NVEO
Natural Volatiles & Essential Oils

Analysis & Characterization Of Pisum Sativum Peels Carbon (PSPC) Used In The Removal Process Of Defluoridation

Ranjit N. Patil*

*Assistant Professor, Department of Civil Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur (M.S.), India, e-mail: ranjeetpatilcivilbcce@gmail.com

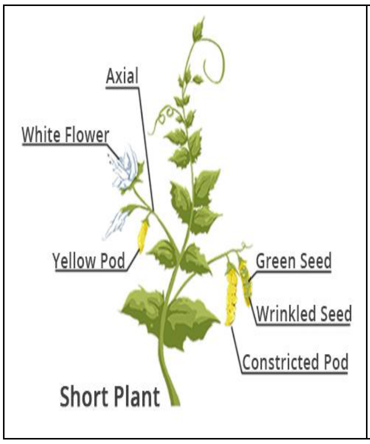
Abstract
In this study, physically activated Pisum sativum peels carbon (PSPC) was used to remove excess fluoride ions from an aqueous solution with detailed characterization and experiments. PSPC was found one of the most promising bio-adsorbents in this research process. In this study, group adsorption experiments were analyzed for various parameters such as pH from 2 to 10, dose of Pisum sativum peels carbon (PSPC) ranging from 0.5 to 3.0 g/L, contact time with the used medium from 30 to 720 minutes. The initial fluoride concentration ranged from 2.0-15 mg/L, in this case a particle size of 75-600 µm was chosen for the analysis, moving at 150 rpm. Under optimal conditions of other parameters, the percentage of removal was maximum in the pH range of 7-9. The observed calculated data fitted in the Langmuir isotherm better than the Freundlich isotherm.

Keywords: Defluoridation, Carbon, Adsorption, bio-adsorbent, Langmuir & Freundlich Isotherm

INTRODUCTION

Fluorine is a dangerous element and has a constant value because it causes more or less health problems. Many countries have discovered the danger of dental and bone fluorosis. In India, many states have a higher risk of fluoride concentration and therefore several researchers have focused on the severity of fluoride ions. Various methods have been described in this direction. Overconcentration is a major challenge for researchers(Bhambulkar, A. V. & Isha. P. Khedikar ,2011). Financing is also a very big problem in developing countries, and because of this problem, expensive methods cannot be used in the fluoride removal. The adsorption method is used in this study because it is a cheap and effective method that has been observed in the fluoride removal. In some areas of the state, no alternative source of drinking water is available instead of groundwater. This study used natural bio-adsorbent peas to provide physical activation process. The Pisum sativum peels waste was activated at 500 0C and this carbon material was tested after several washes. Given that it is made of bio-waste, it is cost-effective. A much smaller amount of carbon is required for processing compared to commercially available adsorbents. This PSPC was studied in batch adsorption with different parameters such as dose effect, effect of pH from acidic to basic, different initial concentrations of metal ions, effect of different practical sizes on the adsorption capacity of the material and effect on contact time (Bhambulkar, A.V. ,2011) The data found in the feces were analyzed and verified by two different adsorption isotherm models, Langmuir and Freundlich, and were also investigated and verified by experimental data.

Plant Description:



- **Plant height**
  Tall or Short
- **Flower color**
  Purple or White
- **Pod color**
  Green or Yellow
- **Seed color**
  Green or Yellow
- **Seed shape**
  Round or Wrinkled

Figure 1: pisum sativum plant description

MATERIAL AND METHODS

Chemicals selected for the study were of analytical grade (AR). Experiments were performed by preparing a fluoride stock solution using 2.21 g of sodium fluoride and diluted in 1000 mL of distilled water. Other working samples for analysis were prepared from the stock solution using appropriate dilution in distilled water.

Preparation of Adsorbent

The adsorbent was prepared from Pisum sativum peels collected from a local market in Nagpur Maharashtra. The collected peels were first washed several times with tap water so that no dust or particles remained on their surface. The washed peels were then thoroughly cut into one-inch pieces and then sun dried for 2 days at an average outdoor temperature of 42 ^{0}C. After that, the sun-dried peels were kept in an oven for 12 hours. The temperature remained the same the whole time (105 ^{0}C). The fully dried peels were cooled to room temperature and then ground using a household blender. Ground peels were kept in a muffle furnace at a temperature of 550 ^{0}C for 3 hours to activate it physically. This physically activated carbon of PSPC was used in analytical and characteristic studies.

