ADSORPTION OF COLOR FROM A STOCK SOLUTION USING NEEM LEAVES POWDER AS A LOW-COST ADSORBENT

Ghanshyam G. Pandhare[1], Nikhilesh Trivedi[2], S. D. Dawande[3]
[1, 2]M.Tech Third Semester & [3]Associate Professor,
Department of Chemical Engineering, Laxminarayan Institute of Technology, R.T.M.Nagpur University, Nagpur, India
ghanshyam_elite000@yahoo.com, nst2011@gmail.com, sddawande@gmail.com

ABSTRACT

The regular commercial activated carbon is expensive, so there is a need of alternatives for such application. In present study Neem leaves powder activated using chemical treatment as a low-cost adsorbent. And experiment has done with different weight of adsorbent. The potential of Neem leaves powder adsorbent to remove color impurities from industrial effluent is good. Adsorption isotherm of color solution on adsorbent were determine and correlation with common isotherm equations such as Freundlich Isotherm and Langmuir isotherm model. The maximum removal efficiency was observed up to 80% from prepared Neem leaves at optimum value of parameter. Industrial effluents, dyes from textile industry are common water pollutants and they may be frequently found in trace quantities in industrial waste water so treatment can be done using this adsorbent. Adsorption has been used successfully in the removal of color from effluents. This adsorbent as local replacement for existing commercial adsorbent materials.

KEYWORDS: *Adsorption; Methyl Red; Neem leaves; $K_2Cr_2O_7$ Freundlich and Langmuir Isotherm*

I. INTRODUCTION

Adsorption is the process through which a substance, originally present in one phase, is removed from that phase by accumulation at the interface between that phase and a separate (solid) phase. In principle adsorption can occur at any solid fluid interface. Adsorption is one of the established unit operations used for the treatment of contaminated water i.e. raw water and/or wastewater. Adsorption studies are usually conducted over batch studies and column studies. Activated carbon is the most used adsorbent. Due to its high cost and considering the enormous quantity of effluent produced by textile industries, researches are turning toward the use of alternative adsorbents, also called non-conventional low-cost adsorbents.

In spite of its widespread use in various cleaning procedures, activated carbon remains expensive; therefore, the development of low-cost alternative adsorbents has been the focus of recent research [10]. Contributions in this regard have been made by many researchers who have utilized a number of substances such as agricultural wastes: coir pith, banana pith, sugar cane dust, sawdust, activated carbon fibers and rice hulls, industrial solid wastes: fly ash, red mud and shale oil ash, and so on[2]. Toxic metals are often discharged by a number of industrial processes and this can lead in turn to the contamination of freshwater and marine environment [1]. Heavy metals are major pollutants in marine, ground, industrial and even treated wastewaters.

Adsorption is usually described through isotherms, that is, functions which connect the amount of adsorbate on the adsorbent, with its pressure (if gas) or concentration (if liquid). One can find in literature several models describing process of adsorption, namely Freundlich isotherm, Langmuir isotherm, BET isotherm, etc [8]. Adsorption is present in many natural physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, capturing and using waste heat to provide cold water for air conditioning and other process requirements synthetic resins, increase storage capacity of carbide-derived carbons for tunable nonporous carbon and water purification.

II. LITERATURE SURVEY

The adsorption process is one of the effective methods for removal dyes from the waste Effluent. The process of adsorption has an edge over the other methods due to its sludge free clean operation and completely removed dyes, even from the diluted solution [3]. Activated carbon (powdered or granular) is the most widely used adsorbents because it has excellent adsorption efficiency for the organic compound.

A large number of plants and their wastes have been used to remove heavy metals and other contamination from water all over the world [10]. Materials like coconut shell carbon (Arulanantham et al., 1992), activated carbon (Muthukumaran et al., 1995; Mariappan et al., 2002; Sivabalan et al., 2002), activated alumina (Kumar, 1995; Li et al., 2001), have been used as adsorbents The colour is aesthetically objectionable and it also reduces light penetration into water decreasing the efficiency of photosynthesis in aquatic plants, thereby, having adverse impacts on their growth [1]. In addition, some of the dyes might be toxic to some organisms. Industrial waste constitutes the major source of various kinds of metal pollution in natural waters.

