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Adsorption of Dyes from Aqueous Solution by Cow Dung Ash

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Abstract

The ability of cow dung ash without any pretreatment to remove color from textile dyes N Blue RGB, Green B and EOSIN YWS from aqueous solution has been investigated in this work. Cow dung ash, an ecofriendly and low cost adsorbent was prepared by burning cow dung cakes in the muffle furnace at 500°C. The adsorption was achieved under different pH and adsorbate concentration. The data was fitted to simple polynomial and the isotherms similar to Langmuir and Freundlich isotherms.

Keywords : *Adsorption, Cow dung ash, Textile dyes, Isotherms*

1. Introduction

Wastewater from dyeing industry contains various contaminants such as color, acid, base and other substances. Color amongst these is the most obvious indicator of water pollution and it has high BOD and COD levels, solids, oils and possibly toxic organics including phenols from dyeing and finishing. This led to an intensive search for the best available technology, which can be used for the removal of dyes. Various treatments have been carried out for the removal of dye by chemical coagulation [1], ozonation [2, 3], and adsorption [4, 5].

The adsorption process is one of the efficient methods to remove the contaminants from the effluent. Activated carbon is widely used due to its effectiveness and versatility, but this method is expensive. Many studies have been carried out by different workers on adsorption of color compounds from their aqueous solutions using low cost ecofriendly adsorbents [6-9].

Robinson, Chandran and Nigam [10] discussed the removal of dyes (Cibacron Yellow C-2R, Cibacron Red C-2G, Cibacron Blue C-R, Remazol Black B, Remazol Red RB) from an aqueous solution by adsorption on three different low cost pretreated agricultural residues viz., Wheat straw, Corncob and Barley husk. They found that a high percentage of dye removal was achieved by the milled samples proving milling to be a better and more cost effective treatment.

Namasivayam, Prabha and Kumutha [11] investigated the adsorption of Direct Red and Acid Brilliant Blue by waste Banana pith and it was found that an acidic pH was favorable for the adsorption of both dyes whereas an alkaline pH favored desorption of the dyes. Gong et. al. [12] investigated the role played by three major functional groups (amino, carbonyl and hydroxyl) in the biomass of peanut hull in adsorption of six dyes (methylene blue, brilliant cresyl blue, neutral red, amaranth, sunset yellow and fast green). The functional group in Peanut hull was chemically modified individually to determine their contribution to the adsorption of ionic dyes.

The present work forms a part of a continuing study for the removal of dyes by adsorption.

2. Experimental

Cow dung ash an ecofriendly and low cost adsorbent was prepared by burning cow dung cakes in the muffle furnace at 500°C. Adsorption studies were performed by the batch technique using cow dung ash as an adsorbent without giving any pretreatment. A stock solution of the dyes with a concentration of 1000 mg/L was prepared and dilutions were made with distilled water to make different concentrations (10 - 100 mg/L) for the adsorption studies. A known weight of the adsorbent (1 g) was added to 50 mL of each of the above concentration in 100 mL measuring flasks. These were placed in an air thermostat for 24 hrs with occasional shaking. The samples were then filtered and analyzed using UV- spectrophotometer (Elico CL54D). The pH values of solutions were adjusted by addition of H_2SO_4 and NaOH.

3. Results and Discussion

3.1. Effect of initial dye concentration

Table 1. Concentration of dyes (C_o) and amount of dye adsorbed per gram of the adsorbent (Q_e) at different pH

Dye Name	N BLUE RGB			GREEN B			EOSIN YWS		
	pH			pH			pH		
	3.74	5.20	8.01	5.15	7.53	9.68	4.12	6.20	8.30
C_o	Q_e	Q_e	Q_e	Q_e	Q_e	Q_e	Q_e	Q_e	Q_e
10	4.6	4.2	4.5	8.8	8.9	7.8	4.4	3.1	1.9
20	8.2	7.5	8.4	17.1	17.6	14.5	8.1	5.7	2.5
30	11.7	9.9	11.8	25.5	26.3	21	10.6	6.5	3.8
40	15.4	12.5	15.0	33.8	34.8	27	13.8	7.8	5.1
50	20.6	14.9	19.6	42.2	42.7	33.6	18.0	8.8	7.0
60	23.6	18.4	23.8	50.7	51.2	40.9	22.6	10.8	8.4
70	26.1	23.0	25.1	58.3	59.3	48	28.2	12.4	9.6
80	27.3	24.9	26.5	65.7	67.5	55.6	32.6	12.3	11.7
90	28.2	26.4	27.6	72.1	70.7	58.2	35.6	15.0	13.6
100	28.4	27.3	29.2	75.6	73.3	61.8	39.6	15.2	14.8

