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RESEARCH ARTICLE

Assessment of Fixed Bed Column Reactor using Low Cost Adsorbent (Rice Husk) for Removal of Total Dissolved Solids

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Abstract

A continuous fixed bed column reactor was designed using low cost media and was assessed for its efficiency of treatment of ground water. The sorption capability of Rice Husk (media) for removing Total Dissolved Solids and Calcium, Magnesium and Chloride ions was evaluated in a fixed bed column reactor. The column experiment was conducted by varying the bed height and solution flow rate. It was observed that by increasing the flow rate of influent synthetic sample, the TDS removal efficiency decreased from 21% to 10.56% as the flow rate was increased from 40 to 102 mL/min. Due to increase in the influent flow rate, the contact period of ground water with the risk husk (media) decreased which resulted in less amount of adsorption of TDS by the media and therefore less removal .At a flow rate (40 mL/min), it was observed that removal efficiency of TDS is 20.79% at a height of 10 cm from the base of column;13.81% and 10.10% for the heights 20 cm and 30 cm respectively. It was inferred that removal efficiency increases as the depth of the adsorption media increases due to greater surface area available for the sample for adsorption. It was also observed that rice husk has a tendency to adsorb a greater amount of calcium ions in comparison to chloride and magnesium ions. This was verified from our observations when at flow rate of 40mL/min and at a height of 10 cm from the base of the column, removal efficiency for calcium ions is 37.5% and for chloride and magnesium ions is 22.33% and 19.9% respectively.

Introduction

Rapid industrialization and massive urbanization in the past decades has led to increase in the concentration of total dissolved solids in the ground water. The industrial effluent is discharged into river bodies without being adequately treated leading to increase in TDS content. Also, the rise in the application of fertilizers and pesticides in agricultural activities has raised the concentration of arsenic and fluoride in the ground water. TDS concentration has been observed to be considerably more in areas with agricultural activities. The use of modern technologies like reverse osmosis to reduce the TDS content to make water potable involves discharging the reject back in to the water table thereby further increasing the concentration of dissolved solids in the ground water. The above scenario necessitates the adoption of new cost effective, easily adaptable, efficient techniques for removal of TDS from ground water.

In the past studies have been carried out to evaluate Rice husk, as an adsorbent for the removal of various pollutants from water and wastewaters. Activated carbons, prepared from low-cost mahogany sawdust and rice husk have been utilized as the adsorbents for the removal of acid dyes[1] from aqueous solution in the past[2-4]. Mechanisms in the biosorption process such as chemisorption, complexation, adsorption-complexation on surface and pores, ion exchange, micro precipitation, and surface adsorption have been studied to assess the process of treatment of water

and wastewater [5][6]. Rice husk, which is a relatively abundant and inexpensive material, has been investigated as an adsorbent for the removal of various pollutants from water, wastewaters.[7-9]and agricultural wastes[10][11].
Fixed bed adsorption studies of Rhoda mine B dye, for As(III),As(V), Cu2+ removal from solution using expanding rice husk [12-14]have assessed the potential of Rise husk for removal of these ions through isotherm and kinetics studies[15-17].Low cost Adsorbents can potentially be an effective solution in future for treatment of water in rural areas[18-29].
Through this study, we further evaluate the efficiency of Rice Husk in removal of TDS and ions such as Calcium, Magnesium and Chloride from ground water.

2. Materials and Methods

2.1. Media used

Rice husk was used as the adsorption media for removal of TDS .It was obtained from a rice mill in Bawana village (located in North West Region of Delhi). It was crushed to form finer aggregates to be used as media in the column reactor.

2.2. Synthetic Sample Preparation

The water sample used for testing purposes of the adsorption column was a synthetic salt solution of T.D.S 1890 mg/L prepared by dissolving sodium chloride (common salt), salt of calcium and salt of magnesium in distilled water.

2.3. Column set up

A PVC column with an inner diameter of 10.15 cm and a length 70 cm was used. The bottom of the column was sealed off with a plastic cap to prevent the loss of adsorbent during the process.
4 different outlets are provided at different heights with 10 cm in the column (as shown in the figure). Water reservoir (bucket) is kept at a certain height above the column to allow water to flow under the action on gravity into the column. A clinical drip was attached from the water reservoir to the column to maintain a constant flow rate of water.
Rice husk (media) is compacted tightly inside the column through which the sample water flows downward. Head loss maintained for the proper functioning of the apparatus and continuously maintained. Finally the water passing through the packed media is collected from one of the outlets into a collecting device (beaker).

