International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 12, Issue 11 (November 2016), PP.34-43

Desalination of Water by Using Natural Adsorbents

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Abstract:- Growing population, accelerating pace of industrialization and intensification of agriculture and urbanization exert heavy pressure on our water resources. With the increase in the age of the earth, clean water is becoming more precious because water is being polluted by several manmade activities, e.g., rapid population growth, alarming speed of industrialization and deforestation, urbanization, increasing living standards and wide spheres of other human activities.Chlorides are generally present in water in the form of NaCl. Chloride in concentration above 600mg/l tends to give water a salty taste. WHO specifies highest desirable concentration of chloride in portable water must be 200ppm. Chloride attack is one of the most important aspects for consideration when we deal with the durability of concrete. Chloride attack primarily induces corrosion, which is responsible for 40% of the failure of structure .As per IS46:2000 the water used for mixing and curing concrete should comprise a chloride content with a permissible limit of 2000mg/l for plain concrete and 500mg/l for reinforced concrete work. In industries there are various methods adopted to produce potable water, of which, the adsorption process is a widely used phenomenon.Water desalination is mean for producing fresh water from saline water abundant in seas and oceans. Various technologies have been used to desalinate sea water such as Adsorption, Reverse Osmosis (RO), Multistage Flash Distillation (MSF), Mediated Electrochemical Oxidation (MEO), Electrolysis, and Ion Exchange. Among them, physical adsorption method is generally considered to be the best, effective, low-cost and most frequently used method for the removal of salts. Here for the removal of chlorine we are using different types of adsorbents such as coconut shell and sugarcane baggase. The objective of our project is to find the adsorption capacity of coconut shell and sugarcane bagasse for the removal of chloride ion in water. The adsorption capacity is found out by Batch studies which include Effect of dosage, Effect of pH, Effect of initial concentration, and adsorption capacity is found out theoretically by Langmuir adsorption isotherm and freundlich adsorption isotherm. The packed bed column study was carried out only for coconut shell powder because it gives maximum removal efficiency for chloride ion removal.

Keywords:- Removal, Adsorption, Hardness, Seawater, Coconut Shell, Sugarcane Bagasse, Langmuir and Freundlich.

I. INTRODUCTION

Water is an essential compound for the survival and sustenance of life on the planet earth. Water is frequently referred to as a universal solvent, because it has the ability to dissolve almost all substance; that comes in its contact. There are various purification methods to make water potable, as required by the public water supply scheme. The water required for domestic consumption should possess a high degree of purity and should be free from suspended impurities, bacteria, etc. Thus, the drinking water must meet the highest standard of purity, which is possible by maintaining the various constituent concentrations in water within the permissible limits. In industries there are various methods adopted to produce potable water, of which, the adsorption process is a widely used phenomenon.

Salinity is the saltiness or dissolved salt content of a body of water. Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water. Now-a-days attention has been focused on the development and use of low cost adsorbent based on waste material. This has shown that many of these materials act through an ion exchange mechanism and that the functional sites are frequently carboxyl or phosphate groups. In this project adsorbent prepare from endocarp of coconut i.e. Coconut Shell powder as well as sugarcane baggase powder is used and functional group was found out by using FTIR Test.

The influences of several parameters, such as pH, initial concentration, and adsorbent dose on the adsorption process are investigated, and adsorption capacity is found out theoretically by Langmuir adsorption isotherm and freundlich adsorption isotherm. Nature has provided plenty of resources that are used to sustain and develop life on the planet. One of the most important resources available to us is water, which was present long before the evolution of life and without it life is not possible. The available water is distributed in an uneven manner.

A. Adsorption

Adsorption is the phenomenon of accumulation of large number of molecular species at the surface of liquid or solid phase in comparison to the bulk. The phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or a solid resulting into a higher concentration of the molecules on the surfaces called adsorption.

II. METHODOLOGY

A. Preparation of artificial sea water

For preparation of artificial sea water I have prepared the standard sodium chloride solution of 0.0141N. This standard sodium chloride solution was prepared by dissolving 824.1mg of NaCl in Chloride free water and dilute to 1 lit.

The solution used for this experiment is of different chloride concentration. I have selected three different concentrations as 100mg/lit, 150mg/lit and 200mg/lit respectively.

B. Materials

Materials are the main constituents which are required to perform experimentation. The materials used in this study are; water, low cost locally available adsorbent i.e. coconut shell powder as well as sugarcane bagasse powder.