Table 2. Values of different constants for polynomial fit data

Constant	N BLUE RGB			GREEN B			EOSIN YWS		
	pH			pH			pH		
	3.74	5.20	8.01	5.15	7.53	9.68	4.12	6.20	8.30
A	1.277	3.533	0.65	2.03	2.796	4.173	3.733	1.715	1.261
B_1	0.2859	0.0703	0.3616	0.6512	0.5866	0.3462	0.0583	0.1761	0.0353
B_2	0.0036	0.0053	0.0013	0.0054	0.0078	0.0080	0.0064	-5.83E-4	0.0019
R^2	0.9973	0.9947	0.9944	0.9998	0.9990	0.9983	0.9980	0.9836	0.9979
SD	0.5597	0.7363	0.7982	0.3951	0.8593	0.9373	0.6584	0.6352	0.2532

Table 1. shows that Cow dung ash was found to be more efficient adsorbent at low concentrations for all the three dyes studied at all three pH values. Decrease in sorption percentage at higher concentration might be due to the relatively less number of active sites available at high dye concentration. With increase in the initial concentration of dyes, total amount of dye adsorbed per gram of the adsorbent (Q_e) also increases. It is observed that Q_e is different for all the three different dyes and for Green B it was maximum for all pH values.

3.2. Effect of pH

Adsorption of the dyes on cow dung ash is greatly affected by the change in pH of the solution. Again from Table1. for N Blue RGB strong acidic condition i.e. pH 3.74 shows maximum adsorption (4.6 mg/g) whereas at mild acidic condition i.e. pH 5.20 adsorption is least (4.2 mg/g) for initial dye concentration of 10 mg/L. Same is the case for Eosin YWS where maximum adsorption is observed at the acidic pH 4.12 (4.4 mg/g) while adsorption is least at basic pH 8.30 (1.9 mg/g). For Green B the amount of dye adsorbed is maximum at pH 7.53 (8.9 mg/g) while it is minimum at pH 9.68 (7.8 mg/g) for initial dye concentration of 10 mg/L.

3.3. Data fit for Simple Isotherm

The experimental data for the dyes studied were fitted to the Polynomial of the type:

$$Q_e = A + B_1C_0 + B_2C_0^2 \quad (1)$$

where C_0 is the initial concentration of the dyes.

The values of the constants A, B_1, B_2 along with the coefficient of correlation, R^2 and standard deviation, SD are given in Table 2 for the three dyes respectively.

Fig. 1 shows that for N Blue RGB at all the three pH

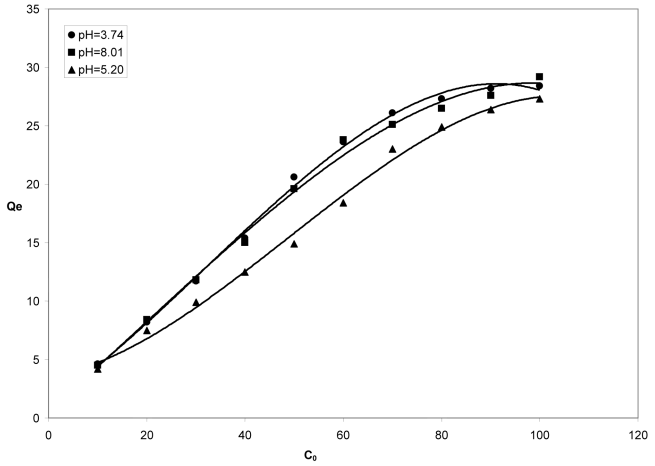


Fig. 1. Adsorption isotherm of N Blue RGB at different pH values.

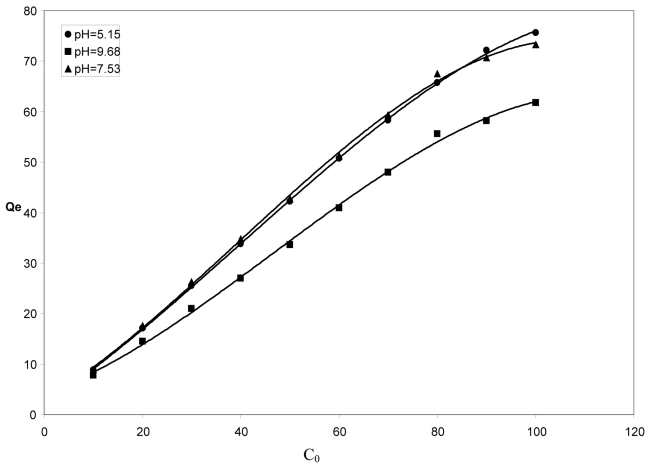


Fig. 2. Adsorption isotherm of Green B at different pH values.