Adsorption is effectively in removing trace components from a liquid phase and may be used either to recover the components or simply to remove noxious substance from industrial waste. Any potential application of adsorption has to be considered along with alternatives such as distillation, absorption and liquid extraction [4]. Each separation process exploits a difference between properties of substance to separate. In distillation the property applied is volatility, in absorption it is solubility, in extraction it is distribution coefficient. Separation by adsorption depends on one component being more readily adsorbed than other. The selection of a suitable process depends upon the ease with which the separated components are removed. Therefore the development of new technologies for the removal of color from waste water is necessary [5]

Adsorption has been used successfully in the removal of color from effluents. Activated carbon is the most used adsorbent. Due to its high cost and considering the enormous quantity of effluent produced by textile industries, researches are turning toward the use of alternative adsorbents, also called non-conventional low-cost adsorbents [12]. Industries like plastic, paper, textile and cosmetics use dyes to color their products.

III. MATERIALS AND METHODS

3.1 Preparation of Adsorbent

Initially Neem leaves were washed repeatedly by using distilled water to remove moisture and soluble impurities. Then Neem leaves kept in dryer at 90^0C, for2-3 hrs till leaves turn pale yellow. Then crushed and screen by 10-15um mesh size.

Neem leaves powder washed to remove moisture and free acid and kept in dryer 20-25 minute. After drying powder was mixed with ortho-H_3PO_4 in silica crucible and kept in furnace at 260^0c for 15-20 minute .The heating period depend on atmospheric temperature then solution was cooled & repeatedly washed using hot water to remove free acid and moisture, total 7 washing taken and kept it in dryer for 20-25 minute the prepared black colored adsorbent kept in bottle for further use.

About 20 gm sample and 10ml Ortho-H_3PO_4 acid taken in silica crucible and kept in furnace. The furnace is initially at normal room temperature then furnace set at 260^0C. Heating was carried out for 20 minute. Then sample was removed and cool. After cooling the sample was repeatedly washed for 7 times using hot water to remove free acid and moisture .Then sample kept in dryer for 20-25 minute and the activated black colored adsorbent stored in bottle.

3.2 Preparation of Methyl Red solution

In a clean beaker 500 ml water is heated, in this boiling water 5gm Methyl Red powder added with constant stirring .The solution is allowed to boil for 5 minute and cooled, then filter the cooled solution to remove suspended matter and undissolved matter .The clear solution is collected and store in beaker for further use.

3.3 Preparation of $K_2Cr_2O_7$ solution

In a clean beaker 500 ml water is heated, in this boiling water 18.112 gm K2Cr2O7 powder added with constant stirring .The solution is allowed to boil for 5 minute and cooled, then filter the cooled solution to remove suspended matter and undissolved matter. The clear solution is collected and store in beaker for further use.

3.4 Experimental setup

The samples are taken and put in dryer for about 30 minutes. After the sample is dried, the sample is weighed as 1gm, 2gm, 3gm, 4gm, and 5gm. The weighed samples are put in the conical flask of 250 ml. The prepared solution of methyl red is poured in the flask. Exactly 100 ml of the solution is poured in each conical flask. After the addition of the solution, the flask is well shaken for 10 minutes and allowed to stand still for 48 hours.
After 48 hours the sample is shaken and filtered. The filtered sample is collected in small plastic bottles and the activated carbon is collected. The collected sample kept in dryer. After drying the samples are packed and colorimeter reading taken of all filtered solution. Same procedure was repeated for K2Cr2O7 solution.

IV. RESULT AND DISCUSSION

4.1 Characterization of the synthesized adsorbent obtained from Neem Leaves Powder by BET method:

The surface area of carbon obtained from Neem Leaves Powder is determined by Brunauer, Emmett and Teller (BET) N_2 sorption procedure with liquid N_2 at 195.72^{o}C. The specific surface area is found to be 421 m^2/g.