Fig 1: Image of Coconut Shell Powder

Fig 2: Image of Sugarcane Bagasse Powder

C. Preparation of Adsorbents

1. Adsorbents were bought at Market and selectively picked .
2. It was soaked for about one hour in water, well scrubbed using a sponge and tap water and then sun dried for three (3) hours.
3. The dried material was then placed on a clean hard surface and broken into smaller pieces with the use of a hammer.
4. These adsorbents then dried in oven at 70o C for 24 hrs and ground to a fine powder and sieved through 600 micron and 300 micron sieves.
5. The 600 micron particle size powder and 300 micron size powdered material were selected for the adsorption and pH study.
6. Materials were dipped in a 1N HCl for 5 hrs. then washed with distilled water, dried and used for the study.[11]
7. The proportion was 70ml of HCL and 930ml of distilled water to make 1N HCL solution.

D. Infrared (IR) spectra study

The IR spectral analysis is important to identify the characteristic functional groups on the surface of the adsorbent, which are responsible for adsorption of chloride ions. IR Spectra of coconut Shell and Sugarcane Bagasse were collected from Sanjivani College of Pharmaceutical Education and Research, Kopargaon, by giving the sample powders of the same. It is a graph plotted between % transmission and wave number. These particular graphs used to identify adsorption friendly functional groups that are responsible for adsorption property**.**

E. Batch mode adsorption studies

Effect of several parameters such as pH, concentration of chloride ion and concentration of adsorbent on adsorption of chloride on prepared adsorbents was studied by batch technique. All experiments were carried out at room temperature so as to avoid the heating of effluent. Batch experiments were carried out at an agitation of 120 rpm, samples at predetermined time intervals were collected, filtered by whatman filter paper and remaining c chloride was analyzed bytitration method. All experiments were carried out at pH values 8 and the initial concentration of metal ion for 100 mg/L, 150 mg/L and 200mg/L. Adsorbent dose of 3gm to 18 gm/l and particle size of 300μm and the contact time of 60min. The percentage removal of chloride ions from the solution was calculated using the equation,

$$\% \text{ Removal} = Ci - Cf / Ci \times 100$$

Where Ci is initial concentration of chloride ions, Cf is final concentration of chloride ions.

F. Packed-Bed Column Studies

As quoted earlier low cost adsorption techniques becoming more popular tool day by day for separation which demands innovation of cheaper and non-toxic easily available adsorbent. Knowledge of the conditions under which the Adsorbent gives best performance is much necessary to make adsorption efficient. This consideration in the study helps in designing and predicting prerequisite for the unit to be implemented.

In the present study, the parameters such as initial concentration (Co), pH, flow rate (F), were studied against the capacity of adsorbent by plotting break through curves. Accordingly observations were obtained, proving the adsorbent as the better adsorbent for the removal of the Chloride ions.

In the present work by varying initial metal ions concentration as 100 and 200 mg/l, flow rate of chloride ions solution as 2 and 2.5 LPH and pH at 8 and 10, at room temperature. Experiments were carried out at different conditions varying one parameter and keeping others at constant.

Experiments were performed in the glass columns of 3 cm diameter and 23 cm in height. The effect of these parameters on the breakthrough time is calculated and represented in graphical form.

Break Through Time- Break through time plays an important role in industrial application, so as to incorporate the best effective continuous adsorption system. It is essential to know the break through points of the used adsorbent, for deciding the efficient and effective parameters in adsorption process by continuous fixed bed system. Break through time is the time when the bed is supposed to be completely saturated by the adsorbate (chloride ions) and at this time final concentration of the effluent coming out from the column is nearly equal to the initial concentration of the chloride ions solution.The break through point and break through time can be determined using the plots of time vs. C/Co.

III. RESULT AND DISCUSSION

A. Infrared (IR) Spectra study

IR Spectra graph is taken between the wave numbers 4000 cm-1 and 1000 cm-1 of coconut shell and sugarcane bagasse is presented in following figures .The peaks appearing in the FTIR spectrum were assigned to various functional groups according to their respective wave numbers. The FT-IR spectrum of coconut shell as well as sugarcane bagasse representing the plot of percentage transmission versus wave number, is given in respective Figures i.e fig 3 and 4.