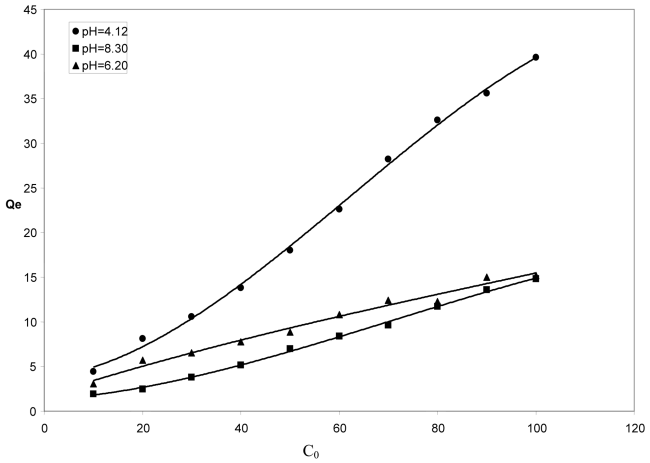


Fig. 3. Adsorption isotherm of EOSIN YWS at different pH values.

values, adsorption (Q_e) at lower concentration of dyes is increasing linearly but at higher concentration Q_e gets stable. For this dye cow dung ash is a better adsorbent at strongly acidic (3.74) and slightly basic pH (8.01) values of aqueous solution of dyes.

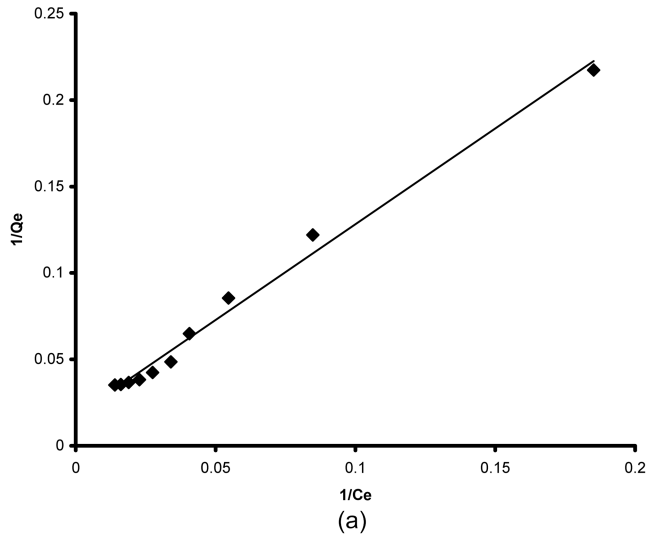
Fig. 2 shows that for Green B almost linear behavior in the adsorption is observed for all the three pH values. The neutral condition (7.53) favors better adsorption than the acidic (5.15) and the basic (9.68) pH values.

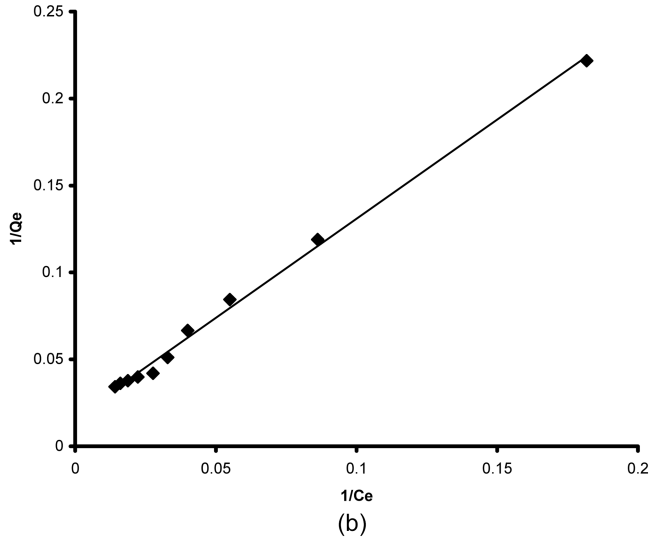
For Eosin YWS it can be drawn from Fig. 3 that acidic pH (4.12) is best suited for the adsorption of the dye and exhibits quite a linear behavior.

