Column Studies To Evaluate Copper Removal Potential By Sawdust And Iron Oxide Nanoparticle

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Abstract- *Development of adsorbents to treat heavy metal contaminated waste water is a major area of investigation, because of its efficient removal and eco-friendly nature. In this work the Adsorption of copper by treated sawdust and iron oxide Nanoparticle is studied thoroughly in batch and column wise experimentation by various influencing parameters such as pH, contact Time, initial concentration , adsorbent doses, bed depth and flow rates. The maximum removal efficiency achieved for batch experimentation by sawdust and iron oxide nanoparticle found to be 81.32 and 98.02% at optimum pH of 6 and equilibrium time of 100min.similarly for column study it was 68.82 and 92.06% at bed depth of 30cm for Sawdust and 7.5cm for Iron oxide at concentration of 10mg/L.*

Keywords- Adsorption, Copper, Iron Oxide Nanoparticle, Sawdust.

I. INTRODUCTION

Water is the most necessary element to life on the earth. In its purest form it is colourless, odourless and tasteless. The level of contaminants increased in the aquatic ecosystem is mainly due to the discharge of industrial effluent to water bodies that leads to development of water demand for domestic and industrial purpose. The heavy metal like Lead, Zinc, Chromium, Mercury, Nickel, Arsenic, Cadmium, Manganese, and Copper originated from Mining activities, Metal plating, Smelting, Tanneries, Battery manufacture, Petroleum refining, Pesticides, Paint manufacture, Printing and Photographic industries, Pigment manufacture etc. The generated metals are non-biodegradable in nature and affects, causes various disease and disorders to living organisms. The heavy metals level exceeds the permissible discharge level in the industrial effluent the removal of toxic metals is essential. The various techniques have been adopted for removing heavy metals from the industrial effluents which includes, Chemical precipitation, Ion exchange, Electrode dialysis, Reverse osmosis, Membrane filtration, Ultra-filtration, Floatation and Adsorption, Coagulation. From the above mentioned techniques adsorption method is widely used because its cost effective nature. The Activated carbon is also a well-established adsorbent for removing heavy metals, because of its high cost and inhibits large scale use an adsorbent. In order to overcome this problem, several investigation have been taken up for synthesizing low cost adsorbent that are obtained from various wastes and by-product such as Coconut husk, Rice husk, Neem bark, Pellets of peanut hull, Sugar cane bagasse, Cow bone charcoal, Sawdust, Moringaoleifera pods, Tamarind fruits shell etc.

The binding of metal ions by the low cost adsorbent might to be attribute to their carbohydrates, proteins and phenolic compounds, which have hydroxyl, carboxyl, phosphate, sulfate and amino groups.

Many recent investigation have been carried out in the Nano technology for removing of heavy metals using Nano particle as a adsorbent, because of their important properties like, high surface area, small size, magnetic properties and reusable properties that leads to decrease in the economic burden.

1.2 PROBLEM IDENTIFICATION

After understanding the fundamental of metal removal technologies by sawdust and nanoparticle of some technical papers, it is felt that the treatment of heavy metal by suitable treatment option is the need of the day. Even though many option are available, these methods are specific and variable specific. Further the low cost adsorbent usage in engineering and technology is gaining in these days. Therefore the topic for dissertation work titled “Removal of heavy metal using low cost adsorbent and nanoparticle” is selected objectives of the dissertation work are listed below.

1. To identify the heavy metals to be tried and their preparation.
2. Characterization of adsorbent and their preparation.
3. To carry out the experimental studies to remove the heavy metal from the synthetic sample using low cost adsorbent and nanoparticle under the varied experimental conditions viz., pH, Concentration, Flow rates, Dosage, Contact time.
4. To assess the maximum adsorption capacity of adsorbent.

II. MATERIALS AND METHODOLOGY

Material considered and methodology adopted to carry out the experimentation and thereby to achieve the objective of the study are discussed in this chapter there issues are covered in detail and are documented below under the heading shown.

2.1 ADSORBENT SELECTION AND THEIR PREPARATIONS

In this present work the selected adsorbents are sawdust and Iron oxide Nanoparticle, the preparation of adsorbent as per the references are mentioned and discussed in details below;

2.1.1 Preparation of Saw dust

The sawdust was collected from the nearby saw mill in the Davnagere city. The sawdust was processed to obtain chemically activated sawdust. To remove the surface adhered particles and colour it was washed with tap water for several time and again washed with distilled water till the clear solution appears. Thereafter it is allowed to dry in open air and sunlight. Later treated with concentrated sulphuric acid diluted with distilled water to 1N and soaked it for 24h, dried at a temperature 105-110^{0}C in oven for 48h. The dried saw dust is sieved through 422µm sieve.