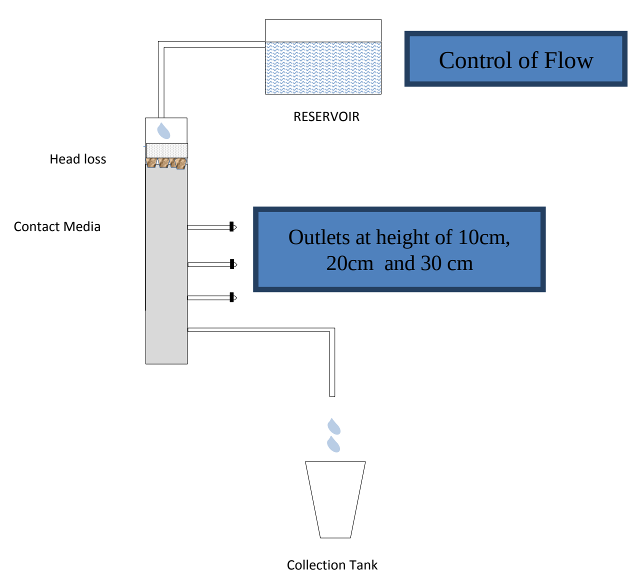

Figure 1. Experimental Setup of the reactor for treating ions

3. Results and Discussion

3.1 Sieve analysis

Sieve analysis was performed to determine the particle size of the risk husk that we used in our study . This test is necessary because it provides us with treatment efficiency of risk husk with respect to a particular size of particles

Physical characteristics of the absorption media (rice husk) used:

- Weight of rice husk used in column: 636 gm.
- Height of husk in column: 70 cm
- Diameter of column: 10.15 cm or 4 inch
- Volume of husk column: 5675.12 cm^3
- Density of rice husk: 112 kg/m^3

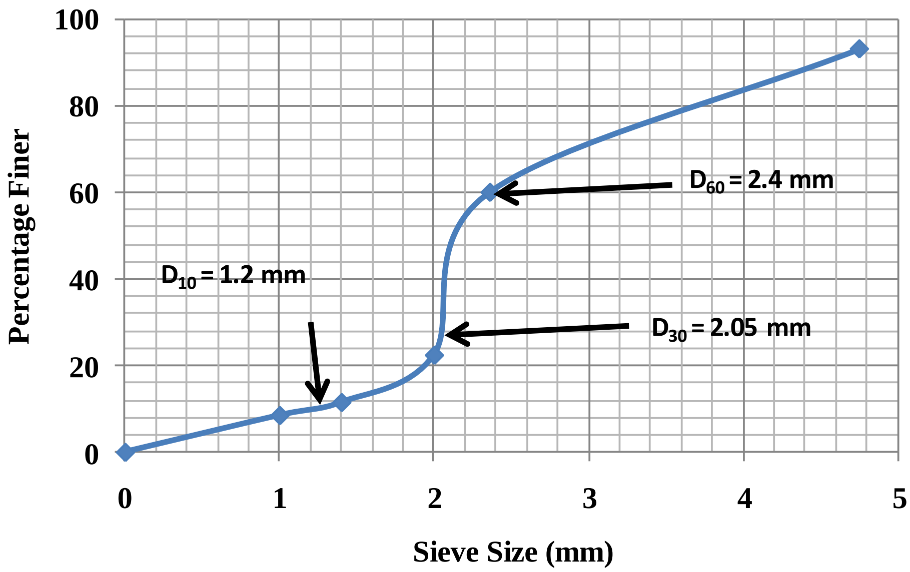

Figure 2. Sieve analysis of rice husk

The following points can be inferred from the sieve analysis of rice husk:

- Effective Size of rice husk, D_{10} = 1.2mm
- Coefficient of uniformity, C_u= D_{60}/D_{10} = 2.4/1.2= 2
- Coefficient of curvature, C_c = $D_{30}^2/(D_{60} \times D_{10})$ = $2.05^2/(1.2 \times 2.4)$ = 1.45

3.2 Assessment of efficiency at different flow rates

The adsorption column was set-up in the Environmental Engineering Laboratory in a PVC pipe of 4-inch diameter .The flow rate in the reactor was controlled using an Intravenous set which was purchased from a medical store. The flow rate was kept in the range of 40 mL/min to 120 mL/min using the IV set and tests were carried out on the samples within this range of flow rate.

