A Quantum Equilibrium Batch Adsorption Study of Soybean Seed Coats (SSC) Carbon Used in the Process of Iron Removal from Synthetic Solution

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Abstract

This research focused on the severity of iron and a quantum equilibrium study of soybean seed coats (SSC) carbon used in the process of iron removal from synthetic solution**.** Iron is found in soluble and in insoluble form. WHO prescribed the limit of iron is 1.0 mg/L in international standard context and 0.3 mg/L in Indian context. Groundwater quality problem are typically associated with high level of iron concentration observed in some part of India which found the level of 17-20 mg/L of iron. In this research study Soybean seed coats (SSC), activated carbon has been selected for the removal of iron. It has remarkable binding characteristics for removal of iron. It has tested in batch experimental analysis and for different parameters such as dose, pH, Initial concentration, Particle size and Contact time. Maximum uptake capacity of iron was noted at pH 3.5-6.0 with 86.34 % of removal.

Key words: ***Groundwater, Iron, SSC, Adsorbent, Isotherm***

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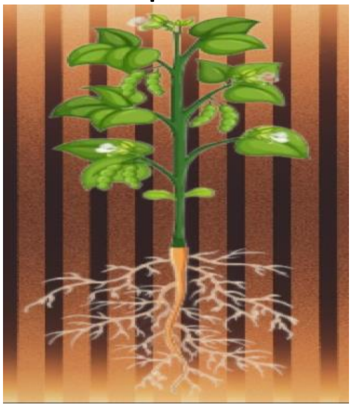
INTRODUCTION

Water is an important constituent of our body. The excess quantity of iron in drinking water leads the problem of lever, heart, joints and continues intake of higher dose may causes savior damages to the living being and its excess continuous intake may also cause the cancer. Verity of adsorbents analyzed by the investigators in the process of adsorption for the removal of iron and found effective low cost adsorbents with the comparison of commercially available adsorbents. In human most of the diseases comes from the polluted water. So water's purity is major factor for good health. Heavy metal pollution is a common environmental problem facing many places worldwide with the rapid development of technology and industries.

Iron is generally divided into two main which are soluble and insoluble. The soluble form of iron is "Clear water" iron which is the most common form and the one that creates the most complaints by water users. This type of iron is identified after you've poured a glass, of cold clear water. If allowed to stand for a few minutes, reddish brown particles will appear in the glass and eventually settle to the bottom. When insoluble iron or "red water" iron is poured into a glass, it appears rusty or has a red or yellow color. Although not very common in Wisconsin's water wells, insoluble iron can create serious taste and appearance problems for the water user. A combination of acid and iron, or organic iron, can be found in shallow wells and surface water. Although this kind of iron can be colorless, it is usually yellow or brown. Finally, when iron exists along with certain kinds of bacteria, problems can become even worse. Iron is an essential mineral for human health in small concentrations (iron deficiency can lead to anemia). Unlike lead and copper, ingesting iron from drinking water is not directly associated with adverse health effects; although, trace impurities and microorganisms that are absorbed by iron solids may pose health concerns. At concentrations most commonly found in drinking water, the presence of iron is not considered a health problem. Iron in drinking water can even provide a health benefit. Small concentrations are essential to human health, because iron helps transport oxygen in the blood. Iron is essential for good health because it transports oxygen in your blood. In India iron mainly found in the states of Tripura (0.11-27.11 mg/L), Assam (0.12-85.76 mg/L), Manipur (0.22-6.78 mg/L), Mizoram (0.01-13.67 mg/L), Nagaland (0.1-3.65 mg/L), Sikkim (0.01-1.38 mg/L), Arunachal Pradesh (0.03-11.90mg/L), Maharashtra (0.11 – 4.1 mg/L) and Karnataka (0.2 - 7.79 mg/L).