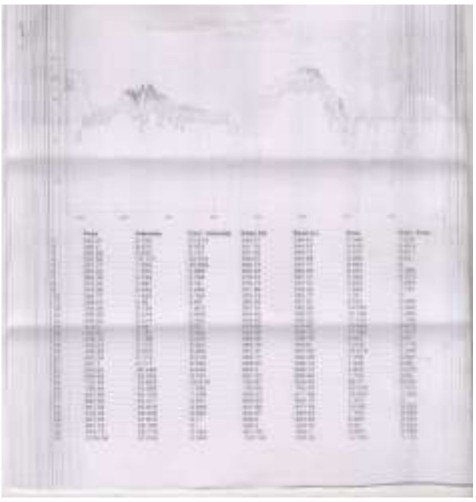

Fig 3: IR Spectra for Coconut Shell Powder

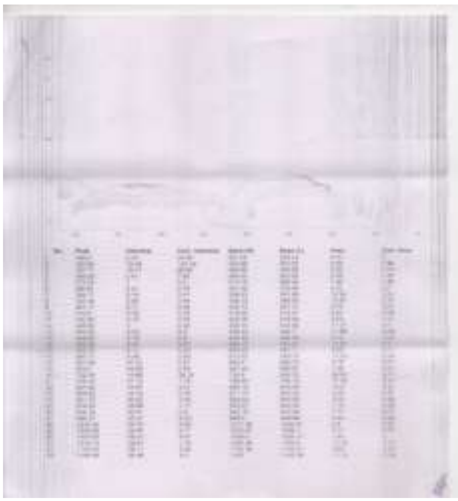

Fig 4: IR Spectra for Sugarcane Bagasse Powder

B. Batch mode adsorption studies

I) Effect of pH: pH variation is one of the most important parameters controlling the uptake of chloride ions from salinated water. The studies were conducted at room temperature with an initial ion concentration of 100 mg/l, 150 mg/l and 200 mg/l and constant adsorbent dose of 10gm/100ml solution, at an agitation of 120rpm for 60 minutes. Effect of pH on adsorption was studied at ranges of 2, 4, 6, 8, and 10 in each solution. It was noticed that the ability of removing chloride by adsorbent depends on pH of solution and this depends on the ion state and nature of material.. Adsorption capacity was found to increase with an increase in the pH, maximum adsorption being observed at a pH of 8-8.2.The percentage adsorption increases with increase in pH, and the maximum range of adsorption was observed at pH 8 and then decreases above pH 8 for both adsorbents which is shown in fig 5 and fig 6.

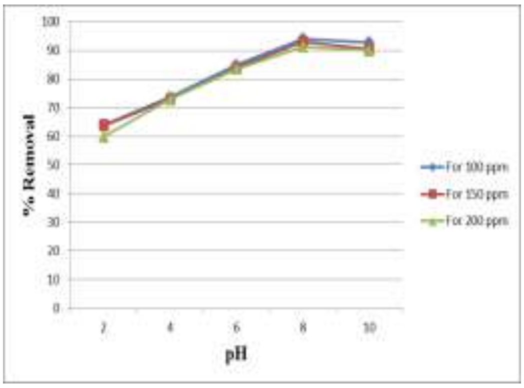

Fig 5: Effect Of pH On Percentage Removal Of chloride by using Coconut Shell Powder as a Adsorbent.

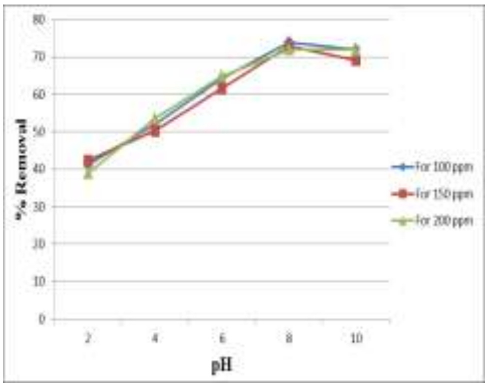

Fig 6: Effect of pH On Percentage Removal Of chloride by using Sugarcane Bagasse Powder as Adsorbent.

II) of amount dose of Adsorbent on Percentage Removal of Chloride

As the amount of adsorbent was increased for Chloride removal, the available number of vacant sites for adsorption also increased. Hence adsorption of chloride ion significantly increased with an increase in amount of adsorbent. The studies were conducted at room temperature with an initial ion concentration of 100ppm, 150ppm and 200ppm with pH of 8 at an agitation of 120rpm and a period of 60min. Effect of amount of adsorbent was conducted at adsorbent doses 3gm/l, 6gm/l, 9gm/l,12gm/l ,15 gm/l. and 18 gm/l. for stock solution. Removal is highly effective at the dose of 18g, and the removal efficiency decreases gradually with decrease in adsorbent dosage for both adsorbents but high removal seen in case of coconut shell powder. Results obtained shown in fig 7 and fig 8.