The outlets were kept at gaps of 10 cm of depth. At one point of time effluent was collected a single outlet only while the others were closed using clips. A synthetic solution similar in characteristics to ground water in North West region of Delhiwas used for testing of the adsorption column.

Table 1: Experiment at Flow rate of 40 mL/min

Characteristic	Influent (mg/L)	Effluent (mg/L) at 30 cm from base	Removal at 30 cm	Effluent (mg/L) at 20 cm from base	Removal at 20 cm	Effluent (mg/L) at 10 cm from base	Removal at 10 cm
Calcium	370	260	29.75%	241	34.75%	231	37.5%
Magnesium	350	316	9.7%	290	16.9%	280	19.9%
Chloride	1140	912	20.1%	903	20.8%	885	22.33%
TDS	1890	1618	14.39%	1535	18.7%	1497	20.79%

Table 2: Experiment at Flow rate of 80 mL/min

Characteristic	Influent (mg/L)	Effluent (mg/L) at 30 cm from base	Removal at 30 cm	Effluent (mg/L) at 20 cm from base	Removal at 20 cm	Effluent (mg/L) at 10 cm from base	Removal at 10 cm
Calcium	370	323	12.75%	291	21.25%	268	27.5%
Magnesium	350	322	7.69%	305	12.8%	300	14.1%
Chloride	1140	977	14.25%	975	14.5%	951	16.5%
TDS	1890	1744	7.7%	1687	10.74%	1629	13.81%

From the following readings we observed that the removal efficiency decreases as the flow rate of the influent is increased, this was because the contact period for the adsorption of dissolved solids is decreased if the flow rate is increased. Hence we observe maximum removal efficiency which is around 21% of TDS removal for flow rate of 40 mL/min and minimum for flow rate of 120 mL/min which is around 10% of TDS removal.

Also, it can be observed that removal efficiency is maximum when the depth of outlet is the maximum, thus providing maximum contact area for the sample before the effluent is taken out. Considering a particular flow rate (40 mL/min), we note that removal efficiency of TDS is 20. 79% at a height of 10cm from the base of column and 13.81% and 10.10% for the heights 20cm and 30cm respectively. Therefore, we infer that removal efficiency increases as the depth of the adsorption media increases due to greater surface area available for the sample for adsorption.

Rice husk has a tendency to adsorb a greater amount of calcium ions in comparison to chloride and magnesium ions. This can be verified from our observations where at flow rate of 40mL/min and at a height of 10cm from the base of the column in table 5.6 where, removal efficiency for calcium ions is 37.5% and for chloride and magnesium ions is 22.33% and 19.9% respectively.

Table 3: Experiment at Flow rate of 120 mL/min

Characteristic	Influent (mg/L)	Effluent (mg/L) at 30 cm from base	Removal at 30 cm	Effluent (mg/L) at 20 cm from base	Removal at 20 cm	Effluent (mg/L) at 10 cm from base	Removal at 10 cm
Calcium	370	334	9.75%	301	18.75%	281	24.75%
Magnesium	350	331	5.3%	317	9.4%	309	11.53%
Chloride	1140	1017	10.75%	1008	11.5%	991	13.1%
TDS	1890	1819	3.7%	1744	7.74%	1699	10.1%

Figures 3-5 indicate removal efficiency of rice husk for various ions at different flow rates and depths.