Plant Description:



- **Plant height**
  Short: 9 to 24 inch
- **Flower color**
  White to Purple
- **Pod color**
  Light brown
- **Seed color**
  yellow
- **Seed shape**
  Round

Fig.1: Soybean plant
https://www.freepik.com/free-photos vectors/ soybean-plant

MATERIAL AND METHODS

Reagents & Instrumentation used

All used chemicals are AR grades. Hydrochloric acid, hydroxylamine, Phenonthroline, ammonium acetate, Ferrous ammonium sulphate, pH buffer solution etc. were used in this research. The concentration range of adsorbate test solutions was prepared from the stock solutions. Every time fresh solution was prepared for experimentation. pH was adjusted by standard acid and base solutions of 0.1 N HCl and 0.1 N NaOH respectively.

SPADNS photometric method was used for the determination of iron ions, at 570 nm using the double beam UV–vis spectrophotometer (UV–VIS-8500, Tech comp Ltd, Hong Kong). The pH of the solution was measured by using the pH meter of the Elico model (LI613).

Preparation of adsorbent

Soybean Seed Coats (SSC) are collected from the farm located at Amravati district, Maharashtra. Collected Seed Coat was washed with distilled water to remove the dust particles then it was soaked overnight in 0.1 N NaOH solutions and again washed well with distilled water and activated at a temperature of 500 ^{0}C. This burned carbon was washed several times so that the ash and other unwanted substances are removed and only the pure carbon cake remained. The remained dried carbon sieved and use as an adsorbent for this study.

Preparation of synthetic iron solution

Synthetic iron solution was prepared in 1000 mg/L quantity by adding calculated amount of ferrous ammonium sulphate in double distilled water. Then the required concentration was prepared from the stock solution.

Method of analysis

SPADNS photometric method was used for the determinatin of iron ions, at 570 nm using the double beam UV–vis spectrophotometer (UV–VIS-8500, Techcomp Ltd, Hong Kong). The pH of the solution was measured by using the pH meter of the Elico model (LI613).

CHARACTERIZATION OF SSC

The characterization of SSC was done by using various tests such as XRD, SEM, XRF etc. in the laboratory.

X-ray Powder Diffraction (XRD)

XRD test of SSC samples were scanned for 2ø range from 5 to 60°.The X-ray diffraction spectrum pattern. In fig.2, it shows the amorphous nature of the product.

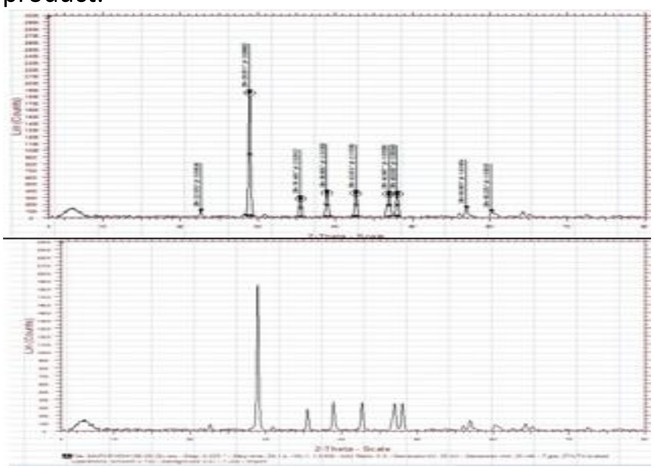


Fig. 2: XRD of Adsorbent SSC

XRD was performed on the treated Soybean Seed Coats (SSC) to predict changes in the crystal structure. Since a few decades ago, one of the most widely used techniques in the modern era for classifying materials and identifying crystals is X-ray diffraction (XRD) examination. SSC, X-ray diffraction before and after, iron ions were adsorbed. Figure shows symmetric, strong peaks in the SSC before iron ion adsorption.

It the position and kind of peaks that result from the adsorption of iron ions, and this peak indicates that the structure is crystalline. No peaks were found to have developed, indicating that the structure is amorphous angles for the samples' scans.

Scanning Electron Microscopy (SEM)

Scanning electrons microscopes analysis was performed to understand the morphology of SSC. From fig.3, it is observed that the openings are enough to remove iron from the water. From fig. 4 shows the openings are blocked after the adsorption of iron.

