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Adsorption Study for Removal of COD from Waste Water Using Sustainable Adsorbent: Experimental and Modelling

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Abstract -- Industrial, agricultural and domestic activities of humans have affected the environmental system, resulting in drastic problems such as wastewater containing high concentration of pollutants. The most important technologies are useful to waste water treatment such as coagulation, membrane technology filtration, ion exchange and advanced oxidation processes. However, most of them above depend on the substantial financial input and their use is restricted because of cost factors. The high cost of coal-based activated carbons has stimulated the search for cheaper alternatives. Various low cost adsorbent like Fullers earth can be used for removing of COD in waste water. The result were studied by mathematical modeling such as Rathi-Puranik model, Weber-Morri's model and Lagregean model, which suggest that Rathi - Puranik model is more appropriate compare to Weber-Morri's model and Lagregean model to predict the COD value at any time in a given system.

Indexed Terms: Waste water, COD, Activated carbon, Fullers earth

I. INTRODUCTION

Water is the most important and it is used in all type of industries for different processes. It may be widely used for washing, dilution, fermentation and condensing the steam. Generally all industry generates waste water that needs urgent attention. Wastewater discharged by industrial activities is often contaminated by a variety of toxic or otherwise harmful substances which have negative effects on the water environment. Pollution of water by organic and inorganic chemicals is of serious environmental concern. Waste water generated from different industry has a high percentage of COD and other different contamination available in waste water which cannot be discharged in water resources without any treatment [2].A number of conventional treatment technologies have been considered for treatment of wastewater such as coagulation process [1], membrane filtration [4] and oxidation process [3]. These methods are generally expensive. Among them, adsorption process is found to be the most effective method. Adsorption process is gaining interest as one of the effective processes of advanced wastewater treatment for industrial effluent [5].

Adsorption is a phase transfer process that is widely used in practice to remove substances from fluid phases. It can be observed as natural process occurring in different environmental compartments [6].

Water is one of the essential enablers of life on earth but pure water is not available to a large fraction of the population of the planet. While availability is an issue, contamination is another major concern which threatens the survival of many species .The Chemical Industry in India is one of the oldest and largest industries in the country. These Industries require large volume of water of high purity and generate equally large volume of waste water which is highly complex and polluted. Different pollution monitoring agencies like State and National Pollution Control Boards have made compulsory for each industry to set up waste water treatment plants In the present study it was aimed to carry out experiments using low cost and non-conventional adsorbents like activated carbon and lignite can be used as adsorbents for removal of organic contaminants especially COD and BOD contributing components from the combined waste water form chemical Industry [6].

II. SCOPE OF EXPERIMENTAL WORK

1) Objective:

Activated carbon is the most widely used adsorbent but it is found to be quite expensive. Considering the resource constraints experienced by the small scale industries, they use adsorption technique only if it is cost effective. Inexpensive adsorbent like fullers earth can be considered for detailed studies with respect to their performance in treating different waste water streams from effluent.

2) Approach:

The conventional flow-sheets refer figure.1 of industrial wastewater treatment shown below include the primary treatment of pH adjustment and clarification, the secondary treatment which may consist of biological/chemical treatment and clarification, and depending on the quality of the waste water and the statutory discharge standards, tertiary treatment with activated carbon.

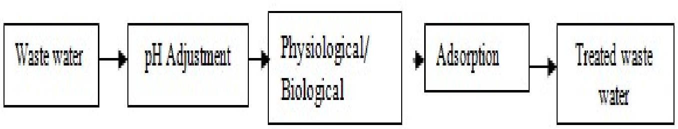


Fig. 1: Conventional Flow sheet of waste water treatment

During primary treatment, neutralization of the waste water results in to increase of salts. Salts in high concentration inhibit biological activity and may cause an increase in non-settle able suspended solids in the treated waste water.

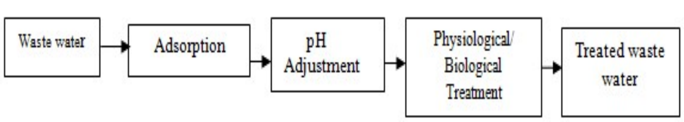


Fig. 2: Modified flow sheet of Waste water treatment

The flow sheet shown figure 2 above is therefore proposed wherein adsorption with inexpensive adsorbents is employed prior to the conventional primary treatment for increasing the efficiency of subsequent biological treatment.

III. EXPERIMENTAL PROCEDURES

1) Sample preparation:

For the contact time experiments, waste water sample was collected in labelled carboys and the carboys were then sealed. The samples were taken from the ETP inlet stream (acidic sample) and ETP outlet / CETP inlet stream (neutral sample). These samples are directly collected from the process plant streams before these had any chance of getting mixed with any other stream. In most of the cases these were concentrated streams, often referred as mother liquor.