3.4. Langmuir isotherms at various pH

The experimental data was fitted to linear form of Langmuir type Isotherm:

$$\frac{1}{Q_e} = \frac{1}{Q} + \frac{1}{bQ}\frac{1}{Ce} \qquad (2)$$





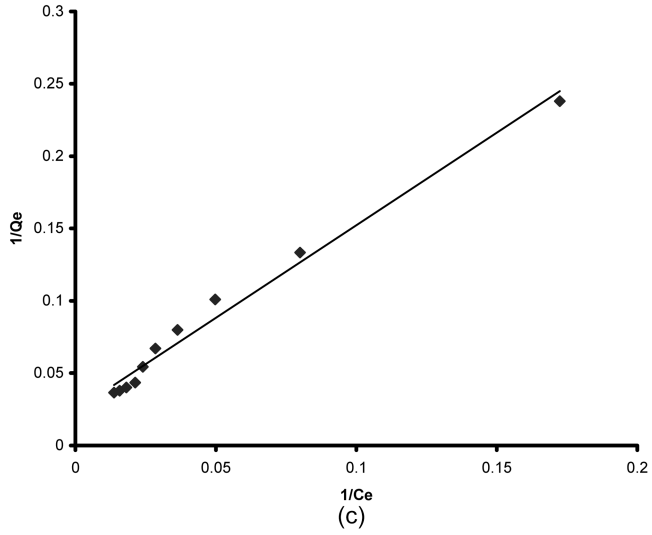
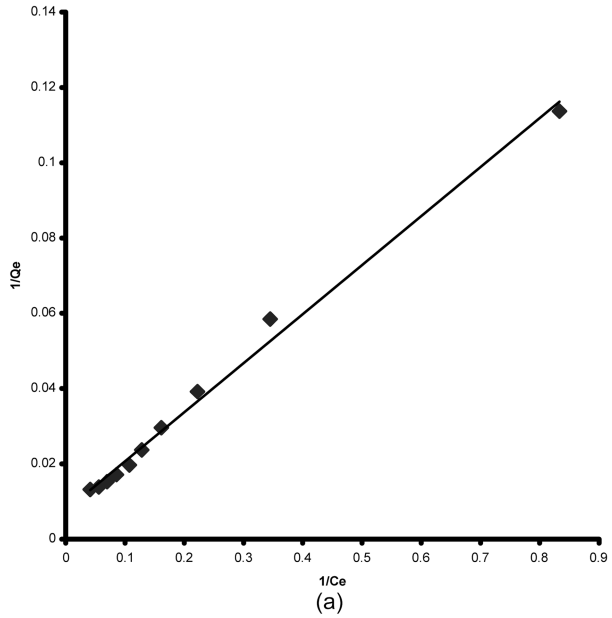
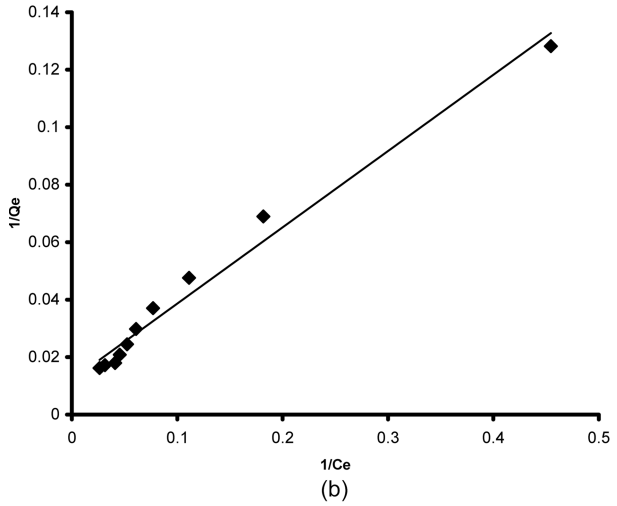


Fig. 4. Langmuir isotherm of N Blue RGB at pH 3.74, 8.01 and 5.20 respectively.