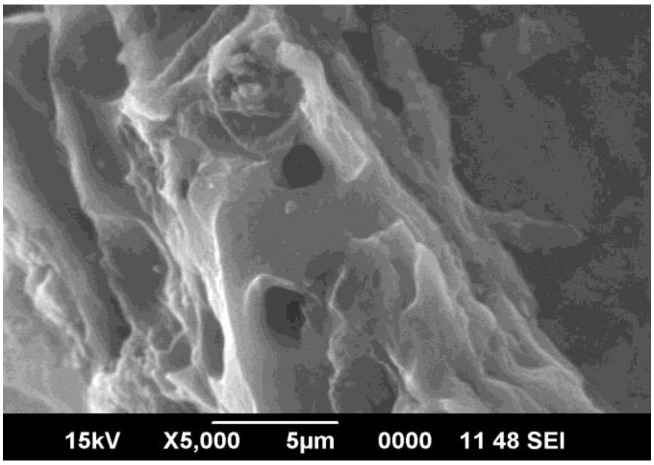


Fig. 3: SEM, Loaded image of adsorbent SSC

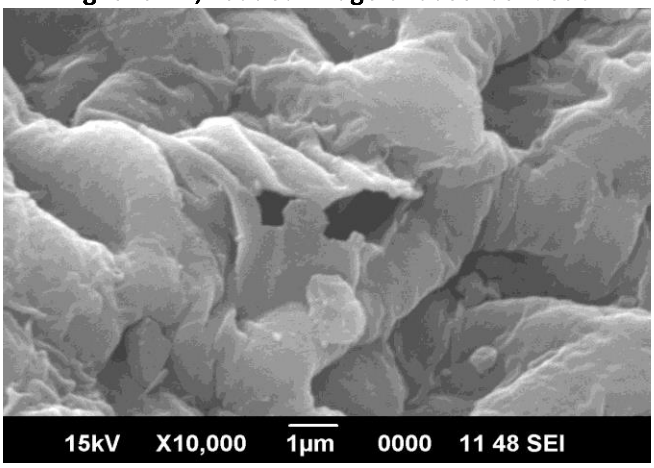


Fig.4: SEM, Unloaded image of adsorbent SSC

BATCH ADSORPTION STUDY

Batch adsorptions were carried out by shaking 100 ml of iron samples in a controlled rotary shaking machine (Model no. CIS-24, Remi Instruments, Mumbai, India) in a glass stopper bottles of 150 ml capacity at different dosages of adsorbent with speed of 150 rpm. The solution was then filtered through whatman filter paper no. 42 and the filtrate was analyzed for residual iron after adsorption in double beam spectrophotometer. All adsorption experiments were conducted at a room temperature and investigate the effect of various parameters like adsorbent dose, pH, temperature, initial iron concentrations, contact time etc. The specific amount of iron adsorbed was calculated.

RESULTS AND DISCUSSION

Effect of Dose

The results for adsorptive removal of synthetic iron solution with respect to adsorbent dose are shown in fig.5. The weight of SSC was varied from 1.0 g/L to 5.0 g/L, keeping all the other experimental variables, viz pH 7.0, initial concentration 5 mg/L, and contact time 600 Min. It is shows that there is a sharp increase in percentage removal with increasing adsorbent dose for total iron. The highest removal efficiency 87.30 % is observed at 1.5 g/L dose of SSC adsorbents. This is expected because more binding sites for metal ions are available at higher dose of adsorbents.

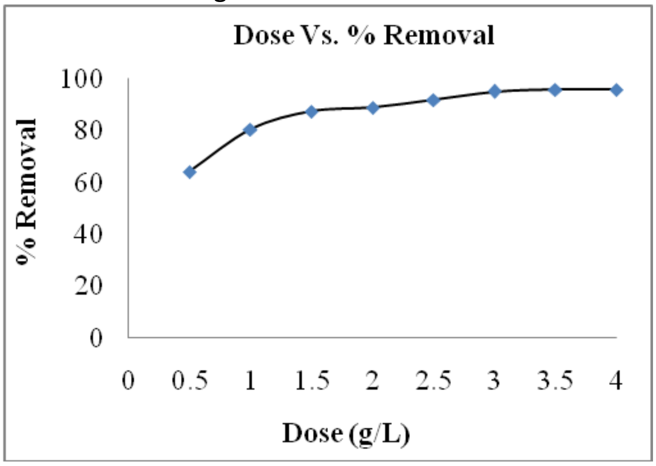


Fig. 5: Dose of Adsorbent Vs. % Removal.