2.1.2 Preparation of Iron Oxide Nanoparticles

- The Precipitation method was adopted for the preparation of iron oxide nanoparticle. About 0.03 mole of 5.96g $Fecl_2$ were dissolved into 150ml of distilled water and stirred vigorously using magnetic stirrer for 20 minutes.
- Precipitation was achieved by adding 100ml of 1M NaOH solution in drop wise under vigorous stirring. The initial pH was observed as 3 and it was increased to pH 12 using 1M NaOH
- The precipitation process was continued until dark black color precipitate obtained. Then the Fe_3O_4 precipitate was taken into centrifuge tube and centrifuged at 1500 rpm for 20 minutes.
- The centrifuged process continued with water and two times with ethanol. Then the precipitate was dried. Finally, iron oxide nanoparticles (Fe_3O_4) is formed.

2.2 SELECTION OF METAL AND PREPARATION OF SYNTHETIC SAMPLE

For the heavy metal removal process in this present study the selected metal is Copper.

- 3.93 g of cupric sulphate $CuSO_4.5H_2O$ was dissolved in 1000 ml of distilled water. It gives 1000 ppm stock solution of copper.
- Stock solution was diluted with distilled water. It gives copper solutions of concentration 10, 20, 30, 40 mg/L.

2.3 EXPERIMENTAL STUDIES

The experimentation was performed by using sawdust and iron oxide nanoparticle as adsorbents. And the experimental procedures are discussed below;

2.4 Column experimental Studies

2.4.1 Parameters considered

The variables considered for experimentation are listed below in Table 2.1.

Table 2.1: Parameters considered for experimentation

SL.No	Parameters	Values
1	pH	6
2	Initial metal concentration	10,40 mg/l
3	Flow rate	20,35,45 ml/min
4	Bed depth	15,30 cm(Sawdust) 3.75,7.5 cm(Iron oxide)

2.4.2 Experimental Setup

- Experimental setup consisting of Glass Column with Internal diameter 6.5 cm and 43.5 cm height for sawdust and 1.5 cm and 15 cm for Iron oxide Nanoparticle.
- Aspiratory bottles.

2.4.3 Experimental procedure

The experimental setup consists of borosilicate glass column. The Column was mounted on a stand and cotton was placed at the bottom of the column which acts as a supporting material for the adsorbent. Constant head was maintained

using two aspiratory bottles which were placed at different heights for gravity and constant flow. Pinch cock was used to adjust the flow rate. Prior to each experiment distilled water was passed through the column to get rid of the column contaminations and air bubbles. Synthetic metal samples of known concentration at required pH were passed through two aspiratory bottles.And then it was passed into the column containing adsorbent and the samples were collected in sample bottles for different flow rates. Then the collected samples was analyzed by using Atomic adsorption Spectrophotometer.
The percentage metal removal was calculated by

$$\% \text{ removal} = \frac{(C_o - C_e)}{C_o} X100$$

Where; C_O is the initial metal ion concentration (mg/L).
Ce is the equilibrium metal ion concentration (mg/L).