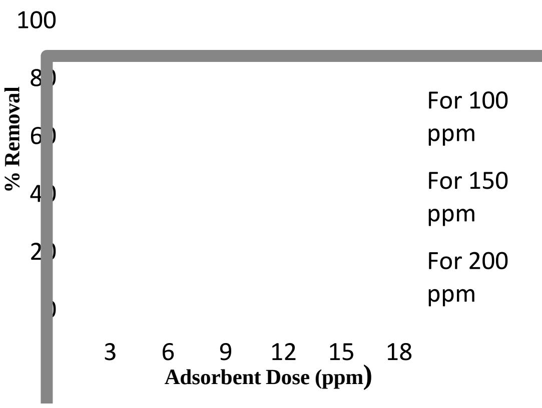

Fig 7: Effect of amount dose of adsorbent on Percentage Removal Of chloride by using Coconut Shell powder as a Adsorbent

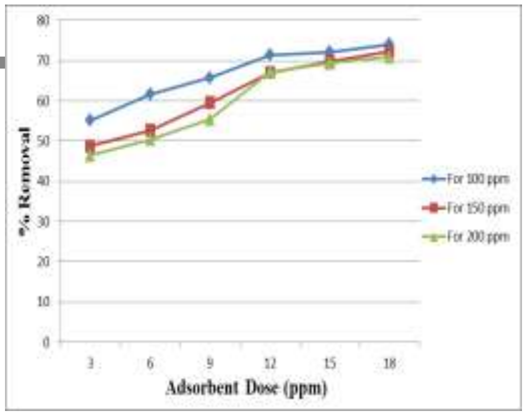

Fig 8 Effect of amount dose of adsorbent on Percentage Removal Of chloride by using Sugarcane Bagasse powder as a Adsorbent

III) Effect of initial concentration of chloride ions on removal of chloride

The adsorption of chloride ion on adsorbent depends on initial concentration and it can be seen that percentage removal decreases with increase in initial chloride ion concentration. At lower initial chloride ion concentrations, sufficient adsorption sites are available for adsorption of chloride ions. However, at higher concentrations the number of chloride ions relatively higher compared to availability of adsorption sites. The studies were conducted at room temperature at constant adsorbent dose of 12 gm/l solution, with pH of 8 at an agitation period of 60 min. Effect of initial concentration of chloride ions was conducted at ranges of 100ppm, 200ppm, 300ppm, 400ppm, 500ppm, 600ppm, 700ppm and 800ppm. The percentage removal is highly effective on 100ppm initial ion concentration, after which percentage removal decreases gradually. Results obtained shown in fig 9.

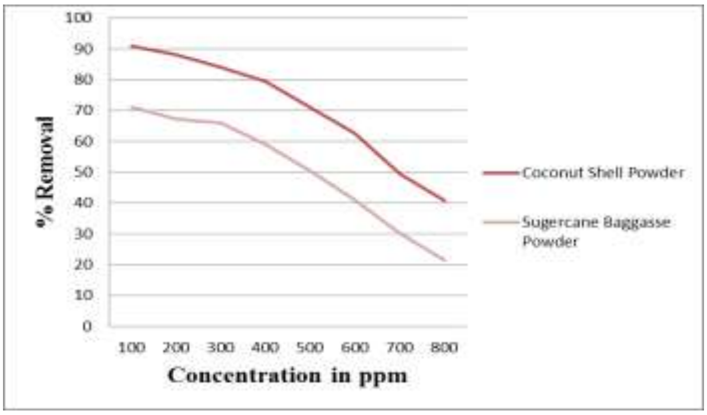

Fig9: Effect of initial concentration of chloride ions on removal of chloride.

IV) Equilibrium Isotherms

Adsorption isotherms describe how adsorbates interact with adsorbents and so are critical in optimizing the use of adsorbents. Thus, the correlation of equilibrium data by either theoretical or empirical equations is essential to the practical design and operation of adsorption systems. Isotherm studies have been performed for different experimental systems. Chloride is removed from waste water at different adsorbent ranging from 2.5mg/L to 15mg/L using coconut shell powder and sugarcane bagasse powder. In order to optimize the design of a sorption system to remove Chloride from effluents, it is important to establish the most appropriate correlation for the equilibrium curves. Two isotherm equations have been tested in the present study, namely, Langmuir and Freundlich.