Effect of pH

The effect of pH on the removal of total iron by SSC, were studied as shown in fig.6. pH of the synthetic solution plays an important operational parameter in the process of adsorption because it affects the solubility of the metal ions, concentration of the counter ions on the functional groups of the adsorbent and the degree of ionization of the adsorbate during reaction. The pH of synthetic iron solution was varied from 2 to 10 with initial concentration of 5.0 mg/L, dose of adsorbent is 1.5 g/L, and contact time of 600 Min. at room temperature and agitation speed were kept at 150 rpm.. Figure shown that increasing pH of the solution from 2 to 8 caused linear increase in uptake capacity of iron. Therefore, at low pH SSC showed very low efficiency for the removal of iron due to prolongation of its functional groups or competition of H+ with metal ions for binding sites. The maximum percentage removals of both adsorbents at pH 6 and thereafter the removal efficiency gradually decreased.

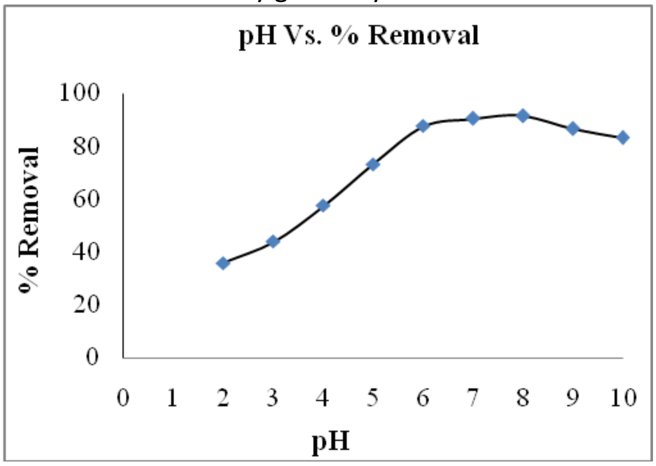


Fig.6: pH Vs. % Removal.

Effect of initial iron concentration

The initial iron concentrations 5.0 mg/L to 20 mg/L were studied. The graph stated that the maximum removal capacity in minimum concentration of iron available while as the initial concentration of iron increases the rate of % removal of iron decreases shown in fig.7, from the figure that the percentage removal decreases with the increase in initial metal ion concentration. At lower initial metal ion concentrations, sufficient adsorption sites are available for adsorption of the heavy metals ions. However, at high concentration the available sites of adsorption become fewer and hence the percentage removal of heavy metal is dependent upon the initial concentration.

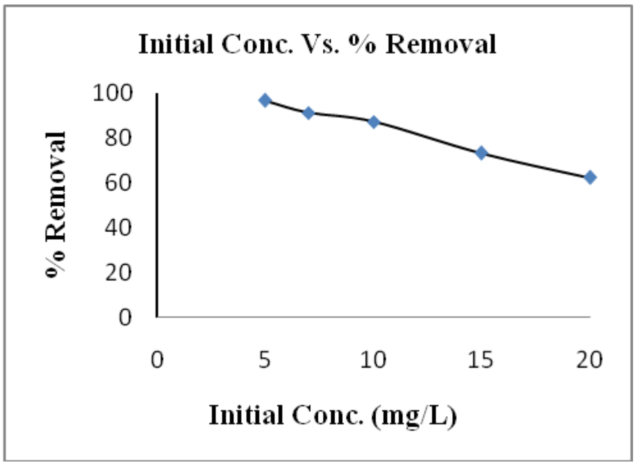


Fig. 7: Initial Concentration Vs. % Removal.

