Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Chemistry

Elixir Appl. Chem. 35 (2011) 2953-2955

ISSN: 2229-712X

The influence of low cost material Fly ash to the removal of COD content of Sugar Industry waste water

Lakdawala M. M. and Nimavat K. S.

Chemistry Department, Government Science College, Gandhinagar, Gujarat, India.

ARTICLE INFO

Article history:

Received: 14 April 2011;

Received in revised form: 21 May 2011;

Accepted: 28 May 2011;

Keywords

Fly ash, COD,

Adsorption isotherm,

Adsorption intensity (1/n),

Adsorption energy(b x 10^3),

Adsorption capacity (K, Θ_0).

ABSTRACT

With the consideration of minimizing the problem of water pollution, it is necessary to clarify the industrial waste water at the place of its generation point by some chemical or biological treatment method. During present study the low cost material fly ash i.e. the waste of thermal power station which itself produce pollution of environment is used for purpose of water pollution control. Fly ash with specific surface area of 6177.15 cm^2/gm is used as a clarifier to the combined waste water of Sugar mill at room temperature. The different dosage of fly ash is kept in contact for 24 hours, then they will analyzed before and after treatment. The results of COD removal follow the Freundlich and Langmuir adsorption isotherm.

Introduction

The Sugar Industry in India is one of the oldest and largest industry in the country. These mills require large volume of water of high and purity and generate equally large volume of waste water which is highly complex and polluted[1]. For removal of the organic contaminants from industrial waste water adsorption has become one of the best effective and economical method, thus this process has aroused considerable interest during recent years. Current research has focused on modified or innovative approach that more adequately address the removal of organic pollutants[2].

In the present study, it was aimed to carry out experiments using low cost material like fly ash from thermal power station for the removal of organic contaminants especially COD contributing components from the combined waste water of Sugar Industry. The activated carbon adsorbent prepared from pod of wood apple[3], Alternanthera Bettzichiana (Regel) Nicols plant material[4] and neem leaf powder[5] can be used as an efficient low cost adsorbent for Cr (VI) and organics removal from aqueous solution. Coal fly ash, the solid waste of the power plants has been used as an adsorbent for the removal of cadmium from the aqueous solutions. Applicability of Freundlich adsorption isotherm was confirmed [6-7]. The laboratory scale studies for reduction of concentration of phenolic compound and COD content with fly ash is carried out and its adsorption characteristics were well explained [8-9].

The use of fly ash for the removal of color from waste water of petrochemical industry was done. Some research workers studied various variables like fly ash dose, contact time, pH of the effluent and color intensity [10]. Removal of COD contributing components, TOC and cadmium of the waste water by adsorption process on fly ash was well studied. The data follow Freundlich and Langmuir type behavior. The reaction rate was evaluated for different time intervals and at different pH [11]. Isotherm data were presented for the sorption of 20 organic compounds including alcohols, ketones and aldehydes by fly ash [12].

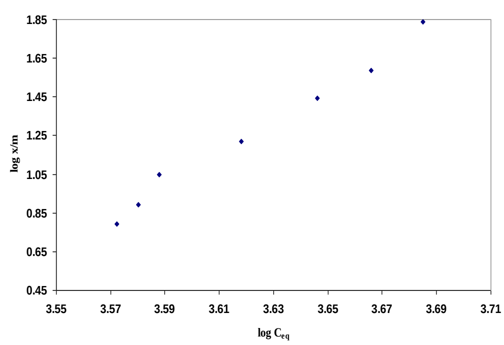
Material and Methods

Fly ash is also as pulverized fuel ash. In modern thermal power station pulverized coal is used and fly ash is obtained as a waste product in large quantities. The source of fly ash material used in present research work is from Ukai Thermal Power Station (Gujarat). It was washed to remove excess fines and oven dried at 100^0C for 24 hours before its use in experiments. It is gray colored material having specific surface area 6177.15 cm^2/gm.

Its chemical composition is approximately as SiO_2 - 51 to 55%, Al_2O_3 – 26 to 28%, Fe_2O_3 -3 to 6%, CaO -3 to 5 %, MgO – 3 to 5% and S as SO_3 trace. The known quantity (1 liter) of sample is treated with different amount of fly ash viz 2, 10, 20, 50, 100, 150, 200 gm/L stirred well and kept in contact for 24 hours at room temperature. Then the samples were filtered and analyzed for various physico-chemical characteristics. This study was especially concentrated on COD removal.