B. Adsorption Isotherms:

Various isotherm models were used for investigation of adsorption capacity in adsorption of Chloride ions from artificial solution. The two models introduced in this study are Langmuir and Freundlich isotherms.

3.1 Langmuir isotherm model:

The Langmuir explains that the adsorption process occurs on the homogeneous surface of the adsorbent by monolayer of the adsorbate which has specific active sites. The linear equation is given by-

$$\frac{Ce}{qe} = \frac{1}{KLqm} + \frac{Ce}{qm}$$

where kL is Langmuir equilibrium constant (L/mg), and qm (mg/g) is the monolayer adsorption capacity, which were calculated from a plot Ce/qe versus Ce (adsorbed equilibrium concentration) Figure 10and 12 . The characteristic parameter of Langmuir isotherm can be illustrated in terms of dimensionless equilibrium parameter, RL known as separation factor -

$$RL = \frac{1}{1+KLCo}$$

where Co in this case is the highest initial solute concentration. The value of separation factor gives an indication for the type of the isotherm and the nature of the adsorption process. Regarding the RL value, adsorption can be unfavorable (RL >0), linear (RL= 1), favorable (0 <RL <1) or irreversible (RL =0). The plots of Ce/qe versus Ce show high linearity confirmed by the values of the correlation
Coefficient R2, which indicated that the isotherm data fit this model.

3.5.2. Freundlich isotherm model

The Freundlich model is usually used to explain the adsorption by a heterogeneous surface of an adsorbent. The well-known logarithmic form of Freundlich is defined by the following equation:

$$\ln q_e = \ln K_f + \frac{1}{n} \ln C_e$$

where Kf (L/g) and n are Freundlich constants related to adsorption capacity and adsorption intensity, respectively.The slope and intercept of straight portion of the linear plot were obtained by plotting ln(qe) versus ln(Ce) figure 11 and 13. The correlation coefficient is used as a tool to determine the best fitting parameters for each model, and to determine the adsorption process that is observed. It is observed that the linearity coefficient was high, and this gives better indication that the adsorption process is followed by the Langmuir isotherm. The correlation coefficient (R2) of 0.99 for both adsorbents indicated that the adsorption process could be best described by Langmuir isotherm for both of the adsorbent.

