iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** X **Month of publication:** October 2015

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Development of Modeling Equation and Kinetics of Phosphate Removal from Pharmaceutical Effluent

Sunil Kanamarlapudi[1], Kasi Pradgna [2], Meena Vangalapati [3]
[1] M.Tech Student, [2] M.Tech Student, [3] Associate Professor , Dept of Chemical Engineering,
AUCE (A), Andhra University, A.P, India

Abstract- ***Phosphates are the naturally occurring form of the element phosphorus, found in many phosphate minerals. Phosphates enter waterways from human and animal waste, phosphorous rich bedrock, laundry, cleaning, industrial effluents and fertilizer runoff. These phosphates become detrimental when they pass over fertilize aquatic plants and cause stepped up eutrophication. A modeling equation was developed to known the phosphate removal with time. The proposed model equation for the removal of phosphate is*** Y_P ***= -0.843t + 160.3 and the model showed good agreement with experimental data (chemical precipitation method) and is significant compared to other methods in the removal of phosphate from pharmaceutical industry using chemical precipitation process. And the phosphate removal efficiency was with*** $CaCO_3$ ***is 97.45%. BOD is reduced from 74 to 28 ppm and COD is reduced from 1045 to 279ppm. The order of reaction was found out by plotting a graph between*** $-r_A$ ***and*** C_A***. From the graph we can say that reaction is of first order and the rate constant is calculated from the values of*** $-r_A$ ***and*** C_A ***and it is*** $0.0303min^{-1}$***. The time required for the phosphate removal in pharmaceutical effluent was calculated by using batch reactor performance equation and the reaction required is found to be 2.03hrs from the calculations and 2.5hrs from the experiments performed. The standard error obtained from the experimental data is*** ± 0.235***.***

Keywords: Phosphate, BOD, COD, Rate equation, Rate constant, Reaction time, Standard error.

I. INTRODUCTION

Phosphate is an important nutrient that occurs widely in the environment. It is the key elements necessary for the growth of plants and animals. It is the eleventh most abundant element on the surface of the earth and is most commonly found as phosphate. Phosphorus is a pre requisite for microbial growth in the aqueous bodies. The increased concentration of phosphate is the key factor for the eutrophication of surface water. Heavy algal growth occurs when phosphate is present in water and as such is undesirable (CHEN Xuechu et al.,2009). Phosphates enter waterways from human and animal waste, phosphorous rich bedrock, laundry, cleaning, industrial effluents and fertilizer runoff. These phosphates become detrimental when they pass over fertilize aquatic plants and cause stepped up eutrophication(Dr. Ehssan Nassef, 2012). Eutrofication is the natural aging process of a body of water such as a river or sea. This process results from the increase of nutrients within the body of water which in turn create plant growth. The plants die more quickly than they can be decomposed. This dead plant matter builds up and together with sediment entering the water, fills in the bed of the bay making it more shallow. Normally this process takes thousands of years. Cultural eutrofication is an unnatural speeding up of this process because of man's addition of phosphates, nitrogen and sediment to the water. Bodies of water are being aged at a much faster rate than geological forces can create new once. In testing for cultural eutrofication, one should expect to find an algal bloom or scum on the water accompanied by a fishy smell to the water and low dissolved oxygen content.
Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems, kidney damage, osteoporosis and hyperphosphatemia could occur from extremely high levels of phosphate.

Removal of phosphate has been largely studied, at present chemical precipitation is used for removal (Sawsan A. M. Mohammed, 2009)(J.M. Chimenos et al., 2003).

II. EXPERIMENTAL PROCEDURE FOR KINETICS OF REMOVAL OF PHOSPHATE BY USING COLUMN STUDIES

An appropriate quantity of cotton was kept at bottom of the column to reduce the loss of $CaCO_3$. Here we use a batch process because the settling time of $CaCO_3$ is fast, so in batch process itself we got results. In the column, adsorbent used is $CaCO_3$ and it

©IJRASET 2015: All Rights are Reserved

was done under optimized conditions (Michael J. Baker et al., 1998).