Effect of Particle Size

Adsorbent particle size has a decisive part in batch adsorption study which affects the process of adsorption. The particle sizes of 75 μm to 300 μm were selected and used in this research. In fig. 8, the result shows that the increase the particle size decreases the removal capacity of iron. Hence it proved that the removal capacity of adsorbent is also depends on the particle size of adsorbent used. 274

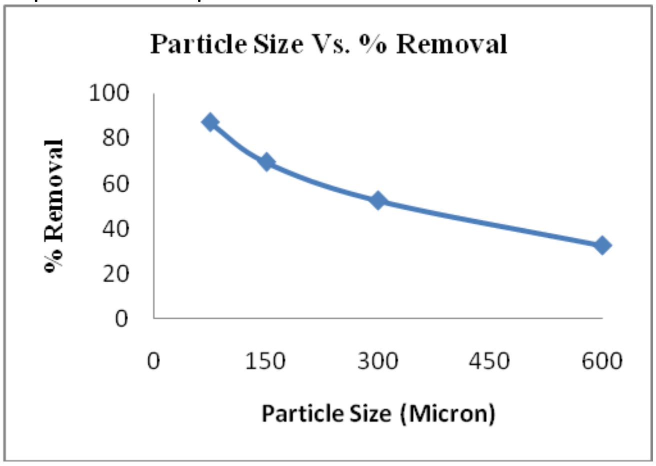


Fig. 8: Particle Size Vs. % Removal

Effect of Contact Time

Contact time plays an important role in the process of iron removal from aqueous solution. This study shows the capacity of adsorbent with respect to the time. The experiments were carried out at different contact times 5 Min. to 720 Min. to using incubator with an agitation rpm 150 for the standard optimized conditions. The Percentage removal of iron was shown in fig. 9. The equilibrium is reached within the first 180 min of shaking time and reached a saturation level. The highest percentage removals of SSC, adsorbents were 91.34. As the contact time increased the active sites on the sorbent were filled.

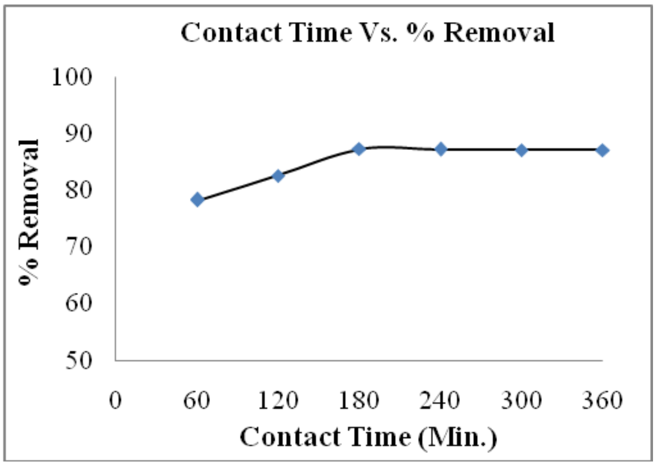


Fig. 9: Contact time Vs. % Removal

ADSORPTION MODEL

A different adsorption isotherm was prepared and the analytical data matched well with Langmuir than Freundlich, which achieved the good adsorption capacity of the adsorbent. The interaction of the adsorbate and the adsorbent was the focus of the isotherm study. The information was seen in a relationship between the Langmuir and Freundlich adsorption isotherms. The Freundlich isotherm is equilibrium based adsorption based on homogeneous surfaces, where as the Langmuir isotherm is an assumption based on the removal due to monolayer sorption happening on a homogeneous surface of the adsorbent without any collaboration between adsorbed particles. The linear equations for the Langmuir and Freundlich isotherms are provided below and are denoted by the equations (a) & (b, respectively.

$$\frac{1}{qe} = \frac{1}{(qmaxKL)}\frac{1}{Ce} + \frac{1}{qmax} \quad \text{Equation (a)}$$

The greatest quantity of iron that may be adsorbed which is shown by qmax in mg/g in the equation above. The equilibrium iron concentration is indicated by Ce in mg/L and the Langmuir isotherm constant is indicated by KL in L/mg.

$$log\ q_e = log\ K_f + \frac{1}{n}\log C_e \quad \text{Equation (b)}$$

Ce is the equilibrium iron concentration, and qe is the amount adsorbed in mg/g in equation 2; K_F is the observational consistent of Freundlich in mg/g and 1/n is the Freundlich type. Plot shows the isotherms in fig.10 and 11.