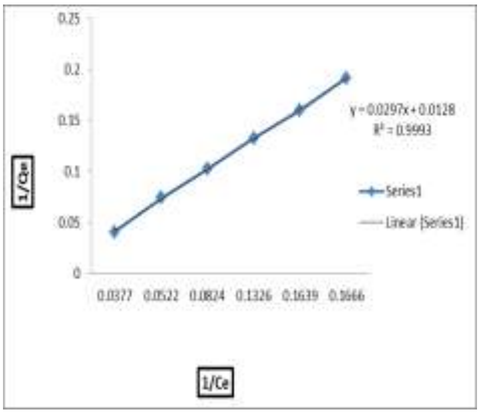

Fig.10:Langmuir Isotherm for Coconut Shell powder

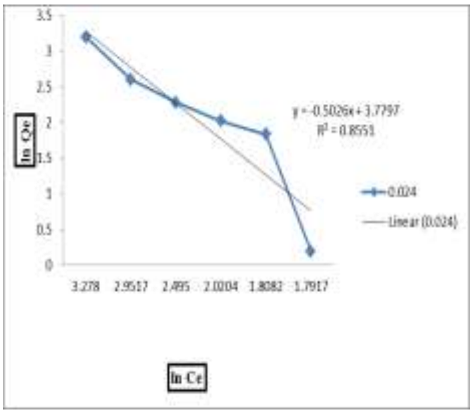

Fig.11: Freundlich Isotherm for coconut shell powder

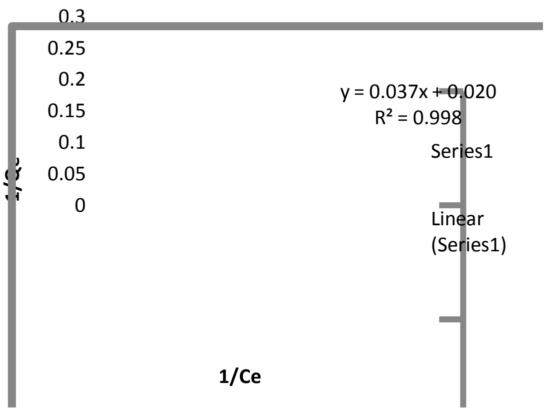

Fig 12:Langmuir Isotherm for Suagarcane powder

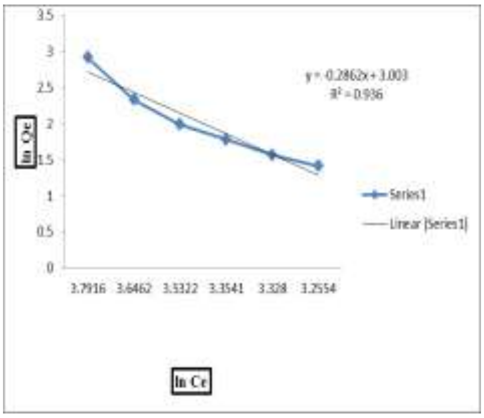

Fig 13: Freundlich Isotherm for Suagarcane powder

V) Packed-Bed Column Studies

The dynamic behavior of a packed bed column is described in terms of breakthrough curve. A plot of effluent concentration versus time is referred as breakthrough curve. The breakthrough profile of chloride ions adsorption on given adsorbent for a given flow rate, chloride ion concentration and pH are shown in following figures.