Initially 100ml of pharmaceutical effluent is taken into the column as batch process. In the column constant flow rate is maintained, for every ten minutes sample is collected and collected sample is taken to calculate phosphate concentration and % removal of phosphate. The removal of phosphate was done under optimized conditions. The parameters we optimized are dosage of $CaCO_3$ - 7.0gm, pH- 8.0, dosage of Alum -0.8gm are maintained for knowing the kinetics of the phosphate removal.

III. MODELING OF PHOSPHATE REMOVAL

In order to describe the phosphate removal from the effluent water the following hypothesis were used. The removal of phosphate is done under atmospheric conditions. The final form of modeling equation was obtained from the kinetics of phosphate removal

$$Y_P = m\,t + c$$

Where,

Y_P = Concentration of phosphate, ppm

t = Time, min

m = Slope and

c = Intercept

IV. RESULTS AND DISCUSSION

A. *Kinetics Of Phosphate Removal Using Column Separation Process*

It is batch process, depending upon the effluent and retention time. Mainly in column separation process adsorbent play vital role. Adsorbent usually employed in column are silica, alumina, calcium carbonate, magnesia, starch etc. In this process $CaCO_3$ is used as an adsorbent. Here in this experiment, the retention time of $CaCO_3$ is high, so the process is done in batch.

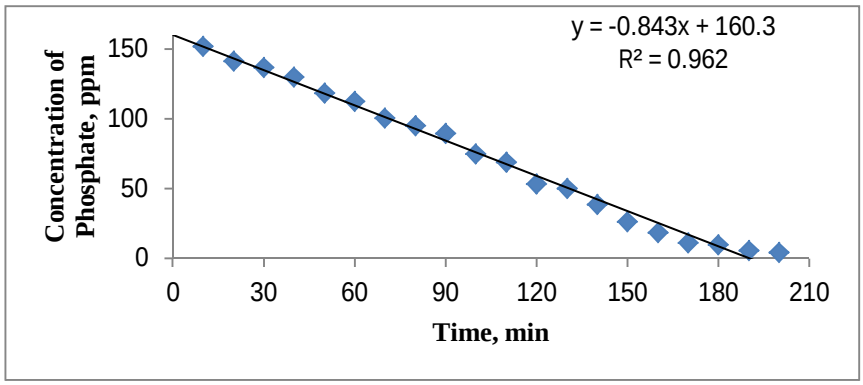


Figure-1: Concentration of Phosphate versus Time

For removal of phosphate from pharmaceutical effluent, we have taken 100 ml of sample and subjected to column separation process. The phosphate concentration was estimated for every 10min. The phosphate concentration was estimated from 10 min. to till the end of sample volume. The phosphate concentration was decreased as the time progress. The above Figure 1 depicts the decrease in phosphate concentration. In this experiment, column is used to know the kinetics of the phosphate removal with respect to time.

B. *Modeling Of Phosphate Removal By Using Column Separation Process*

To describe the removal of phosphate in effluent using chemical precipitation process, a modeling equation was developed. The

©IJRASET 2015: All Rights are Reserved

highest percentage removal of phosphate was found to be 97.45 % from the optimized conditions. The final form of the proposed model equation for the removal of phosphate is

$$Y_P = -0.843t + 160.3$$

Where, Y_P = Concentration of phosphate, ppm

t = Time, min

The model showed good agreement with experimental data by R^2 value of about 0.962 in removal of phosphate from pharmaceutical effluent using chemical precipitation.

