REMOVAL OF COLOR FROM TEXTILE WASTEWATER BY ADSORPTION PROCESS

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ABSTRACT

Wastewater discharge into surrounding natural watercourses has caused surface and groundwater pollution, leaving water unsafe for potable use and impairing industrial use without major and costly treatment. Adsorption is the most used method in physicochemical wastewater treatment, which can mix the wastewater and the porous material powder or granules, such as orange and banana peel (OBP). In the present paper natural adsorbent OBP were used for removal of color from waste effluent of textile industry. The materials were obtained from local fruit market, dried and sieved for the adsorption experiment and used in the removal of color at different doses. Adsorption efficiency of OBP are also evaluated at different pH and time. Characterize the adsorption efficiency of these materials, moisture content, volatile matter and ash content are measured. The materials are capable of removing color from waste water, their color removal capacity for banana peel is 80% and orange peel is 65% respectively at normal pH and temperature conditions. The equilibrium time was found 60min for orange and banana peel. Maximum removal of color is found 90% for 2.5g dose. The experimental adsorption data fitted with Langmuir and Freundlich adsorption isotherms. Both isotherm results show a straight line which indicates that adsorption system fits these isotherms. Final concentration obtained from the experimental and these isotherms are similar to each other. The result shows that the materials have good potential to remove color from effluent and good potential as an alternate low cost adsorbent. Finally, wastewater treated with low cost adsorbents as well as treatment costs reduced at the same time.

Keywords: *Textile wastewater, Adsorption, Banana peel, Orange peel, Color removal*

1. PROBLEM STATEMENT

The area for industrial pollution is immense. Different types of industries pollute the environment in different ways. Textile industries discharge their wastewater directly into the river or city corporation drain without any kind of treatment. Samples are collected from industries. Then the tests are performed in the laboratory. Data range varies with time, lab facilities etc. Load shedding and limitations of laboratory facilities have also faced.
This study tried to develop a simple and economical treatment process for the effluents of the textile industries so that the disposed wastewater can be acceptable according to the environmental and aesthetic point of view. The textile industry is one of the longest and most complicated industrial chains in manufacturing industry composing of a wide number of sub-sectors, covering the entire production cycle from the production of raw materials (man-made fibers) to semi-processed (yarn, woven and knitted fabrics with their finishing processes) and final products (carpets, home textiles, clothing and industrial use textiles). Broadly defined, the textile industry consists of establishments engaged in spinning natural and manmade fibers into yarns and threads. These are then converted (by weaving and knitting) into fabrics. Finally, the fabrics and in some cases the yarns and threads used to make them, are dyed and finished (M C,Somasekhara Reddy, 2006).

Background

The textile industry is known as a water intensive sector, which employs a wide variety of processes. The textile chain begins with the production of raw fiber continues with pretreatment, dyeing, finishing, printing, coating, and other processes (Tabrez a khan et.al, 2004). These processes represent the core of the applied processes. Among these processes dyeing and finishing are major water consuming processes that generate highly polluted effluents. The main source of residual chemicals in effluents is their incomplete exhaustion during production phases. Several common treatment options such as physical, chemical and biological methods are available for the treatment of these effluents, but the residuals are hard to remove, either by conventional or by advanced treatment processes. In the textile industry, the choice of the most effective and less expensive treatment processes or their combinations depends on the chemicals and methods used during the production. The dyeing step in the textile production has the largest risk for the environment due to high concentrations of organic dyes, additives and salts used. Therefore, among the processes applied in the textile industry, dyeing process wastewater should be dealt with seriously. Most of the time, this process constitutes the major part of the water consumption and generates wastewaters distinguished by high chemical oxygen demand (COD), high dissolved and suspended solids, and high color contents.

Thus, dyeing wastewaters originating from rinsing operations are great candidates for recovery and reuse. The stringent environmental regulations for discharge today and the scarcity of the water resources are forcing the textile manufacturers to assess the potential for reuse of water by innovative technologies.

The specific objectives of this study are as below

- To remove toxic dye from the textile effluent using organic, low-cost, available adsorbent such as orange and banana peels.
- To evaluate the removal efficiency of color from textile wastewater.
- To measure the optimum treatment condition using batch experiment with different adsorbent dose and pH values.