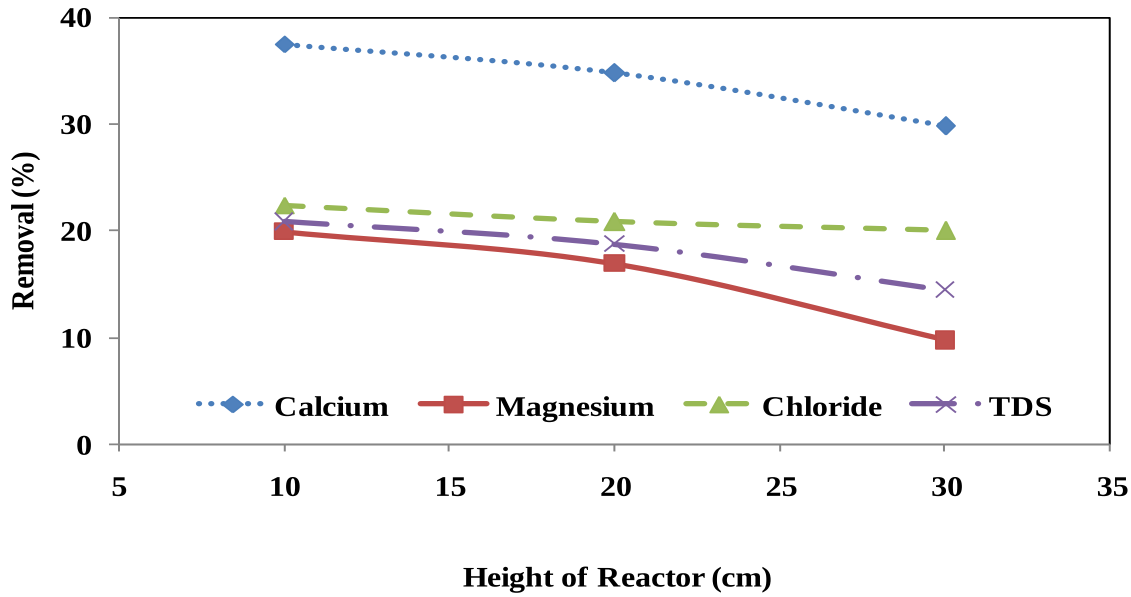

Figure 3: Removal efficiency for various ions at flow rate of 40 mL/min

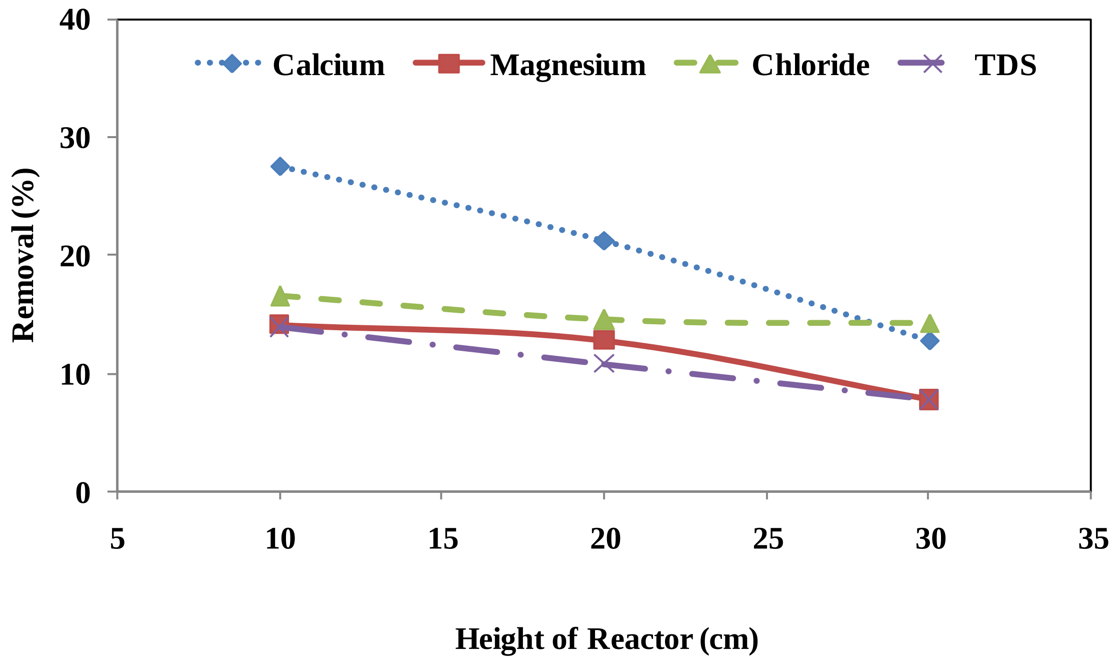

Figure 4: Removal efficiency for various ions at flow rate of 80 mL/min

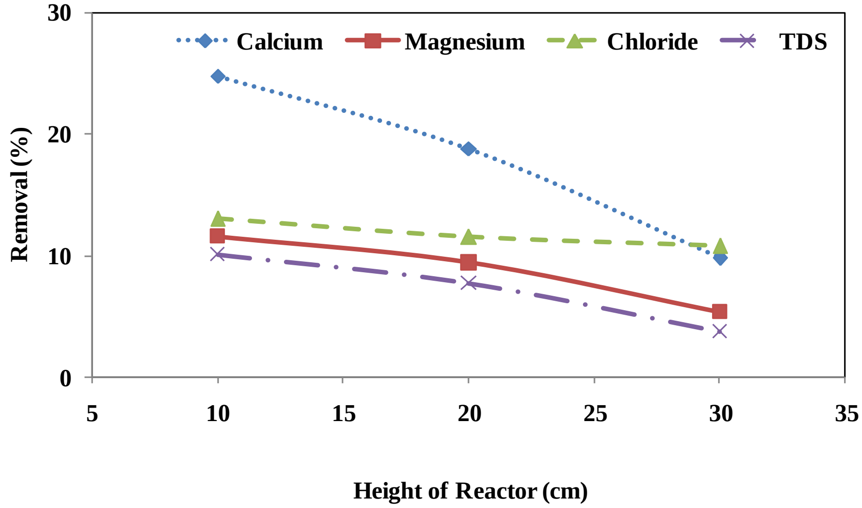

Figure 5: Removal efficiency for various ions at flow rate of 120 mL/min

4. Conclusion

Low cost material rice husk was employed for removal of TDS. Synthetic samples suggested that 20.79% removal can be achieved using rice husk as the adsorption media. It was observed that the percentage removal decreased with increase in the flow rate. When the flow rate was increased from 40mL/min to 120mL/min, the percentage removal of TDS decreased from 20.79% to 10.56%. It was observed that rice husk has a tendency to adsorb a greater amount of calcium ions in comparison to chloride and magnesium ions. This was verified from our observations when at flow rate of 40mL/min and at a height of 10cm from the base of the column, removal efficiency for calcium ions is 37.5% and for chloride and magnesium ions is 22.33% and 19.9% respectively.

References

[1]P.K. Malik (2003).”Use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study of Acid Yellow 36”.Dyes and Pigments, 56(3):239-249

[2]V.K. Gupta, Suhas (2009),” Application of low-cost adsorbents for dye removal– A review”, Journal of Environmental Management, 90 (8)

[3]Aenab AM, SK Singh (2014), “Critical Assessment of River water Quality and Wastewater Treatment Plant (WWTP)”, IOSR Journal of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT), 8(2): 44-48