C. Removal Efficiency

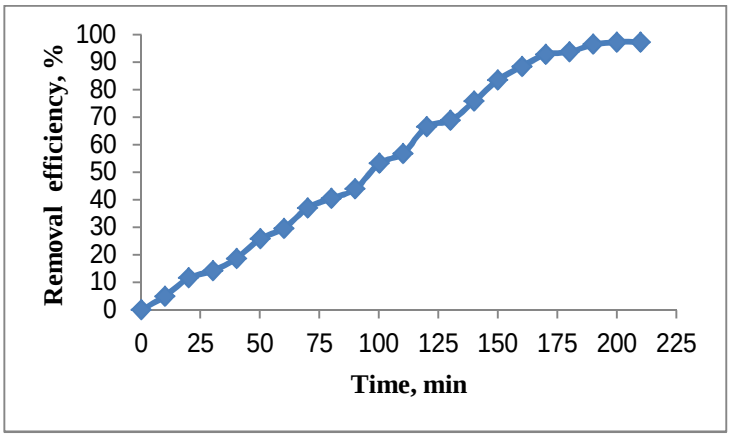


Figure-2: Removal efficiency of phosphate versus Time

As the time proceeds, the phosphate concentration in the effluent decreased and removal efficiency increased. Removal efficiency is calculated by taking the ratio of difference concentration to the initial concentration. From the optimized conditions, the percentage removal of phosphate was found to be 97.45% and it remained constant. The results are shown in above Figure 2.

D. Rate Equation

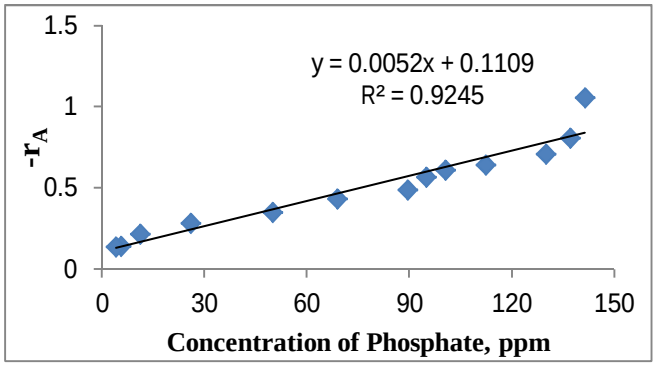


Figure-3: $-r_A$ versus Concentration of phosphate

The $-r_A$ versus C_A plot shows that the rate of reaction is low when concentration of phosphate is high. And the rate is high when the concentration of phosphate is low and we can also say that the reaction is of first order (n = 1). The plot and the values are shown in the above Figure 3.

E. Reaction Time Required For The Removal Of Phosphate

The above all experiments were performed in a glass beaker by means of magnetic stirring as a batch reactor. So, we use the batch

©IJRASET 2015: All Rights are Reserved

reactor equation to find out the reaction time required for the removal of phosphate from the pharmaceutical effluent.

For the first order reaction the rate equation is

$$-r_A = k\,C_A$$

The performance equation for the batch reactor is

$$\ln\frac{C_{A0}}{C_A} = k\,t$$

Where, C_{Ao} is the initial concentration of phosphate, ppm

C_A is the final concentration of phosphate, ppm

k is the rate constant, min^{-1}

t is theoretical reaction time, min

We can get the k value from slope of the $-r_A$ versus C_A plot and we get,

$$k = \frac{0.713 - 1.058}{129.96 - 141.31}$$

$$K = 0.0303 min^{-1}$$

Substituting the above k value in the performance equation gives the time required for the phosphate removal,

$$\ln\frac{160.01}{4.07} = 0.0303t$$

$$t = 122.386\,min$$

$$t = 2.03 hrs$$

Therefore, the reaction time required for the phosphate removal from the pharmaceutical effluent was found to be 2.03 hrs from the above calculations and 2.5 hrs from the experiments performed. The standard error obtained from the experimental data is ± 0.235.