EXPERIMENTAL METHODS

In this study, the adsorption method is used, which has a cheap and easy-to-use method. Parameters such as dosage, pH, initial concentration, particle size and mixing were selected and tested for this adsorption method. Test samples were prepared and run separately for the parametric study using 200 mL plastic bottles containing 100 mL of fluoride sample. The pH of bottled fluoride samples was adjusted with 0.1 N HCl or 0.1 N NaOH solutions. After the whole process, the prepared complete samples were tested to estimate the amount by spectrophotometer.

RESULTS AND DISCUSSION

Effect of Dose

This experimental study to measure the amount of fluoride using different doses, which estimates the optimal dose necessary to remove fluoride ions from an aqueous solution. The initial fluoride concentration was 5.0 mg/L. The analyzed report shows the effectiveness of physically removing activated carbon from the Pisum sativum peels in percentages at different doses and amounts. Selected dosages such as 0.5 g/L to 3.0 g/L PSPC were tested and the experimental analysis clearly shows that PSPC is one of the cheap and effective bio-adsorbents in the fluoride removal process shown in figure 2. The tested results of the effect of different doses on the fixed initial concentration of fluoride show that when the percentage removal capacity of fluoride increases to a certain limit, the dosage amount of the adsorbent PSPC also increases. Fluoride removal percentage increases to 94.62 at 2.0 g/L. This dose was necessary to achieve the desired limit of fluoride. An optimized PSPC dose of 2.0 g/L was selected and used for the further additional study parameters. The precursor was also tested in the fluoride evaluation process and this study of the pre-adsorbent shows a much lower fluoride removal capacity. It is also found that the raw material is not suitable for the removal of fluoride ions because it does not meet the drinking water standards given by BIS, while PSPC has a good ability to remove fluoride ions from an aqueous solution.

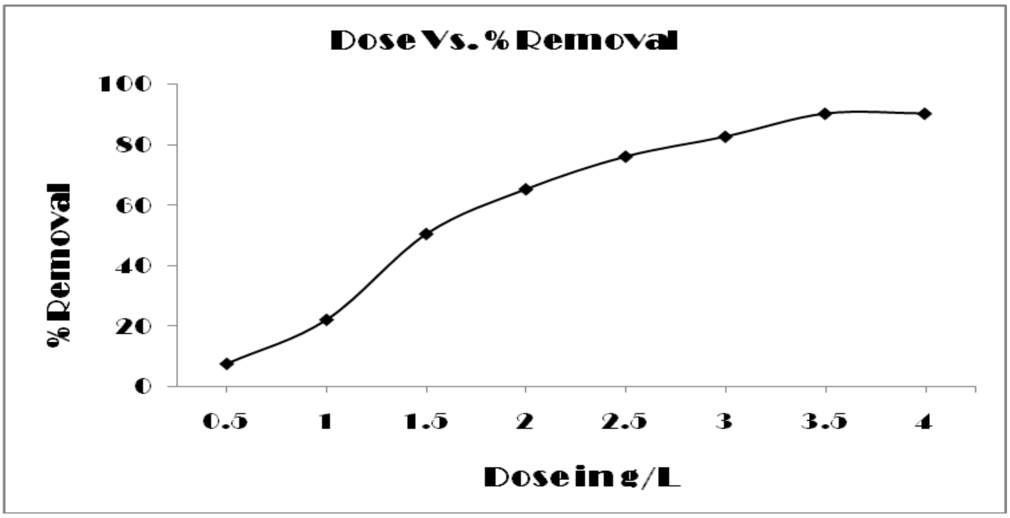


Figure 2: Dose of Adsorbent Vs. % Removal.

Effect of pH

In the process of removing fluoride by adsorption method, pH is very important, which plays an important role. This study also showed that the percentage of fluoride removal is highly dependent on the pH of the test solution. The pH range for this study was 2-10. The fluoride removal efficiency increased with the observed increase up to pH 6 and then after a sharp decrease was observed and after that the fluoride removal efficiency decreased with increasing pH as shown in figure 3. The result shows that the adsorption rate of fluoride ions in the lower region decreased slightly, the reason may be the formation of weak hydrofluoric acid. Decrease in pH due to the competition of the hydroxyl group in the fluoride adsorption process.