[4]JN Sharma, Raj Shailesh Kanakiya, SK Singh, (2015), “Characterisation Study and Correlation Analysis For Water Quality of Dal Lake, India”, International Journal of Lakes and Rivers, 8(1), 25-33.

[5]Shashank Shekhar Singh, S.K.Singh (2015). “Identification and Comparison of Flaws in Conventional Treatment Techniques of Fluoride”, International journal of Engineering and Management Research 5(3):215-217

[6]Deepika and S. K. Singh (2015).” Water Quality Index Assessment of Bhalswa Lake ,New Delhi” , International Journal of Advanced Research 3(5): 1052-1059

[7]Gupta, V. K., Mittal, A., Gajbe, V. (2004). “Adsorption kinetics and column operations for the removal and recovery of malachite green from wastewater using bottom ash”. Separation and Purification Technology,Vol 40: 87-96.

[8]T.G. Chuah, A. Jumasiah,I. Azni,S. Katayon, S.Y. Thomas Choong,(2005). ”Rice Husk as a Potentially Low-Cost Biosorbent for Heavy Metal and Dye Removal: An Overview”, Desalination, 175(3):305-316

[9]Ayhan Demirbas (2008).”Heavy metal adsorption onto agro-based waste materials: A review”. Journal of Hazardous Material , 2008 Sep 15;157(2-3):220-229

[10]S.K. Singh, Dhruv Katoria, Dhruv Mehta , Dhruv Sehgal(2015) . “Fixed Bed Column Study and Adsorption Modelling on the Adsorption of Malachite Green dye from wastewater using Acid Activated Sawdust”. International Journal of Advanced Research, 3(7):521-529

[11]SK Singh, Anshika Bisht, (2015). “Environmental Management in Mass Gatherings”, International Journal of Engineering Science & Management. (IJESM), 5(1): 130-138.