2. METHODOLOGY

The different phases of this project of work are shown in the following diagram. The figure simply describes the experimental strategy of this study. Figure 2.1 shows flow diagram of experimental strategy.

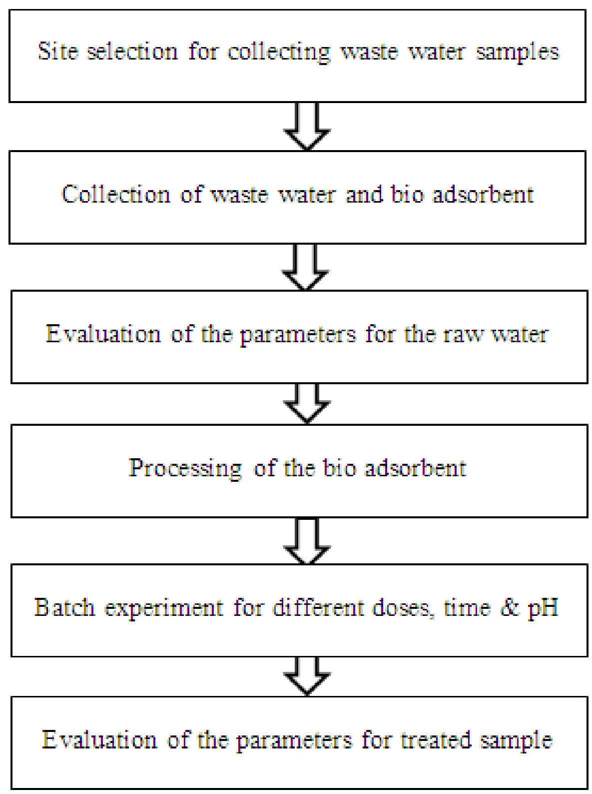

Figure 2.1: Flow diagram of experimental strategy

The study area is situated in Dhaka District, which is located about 40 km South of main city. This area is famous for producing all types of textile products which are exported to the foreign country. The technological problems resulting from the discharge of effluents from textile mills into drainage have been among the most important water and soil pollution problem in this area. Local peoples have been facing many problems including health, sanitation due to pollute water of this area. Under these circumstances, it is necessary to assess the impact of industrial effluents on surface water quality and also to treat the water.

2.1 Moisture Content, Volatile Matter And Ash Contain Of Adsorbent

Table shows physical characteristics of orange and banana peels at temperatures (100^0C, 550°C). From the results, the orange peel showed a higher moisture content 37.05% and volatile matter (71.67%). Thus the rate of ash (4.24%) less than that of banana peel. On the other hand, banana peel showed lower moisture content (6.91%), volatile matter (76.09%) which is greater than orange peel. Concerning banana peel, found the result of ash content 9.87%. Table 2.1 shows MC, VM and Ash content of orange and banana peel.

Table 2.1: MC, VM and Ash content

	Orange Peel	**Banana Peel**
Moisture content (%)	37.05	6.91
Volatile matter (%)	71.67	76.09
Ash content (%)	4.24	9.87

2.2 Batch Adsorption Experiments

The batch adsorption experiments were conducted to study optimum removal of color from textile wastewater. Required quantity of different doses of orange peel and banana peel added with 500 ml textile industry waste effluent. The beakers were kept in shaker at 30^0C temperature at 100 rpm. The contents were filtered using whatman filter paper. The equilibrium time and optimum dose of adsorbent were optimized by repeating the same experiment at different conditions. The same procedure is applied for 15, 30, 60, 120, 240 min to obtain the maximum removal of color.

2.2.1 Effect of Adsorbent Dose

The different doses of adsorbent namely Orange and Banana peel taken such as 1g to 2.5 g with 500 ml textile effluent in beaker in shaker at about 30^0C and 100 rpm. For each dose, ratio of orange and banana peels were taken 1:1.

2.2.2 Effect of Time

To study the effect of time on efficient removal of color from textile waste the study was carried out. The effect of contact time was investigated for 15, 30, 60, 120, 240 minute.

2.2.3 Effect of pH

To study the effect of pH on color removal capacity of Banana and Orange peel, Color removal was studied at pH ranging between 4 and 10 by maintaining pH of waste water sample with diluted H_2SO4 and NaOH solution.