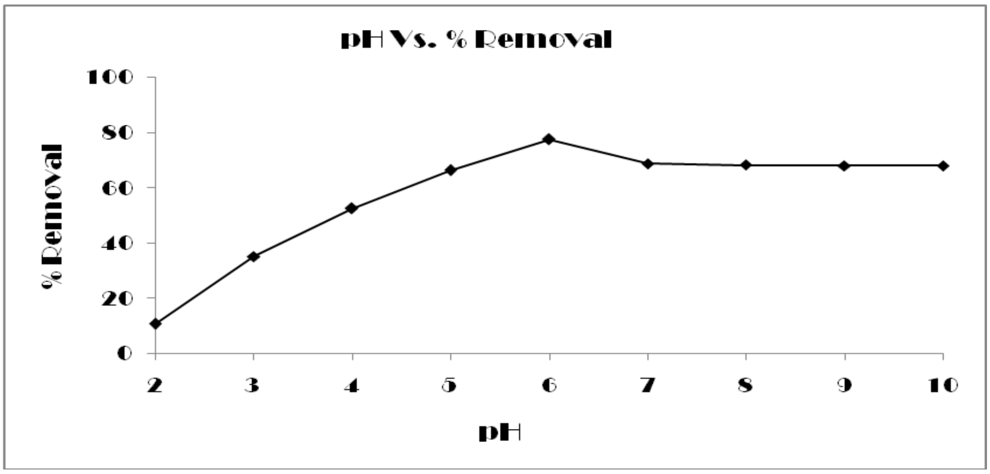


Figure 3: pH Vs. % Removal.

Effect of initial metal ion concentration

Higher levels of fluoride have been found in many countries around the world. In India, higher fluoride levels affect many states. This research parameter shows the influence of different initial higher fluoride concentrations and the absorption capacity of PSPC in the fluoride removal process from aqueous solutions. Initial fluoride concentrations from 2.0 mg/L to 15 mg/L were investigated. The graph shows the maximum removal capacity at the lowest available fluoride concentration, while as the initial fluoride concentration increases, the percent fluoride removal decreases as shown in figure 4.

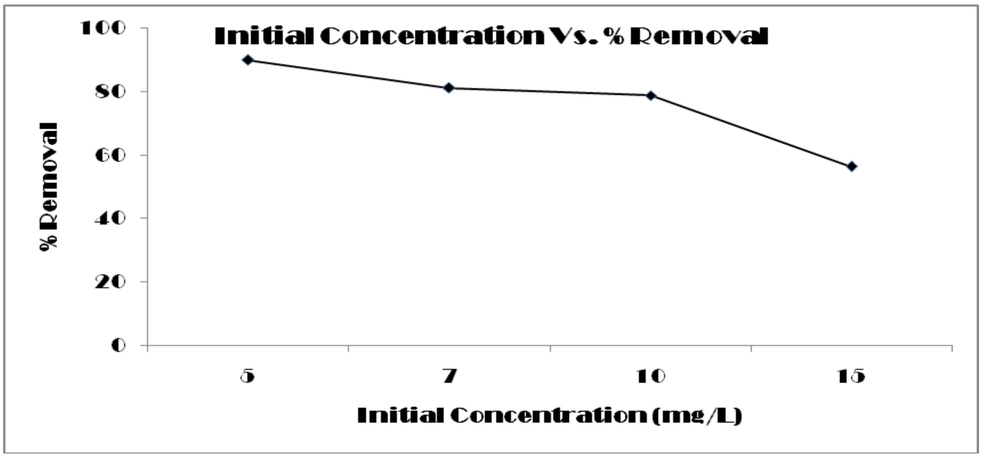


Figure 4: Initial Concentration Vs. % Removal

Effect of Particle Size

Particle size is one of the most important parameters in adsorption research, which directly affects the adsorption process. Particle sizes from 75 µm to 600 µm were used in this research analysis. The result shows that the particle size increases and the fluoride removal percentage decreases. This shows that the removal performance of the adsorbent also depends on the particle size of the adsorbent used, as shown in figure 5.