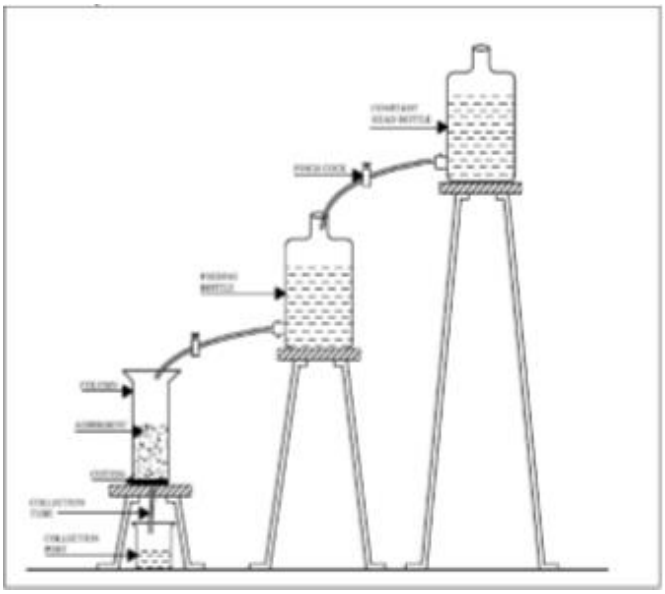

Fig.1 Line Diagram of Experimental Setup

III. RESULTS AND DISCUSSIONS

Findings of experimentation carried out to evaluate removal potential of two adsorbent such as, sawdust and Iron oxide Nanoparticle. In removing copper metals under varied experimental conditions namely, pH, Initial metal concentration, adsorbent dosage, Contact time are tabulated on this chapter. For clarity and convenience of discussions and thereby to draw the inferences the result also be represented in graphs the inferences so drawn are also documented in this chapter.

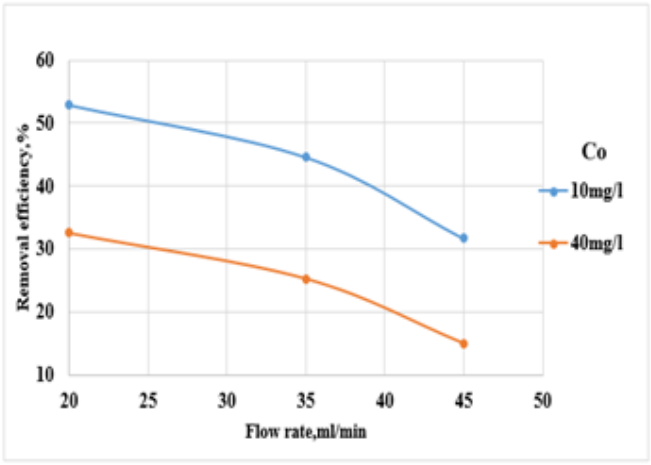

Figure: 3.1 Effect of flow rate on removal efficiency with sawdust adsorbent. (pH- 6, Bed Depth-15 cm)

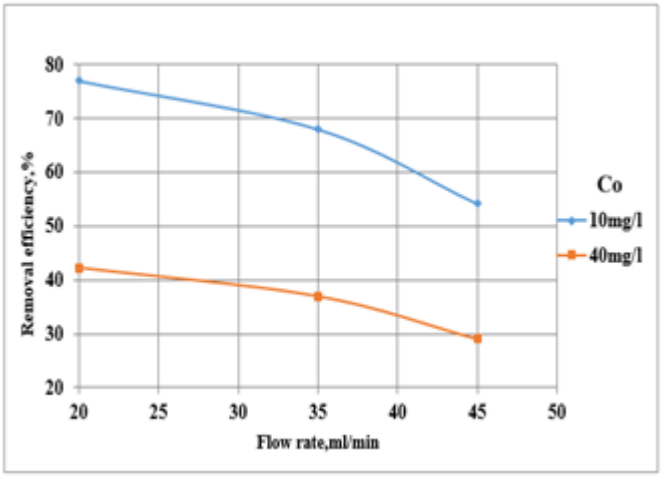

Figure: 3.2 Effect of flow rate on removal efficiency with Iron oxide Nanoparticle adsorbent. (pH-6, Bed Depth-3.75 cm)

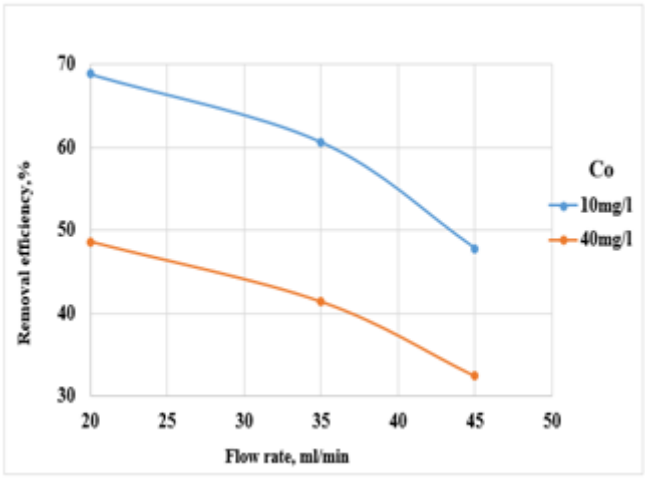

Figure: 3.3 Effect of flow rate on removal efficiency with sawdust adsorbent.(pH- 6, Bed Depth-30 cm)

