm for 4 minutes, followed, by 40 rpm for 30 minutes and 1 hour sedimentation. The Jar tests carried out before and after treatment with Moringa oleifera seed powder to evaluate the quality parameters such as pH, turbidity, conductivity, TDS, COD, BOD, NH3-N and NO3- N. The results showed that turbidity was decreased by 98.08% and 96.71% for high and low turbid water. BOD reduction was found to be 66.67% and 27.27% for high and low turbid water. The NH3-N and NO3-N values were unstable. 0.05g/500mL of MOSP used for river water treatment gave a significant improvement in the quality of water.

Anant Patel, et.al, (2020) "Sustainable solution for lake water purification in rural and urban areas" in this research several experiments were conducted for the treatment of lake water with the usage of vetiver grass, conventional sand, rice husk, coconut fibrers, activated carbon, oysters and Moringa seeds. A filtration unit was designed such that it was economical, sustainable and easy to assemble with their components easy to purchase or acquire. The results showed that this treatment method can remove most of the pollutants such as TDS (50%), Alkalinity (60-65%), Hardness (65-70%), Chlorides (45-50%), Sulphates (40%) and BOD and COD were

also removed from water to its acceptable limits, also the treatment was very economical.

Alakaparampil Joseph Varkey, (2020) "Purification of river water using Moringa Oleifera seed and copper for point-of-use household application", this paper involves the use of moringa seed powder as a natural coagulant and flocculent to clarify water and copper as an antibacterial agent to kill the pathogens like E. coli to produce clean drinking water. It shows that the turbidity level was reduced and was in the range of 3 NTU – 5 NTU and E. coli count was not detected after purification. This study concludes that moringa seed powder was an excellent coagulant and copper has antibacterial property to disinfect E. coli in the water. It suggests this purification system can be equipped and it is economical since it does not require any power source or high technical assistance.

Richard Agbo Kwabena, et.al, (2020) "Antimicrobial and coagulation potential of Moringa oleifera seed powder coupled with sand filtration for treatment of bath wastewater from public senior high schools in Ghana", this study investigates the efficiency of Moringa oleifera seed powder coupled with sand filtration in treating greywater. Moringa oleifera seed powder was added to raw greywater and then filtered through a sand filter bed. Mean turbidity TDS, TSS, phosphate, nitrogen and E. coli were removed by 98.14%, 72.7%, 98.9%, 75.64%, 43.11% and >99% respectively. There is an increase in BOD after filtration.

Ignatius Makafui Kumatse, et.al, (2020) "Evaluation of selected activated carbon filters and sand media for nutrient and pathogen removal from an anaerobic baffled reactor effluent system", the performance of biochar media filters derived from cocoa pod husk and coconut shell was assessed in comparison with sand media under hydraulic loading rates of 0.105-0.210 m3 /m2 .d during a 9 weeks study period. The removal at the end of week 7 showed cocoa pod husk had the best removal efficiency of 99.68% NH3-N, 89.33% P and E. coli was not detected. The performance of cocoa pods and coconut shell improved and were better than sand media at the end of week 7. The study results indicate that the activated carbons are better utilization for the removal of nutrients and pathogen from ABR effluent.

Anshul Agarwal, et.al, (2020) "Designing an economical slow sand filter for household to improve water quality parameters", this research aimed to invent and install an economic and non-conventional slow sand filter for treating water to resolve the issues related with impure water. Designed sand filter has been operated under the hydraulic loading of 4.6296L/sec/m2 and an operational period of one hour. Major parameters like pH, TDS, turbidity, salinity and conductivity of filtered water has been tested and the parameters were compared with Indian standard parameters. Test results showed the slow sand filter is highly effective in improving water quality parameters. pH has been changed from 8.6 to 7.2 and TDS was removed up to 80%.

B. Vijila, et.al, (2020) "Removal of fluoride with rice husk derived adsorbent from agro waste materials", this investigation highlighted the elimination percentage of Fluoride from water with the aid of low cost material, rice husk. Rice husk is used to detoxify fluoride rich water and making it safe for human. 0.5g/100mL of adsorbent accomplished 87% of fluoride removal. The elimination of fluoride efficacy is associated with increase of adsorbent concentration, acidic pH, room temperature and lesser contact time respectively.

Tefera. T, et.al, (2020) "The use of Moringa oleifera, Carcia papaya and Aloe debrana plant extract as alternate natural material for water purification", the study shows strong potential of plant extracts as a

low-cost technology in purifying water. A rapid screening on the coagulative and disinfection potential of three most frequently used plants Moringa oleifera, Carcia papaya and Aloe debrana was carried out against control samples. A 95% reduction in turbidity by Moringa plant at dose of 125g/ml in 4 hrs of retention time was observed. Other plants reduced the turbidity between 75 to 90%. The highest alkalinity reduction was observed with Carcia papaya at dose of 125g/ml. All the three plants showed phytocoagulant and phytodisinfectant activity.

Priscila Vega Andrade, et.al, (2020) "Use of Moringa oleifera seed as a natural coagulant in domestic wastewater tertiary treatment: Physicochemical, cytotoxicity and bacterial load evaluation", this study aimed to evaluate the use of Moringa oleifera seed aqueous extract for tertiary treatment of a domestic wastewater by coagulation, flocculation, sedimentation and rapid granular filtration. It compared the capability of MO seed and alum to remove turbidity, BOD, COD, TOC, nutrients, sludge, pH and alkalinity present in water. MO at the optimal dosage of 600 mg/L showed results statically equal to the use of alum (200 mg/L), achieving bacterial load, turbidity and apparent color removal higher than 99%, 92% and 66%. Effluent treated with MO has improved the cytotoxicity to low providing an effluent less harmful that can be used for drinking and agricultural purpose, so MO seed aqueous extract is a potential substitute of alum.