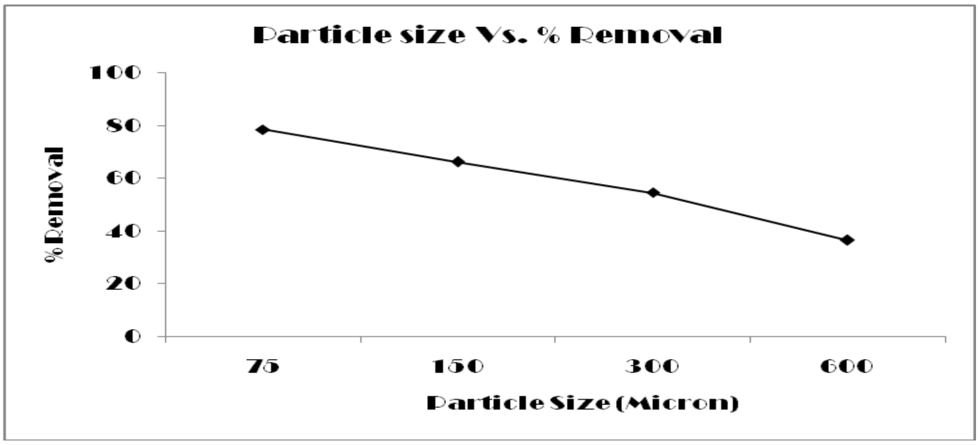


Figure 5: Particle Size Vs. % Removal.

Effect of Contact time

This study shows the adsorption capacity as a function of time. The analysis shows the effectiveness of PSPC in different exposure times. The obtained results show that the PSPC adsorption capacity increases as the contact time increases. The maximum required fluoride consumption after 480 min shown in Figure 6.

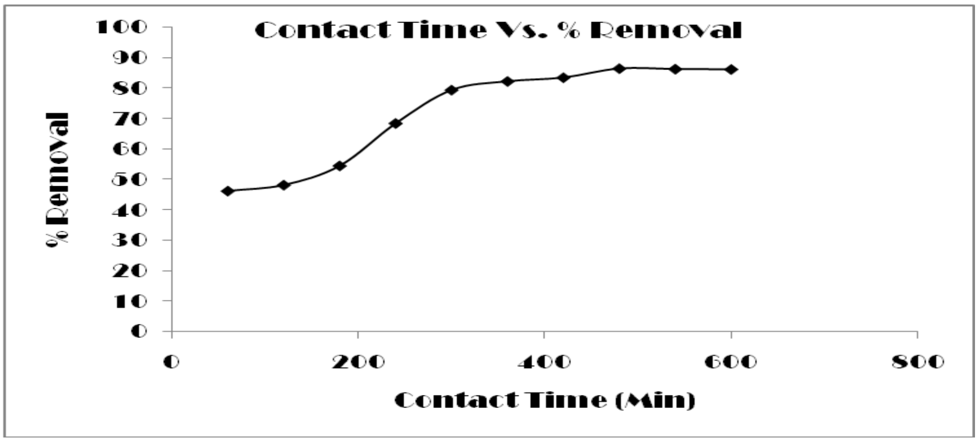


Figure 6: Contact time Vs. % Removal.

SEM ANALYSIS

Various adsorption models were constructed and it was found that the best fitted isotherm was Langmuir based on the analytical data, which showed the adsorption capacity in favor of the adsorption Pisum sativum peels carbon (PSPC) shown in figures 7 and 8.