For neutralised sample the acidic sample was neutralised using NaOH in the laboratory and further analysis were carried out on neutralised sample.

2) Procedure:

While carrying out experimental studies on the waste water from each carboy sample was analyzed for pH and COD. During experiment 100 ml of sample was taken from the respective carboy in a cylindrical flask. In which 1% (2gm) Activated carbon (A/C) was added in to the flask and magnetic stirrer was started. At the end of 1 hour the stirring is stopped and the experiment was terminated. The experiments were repeated terminated. The experiments are to be repeated with 2% A/C, 3% A/C and 4% A/C, and similar procedure followed by fullers' earth adsorbent. All the experiments were to be carried out at room temperature of around 30^{o}C.

IV. RESULTS AND DISCUSSION

1) Effect of Quantity of adsorbent:

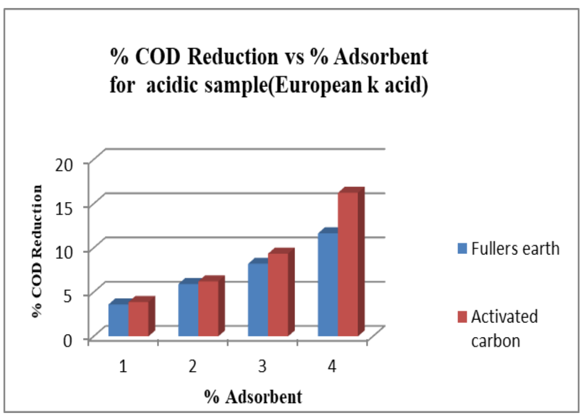
COD Reduction for acidic sample (Vinyl sulfone ester) of using fullers earth is 2.51 % to 35.01 % for 1% fullers earth to 4% fullers earth and using Activated cabon is 5.15 % to 44.29 % for 1% Activated carbon to 4% activated carbon .

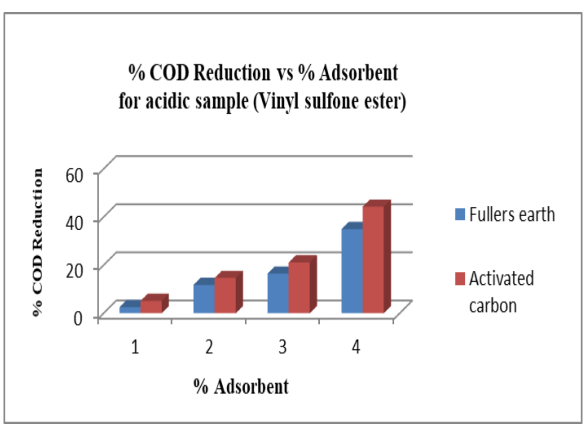
COD Reduction for acidic sample (European k acid) of using fullers earth is 3.62 % to 11.65 % for 1% fullers earth to 4% fullers earth and using Activated cabon is 3.88 % to 16.24 % for 1% Activated carbon to 4% Activated carbon.

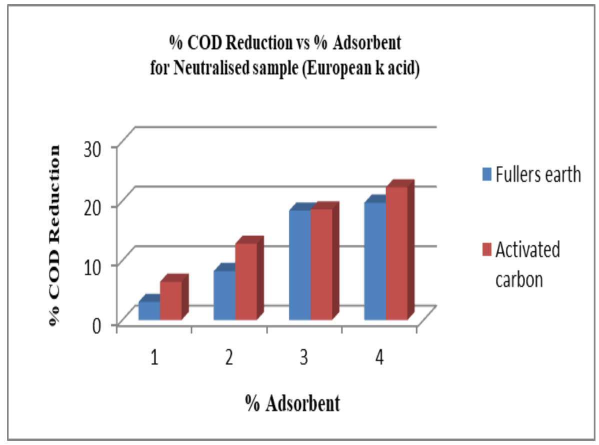
COD Reduction for neutralised (Vinyl sulfone ester) Sample using fullers earth is 4.78 % to 54.36 % for 1% to 4% Fullers earth and using Activated carbon is 11.10 % to 62.58 % for 1% Activated carbon to 4% Activated carbon.

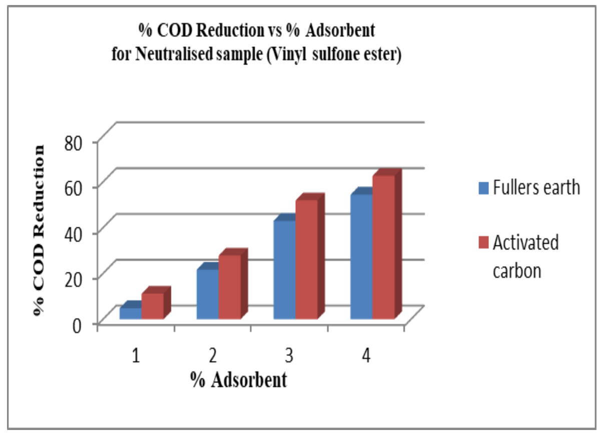
COD Reduction for neutral (Vinyl sulfone ester) Sample using fullers earth is 12.47 % to 31.25 % for 1% Fullers earth to 4% Fullers earth and using Activate is 25 % to 42.50 % for 1% Activated carbon to 4% Activated carbon .