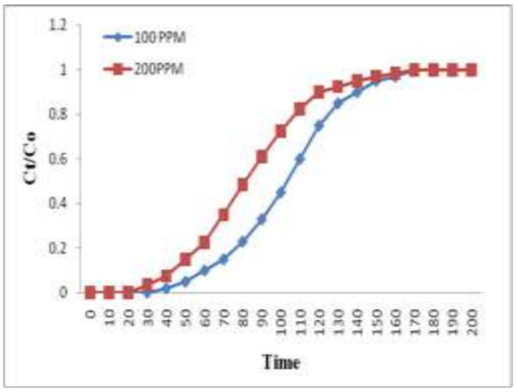

Fig 14: Effect of Concentration with pH 8, Flow rate 2 LPH

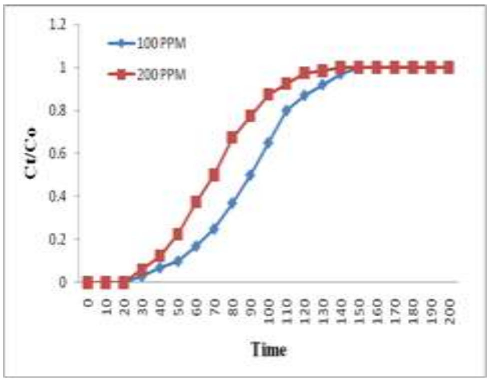

Fig 15: Effect of Concentration with pH 10, Flow rate 2 LPH

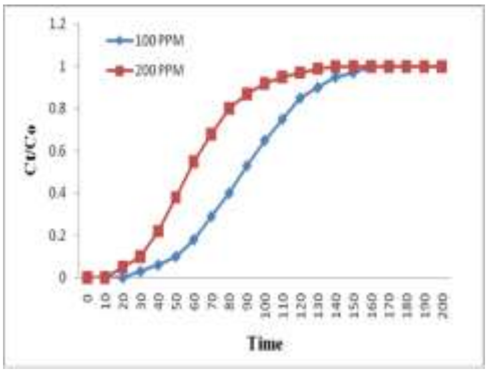

Fig 16: Effect of Concentration with pH 8, Flow rate 2.5 LPH

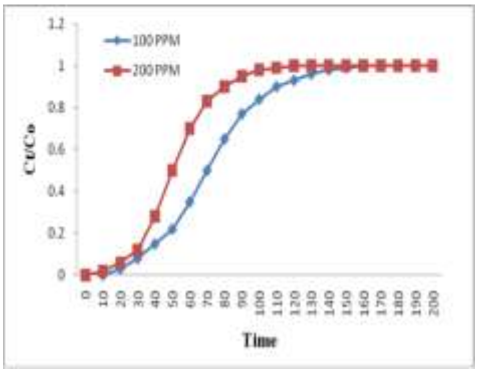

Fig 17: Effect of Concentration with pH 10, Flow rate 2.5LPH

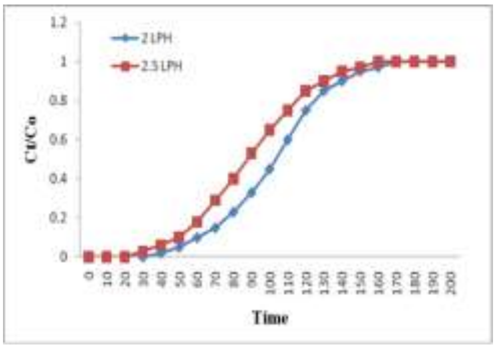

Fig18: Effect of flow rate with Concentration 100 PPM, pH 8

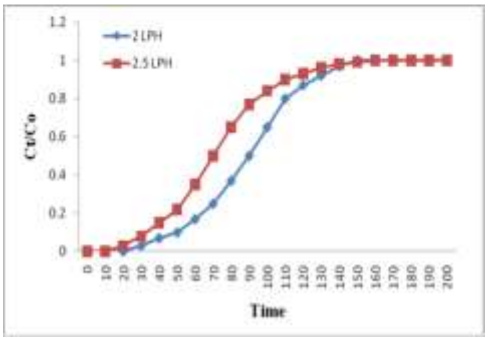

Fig 19: Effect of flow rate with Concentration 100PPM, pH 10

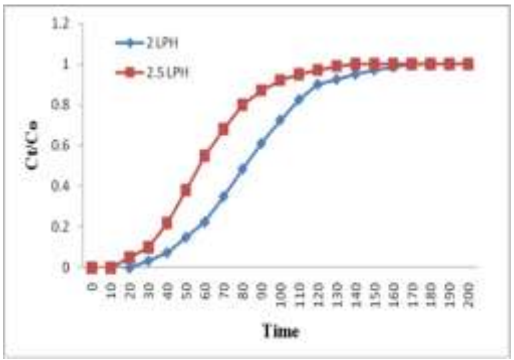

Fig 20: Effect of flow rate with Concentration 200 PPM, pH 8

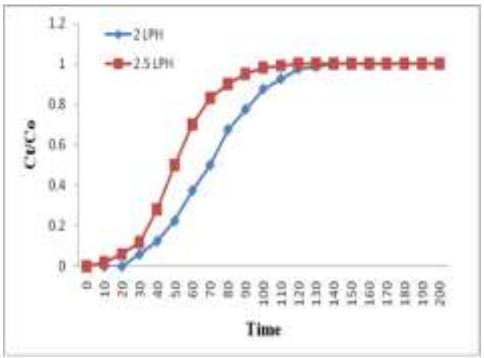

Fig 21: Effect of flow rate with Concentration 200PPM, pH 10

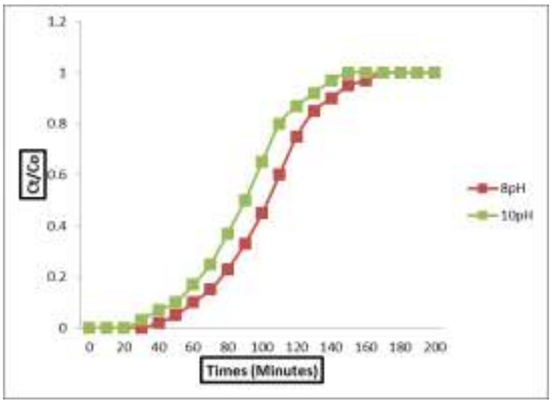

Fig 22: Effect of pH with Concentration 100 PPM, Flow rate 2 LPH

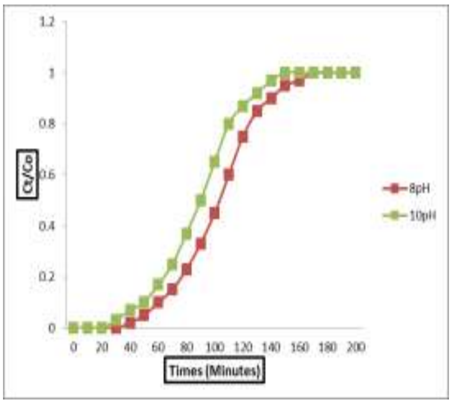

Fig 23: Effect of pH with Concentration 200PPM, Flow rate 2LPH

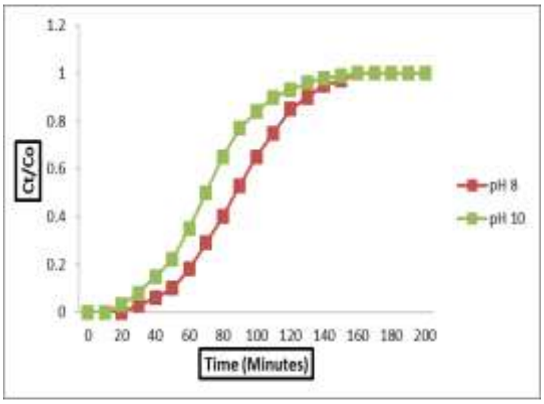

Fig 24: Effect of pH with Concentration 100 PPM**,** Flow rate 2.5LPH

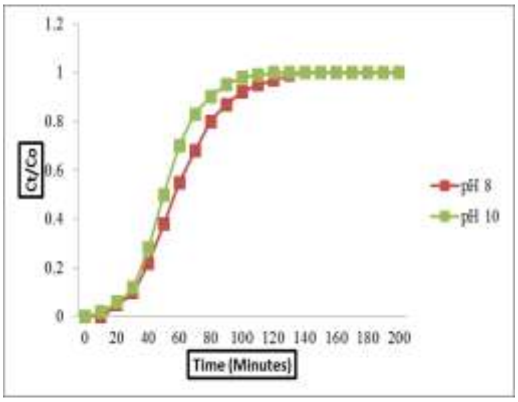

Fig 25: Effect of pH with Concentration 200PPM, Flow rate 2.5LPH

IV. CONCLUSIONS

1. Chloride removal by using new natural adsorbent like coconut shell powder and sugarcane bagasse powder was studied.
2. Infrared (IR) Spectra study shows the presence of nitrite group, Alcoholic group and hydroxyl groups which are responsible for adsorption process in both adsorbents.
3. Batch test on Artificial salinated water recommends that, a coconut shell powder dose of 100g/L produces appreciable removal of 94% high saline water respectively with residual chloride 18 g/L of at 8 pH at contact time 60minutes as well as sugarcane bagasse powder dose of 100g/L produces appreciable removal of 74.07% high saline water respectively with residual chloride 18 g/L of at 8 pH at contact time 60minutes from this it is observed that the coconut shell powder has great efficiency of removal of chloride from artificial sea water
4. The adsorbents and adsorbate followed the Langmuir and Freundlich isotherms. Values of the equilibrium parameter (R2) from Langmuir isotherm and Freundlich isotherm were found < 1 this indicate that the adsorption process is favorable for the chloride ions. The equilibrium data also fit well with the Langmuir adsorption isotherm for both adsorbents.