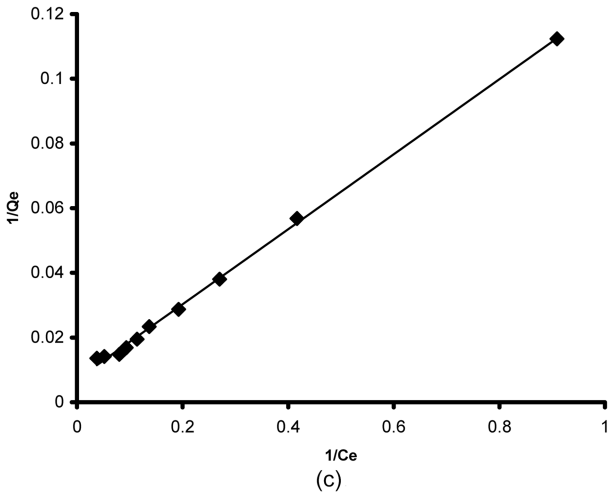
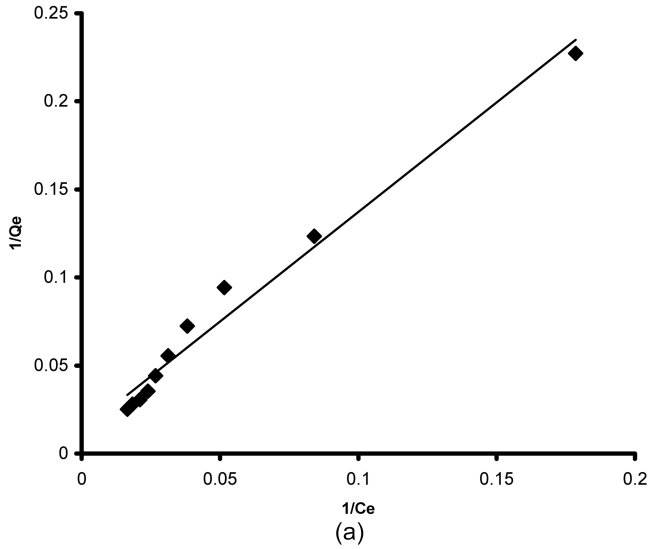
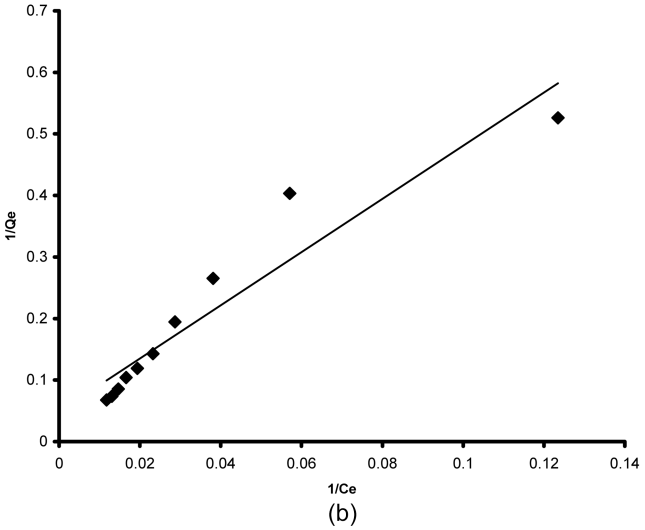


Fig. 5. Langmuir isotherm of Green B at pH 5.15, 9.68 and 7.53 respectively.





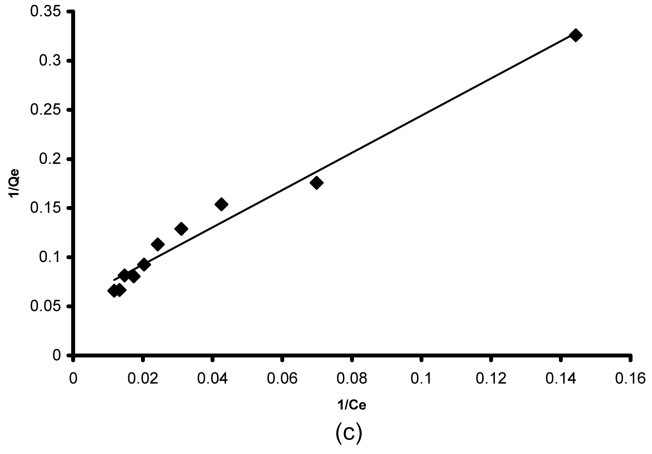


Fig. 6. Langmuir isotherm of EOSIN YWS at pH 4.12, 8.30 and 6.20 respectively.

Table 3. Values of different constants for Langmuir isotherms at various pH

Dye Name	N BLUE RGB			GREEN B			EOSIN YWS		
parameter	pH			pH			pH		
	3.74	5.20	8.01	5.15	7.53	9.68	4.12	6.20	8.30
R	0.99499	0.99187	0.99804	0.9966	0.99924	0.99034	0.9885	0.98894	0.95024
SD	0.00616	0.00848	0.0039	0.00273	0.00127	0.00513	0.01007	0.01236	0.05138
Q	57.47	41.06	59.10	130.03	139.86	82.50	78.92	18.29	20.55
b	0.01927	0.03116	0.01928	0.00100	0.00082	0.00321	0.01577	0.10357	0.21035

where C_e is the equilibrium concentration of dye in mg/L.