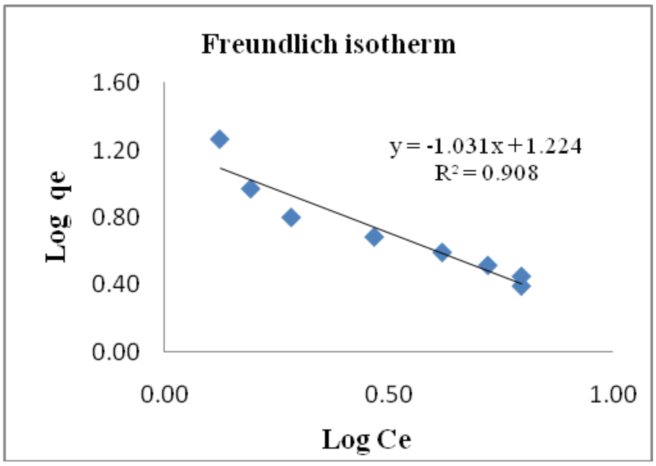


Fig. 10: Freundlich Adsorption Isotherm

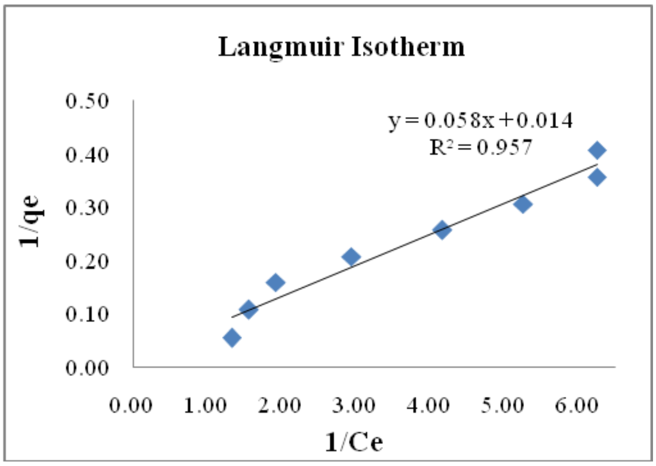


Fig. 11: Langmuir Adsorption Isotherm

CONCLUSIONS

This research study analyzed several parameters and characterizations during the experimentations and on the basis of results found following conclusions are made.

- ❖ Soybean seed coat and the research stated that SSC activated carbon has a good uptake capacity of iron for the initial concentration 5.0 mg/L.
- ❖ The efficiency of SSC carbon was recorded 92.37% at pH 6.0, Dose 1.5 g/L, contact time 280 Min., Temperature 30^{0}C and a particle size 75 Micron.
- ❖ Efficiency increases with lower initial metal concentration and with higher adsorbent dose.
- ❖ SSC is an agricultural solid waste which is easily available, and hence it is an one of the low cost adsorbent option for the removal of iron.
- ❖ In adsorption Freundlich and Langmuir models were tested and found the best fitted model was Langmuir than the Freundlich.

❖ The use of natural agricultural waste reduces somehow the burden of environment.

IX. REFERENCES

[1] G. H. Tao and Z. Fang, “Dual stage preconcentration system for flame atomic absorption spectrometry using flow injection on-line ion-exchange followed by solvent extraction,” J. Anal. Chem., vol. 360, pp. 156–160, June 1997.

[2] E. Ryoma Bun, N. Kawasaki, F. Ogata, T. Nakamura, K. Aochi and S. Tanada, “Removal of lead and iron ions by vegetable bio mass in drinking water,” Journal of oleo science., vol. 55, pp. 423-427, Apr 2006.

[3] R. Munter, H. Ojaste and J. Sutt, “Complexed iron removal from ground water,” Journal of Environmental Engineering., vol. 131, pp. 1014-1020, July 2005.

[4] D. Mohan and K. P. Singh, “Single and multi-component adsorption of cadmium and zinc using activated carbon derived from bagasse an agricultural waste,” Water. Res., vol. 36, pp. 2304–2318, may 2002.

[5] M. Ajmal, R. A. Rao, R. Ahmad and J. Ahmad, “Adsorption studies on Citrus reticulata (fruit peel of orange) removal and recovery of Ni (II) from electroplating wastewater,” J. Hazard. Mater. vol. 79, pp. 117–131, Dec 2000.