The method for determination of COD practicable is dichromate reflux method followed from 'Standard methods for the water and waste water'[13]. The results for each dose are presented in Table I, 2 and figure 1, 2.

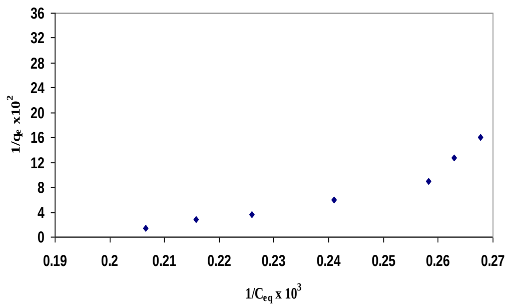
Fig. 1: Freundlich adsorption isotherm for COD in presence of Fly Ash



Tele:

E-mail addresses: drmilan_ml@yahoo.com, kirankartik@yahoo.com

Fig. 2: Langmuir Adsorption Isotherm for COD in presence of Fly Ash



Results and discussion

Table I shows the influence of dose variation of fly ash onto various physico-chemical characteristics of the combined waste water of Sugar Industry at room temperature. The pH of the sample increased with increase in dosage i.e from 7.05 to 7.97. Conductance and hardness decreased upto 50 gm/L and then remain constant for higher dosages. Conductance decreases from 3.9 m mho (initial) to 3.33 m mho and hardness decreases from 2610 mg/L (initial) to 2060 mg/L. The alkalinity decreased considerably from 2625 mg/L (initial) to 1700 mg/L with increasing amount of fly ash. Chloride content reduced slightly upto 187.441 mg/L from 104.936 mg/L (initial) by 10 gm/L of fly ash. The initial COD content of the waste water was 4979.52 mg/L is reduced to 3734.64 mg/L with 200gm/L of fly ash and remains the same at 400gm/L. the BOD content in the initial stage was 1410.5 mg/L is decreased to 1116 mg/L by 150gm/L of fly ash and remain constant for higher doses.

Table II represents the data for Freundlich and Langmuir adsorption isotherms along with percent removal of COD exerting components. There is a considerable decrease in adsorption per unit weight of adsorbent with increase in adsorbent concentration. The removal of COD contributing components is found to decrease from 69.16 mg/gm to 6.224 mg/gm respectively with varying amounts of fly ash from 2 gm/L to 200gm/L

Fig. 1 represents the plot of log C_{eq} Vs log x/m for COD on fly ash. The straight line nature of the plot corresponds to slope 1/n and intercept K. 1/n is related to adsorption intensity whose value is 12.5125 for COD while intercept K on Y-axis related to adsorption capacity is found to be 0.61

Fig. 2 represents the plot of Langmuir parameters viz, $1/C_{eq} \times 10^3$ and $1/q_e \times 10^3$. The nature of the curve for COD onto fly ash from thermal power station is linear however the intercept on X-axis related to adsorption energy (L/mg) i.e. $b \times 10^3$ is 0.1970 L/mg for COD exerting components. These values can be used to calculate the adsorption capacity Θ_0 i.e 47.0415 (mg/gm).

Influence of different dose of fly ash on various physico-chemical characteristics can be explained as the pH increases with increasing amount of fly ash suggest the presence of basic components into fly ash which leads to higher the results. The conductance, hardness, chloride content and alkalinity removal can be explained by adsorption phenomena similar to that of organic constituents like COD and BOD.

Table II represents the data for Freundlich and Langmuir adsorption isotherms along with percent removal for COD onto fly ash. These information are used to prove the adsorption isotherm model and from that the Adsorption intensity, Adsorption energy and Adsorption capacity can be calculated. The percent removal of COD seems to be increased with increase in dose of adsorbent. The logarithmic and inverse values of C_{eq} and x/m are used for plot of isotherm.