F. Biological Oxygen Demand (BOD) And Chemical Oxygen Demand (COD)

In this process the BOD and COD test is conducted to effluent water in the starting of the process and after the completion of the process. The results are shown in Table 1 in this process the BOD is reduced from 52 ppm to 28 ppm and COD is reduced from 1045 ppm to 279 ppm

Table-1: Effect of BOD and COD

Pharmaceutical Effluent	BOD, ppm	COD, ppm
Initial	74	1045
Final	28	279

V. CONCLUSION

For the removal of phosphate, a modeling equation is developed to know the phosphate removal with respect to time. The proposed model equation for the removal of phosphate is Y_P = -0.843t + 160.3 and the model showed good agreement with experimental data

©IJRASET 2015: All Rights are Reserved

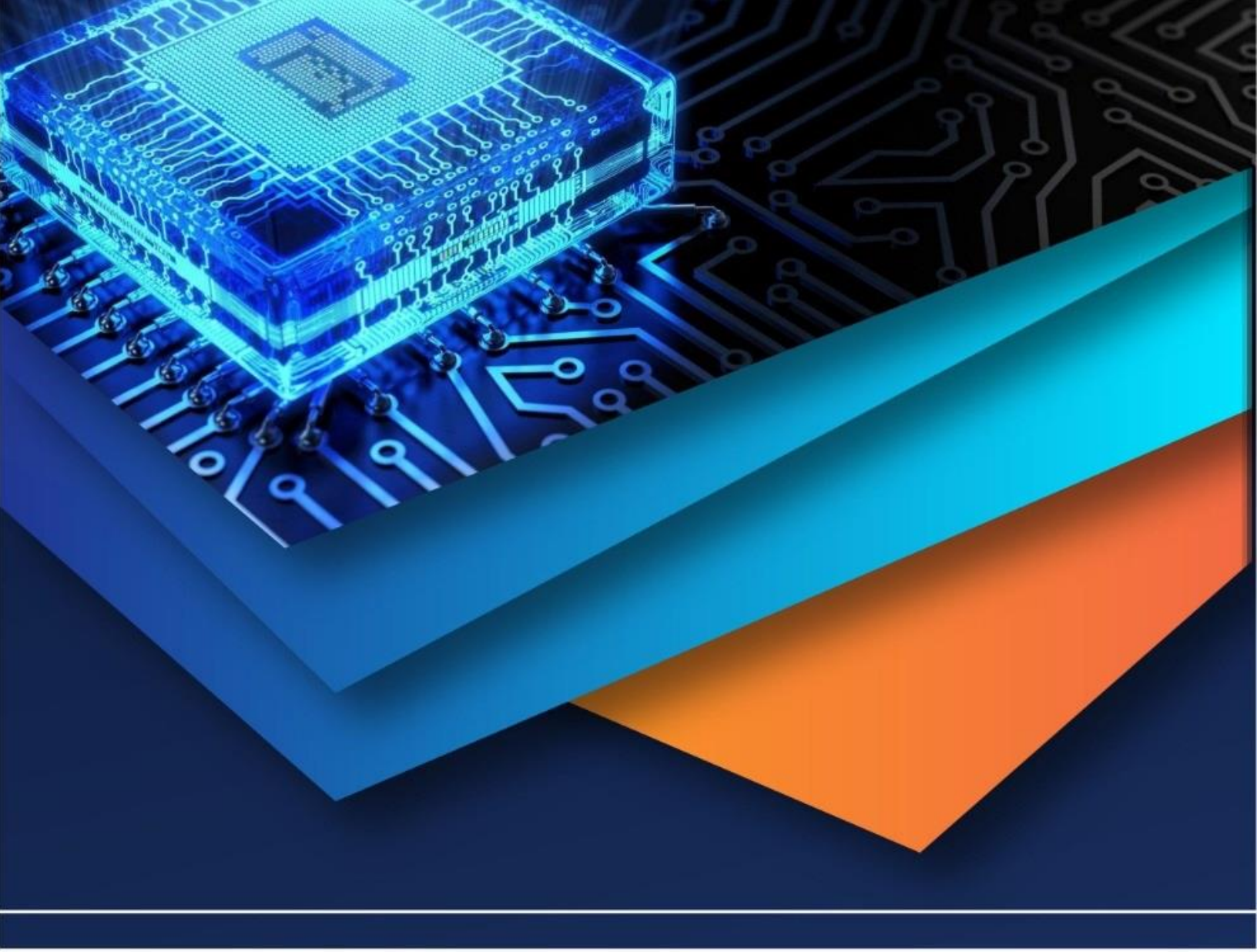
(chemical precipitation method) and is significant compared to other methods in the removal of phosphate from pharmaceutical industry. And the phosphate removal efficiency with $CaCO_3$ observed was 97.45% under optimized conditions.