4.2 Colorimeter reading and % Adsorption

The collected solution after the experiment is used for calculating percentage adsorption. At first the reading for water is taken this is blank reading. Then colorimeter reading taken for all sample solution. This is reference reading. Reduce concentration of solution calculate from the standisation graph of Methyl Red solution colorimeter reading. The % Adsorption of all sample calculated by following formula,

$$\%\ \text{Adsorption} = \frac{Initial\ conc. - Final\ conc.}{Initial\ conc.} * 100$$

Following table shows the colorimeter reading and % Adsorption for Methyl Red solution using various weight of adsorbent.

Table-1: Sample 1- Methyl Red Solution

Sr.no.	Wt. of adsorbent/Vol. of solution	Colorimeter reading	% Adsorption
1	1 gm/100ml	0.22	46.10%
2	2 gm/100ml	0.19	55.37%
3	3 gm/100ml	016	62.56%
4	4 gm/100ml	0.12	74.15%
5	5 gm/100ml	0.09	79.23%

The figure-1 shows the behavior of amount of adsorbent and the concentration of solution. It can be concluded that the amount of adsorbent increases the concentration of solution decreases as the surface for adsorption increases. The figure-2 shows the behavior of amount of adsorbent and the %

Adsorption. It can be concluded that the amount of adsorbent increases the % Adsorption increases as the surface for adsorption increases.

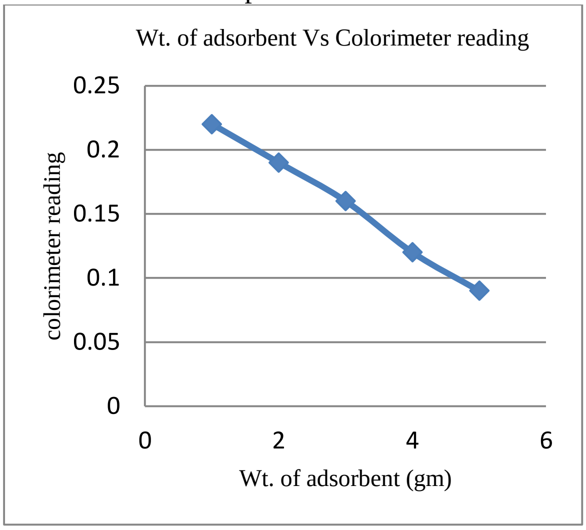


Figure 1: Wt. of Adsorbent Vs Colorimeter reading

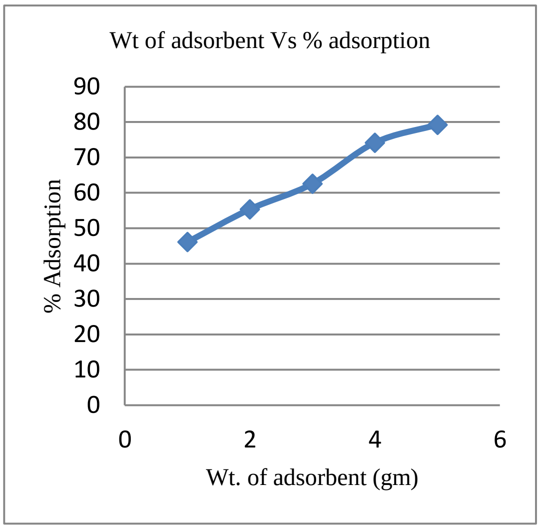


Figure 2: Wt. of Adsorbent Vs % Adsorption

Following table shows the colorimeter reading and % Adsorption for $K_2Cr_2O_7$solution using various weight of adsorbent.