[6] Ashutosh Tripathi and Manju Rawat Ranjan(2015),Heavy metal removal from wastewater using low cost ,adsorbents,Journal of bioremediation & biodegradation,6,1-5

[7] Jai M Paul, Jis Jimmy, Josento M Therattil, Linda Regi and Shirin Shahana (2017),Removal of heavy metals using low cost adsorbents,IOSR-JMCE, 3, 48-50.

[8] Lavanya V, Elangovan N.S and Arunthathi S (2015), Removal of chromium from groundwater using neem leaves as adsorbent, IJER, 2,439-444. [9] N.Sangeetha P.Iyshwarya and R.G.Ramya Gayathri (2016), Removal of iron content from drinking water by using coconut coir and sugar bagasse, IJARMATE, 4, 3- 4.

[10] Chaturvedi, S.; Dave, P.N. Removal of iron for safe drinking water. Desalination 2012, 303, 1-11, https://doi.org/10.1016/j.desal.2012.07.003.

[11] Barhoumi, A.; Ncib, S.; Bouguerra, W.; Hamrouni, B.; Elaloui, E. Combining adsorption on activated carbon with electrocoagulation process for copper removal from used water. Desalination and Water Treatment 2017, 83, 212-221, https://doi.org/10.5004/dwt.2017.20984.

[12] Varaprasad, K.; Nunez, D.; Yallapu, M.M.; Jayaramudu, T.; Elgueta, E.; Oyarzun, P. Nano-hydroxyapatite polymeric hydrogels for dye removal. RSC Advances 2018, 8, 18118-18127, https://doi.org/10.1039/C8RA01887A.

[13] Ajayi O. O., Omole, D. O. and Emenike, C. P(2016), Use of Agricultural Wastes and Limestone for the Removal of Iron from Drinking Water, 3rd International Conference on African Development Issues (CU-ICADI 2016) ISSN:2449-075X.

[14] Animesh Agarwal1 and Puneet Kumar Gupta(2015) Removal of Cu & Fe from aqueous Research, 2014, 5(2):75-79

[15] Neethu.P and M.A Chinnamma,(2017), Natural Adsorbents for Agricultural Waste Water Treatment, IJAEMS, [Vol-3, Issue-4, Apr- 2017] ISSN: 2454-1311.

[16] N.Ahalya, R.D. Kanamadi and T.V. Ramachandra, Cr (VI) and Fe (III) removal using Cajanus cajan husk ,India Journal of Environmental Biology October 2007, 28(4) 765-769 (2007)

[17] R. Shokoohi, M. H. Saghi, H. R. Ghafari , M. Hadi , Biosorption of Iron from aqueous solution by dried biomass of activated sludge , Iran. J. Environ. Health. Sci. Eng., 2009, Vol. 6, No. 2, pp. 107-114

[18] Paul B Tchounwou, Clement G Yedjou, Anita K Patlolla, and Dwayne J Sutton , NIH-RCMI Center for Environmental Health, EXS. 2012 ; 101: 133–164.

[19] S.S.Ahluwalia, D.Goya ;Removal of heavy metals by waste tea leaves from aqueous solutions Eng.Life.Sci.2005,5,No.2

[20] Ageena N.A. (2010), The use of local sawdust as an adsorbent for the removal of copper ion from wastewater using Ÿixed bed adsorption, “Engineering and Technology Journal” No. 28(2), p. 224-235

[21] Kumar V. et al. (2017), Studies on high iron content in water resources of Moradabad district (UP), India, “Water Science” No. 31(1), p. 44-51, DOI: 10.1016/j.wsj.2017.

[22] Pragati S.S.T. et al. (2015), Removal of zinc from synthetic wastewater by sawdust as an adsorbent, “International Journal of Innovative Science, Engineering & Technology” No. 2(6), p. 307-354

[23] Xiong, S.C.; Zhou, Y.F.; Huang, X.L.; Yu, R.J.; Lai, W.H.; Xiong, Y.H. Ultrasensitive direct competitive FLISA using highly luminescent quantum dot beads for tuning affinity of competing antigens to antibodies. Anal. Chim. Acta 2017, 972, 94–101.