At the same time, the water quality parameters Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were also estimated and were found to be initial effluent water was 74 ppm and 1045 ppm respectively. After the phosphate removal, the parameters obtained were 28 ppm and 279 ppm respectively. From the $-r_A$ versus C_A plot we found that the reaction is a first order reaction (n=1) and the rate constant, k is $0.0303min^{-1}$. The time for the removal of phosphate is calculated by using the batch reactor performance equation and the reaction time required for the phosphate removal from the pharmaceutical effluent is found to be 2.03 hrs from the above calculations and 2.5 hrs from the experiments performed. The standard error obtained from the experimental data is± 0.235.

REFERNCES

[1] CHEN Xuechu, Kong Hainan, Wu Deyi, Wang Xinze, Lin Yongyong, "Phosphate removal and recovery through crystallization of hydroxyapatite using xonotlite as seed crystal" in Journal Environmental Sciences, vol. 21, pp 575–580, 2009.
[2] Dr. Ehssan Nassef, "Removal of Phosphates from Industrial Waste Water by Chemical Precipitation" in Iracst – Engineering Science and Technology: An International Journal (Estij), vol. 2, no. 3, 2012.
[3] Sawsan A. M. Mohammed and Haider Abbas Shanshool, "Phosphorus Removal from Water and Waste Water by Chemical Precipitation Using Alum and Calcium Chloride" in Iraqi Journal of Chemical And Petroleum Engineering, vol. 10, no. 2, pp 35-42, 2009.
[4] J.M. Chimenos, A.I. Fern!andez, G. Villalba, M. Segarraa, A. Urruticoechea, B. Artaza, F. Espiell, "Removal of ammonium and phosphates from wastewaterresulting from the process of cochineal extraction using MgO-containing by-product" in Journal of Water Research, vol. 37, pp 1601–1607, 2003.
[5] Michael J. Baker, David W. Blowes and Carol J. Ptacek, "Laboratory Development of Permeable Reactive Mixtures for the Removal of Phosphorus from Onsite Wastewater Disposal Systems" in Journal Of Environmental Science Technology, vol. 32, pp 2308-2316,1998.
[6] Barbara Grzmil, Jaroslaw Wronkowski, "Removal of phosphates and flourides from industrial waste water" in Journal of Desalination, vol. 189, pp 261-268,2006.
[7] Mbarka Gouider, Mongi Feki and Sami Sayadi, "Treatment of Wastewaters from Phosphate Fertilizer Industry" in Journal of Environmental Progress & Sustainable Energy, vol. 33, no. 2, 2014.
[8] Maya R. Unnithan, V. P. Vinod, T. S.Anirudhan, "Ability of Iron(III)-Loaded Carboxylated Polyacrylamide-Grafted Sawdust to Remove Phosphate Ions from Aqueous Solution and Fertilizer Industry Wastewater: Adsorption Kinetics and Isotherm Studies" in Journal of Applied Polymer Science, vol. 84, pp 2541–2553, 2002.
[9] E. Klimiuk, U. Filipkowska, B. Libecki, "Coagulation of Wastewater Containing Reactive Dyes with the Use of Polyaluminium Chloride (PAC)" Polish Journal of Environmental Studies, vol. 8, no. 2, pp 81-88, 1999.
[10] A.H. El-Shazly, M.A. Daous, "Kinetics and Performance of Phosphate Removal from Hot Industrial Effluents Using a Continuous Flow Electrocoagulation Reactor", in INT. J. ELECTROCHEM. SCI., VOL. 8, pp 184 – 194, 2013.