The logarithmic value of equilibrium concentration and removal per unit weight gives the linear plot for COD by fly ash confirm the applicability of Freundlich adsorption isotherm. It is the most widely used mathematical description of adsorption in aqueous systems. The equation is an empirical expression that covers the heterogeneity of the surface and exponential distribution of sites and their energies. With the purpose of linearization the equation is represented in logarithmic form as—

$$\log x/m = \log K + 1/n \log C_{eq}$$

The plot of log C_{eq} versus log x/m gives straight line with a slope of 1/n and log K is the intercept of log x/m at log $C_{eq} = 0$ which indicates that Freundlich adsorption isotherm model is applicable.

The same table shows the Langmuir adsorption isotherm for COD by fly ash. Langmuir isotherm is a plot of the amount of impurity adsorbed by fly ash against the amount of impurity that remains in solution. It is a preliminary test to check the efficiency of particular material.

These mode of action can be explained on the basis of Langmuir's model, i.e. 'Ideal localized monolayer model' according to which:

1. The molecules are adsorbed at definite sites on the surface of the adsorbent.
2. Each site can accommodate only one molecule (monolayer).
3. The area of each site is a fixed quantity determine solely by the geometry of the surface.
4. The adsorption energy is the same at all the sites.

Such behavior on the basis of kinetic consideration, presuming that the adsorbed molecules cannot migrate across the surface of the interact with another neighboring molecules can be mathematically expressed as under

$$1/q_e = 1/\Theta_0 b \;\; x \;\; 1/C_{eq} + 1/\Theta_0$$

Where-

q_e = amount of solute adsorbed per unit weight of adsorbent(mg/gm)

= x/m i.e. x is amount of adsorbate adsorbed (mg/L)

m is weight of adsorbent (gm/L)

C_{eq} = equilibrium concentration of the solute (mg/L)

Θ_0 = Langmuir constant related to adsorption capacity (mg/gm)

b = Langmuir constant related to adsorption energy (L/mg)

Plot of log C_{eq} versus log x/m is a straight line in nature, presented in figure 1 suggests the applicability of this isotherm and indicate a monolayer coverage of the adsorbate on the outer surface of the adsorbent.

The steep slope indicates high adsorptive intensity at high equilibrium concentration that rapidly diminished at lower equilibrium concentration covered by the isotherm. As Freundlich equation indicates the adsorptive capacity x/m is a function of the equilibrium concentration of the solute. Therefore, higher capacity is obtained at higher equilibrium concentrations.

Fig. 2 represents the plot of Langmuir adsorption isotherm for COD contributing components onto fly ash. The straight line nature of the plot confirms the applicability of the Langmuir model and also the monolayer coverage. The Langmuir constant Θ_0 in mg/gm related to adsorption capacity indicate availability of more surface active region onto adsorbent site and $b \times 10^3$ L/mg related to adsorption energy in terms of x/m is a characteristic of the system.

Conclusion

This study leads us to the conclusion that the final combined waste water of Sugar manufacturing unit is highly polluted having higher COD value. Due to some practical limitation only COD parameter is emphasized in this paper when the final combined waste water of Sugar mill is treated with finely divided low cost material fly ash at room temperature for 24 hours of contact duration the following results are achieved.

i. The maximum COD removal is found at 200gm/L of fly ash concentration i.e. 25%

ii. Fly ash of the thermal power station moderately removes BOD contributing components of the waste water.

iii. The alkalinity, hardness and chloride content of the sample reduced with increasing amount of fly ash.

iv. At room temperature fly ash works as an adsorbent and follow Freundlich and Langmuir isotherm models. The results give straight line which confirms the applicability of isotherm.

a. The Freundlich constant K an intercept on X axis is related to adsorption capacity is found to be 0.61 while the slope 1/n is related to adsorption intensity is found to be 12.5125

b. The straight line of the Langmuir plot gives intercept on Y axis called b x 10^3 L/mg i.e. adsorption energy is 0.1970 and the calculated adsorption capacity Θ_0 mg/gm is 47.0415

References

1 Nagraj J. Industrial Safety and Pollution Control Handbook. IInd edition, National safety council and associate (Data) Publishers Pvt Ltd; 1993

2 Weber WJ. Jr, Benjamin M Van Vliet. J. AWWA 1981; 73(8):420-26

3 Renugadevi N, Sreeja M, Lalitha P. Kinetics of chromium (VI) removal from aqueous solution by adsorption technique using activated carbon from pod of wood apple. Res J Ultra Chem 2010; 6(1): 27-34