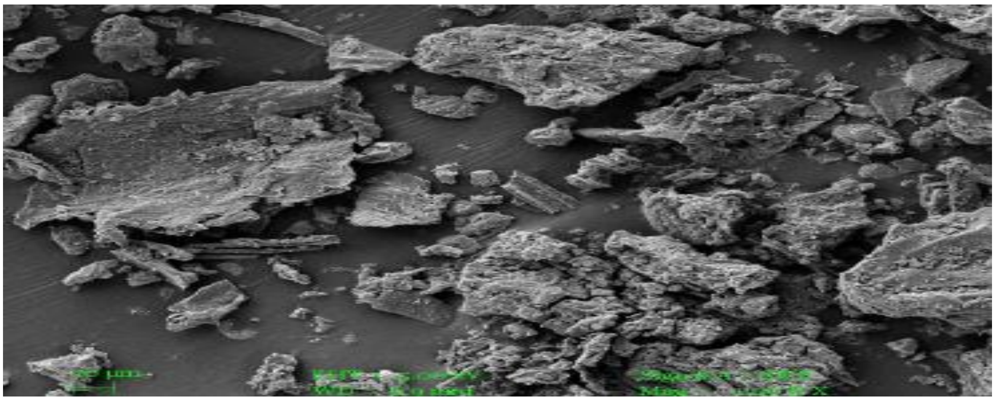


Figure 7: SEM analysis of Unloaded PSPC

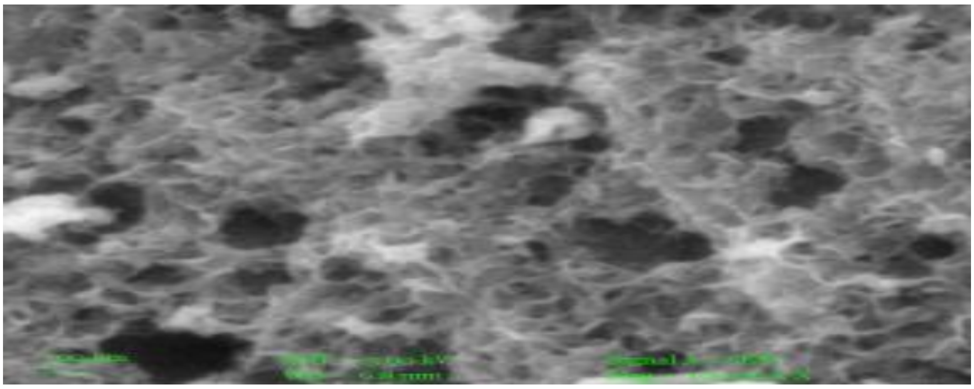


Figure 8: SEM analysis of Loaded PSPC

I. X-RAY POWDER DIFFRACTION (XRD)

To foretell changes in the crystal structure of the treated Pisum sativum peels bark (PSPC), XRD was conducted on the PSPC. Since a few decades ago, X-ray diffraction (XRD) analysis has been one of the most popular methods in the scientific period for determining the kind of material and the identification of crystals. XRD patterns of Pisum sativum peels before and after fluoride ions were adsorbed. The PSPC prior to fluoride ion adsorption is depicted in figure 9 as having symmetric, sharp peaks. This peak indicates that the structure is crystalline, and the figure below illustrates the position and kind of peaks following the adsorption of fluoride ions. It was discovered that no peaks had formed, suggesting that the structure is amorphous. Scan angles for the samples were 2° and 5.

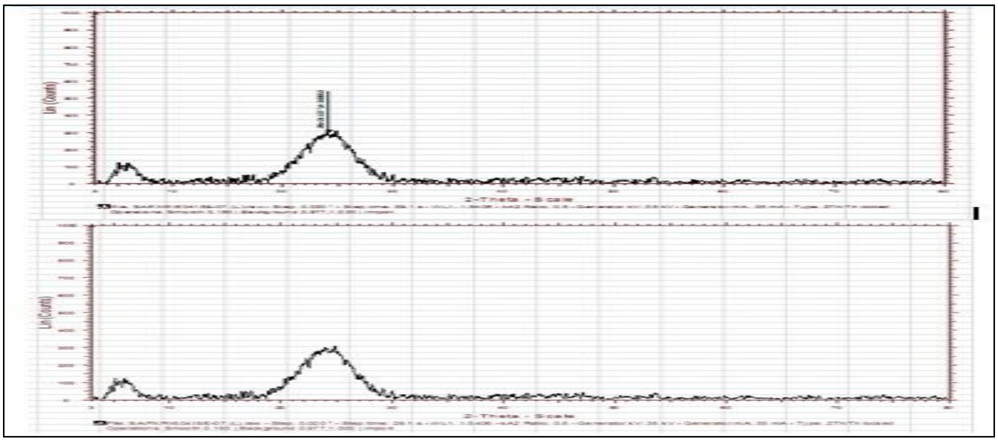


Figure 9: XRD of PSPC (Loaded & Un-loaded)

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.

$$\frac{1}{qe} = \frac{1}{(qmaxKL)}\frac{1}{Ce} + \frac{1}{qmax}$$

Equation (a)

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

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

Equation (b)

Ce is the equilibrium fluoride 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. The direct plot shows the Langmuir and Freundlich isotherm application in fig.10 and 11.