3. ILLUSTRATIONS

The investigation of color, pH and the effects of different doses of adsorbent, are shown in graphical form. The removal performance found from the experimental data was fitted with the Langmuir and Freundlich Isotherm equations to calculate the theoretical amount of color removal.

3.1 Adsorption Efficiency Of The Adsorbents

In the treatment process, both orange and banana peel ratio have taken equally. Because, from the experiment, it is found that orange peel has removal efficiency almost 65% and banana peel has 80%. So, the ratio during batch experiment has taken 1:1. An individual batch experiment for orange and banana peel has done and results are given below in the following tabular form.

For 0.3g dose of Orange Peel, at pH 7.11 after 120 min maximum color removal is found. The batch experiment is done at 15, 30, 60, 120 and 240 min to obtain the maximum color removal. pH remains constant. Table 3.1 shows batch experiment result for 0.3g OP.

For 0.3g (0.6/L) Orange Peel

Initial pH= 7.13 Initial Color= 7230 Pt.Co.

Table 3.1: Batch experiment result for 0.3g OP

Time	pH	Color	% Removal
15	7.13	5786.00	20.00
30	7.11	4976.50	31.00
60	7.11	2675.10	63.00
120	7.11	2530.50	65.00
240	7.11	2489.00	65.67

For 0.3g (0.6/L) Banana Peel
Initial pH= 7.13 Initial Color= 7230 Pt.Co
Same procedure is applied for 0.3g banana peel and maximum removal is obtained after 120 min at pH 7.13. table 3.2 shows batch experiment result for 0.3g BP.

Table 3.2: Batch experiment result for 0.3g BP

Time	pH	Color	% Removal
15	7.13	5422.50	25.00
30	7.14	4892.00	32.34
60	7.12	1518.30	79.00
120	7.11	1453.23	79.90
240	7.11	1453.00	79.90

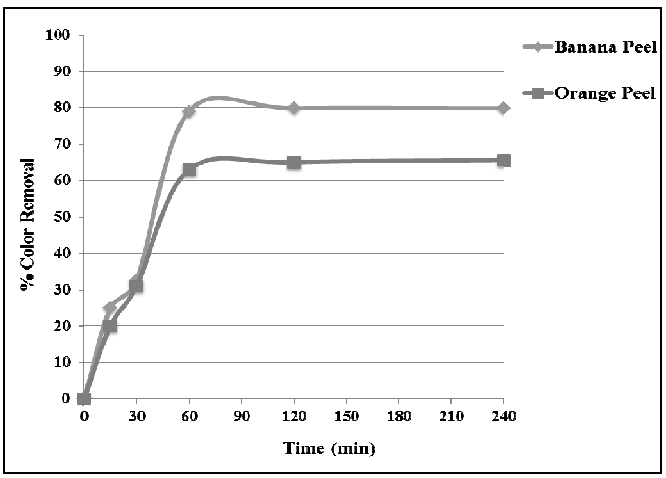

Figure 3.1: Adsorption efficiency of Orange and Banana peel

Figure 3.1 shows the experimental data, % color removal VS. time graph. In the graphical presentation, orange peel shows maximum color removal efficiency 65% whereas banana peel shows 80%. Their maximum removal efficiency is shown after 120 min from the initial stage. The graph shows a linear relationship between time and percent color removal but stops the removal efficiency after a certain time.

3.2 Effect Of Adsorbent Dose

The different doses of adsorbent namely Orange and Banana peel taken such as 1g to 2.5g with 500 ml textile effluent in beaker in shaker at about 30^0C and 100 rpm. It was found that maximum color removal efficiency for Orange peel was 65% at 0.3g dose of adsorbent and for Banana peel 80% at dose of 0.3g of adsorbent. From the comparative results it was found that effect of banana and orange peel are same almost. The graphical representation is shown below in Figure. It was found that adsorption was found decreasing further with increase in dosage in both the case of adsorbents. Table 3.3, 3.4, 3.5, 3.6 show batch experiment result for 1, 1.5, 2, 2.5g OBP, where adsorbent ratios were 1:1.
Initial pH=7.13 Initial color=7230 Pt.Co.