[12]Manase Auta (2012).”Fixed bed adsorption studies of Rhoda mine B dye using oil palm empty fruits bunch activated carbon”. Journal of Engineering Research and Studies, Vol. 3.

[13]Khattri, S.D Singh, M.K. (1999). “Color removal from dye wastewater using sugar cane dust as an adsorbent”. Adsorption Science & Technology, 269-282

[14]Dhruv Mehta, Siddharth Mazumdar , S.K. Singh(2015). “Magnetic adsorbents for the treatment of water/wastewater— A review”, Journal of Water Process Engineering 7(9), 244-265

[15]K.Y. Foo, B.H. Hameed(2009). “Utilization of rice husk ash as novel adsorbent: A judicious recycling of the colloidal agricultural waste”. Advances in Colloid and Interface Science,152(1), 39-47

[16]Biswajit Singha, Sudip Kumar Das (2013). “Fixed-bed column study for As(III) and As(V) removal and recovery by bacterial cells immobilized on Sawdust/$MnFe_2O_4$ composite”. Colloids and Surfaces B: Biointerfaces, 107, 97-106

[17]Imran Ali, Mohd. Asim, Tabrez A. Khan (2012).”Low cost adsorbents for the removal of organic pollutants from wastewater”. Journal of Environmental Management, 113,170-183

[18]Md. Ahmaruzzaman (2008).”Adsorption of phenolic compounds on low cost Adsorbents: A review”. Advances in Colloid and Interface Science, 143,(1–2, 4), 48-67

[19]Xuegang Luo, Zaifang Deng, Xiaoyan Lin, Chi Zhang. “Fixed-bed column study for Cu^{2+} removal from solution using expanding ricehusk.Journal of Hazardous Materials”, Volume 187, Issues 1–3, 15 March 2011, Pages 182-189

[20]Lokesh Kumar, S.K.Singh (2015). “Removal of Chloride from Groundwater by Bio adsorption, International Journal of Advance Research”, 3(5), 140-154

[21]Neetu Sharma, D.P. Tiwari, S.K. Singh, (2014), “The Efficiency Appraisal for Removal of Malachite Green by Potato Peel and Neem Bark: Isotherm and Kinetic Studies”, *International Journal of Chemical and Environmental Engineering*, 5(2): 83-88

[22]D.P.Tiwari, S.K.Singh, Neetu Sharma (2014), “Sorption of Methylene Blue on Treated Agricultural Adsorbents: Equilibrium and Kinetic Studies”, Journal of Applied water Science, 4(1)

[23]Abhas Jain, S.K. Singh (2014), “Defluoridation of Water Using Alum Impregnated Brick Powder And Its Comparison with Brick Powder”, International Journal of Engineering Science and Innovative Technology , 3(2)

[24]Neetu Sharma, D.P.Tiwari, S.K.Singh, (2014), “Efficiency of chemically treated potato peel and neem bark for Sorption of direct Red Dye-81 from aquous solution”, Rasayan, 7(4): 399-407

[25]Allaa M. Aenab and S.K. Singh (2012), “Evaluation of Drinking Water Pollution and Health Effects in Baghdad”, Iraq . Journal of Environment Protection, 2012 (3): 533-537.

[26]Neetu Sharma, DP Tiwari and S.K. Singh (2012), "Decolorisation of synthetic dyes by Agricultural Waste: a Review", International Journal at Scientific & Engineering Research, 3(2): 1-10.

[27]SK Singh, Lokesh Kumar (2014), "Characterization of rural drinking water sources in Bhiwani District, Haryana: A Case Study". International Journal of Interdisciplinary Research and Innovations 2(4) : 27-37

[28]Tarundeep Gill ,S.K.Singh, P. Albino Kumar (2015). "Treatment of Heavy Metals Contaminated industrial waste water by Functionalized Polymers", International Journal of Advanced Research, 3(9), 178-181

[29]C.M.VivekVardhan and J.Karthikeya (2011)."Removal of Floride from water using low cost materials", Fifteenth International Water Technology Conference, IWTC-15 2011, Alexandria, Egypt,2011