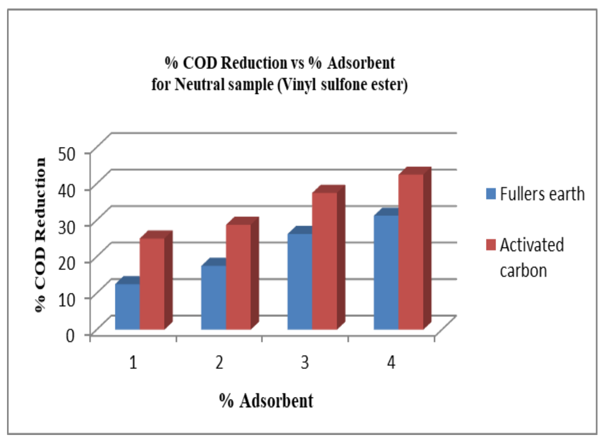
The above observations were made for two different adsorbents such as Fullers earth and Activated carbon , it was found that the value of COD reduction for the case of acidic effluent are lower than the values of COD reduction for the case of neutral effluent











V. MATHEMATICAL MODELING

- The COD values are predicted using the following models which are available in literature.

1) Lagergean equation:

- Lagergean equation has been most widely used for the adsorption of an adsorbate from an aqueous solution.
- Lagergean the pseudo-first order rate equation for the liquid-solid adsorption system is :

$\frac{dx}{dt}$k= (C-C_{eq})

C and C_{eq} (mg g^{-1}) are the adsorption capacities at equilibrium and at time t, respectively. k (min^{-1}) is the rate constant of pseudo-first order adsorption.

- The most popular form used is

log (C-C_{eq}) = m_2+ c

Where,

C=Concentration at time t

Ceq= Equilibrium concentration

m_2 = slope

C= Constant

These model are useful to predict COD value at different time interval.

2) The Weber and Morris model:

- The Weber and Morris model is used determines the adsorption rate in most of the liquid systems

$q= k_{in}t^n + c$

- Where the rate constant (k_{in}) is obtained from the plot of q versus $t^{0.5}$. Both processes are generally observed for adsorption kinetics on activated carbons – the external mass transfer from the solution to the liquid-solid interface and the diffusion of the adsorbed species inside the porous particle.
- The different mechanisms of mass transfer are manifested as different slopes in the linear plot of q versus t^0

q= Ci-C)/Ci

Ci-C)/Ci = m1 $t^{0.5}$ + c_1

Where, Ci = initial concentration

C= Concentration at time t

m_1 = slope

C= Constant

- They correspond to different consecutive stages of mass transport with decreasing rate: external mass transfer and intraparticle diffusion in the macro-, meso- and microporous structure of the adsorbent.

3) Rathi-Puranik model:

Log (CODRT) = m t + c

Where, CODRT = (Ci-C)/t

Ci = Initial concentration

C= Concentration at time t

t = time in minute

m = slope

c = constant

These models are useful to predict COD value at different time interval.

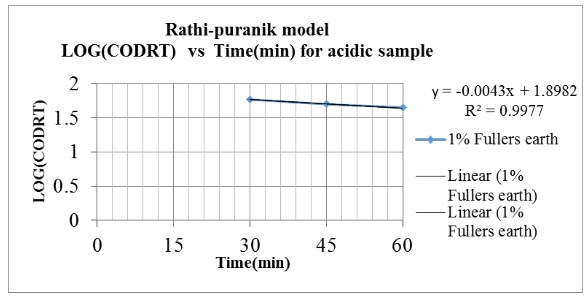


Fig. 8: Rathi - puranik model for LOG (CODRT) vs Time (min) for acidic Sample (European k acid)

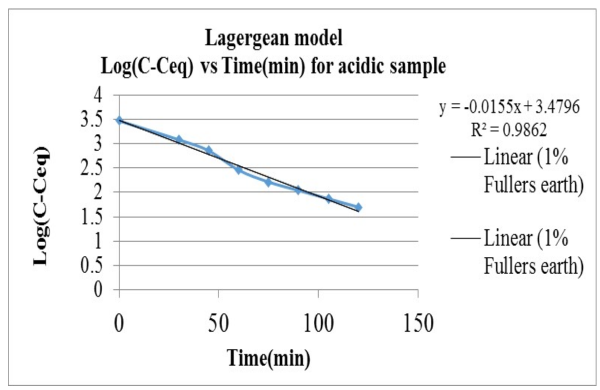


Fig. 9: Lagergean model for Log(C-Ceq) vs Time (min) for acidic sample (European k acid)