Table 3.3: Batch experiment result for 1g OBP

Time	pH	Color	% Removal
15	7.09	1626.75	77.00
30	7.09	1301.40	82.00
60	7.09	795.30	89.00
120	7.09	759.20	89.50
240	7.09	755.80	89.50

For dose 1.5g (3g/L) OP and BP ratio 1:1
Initial pH=7.1 Initial color=7100 Pt.Co.

Table 3.4: Batch experiment result for 1.5g OBP

Time	pH	Color	% Removal
15	7.06	1562.00	78.00
30	7.06	1441.30	79.70
60	7.05	731.30	89.60
120	7.05	731.30	89.70
240	7.05	731.30	89.70

For dose 2g (4g/L) OP and BP ratio 1:1
Initial pH=7.1 Initial color=7100 Pt.Co

Table 3.5: Batch experiment result for 2g OBP

Time	pH	Color	% Removal
15	7.03	1349.00	81.00
30	7.03	1270.90	82.10
60	7.03	731.30	89.70
120	7.02	731.30	89.70
240	7.02	717.10	89.90

For dose 2.5g (5g/L) OP and BP ratio 1:1
Initial pH=7.1 Initial color=7100 pt.co

Table 3.6: Batch experiment result for 2.5g OBP

Time	pH	Color	% Removal
15	7.03	1349.00	81.00
30	7.02	965.60	86.40
60	7.01	702.90	90.10
120	7.01	702.90	90.10
240	7.01	695.80	90.20

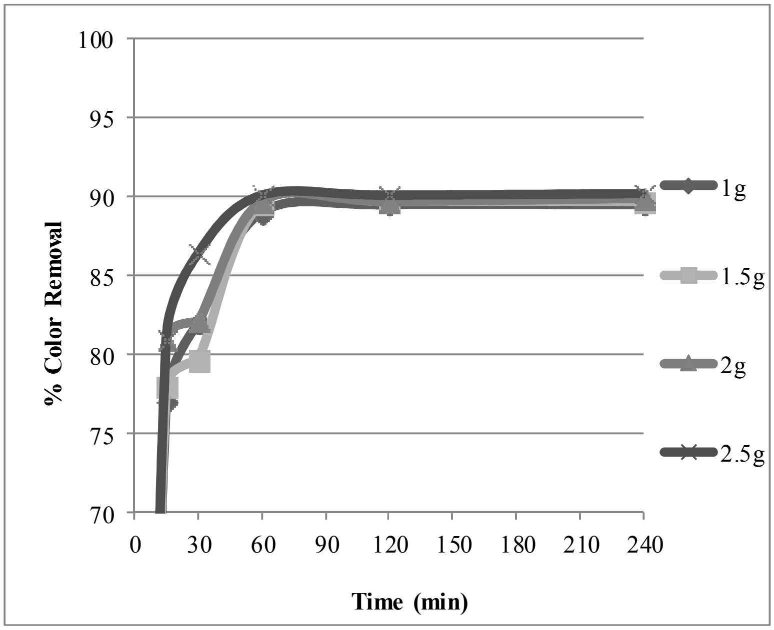

Figure 3.2: Color removal efficiency of OBP for different doses

For different doses percent color removal VS. time graph is obtained from figure 3.2. From the graph is it clearly noticed that maximum removal is found at 2.5g. Orange and banana peel were mixed equally and applied on the effluent.

3.3 Effect Of Time

To study the effect of time on efficient removal of color from textile waste the study was carried out. The wastewater sample was taken in a 500 ml beaker and kept in a shaker at temperature 30^0C and 100 rpm. The sample was withdrawn from the beaker at pre-determined time interval each and results are compared with original color concentration of waste water to know the color removal efficiency of adsorbents. It is clear from the results that time plays an important role is color removal for Orange and Banana peel. The optimum time duration required for color removal is 60mins for both banana peel and orange peel. The comparative results for efficiency of various adsorbents with respect to time are given in Figure 3.2.