Table-2: Sample 2: $K_2Cr_2o_7$ Solution

Sr.no.	**Wt. of adsorbent/Vol. of solution**	**Colorimeter reading**	**% Adsorption**
1	1 gm/100ml	0.46	46.35%
2	2 gm/100ml	0.44	50.61%
3	3 gm/100ml	0.40	64.85%
4	4 gm/100ml	0.35	71.01%
5	5 gm/100ml	0.32	74.25%

The figure-3 shows the behavior of amount of adsorbent and the concentration of solution. It can be concluded that the amount of adsorbent increases the concentration of solution decreases as the surface for adsorption increases. The figure-4 shows the behavior of amount of adsorbent and the % Adsorption. It can be concluded that the amount of adsorbent increases the % Adsorption increases as the surface for adsorption increases.

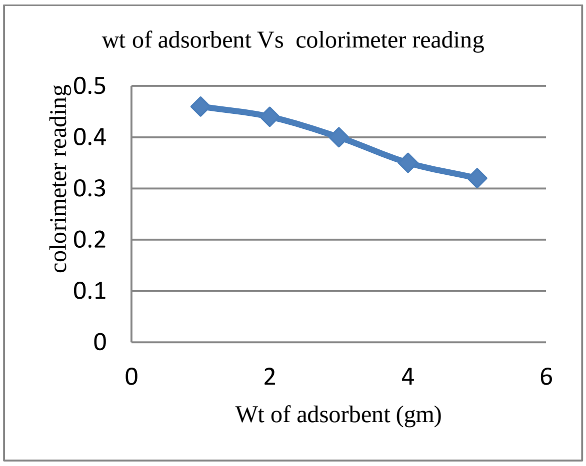


Figure 3: Wt. of Adsorbent Vs Colorimeter reading

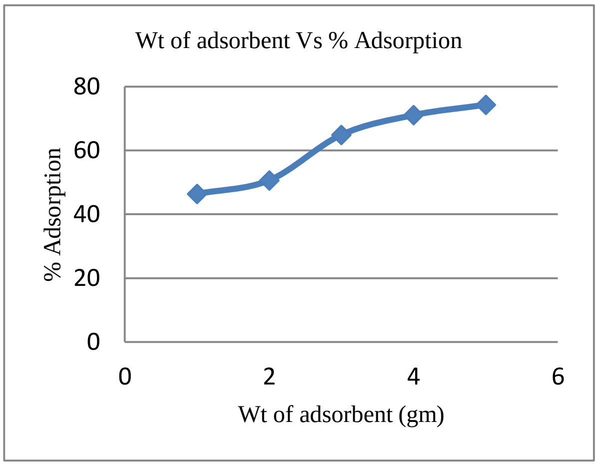


Figure 4: Wt. of Adsorbent Vs % Adsorption

4.3 Adsorption isotherm

Adsorption dosages on the removal of color from Methyl Red (conc. 10gm/lit) and $K_2Cr_2O_7$ (conc.36.224gm/lit) solution. For modeling of Adsorption, two adsorption model used. The original and linear equations are as following forms,

1. Langmuir isotherm

Original form: $Q = (q_m. K_f. C)/ (1+ K_f.C)$……………………………… (1)

Linearised form: $C/q = 1 / (K_f .q_m) + (C/q_m)$……………………………. (2)

2. Freundlich Model:

Original form: $q = K_f C^{1/n}$…………………………………………….. (3)

Linearised form: $\log q = \log K_f + (1/n) \log C$ ……………..…………… (4)

Langmuir isotherm holds at low concentration but fails at high concentration so C is low, factor (C/k) may be ignored and isotherm assumes form x= K'C Hence at low concentration the amount of gas adsorbed (x) is directly proportional to concentration (C) at high concentration. The mass adsorbed reaches a constant value K'' when the adsorbent surface is completely covered with unimolecular layer of gas at this stage the adsorption is independent of concentration.