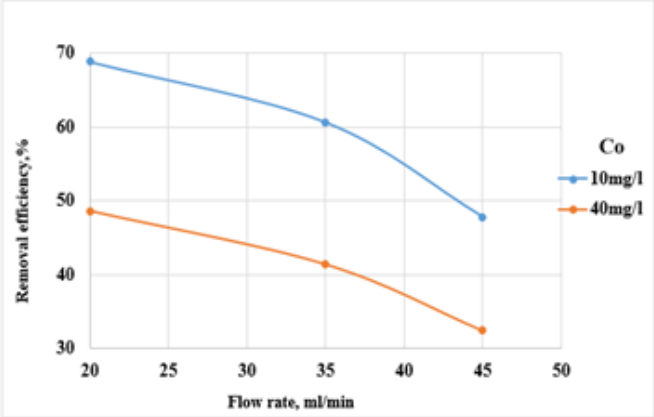

Figure: 3.4 Effect of flow rate on removal efficiency with Iron oxide Nanoparticle adsorbent. (pH- 6, Bed Depth-7.5 cm)

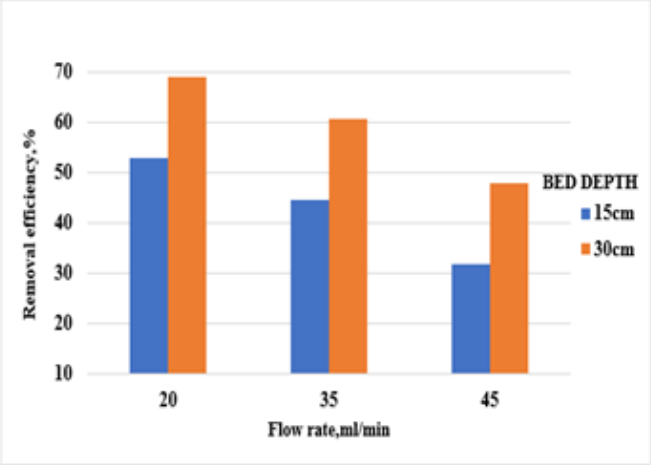

Figure: 3.5 Effect of bed depth on removal efficiency with sawdust adsorbent. (pH-6, Co-10 mg/L)

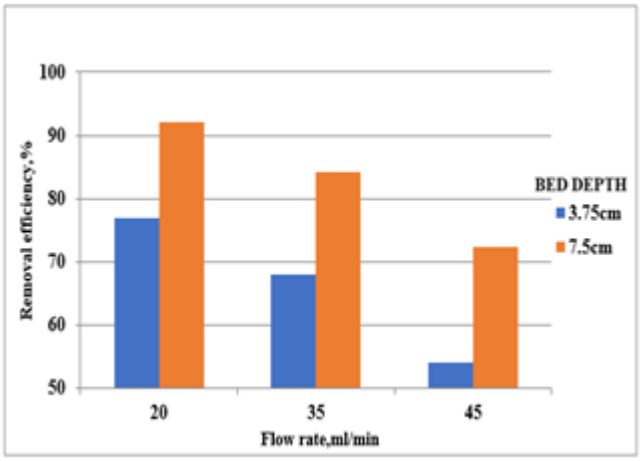

Figure: 3.6 Effect of bed depth on removal efficiency with Iron oxide Nanoparticle adsorbent. (pH-6, Co-10 mg/L)

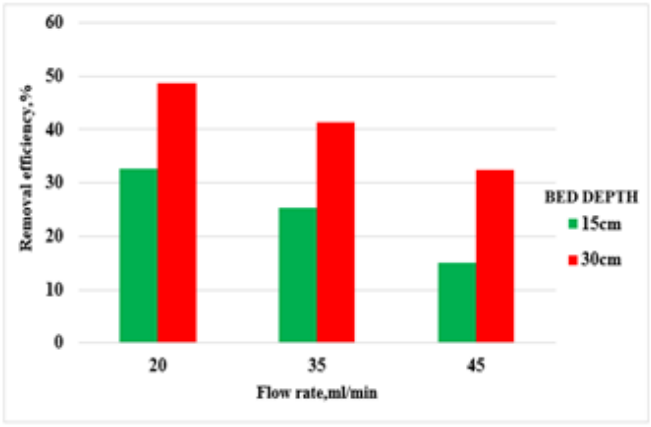

Figure: 3.7 Effect of bed depth on removal efficiency with sawdust adsorbent. (pH- 6, Co-40 mg/L)