[11] Safaa M. Ragheb, "Phosphate removal from aqueous solution using slag and fly ash" in Hbrc Journal, vol. 9, pp 270–275, 2013.
[12] A. Negrea, L. Lupa, P. Negrea, M. Ciopec and C. Muntean, "Simultaneous Removal of Ammonium and Phosphate Ions from Wastewaters and Characterization of the resulting Product" in Journal of Chemical Bulletin of Politehnica University of Timisoara, Romania Series of Chemistry And Environmental Engineering, vol. 55, no. 69, 2010.
[13] Jing Chen and Zhaokun Luan, "Enhancing phosphate removal by coagulation using polyelectrolytes and red mud" in Journal of Fresenius Environmental Bulletin, vol. 19, no. 10, 2010.
[14] Zhipan Wen, Yalei Zhang, Chaomeng Daib, "Removal of phosphate from aqueous solution using nanoscalezerovalent iron (nZVI)" in Journal of Colloids and Surfaces A: Physicochemical and Engineering Aspects, vol. 457, pp 433–440, 2014.
[15] Ke Xu, Tong Deng, Juntan Liu, Weigong Peng, "Study on the phosphate removal from aqueous solution using modified fly ash" in Fuel, vol. 89,pp 3668–3674, 2010.
[16] Dr. Ehssan Nassef, "Removal of Phosphorous Compounds by Electrochemical Technique" in Iracst – Engineering Science and Technology: An International Journal (Estij), vol.2, no.3, 2012.
[17] Asmaa Shalaby, Ehssan Nassef, Ashraf Mubark, Mohamed Hussein, "Phosphate removal from wastewater by electrocoagulation using aluminium electrodes" in American Journal of Environmental Engineering And Science, vol. 1, no.5, pp 90-98, 2014.
[18] A.H. El Shazly, A.A. Al-Zahrani and Y.A. Alhamed, "Kinetics and Performance Analysis of Batch Electrocoagulation Unit Used for the Removal of a Mixture of Phosphate and Nitrate Ions from Industrial Effluents" in Int. J. Electrochem. Sci., vol. 8, pp 3176 – 3185, 2013.
[19] Yang Zhang, Evelyn Desmidt, Arnaud Van Looveren, Luc Pinoy, Boudewijn Meesschaert, and Bart Van Der Bruggen, "Phosphate Separation and Recovery from Wastewater by Novel Electrodialysis" in Journal of Environ. Sci. Technol., vol. 47, pp 5888−5895, 2013.
[20] Dr. C. R. Ramakrishnaiah, Vismitha, "Removal of phosphate from wastewater using low-cost adsorbents" in International Journal of Engineering Inventions, vol. 1, NO. 7, pp 44-50, 2012.
[21] V. Kuokkanen, T. Kuokkanen, J. Rämö, U. Lassia, J. Roininen, "Removal of phosphate from wastewaters for further utilization using electro-coagulation with hybrid electrodes – Techno-economic studies" in Journal of Water Process Engineering, vol.94, 2014.
[22] Sukru Dursun, Dunyamin Guclu, Mehmet Bas, "Phosphate removal by using activated red mud from Seydisehi Aluminium Factory in Turkey" in J. INT. ENVIRONMENTAL APPLICATION & SCIENCE, VOL. 1, NO. 3&4, pp 98-106, 2006.
[23] Jonathan R. Chinhanga, "Impact of industrial effluent from an iron and steel company on the physicochemical quality of Kwekwe River water in Zimbabwe" International Journal of Engineering, Science And Technology, vol. 2, no. 7, pp 129-140, 2010.

©IJRASET 2015: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)