$$(x/m) = KC^{(1/n)}$$

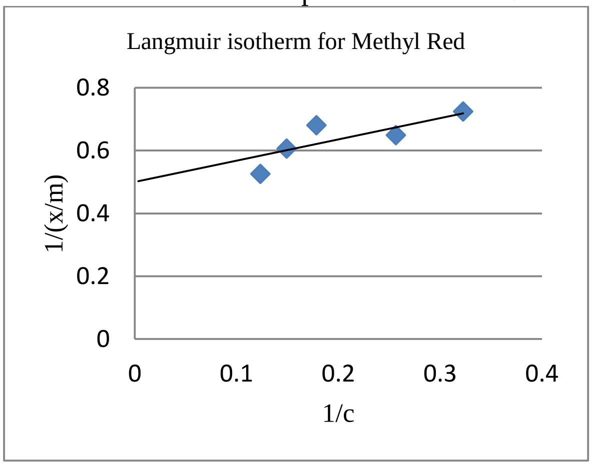
$$\text{Log } (x/m) = \log + 1/n \log C$$

This equation straight line plot of log (x/m) Vs log C should be straight line with slope 1/n and intercept log K however it is actually found that the plot were straight line at low concentration, while at higher concentration they showed a straight curvature especially at low this indicate that Freundlich equation approximate and does not apply to adsorption of gases by solids at high concentration.

Table 3: Amount Adsorbed using Different Weight of Adsorbent

Adsorbent dosage (gm/100ml)	Methyl Red solution		$K_2Cr_2O_7$ solution	
	Amount Adsorbed (x/m) gm/lit	Concentration (C) gm/lit	Amount Adsorbed (x/m) gm/lit	Concentration (C) gm/lit
1gm	1.9 gm/lit	8.1 gm/lit	16.242gm/lit	19.8 gm/lit
2gm	1.65gm/lit	6.7 gm/lit	8.987 gm/lit	18.25 gm/lit
3gm	1.47gm/lit	5.6 gm/lit	7.708 gm/lit	13.1 gm/lit
4gm	1.52gm/lit	3.9 gm/lit	6.431 gm/lit	10.5 gm/lit
5gm	1.38gm/lit	3.1 gm/lit	5.304 gm/lit	9.7 gm/lit

In order to determine the adsorption isotherm, chemically activated Neem Leaves Powder adsorbent used. The experiments were performing at various weight of adsorbent. The effect of final concentration (C) on the color adsorbed per specific mass of adsorbent (x/m) is presented in fig.5& 6 the shape of adsorption isotherm indicate that adsorption of color from Methyl red and $K_2Cr_2O_7$ solution on Neem leaves powder adsorbent.



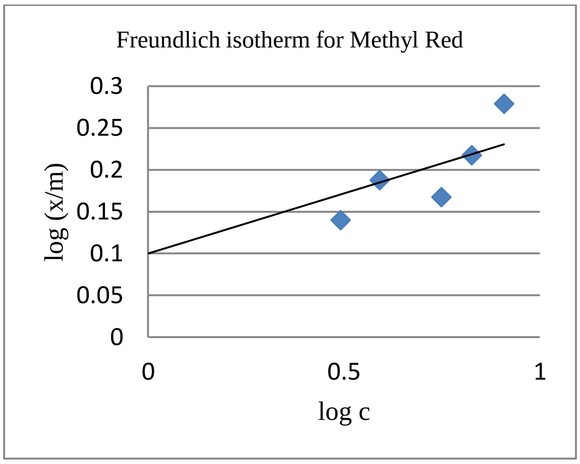
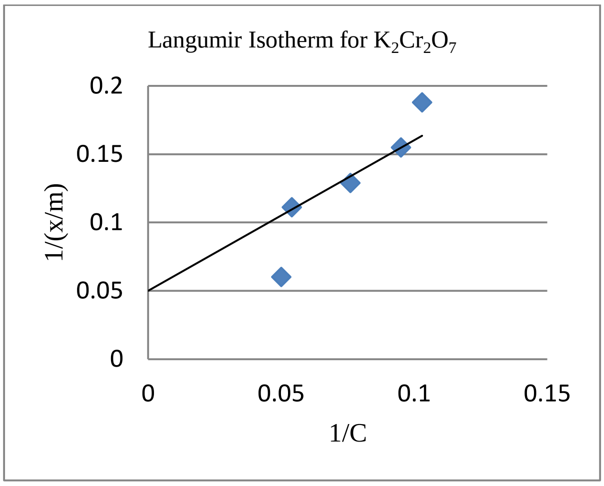