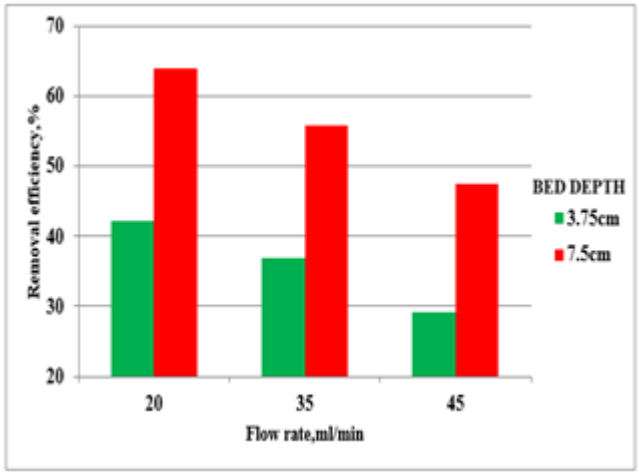

Figure: 3.8 Effect of bed depth on removal efficiency with Iron oxide Nanoparticle adsorbent. (pH-6, Co-40 mg/L)

3.1.1 Effect of flow rate

Figure 3.1 and 3.2 shows that, as flow rate increases from 20, to 35, 45 ml/min the removal efficiency decreases. For given bed depth of 15 cm, 30 cm and 3.75 cm, 7.5 cm with different flow rates and concentration of 10 mg/l and 40 mg/l the efficiency decreased from 52.86 to 31.76, 68.82 to 47.75% and 32.6 to 15.10, 48.62 to 32.37 for sawdust. Similarly 77 to 54.16%, 92.06 to 72.35% and 42.23 to 29.13, 64.10 to 47.60 for Iron oxide Nanoparticle.

3.1.2Effect of initial metal concentration

The effect of initial metal concentration 10 and 40 mg/l on removal of copper shown in figure 3.1 to 3.4. The increasing copper concentration 10 to 40 mg/l, the removal efficiency for flow rate 20 ml/min and bed depth of 30 cm for sawdust and 7.5 cm for iron oxide will be 68.82 to 48.62% and

92.06 to 64.10% respectively. From the result it was found that as the rise in concentration removal efficiency reduces.

3.1.3 Bed depth

The removal efficiency of copper was increased as the depth of adsorbent increases. Figure 3.5 to 3.7 it convey that, by changing bed depth of 15 to 30 cm and 3.75 to 7.5 cm for sawdust and iron oxide Nano particle with pH-6 the removal efficiency rise 52.86 to 68.82% and 77 to 92.06%.

IV. CONCLUSIONS, LIMITATIONS AND SCOPE FOR FUTURE STUDY

In this present dissertation work experiments were done to estimate the potential efficiency of the adsorbents such as, sawdust and iron oxide nanoparticles for the removal of copper ions. The results obtained are discussed detail in chapter 4 and conclusions for the same are mentioned below:

- It is concluded that removal efficiency decreases with increase in flow rate.
- It is concluded that the bed depth increased from 15 to 30 cm for sawdust and 3.75 to 7.5 cm for Iron oxide results in increased efficiency.
- It is concluded that the removal potential of copper from the sample by sawdust has lesser degree compared to Iron oxide Nanoparticle.
- It is concluded from acquired results represents that the maximum removal efficiency from column experimentation will be 68.82 and 92.06% at bed depth of 30 cm for Sawdust and 7.5 cm for Iron oxide at concentration of 10 mg/L.

4.1 LIMITATIONS OF PRESENT STUDY

The following are the limitations of present study

[1] The studies were carried out for selected range of variables and conclusions and inferences are drawn considering the best out of these variables. However the refined optimization of variables of experimentation is the limitations of present setup.

[2] Generally metal plating industry effluent will be containing many metal ions at a time. Therefore, in a practical sense potential of adsorbent in treating actual effluent is to be studied, for optimum condition.

4.2 SCOPE FOR FUTURE WORK

[1] The issues covered in the limitations above can be considered as subject matter for few further study.

[2] In the present study the removal of heavy metals conducted only for sawdust and iron oxide Nanoparticle as adsorbent for the future scope the test is performed for the combination of different bio adsorbent and nanoparticle for the efficient removal.

[3] The experimentation conducted only up to the concentration of 40mg, for further studies the copper concentration can be increased and various water quality parameters are determined.