The plots of $\frac{1}{Q_e}$ and $\frac{1}{Ce}$ for all the three dyes studied at three different pH values were drawn, as shown in Figs. 4, 5 and 6. From the slope and intercept, the values of constants "Q" and "b" were calculated. The constant "Q" signifies the adsorption capacity (mg/g) and "b" relates to the energy of adsorption (L/mg).

Table 3 gives the values of the Langmuir constants "Q" and "b" along with the values of R and SD for all the three dyes studied.

3.5. Freundlich isotherm at various pH

The experimental data was fitted to linear form of Freundlich Isotherm which is given by

$$\text{Log } Q_e = \log K_F + \frac{1}{n} \log Ce \tag{3}$$

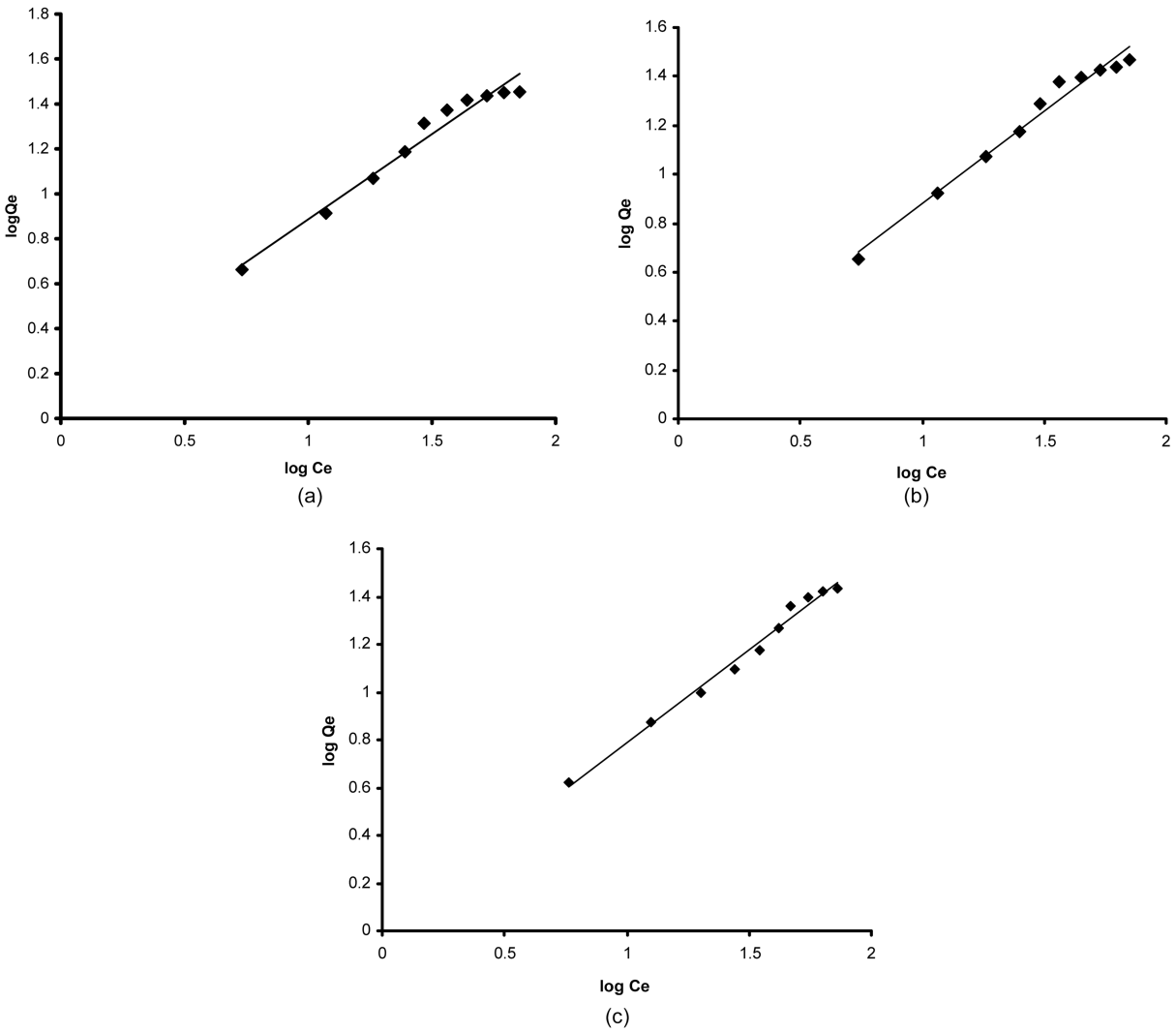
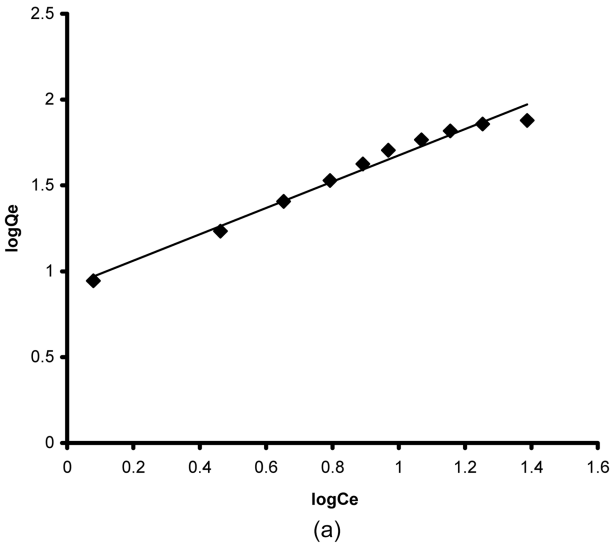
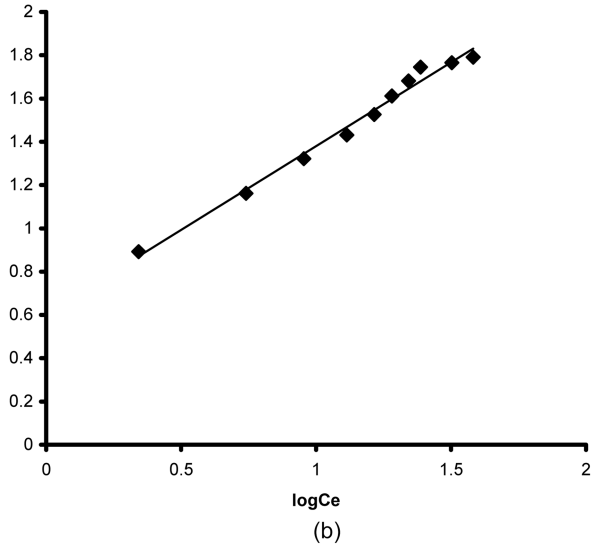