Figure: 5 Langmuir and Freundlich Isotherm for Methyl Red solution



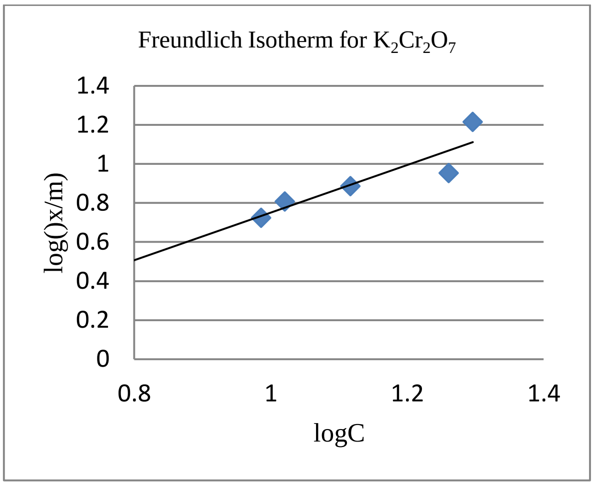


Figure: 6 Langmuir and Freundlich Isotherm for $K_2Cr_2O_7$ solution

The amount of adsorbent (x/m) in Langmuir model for adsorption of color from Methyl red and $K_2Cr_2O_7$ solution were 1.9gm/lit and 16.242gm/lit respectively. These results indicate that adsorption of Methyl Red is superior to the adsorption of $K_2Cr_2O_7$ and the affinity of Neem leaves powder for adsorption is high.
The correlation coefficient (R^2) of Langmuir model for adsorption of color from Methyl red and $K_2Cr_2O_7$ solution 0.997 and 0.967 respectively, which were higher than R^2 values of Freundlich model and the good applicability of the Langmuir model to these adsorption.

Table 4: Correlation coefficient and constant (n & k) of isotherm model for adsorption of Methyl Red and $K_2Cr_2O_7$ solution.

Solution	Langmuir isotherm model			Freundlich isotherm model		
	R^2	q (gm/l)	K_f	K_f	n	R^2
Methyl Red	0.997	1.9	3.26	1.10	5.044	0.886
$K_2Cr_2O_7$	0.967	5.304	0.153	1.64	3.09	0.897

V. CONCLUSION

The Neem leaves commonly available waste material in India. It is useful in medicine, but utilization of Neem leaves using various treatments can be used as a low cost adsorbent instead of high cost adsorbent. The chemically activated Neem leaves powder adsorbent capacities for Methyl Red and $K_2Cr_2O_7$ solution were 79% and 74% respectively. The surface area and particle size are 421m^2/g and 5um respectively also studied.
In the present work the Neem Leaves Powder converted into the activated carbon by chemical activation. This activated carbon was utilized for the adsorption of color from the prepared stock solution of methyl Red and $K_2Cr_2O_7$ solution. Various amount of the sample was taken and the adsorption study was carried out. It was seen that the weight of Adsorbent increased at a desired parameter the percentage adsorption also increases. Thus from the studies carried out it can be concluded that the prepared activated carbon can be used effectively to adsorb color. There is a tremendous potential in these materials to be explored as industrial low cost effective adsorbents. The correlation coefficient and constant were calculated using Langmuir and Freundlich isotherm.

ACKNOWLEDGMENT

The authors would like to acknowledge the Director, LIT, Nagpur for the facilities and encouragement provided. Authors also wish to express the sincere gratitude towards the Director ANACONLABS Nagpur for the analysis of adsorbent by BET surface area method.