4 Patil AK, Shrivastva VS. Removal of Cr (VI) by a low cost Adsorbent prepared from Alternanthera Bettzichina(Rrgel) Nicols Plant material. Res J Chem. Environ 2009;13(2): 47-57

5 Venkateswarlu P, Venkata Ratnam M, Subba Rao D, Vankateswara Rao M. Removal of Chromium from an aqueous solution using Azadirachta indica (neem) leaf powder as an adsorbent. International J Physical Sciences 2007; 2(8):188-95

6 De AK, Adsorption of cadmium on coal fly ash. Res J Chem. Environ 2001; 5(3): 72-79

7 Rathore HS, Sharma SK, Agarwal M, Adsorption of some organic acids on fly ash. Res J Environ. Protection 1985; B10**:**

8 Pankejavalli R, Balachandran TR, Shanmugam T, Fly ash in effluent treatment. Ind J Environ Protection 1987; 7(3): 209-11

9 Singh BK, Mishra NM, Rawat NS, Sorption characteristics of phenol on fly ash. Ind J Environ. Health 1994; 36(1): 1-7

10 Kapadia MJ, Farsram RP, Desai DH, Bhatt MM, Fly ash for removal of color from effluent of petrochemical industry. Res J Chem. Environ 2000;4(4): 41-48

11 Motwani VM. Laboratory studies on adsorption. M. E. Dissertation, Faculty of Environmental Engineering , S. G. Uni., SVRCET, Gujarat, India (1989) 2-94

12 Benerjee K. et al. Sorption of selected organic pollutants by fly ash. Proc. Of the 43rd Ind. Waste Conf; Purdue. Univ., West Lafayette, India;1988: 42, p 397

13 Standard Method for Examination of Water and Waste Water, 18th Edition, American Public Health Association, Washington DC, 1992: p 1134.

Table I The influence of dosage variation of Fly ash on various physico-chemical characteristic of Sugar Industry Waste Water

Adsorbent: Fly ash | Room temperature: 25± 1^0C
Specific Surface Area: 6177.15 Cm^2/ gm | Contact duration: 24 Hours

Parameter	Untreated	2 gm/L	10 gm/L	20 gm/L	50 gm/L	100 gm/L	150 gm/L	200 gm/L
pH	7.05	7.55	7.6	7.68	7.71	7.84	7.05	6.97
Conductance (m mho)	3.92	3.75	3.7	3.61	3.2	3.33	3.53	3.26
COD (mg/L)	4979.52	4841.2	4633.72	4426.24	4149.6	3872.5	3803.8	3734.64
BOD (mg/L)	1410.5	1317.5	1302	1253.5	1193.5	1147.5	1196	1116
Alkalinity (mg/L)	2625	2250	2100	2000	1825	1800	1750	1700
Hardness (mg/L)	2610	2375	2300	2250	2060	2060	2060	2060
Chloride (mg/L)	204.93	199.93	187.44	187.44	187.44	187.44	187.44	187.44

Table II Freundlich and Langmuir adsorption isotherm parameters for COD contributing components and percent removal of COD

Adsorbent: Fly ash | Room temperature: 25± 1^0C
Specific Surface Area: 6177.15 Cm^2/ gm | Contact duration: 24 Hours

No	Adsorbent concentration m (gm/L)	Eq. Conc. C_{eq} (mg/L)	Removal $x=C_0-C_{eq}$ (mg/L)	q_e=x/m (mg/gm)	Removal %	log C_{eq}	log x/m	$1/C_{eq}x10^3$	$1/q_ex10^2$
1	0	4979.52	-------	------	-------	3.6972	--------	0.2008	-------
2	2	4841.2	138.32	69.16	2.77	3.6849	1.8398	0.2065	1.4459
3	10	4633.72	345.8	34.58	6.94	3.6659	1.588	0.2158	2.8914
4	20	4426.24	553.28	27.66	11.11	3.646	1.4419	0.2259	3.6148
5	50	4149.6	829.92	16.66	16.66	3.618	1.22	0.241	6.0214
6	100	3872.5	1107.02	11.07	22.23	3.588	1.049	0.2582	9.0331
7	150	3803.8	1175.72	7.838	23.61	3.5802	0.8942	0.2629	12.7583
8	200	3734.64	1244.88	6.224	25	3.5722	0.7941	0.2677	16.0658