5. For the continuous study from the experiment it is observed that due to increase in the initial concentration of the chloride ions in the inlet stream, the break through time decreases that means the adsorbent bed reached at the exhaustion earlier. It this study it is observed that exhaustion time approaches at lower values of 120 min at high value of initial concentration of chloride ions solution as 200 mg/l in inlet stream, and exhaustion time approaches at higher values of 160 min. at low value of the initial concentration of chloride ions solution as 100 mg/l in feed stream.
6. From the experiment it is observed that due to increase in the initial pH of the chloride ion solution in the inlet stream, the break through time increases at 8 solution pH and then it decreases. That means the bed reached at the exhaustion earlier at solution pH equal to 10 and the bed reached at the exhaustion later at solution pH equal to8. Thus the pH value of 8 has been found to be optimum one.
7. It is also observed that exhaustion time approaches at lower values of 130 min at low value of pH of chloride ions solution as pH 8 in inlet stream, and exhaustion time approaches at higher values of 160 min. at low value of the pH of chloride ions solution as pH 10 in inlet stream.

8. It was observed that the break through time decreases, as the flow rate is increases. If the flow rate is increased the inlet concentration of chloride increases with time and also the contact time of the chloride ions in water with adsorbent decreases.

9. It is also observed that exhaustion time approaches at lower values of 120 min at high value of flow rate of chloride ions solution as 2.5 LPH in inlet stream, and exhaustion time approaches at higher values of 160 min. at low value of the flow rate of chloride ions solution as 2 LPH in feed stream.

From proposed results, it can be suggested that coconut shell powder adsorbent can be effectively used for the removal of chloride ions from sea water.

ACKNOWLEDGMENT

I am highly indebted to my guide Prof. Ms.Sasane V.V. for her meticulous guidance. The paper has taken its shape because of her constant and keen supervision. I would like to offer my sincere thanks to Dr. M. V. Jadhav (PG Co-ordinator SRESCOE, Kopargaon) for the encouragement and motivation. I would like to express my gratitude towards Prof. M.S.Purkar (H.O.D. Civil Department, SRESCOE, Kopargaon) for his guidance at various stages of the seminar work. I am equally grateful to Dr. D.N.Kyatanavar (Principal, SRESCOE, Kopargaon) for his kind co-operation.

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