REFERENCES

[1] Bhattacharyya, K. G and Sharma, a (2005). Kinetics and thermodynamics of methylene blue adsorption on Neem (Azadirachta indica) leaf powder Dyes and Pigments 65: 51 – 59

[2] Sunil Kumar, Asha Gupta, J.P.Yadav. "Removal of fluoride by thermally activated carbon prepared from neem leaves (Azadirachta indica) and kikar leaves (Acacia aeabica)". Journal of Environmental Biology, March **2008**, 29(2) 227-232.

[3] P.Venkateswarlu, M.Venkata Ratnam, D.Subba Rao & Venkateswara Rao. "Removal of chromium from an aqueous solution using Azadirachta indica (neem) leaf powder as adsorbent", International Journal of Physical Sciences, August **2007,** Vol. 2 (8), pp. 188-195

[4] O.Olayinka Kehinde, T.Adetunde Oluwatoyin, & O.Oyeyiola aderonke. "Comparative analysis of the efficiencies of two low cost adsorbents in the removal of Cr (VI) & Ni (II) from aqueous solution". African Journal of Environmental Science and Technology Vol. 3 (11), pp. 360-369

[5] Velmurugan .P, Rathina Kumar's, Dhinakaran.G. "Dye removal from aqueous solution using low cost adsorbent", International Journal of Environmental Sciences **2011,** Volume 1, No 7.

[6] Amir Hossein Mahvi, Dariush Naghipour, Forugh Vaezi and Shahrokh Nazmara. "Tea waste as An Adsorbent for Heavy Metal Removal from Industrial Wastewaters". American Journal of Applied Sciences, **2005,** 2 (1), 372-375.

[7] K.S. Rao, M. Mohapatra, S.Anand, P. Venkateswarlu. "Review on cadmium removal from aqueous solutions" International Journal of Engineering, Science and Technology Engineering, Vol. 2, No. 7, **2010**, pp. 81-103.

[8] Alau K.K., Gimba C.E. and Kagbu J.A. "Removal of Dyes from Aqueous Solution Using Neem (Azadirachta Indica) Husk as Activated Carbon". Archives of Applied Science Research, **2010**, 2 (5):456-461.

[9] Ghanshyam Pandhare, Nikhilesh Trivedi, Nitin Kanse, S.D.Dawande "SYNTHESIS OF LOW COST ADSORBENT FROM AZADIRACHTA INDICA (NEEM) LEAF POWDER" IJAERS/Vol.-II/Issue-II/Jan-March,2013/29-31

[10] Axtell, N.R., S.P.K. Sternberg and K. Claussen: Lead and nickel removal using Microspora and Lemna minor. Biores. Technol., 89, 41-48(2003).

[11] Muthukumaran, K., N., Balasubramanian and T.V. Ramakrishna: Removal of fluoride by chemically activated carbon. Ind. J. Environ. Protect. 15, 514-517 (1995).

[12] Low K.S., C.K. Lee and S.C. Liew, 2000. Sorption of cadmium and lead from aqueous solution by spent grain. Process Biochemistry, 36: 59-64.

AUTHORS

S. D. Dawande is working as associate professor in Chemical Engineering department of Laxminarayan Institute of Technology, Rashtrasant Tukadoji Maharaj Nagpur University Nagpur. He has guided number of M.Tech and PhD projects and has published large number of articles in journal of national and international standard. He has authored books titled 'Process Equipment Design, Chemical Reaction Engineering, Chemical hazards and Safety etc. He is currently working as Director In-Charge at LIT Nagpur.

Ghanshyam G. Pandhare received the Bachelor of Technology in Chemical Engineering in 2008 from Laxminarayan Institute of Technology, Rashtrasant Tukadoji Maharaj Nagpur University; Nagpur. He is currently pursuing the M.Tech. (Chemical Engineering) at Laxminarayan Institute of Technology, Nagpur.

Nikhilesh Trivedi received the Bachelor of Technology in Chemical Engineering from 2011 Priyadarshini Institute of Engineering and Technology, Rashtrasant Tukadoji Maharaj Nagpur University; Nagpur He is currently pursuing the M. Tech. (Chemical Engineering) at Laxminarayan Institute of Technology, Nagpur.