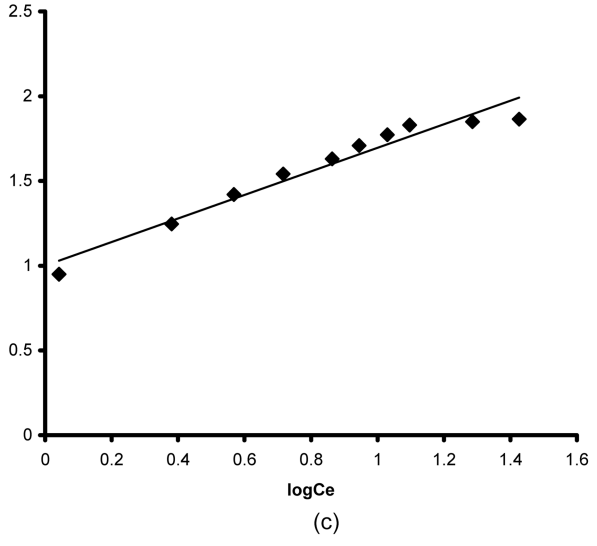
Fig. 7. Freundlich isotherm of N Blue RGB at pH 3.74, 8.01 and 5.20 respectively.



(a)

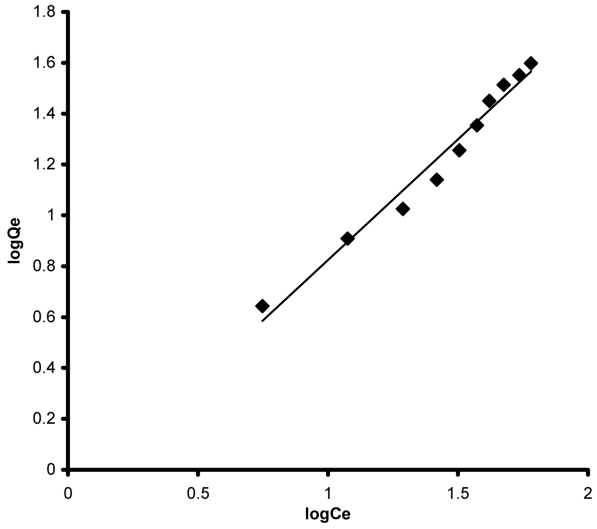


(b)