G. Hemalatha, et.al, (2020) "Sewage water treatment using vetiver grass", in this work a pilot scale experiment was set up to test the efficiency of vetiver removal of pollutants from the grey water collected from the household. It uses wetland technique to treat the water. Water samples are collected from the inlet and outlet and the various tests such as pH, BOD, COD, DO, TSS was carried out. The result showed that the water contamination is less and there is a decrease in pH, BOD, COD and TSS and increase in DO level, so the water is useable for various household purposes.

Rajeswari. M, et.al, (2021) "Modelling and efficiency assessment of the up flow fixed bed process packed with Moringa oleifera for continuous Cd(II) removal from drinking water", the biosorption ability of Moringa oleifera seed powder for the expulsion of cadmium from waste water was investigation by performing packed column tests. At 6g of Moringa oleifera dose, 2 mL/min of flow rate and 33 µg/L of influent cadmium, the cadmium uptake was found to be 65.44 µg/g. The results reveal that the seed contains various active functional groups which are appears to play a significant role in biosorption of cadmium ions. The Cd(II) removal efficiency of 88.6% was attained at optimum process conditions.

Packialakshmi S, et.al, (2021) "Treatment of industrial wastewater using coconut shell based activated carbon", the investigation show that coconut shell charcoal can be effectively utilized as adsorbent for treating the industrial wastewater. It proves that a dosage of 15 g/l is adequate to remove 90% of phosphate and 97% of zinc for 150 µ particle size. It results in the better adsorption capacity of coconut shell charcoal. Freundlich isotherm model fitted best. It is a cost effective technique since it uses inexpensively available raw material.

2.1 Summary of Literatures

- Moringa seed as proves to be effective coagulant activity which can be used as adsorption, coagulants and disinfectants.
- Moringa oleifera seed powder should be used to optimum dosage and when we increase the dosage more than the limit there will be no reduction in the pollutants and it will also form some fine suspended particles present in treated water.

- pH stability is major advantage of Moringa seed over alum To study the efficiency of natural coagulant and adsorbent in collected water sample.
- Activated carbon coconut shell are used as natural adsorbent because they have high micropores range and it attracts many toxic pollutants and settle down is more effective when compare to wood, coal and rice husk activated carbon.
- Coconut shell provides better desalination when equipped in water purification system.
- Addition of coconut shell activated carbon in media filter is more effective in reduction of chloride and hardness.
- Water treated with vetiver contains less contaminants, it shows reduction in BOD level and increase in DO in the effluent.
- When Coconut shell activated carbon, Moringa oleifera seed powder and Chrysopogon zizanioides (Vetiver) combine and used as the filter media there will considerable reduction in pollutants present in water.

III. CONCLUSION

The study demonstrated the 2 different methods for desalinating the brackish water with bio filter developed using Moringa oleifera seed powder, coconut shell activated charcoal and dried vetiver grass. The filter was operated under hydraulic loading of 0.185 L/s/m2. The rate of filtration of the filter is found to be 188.8 L/m2/h and 95% of the total raw water has been obtained water filtration. The raw water from the Chunnambar Estuary was found to be unsuitable for drinking and other potable use. The pH, turbidity of the method 1 filtered water was reported as 4.59 and 23 NTU and TDS and conductivity were reduced by 99.9% and 99.9%. Though the contaminants are greatly reduced, the filtered water had objectionable odour, colour and taste due to the excessive use of the natural coagulant. The Moringa oleifera seed powder should be used in the optimum dosage and if it is used more than the optimum level, the excessive proteins of the seed disperses in water and makes it more turbid and unfit for potable use. The optimum dosage of the natural coagulant was determined as 0.5 g/L by performing jar test. After performing coagulation with Moringa oleifera seed powder, the pH and turbidity were reduced to 7.30 and 3 NTU and the parameters like TDS, chloride, sulphate, hardness and E. coli were reduced by 37.7%, 46.5%, 69.6%, 41.4% and 96.5% respectively. The DO level is increased to 4.762 mg/L whereas BOD is decreased to 15.23 mg/L. The pH and turbidity of the method 2 desalinated water were reported as 7.21 and 2 NTU. The removal efficiency of TDS was found to be 79.5%, 90.5%, 92.3% and 93.8% after the detention of coagulated water for 30 minutes, 1 hour, 2 hours and 3 hours in the filter. Chloride ions were reduced by 79%, 93.4%, 94.9% and 95.2% after the detention of water in the filter for 30 minutes, 1 hour, 2 hours and 3 hours respectively. Turbidity, TDS, conductivity, chloride and sulphate were reduced by 90%, 93.8%, 93.7%, 95.2% and 95.5% respectively after performing desalination by method 2 and were within the permissible limit. The alkalinity level and the concentrations of nitrate, fluoride and iron were also found to be within the BIS specifications for drinking water. The total hardness is reduced by 88.7% by the method 2 desalination process but not meet the permissible limit. The DO level is increased to 6.57 mg/L and BOD is decreased to 1.026 mg/L after performing desalination. 100% removal efficiency of E. coli has been reported after the desalination process. The study concludes that the adopted method is efficient and cost effective technique to desalinate and purify brackish water.

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