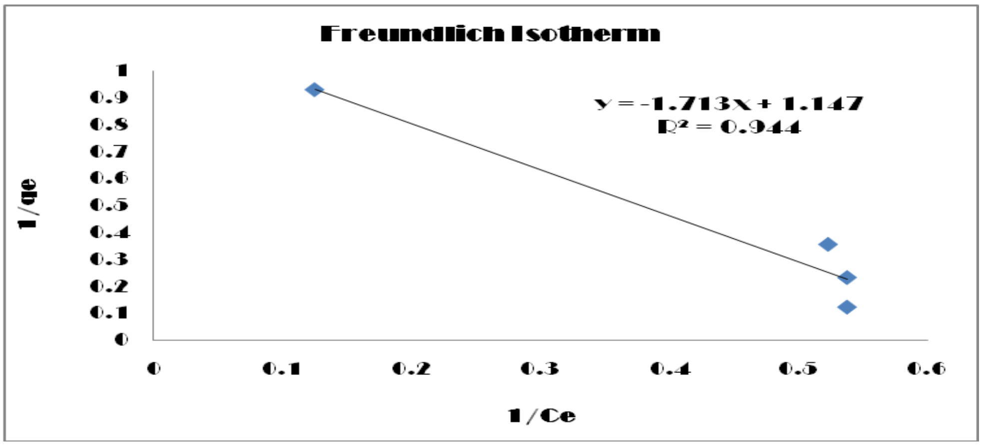


Figure 10: Freundlich Adsorption Isotherm

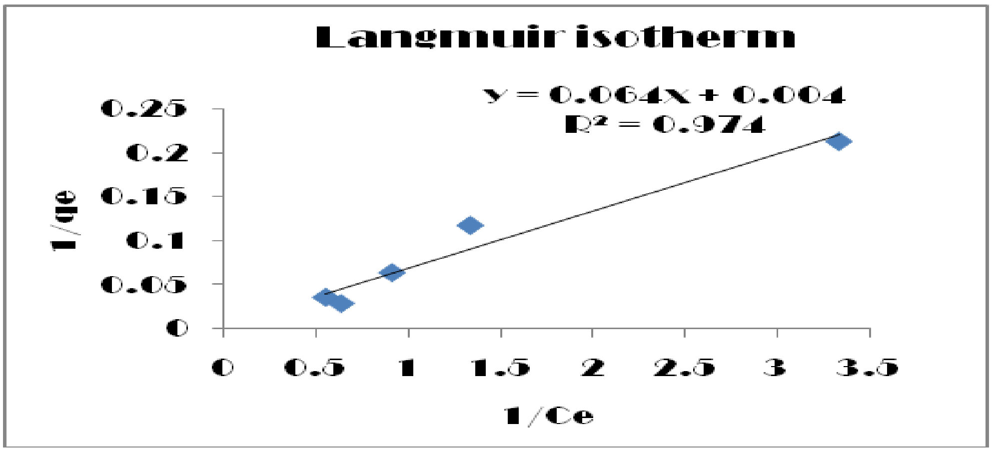


Figure 11: Langmuir Adsorption Isotherm

CONCLUSIONS

1. The results conclude that the PSPC has the good fluoride removal capacity used in the form of physically activated carbon.
2. The optimum dose of PSPC was found 2.0 g/L for an initial fluoride concentration of 5.0 mg/L.
3. Adsorption capacity was obtained more up to the pH 6.
4. The maximum removal of fluoride was found at lower particle size of adsorbent.
5. The optimal contact time was found 480 Min. which has got a required % removal as per the norms.
6. The adsorption equilibrium data follows Langmuir isotherm than Freundlich isotherm.