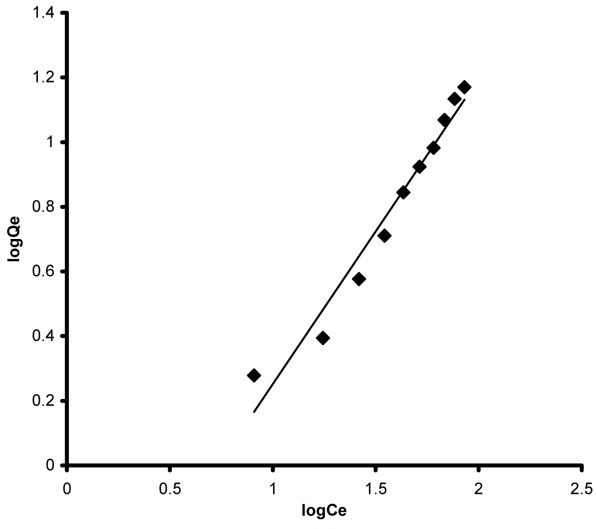


(c)

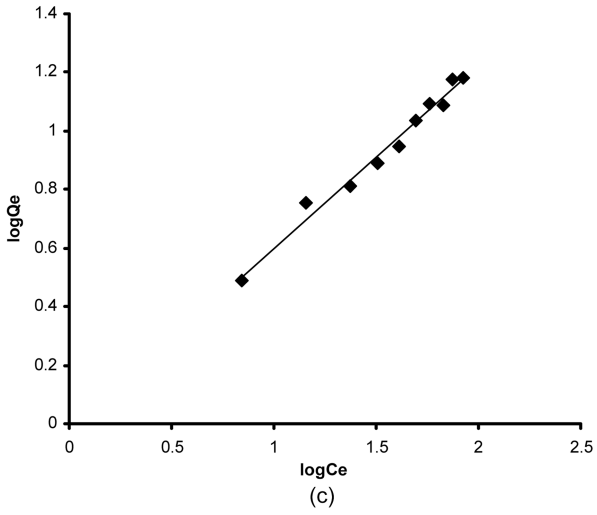
Fig. 8. Freundlich isotherm of Green B at pH 5.15, 9.68 and 7.53 respectively.



(a)



(b)



(c)

Fig. 9. Freundlich isotherm of EOSIN YWS at pH 4.12, 8.30 and 6.20 respectively.

Table 4. Values of different constants for Freundlich isotherms at various pH

Dye Name	N BLUE RGB			GREEN B			EOSIN YWS		
parameter	pH			pH			pH		
	3.74	5.20	8.01	5.15	7.53	9.68	4.12	6.20	8.30
R	0.9844	0.9938	0.98889	0.98998	0.97584	0.99335	0.98661	0.99041	0.98068
SD	0.05026	0.03176	0.04214	0.04552	0.06948	0.03598	0.05405	0.03189	0.0643
K_F	1.136	1.013	1.132	2.482	2.719	1.831	0.882	0.981	0.500
n	1.318	1.289	1.323	1.305	1.438	1.291	1.053	1.613	1.058

Log $Q_e$and log Ce values were plotted for all the three dye systems studied at different pH values as shown in Figs. 7, 8 and 9. From the intercept and slope the values of Freundlich constants "K_F" (parameter relative to adsorption capacity) and "n" (process intensity) were calculated. The values of "K_F" and "n" along with R and SD are given in the Table 4.

4. Conclusions

Cow dung ash can be used for the removal of dyes from the wastewater by adsorption. The present study shows that there is a decrease in percentage removal of dye per gram with the increase in the concentration of the dye. Change in pH values also showed a marked effect on the adsorption of dyes. As N Blue RGB was adsorbed maximum at pH 3.74, Green B showed maximum adsorption at pH 7.53 whereas for Eosin YWS it was best at 4.12. The three dyes obey the Langmuir and Freundlich isotherms and the pH value of the dye solution has a marked effect on the applicability of these isotherms. N Blue RGB at pH 8.01, Green B at pH 7.53 and Eosin YWS at pH 6.20 are best fitted to the Langmuir equation whereas these are best fitted to the Freundlich equation at pH 5.20, 9.68 and 6.20 respectively.

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