[4] The study conducted only for copper ions as adsorbate so for future the effectiveness removal of different heavy metal ions such as Arsenic. Nickel, Iron etc can be studied.

[5] Instead of using synthetic copper water sample onsite sample having more concentration of copper ions with other impurities can be studied.

REFERENCES

[1] AakritiVerma , KushagraRejendra, Kalpana Singh, Sudeep Shukla, (2017),"Use of Low Cost Adsorbents for the Remediation of Heavy Metals from Waste Water", International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS),6(7),2278-2540.

[2] AshutoshTripathi and ManjuRawatRanjan,(2015), "Heavy Metal Removal from Wastewater Using Low Cost Adsorbents", Journal of Bioremediation & Bio degradation,6(6),2155-6199.

[3] Brahmaiah. T, L. Spurthi, K. Chandrika, S. Ramanaiah, and K. S. Sai Prasad, (2015), "Kinetics Of Heavy Metal (Cr & Ni) Removal From The Wastewater By Using Low Cost Adsorbent", World Journal Of Pharmacy And Pharmaceutical Sciences, 4(11),2278 – 4357.

[4] BULUT Yasemin and TEZ Zeki, (2006), "Removal of heavy metals from aqueous solution by sawdust adsorption", Journal of Environmental Sciences, 29(8),160-166.

[5] Cakir E, Tosunoglu V, Boncukcuoglu R, Korkmaz M, and Fil B.A,(2017), "kinetic and Fixed bed studies for copper removal from solutions by walnut tree sawdust", Global NEST journal, 19(12),327-335.

[6] FarnoushUsef, (2016), "Application of Iron Oxide Nanomaterials for the Removal of Heavy Metal", Journal of Materials Science & Surface Engineering, 4(2), 347-350.

[7] GayathriGangadhar, UtkarshMaheshwari and Suresh Gupta, (2012); Application of Nanomaterials for the Removal of Pollutants from Effluent Streams; Nanoscience and Nanotechnology-Asia, 2, 140-150.

[8] Marina SCIBAN and Mile KLASNJA, (203), "Optimization of usage of wood sawdust a an adsorbent of heavy metal ions from water", ISIRR, 3, 51-55.
[9] OKOLI and IBE EZUMA, (2014), "Adsorption Studies of Heavy Metals by Low-Cost Adsorbents", Appl. Sci. Environ. Manage, 18(3), 443-448.
[10] Pragati, Prof. Sumint Singh Trivedia, Laxikant Pandey, (2015), "Removal of Zinc from Synthetic Waste Water by Saw Dust as an Adsorbent", IJISET - International Journal of Innovative Science, Engineering & Technology, 2(6), 2348 – 7968.
[11] Preethi.T.N, Manjunath.N.T, Shiva Keshava Kumar, (2016), "Comparative Evaluation of Removal of Fast Green and Reactive Orange by Low-Cost Adsorbent", IJSART, 2(9), 2395-1052.
[12] Preethi.T.N, Manjunath.N.T, Nagarajappa.D.P, Rashma Shetty, (2016), "Feasibility Studies to Evaluate Color Removal Potential of Banana Pith", International Research Journal of Engineering and Technology (IRJET), 3(8), 2124-2128.
[13] Pragnesh N. Dave and Lakhan V. Chopda, ((2014), "Application of Iron oxide Nano material for the removal of heavy metals", Journal of Nanotechnology, 3(2), 1-14.
[14] Premkumar. V, M.R.RajanR.Ramesh, (2016), "Removal Of Toxic Substances From Textile Dyeing Industry Effluent Using Iron Oxide Nanoparticles", Indian Journal of Research, 5(6), 639-648.
[15] Rajeshwar Man Shrestha, Raja Ram Pradhananga, Margit Varga, ImreVarga,(2011), "Preparation of Activated Carbon for the Removal of Pb (II) from AqueousSolutions",IJLTEMAS,2(8),94-101.
[16] RedouaneOuafi, ZakiaRais, Mustapha Taleb, Mohamed Benabbou, and MeryemAsri, (2017), "Sawdust in the treatment of heavy metals-contaminated waste water", Environmental Research Journal, (11), 1935-3049.
[17] Yasmin.M Regina, S. Saraswathy, B.Kamal, V.Karthik, K. Muthukumaran, (2015), "Removal Of Nickel (Ii) Ions From Waste Water Using Low Cost Adsorbents: A Review", Journal of Chemical and Pharmaceutical Sciences, 8(1), 1974-2115.