REFERENCES

1. A.M. Raichur, M.J. Basu, Adsorption of fluoride onto mixed rare earth oxides, Sep. Purif. Technol. 24 (2001) 121–127.
2. Angelie I. Jover , Jonathan W. L. Salvacion, Adsorption Capability of Gmelina arborea Bark using Crystal Violet 2nd International Conference on Environment and Industrial Innovation IPCBEE vol.35 (2012),87-92
3. Bhambulkar, A. V. Isha. P. Khedikar (2011),'Municipal solid waste (msw) collection route for laxmi nagar by geographical information system'. International Journal of Advanced Engineering Technology, 2, 102-109.
4. Bhambulkar, A.V. (2011). Municipal Solid Waste Collection Routes Optimized with ARC GIS Network Analyst. International Journal Of Advanced Engineering Sciences And Technologies, 11(1): 202-207.
5. biocomposite for waterTreatment: optimization forfluoride removal j fluorine chem volume 130, 8,718-726.
6. D. Thakre, P. Dixit, S. waghmare et al. , Synthesis optimization and fluoride uptake properties of high capacity composite adsorbents for defluoridation of drinking water‖, Environmental Progress & Sustainable Energy, Vol. 34(6), pp. 1576-1585, Nov/Dec 2015.
7. Davila R., Vladimir E. B., Keiko S. and Jose R.Rangel-M., 2009,: Synthesis of a chitin-based
8. H.M.F. Freundlich, J. Phys. Chem., 1906**,** A 57, 385-471.
9. H.Rehman, M. Shakirullah, I. Ahmad, S. Shah and Hameedullah, .Journal of the Chinese Chemical Society, 2006, 53, 1045-1052.
10. Hameed, B.H., 2009. Spent tea leaves: A new non-conventional and low-cost adsorbent for removal of basic dye from aqueous solutions. Journal of Hazardous Materials, 161, 753–759.
11. I. Langmuir,Am.Chem. Soc., **1918**,40,1361-1403.
12. K. Kamal Das, D. Vijay Kumar, G. Udayalaxmi and M. Muralidhar, Fluoride Contamination in the Groundwater in Mathadi Vague Basin in Adilabad District, Telangana State, India. International Journal of Civil Engineering and Technology (IJCIET), 5(7), 2014, pp.55-63
13. M. A. Ackacha and S. A. Elmahdy, "Utilization of activated carbon derived from date stones to reduce lead and cadmium from aqueous
14. M. Mamatha, H.B.Aravinda, S.Manjappa, E.T.Puttaiah, Kinetics and Mechanism for Adsorption of Lead in Aqueous and Industrial Effluent from Pongamia pinnata Tree Bark, Journal of Environmental Science, Toxicology And Food Technology, Volume 2, Issue 3 (Nov. - Dec. 2012), PP 01-09
15. M. Rao, A. V. Parwate and A.G. Bhole, Uptake of Nickel from aqueous solution using low cost adsorbent, Enviromedia, 20 (4), 669 - 675.
16. Nawar SS, Doma HS. Removal of dyes from effluents using low cost agricultural byproducts. Sci Total Environ 1989;79:271–9.
17. Patil, S., S. Renukdas, and N. Patel, 2011. Removal of methylene blue, a basic dye from aqueous solutions by adsorption using teak tree (Tectona grandis) bark powder. International Journal of Environmental Sciences,1(5), 711-726.
18. Ranjit N. Patil, Dr. P. B. Nagarnaik et al. An Experimental Analysis of Adsorption Behavior of HTB for the Removal of Fluoride, International Journal of Engineering Research & Technology, 4 (2016) 89-90.

19. S.Venkata Mohan , S.V. Ramanaiah , B. Rajkumar, Sarma P.N., 2007, Biosorption of fluoride from aqueous phase onto algal Spirogyra IO1 and evaluation of adsorption kinetics, Bioresource Technology, 98 , 1006–1011.
20. Sanghratna Waghmare, Tanvir Arfin et al. Adsorption Behaviour of Modified Zeolite as Novel Adsorbents for Fluoride Removal from Drinking Water: Surface Phenomena, Kinetics and Thermodynamics Studies International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 12, December 2015 4114
21. solutions," in Proc. 2nd ICEST Conf. Environmental Science and Technology, Singapore, pp. 40-44, 2011.
22. Walker GM, Weatherley LR. Adsorption of acid dyes onto granular activated carbon in fixed beds. Water Res 1997;31:2093–101.
23. WHO Report, Fluoride and Fluorides: Environmental Health Criteria, World Health Organization, 1984.