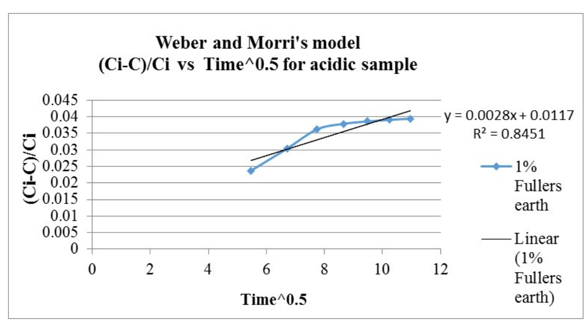


Fig. 10: Weber and Morri's model for (Ci-C)/Ci vs Time^0.5 for acidic sample (European k acid)

VI. CONCLUSION

- The above observations were made for two different adsorbents such as Fullers earth and Activated carbon, it was found that the value of COD reduction for the case of acidic effluent are lower than the values of COD reduction for the case of neutralised effluent.
- From the comparison of COD and %COD reduction values for Acidic, Neutralized and Neutral sample, I can conclude that, as time increases and adsorbent quantity increases the COD value decreases and % COD reduction increases.
- From the comparison of COD values and %COD reduction values between Fullers earth and Activated carbon it is found that, %COD reduction value are higher for Activated carbon than Fullers earth. But Activated carbon is generally expensive it is not suitable for small scale industry Thus, high cost activated carbon can be replaced by Fullers earth.
- Study on mathematical modelling for three mathematical models- Rathi Puranik model, Weber-Morri's model and Lagergean Model we conclude that Rathi-Puranik model is more appropiate than Weber- Morri's model and Lagergean model to predict the COD value at any time in a given system.

REFERENCES

[1] N.B.Prakash, Vimala Sockan, and P.Jayakaran, Waste Water Treatment by Coagulation and Flocculation" International Journal of Engineering Science and Innovative

[2] Imran Ali, Mohd. Asim, Tabrez A. Khan, Low cost adsorbents for the removal of organic pollutants from wastewater, Journal of Environmental Management 113 (2012) 170-183.

[3] Parsons, S. "Advanced oxidation processes for water and wastewater treatment". Water Intelligence Online, 4, p.9781780403076.2005

[4] Zularisam, A. W., A. F. Ismail, and Razman Salim. "Behaviours of natural organic matter in membrane filtration for surface water treatment—a review. "Desalination 194.1 (2006): 211-231.

[5] Crini, Gregorio. "Non-conventional low-cost adsorbents for dye removal: a review." Bioresource technology 97, no. 9 (2006), pp. 1061-1085.

[6] Vinesh V. Rakhodiya, Dr.S.A.Puranik " COD Reduction using modified industrial effluent flow sheet and low cost adsorbents as a part of cleaner production''Pelagia Research library, Advance in Applied Science research,2012.

[7] McDougall, G.J., 1991. The physical nature and manufacture of activated carbon. Journal of the South African institute of mining and metallurgy, 91(4), pp.109-120.

[8] Bajpai, A.K. and Vishwakarma, N., 2000. Adsorption of polyacrylamide onto Fuller's earth surface. INDIAN JOURNAL OF CHEMISTRY SECTION A,39(12), pp.1248 1257.

[9] Babel, Sandhya, and Tonni Agustiono Kurniawan. "Low-cost adsorbents for heavy metals uptake from contaminated water: a review." Journal of Hazardous materials 97, no. 1 (2003) .pp.219-243.

[10] V. K Gupta. "Application of low-cost adsorbents for dye removal–A review. "Journal of environmental management ''90.8 (2009), pp.2313-2342.

[11] Mohammed, M. A., A. Shitu, and A. Ibrahim. "Removal of methylene blue using low cost adsorbent: a review." Research Journal of Chemical Science, (2014).

[12] Lokeshwari, N., and Keshna Joshi. "Low Cost Adsorbent for Reducing Organic Components."Jr. of Industrial Pollution Control 30(1) pp 53-58. 2014.

[13] A.K.A.Rathi, S.A.Puranik, "Chemical industry waste water treatment using Adsorption'' Journal of scientific & Industrial Research, vol-61, January 2002.

[14] Akhilesh R. Yadav, Dr. S. A. Puranik,” Industrial Waste Water Treatment by Adsorption”, Asian International Conference on Science, Engineering & Technology, 2015.

[15] Dasani Khushboo B, Dr. S. A. Puranik, “Modification in COD Reduction By Adsorption in Dyes & Dyes Intermediate Industry”, Global Research Analysis, vol-II, Issue: V, May, 2013.