3.4 Effect Of pH

To study the effect of pH on color removal capacity of Banana and Orange peel, color removal was studied at pH ranging between 4 and 10 by maintaining pH of waste water sample with diluted H_2SO_4 and NaOH solution. The maximum removal of color from waste water is at 7 pH. The removal slightly depend on pH and it is found that many adsorbent shows change in adsorption capacity with variation in pH. At acidic and alkaline pH new color of higher wavelength was found. The graphical representation is shown in Figure 3.3. Table 3.7 shows Batch experiment result for different pH.

Initial pH=7.1 Initial Color=7200 Pt.Co.

Table 3.6: Batch experiment result for different pH

Time	pH	Color	%Removal
15	4	4699.5	35
15	5	3181.2	56
15	6	2602.8	64
15	7	1626.75	77.0
15	8	3759.6	48
15	9	5567.1	23

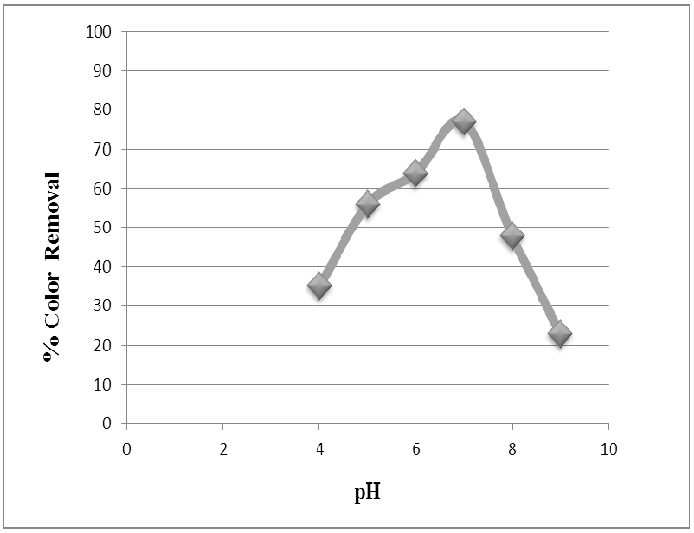

Figure 3.3: Color removal efficiency of OBP for different pH

Figure 3.3 shows a linear relationship between pH and percent color removal at a certain point. With the decreasing of pH, removal efficiency decreases and at 7 pH shows the maximum removal which is similar to the previous study (Mane, Bhusari, 2012). Many adsorbents show change in adsorption capacity with variation in pH. However, this study shows non-acidic, non-alkaline environment is better for the maximum removal efficiency.

3.5 Adsorption Isotherm

The study of isotherm data is important to find out the adsorption capacity of various adsorbents. In order to investigate the adsorption isotherm, two equilibrium isotherms were analyzed: Langmuir and Freundlich isotherms are used for fitting the experimental data in adsorption studies to understand the extent and degree of favorability of adsorption (Dhinakaran, 2011).

3.5.1 Langmuir Isotherm

The Langmuir model was developed based on the assumption of the formation of a monolayer of the absorbate species onto the surface of the adsorbent. It has also been assumed that the surface sites are completely energetically homogeneous. But in the true sense, the adsorbent surface is energetically homogeneous. The study of the Langmuir isotherm is essential in assessing the adsorption efficiency of the adsorbent. This study is also useful in optimizing the operating conditions for effective adsorption. In the respect, the Langmuir isotherm is important, though the restrictions and the limitations of this model have been well recognized.
The Langmuir and the arranged Langmuir equations are given below,

$$Qe = bKLCe/(1 + bCe) \quad \textbf{(1)}$$

Where, Qe = amount of dye adsorbed on the adsorbent (g/L)
Ce = dye concentration at equilibrium (g/L)
b and K_L = Langmuir constants
Where Qe is the amount of dye adsorbed per unit weight of the adsorbent, Ce is the
Concentration of dye remaining in solution at equilibrium, Ce is the amount of dye adsorbed.
This model is rearranged to the linear form as follows:

$$1/Qe = 1/KL + 1/(bKLCe) \quad \textbf{(2)}$$

Table 3.7: Experimental data

1/Qe	1/Ce
0.000618	0.00132
0.000942	0.00137
0.00125	0.00139
0.00156	0.00144

The experimental data from table 3.8 were plotted in the figure 4.5 and the obtained equation from the graph is compared to the y=mx + c equation. The plots of 1/Qe against 1/Ce (figure), is showed in figure 3.4.

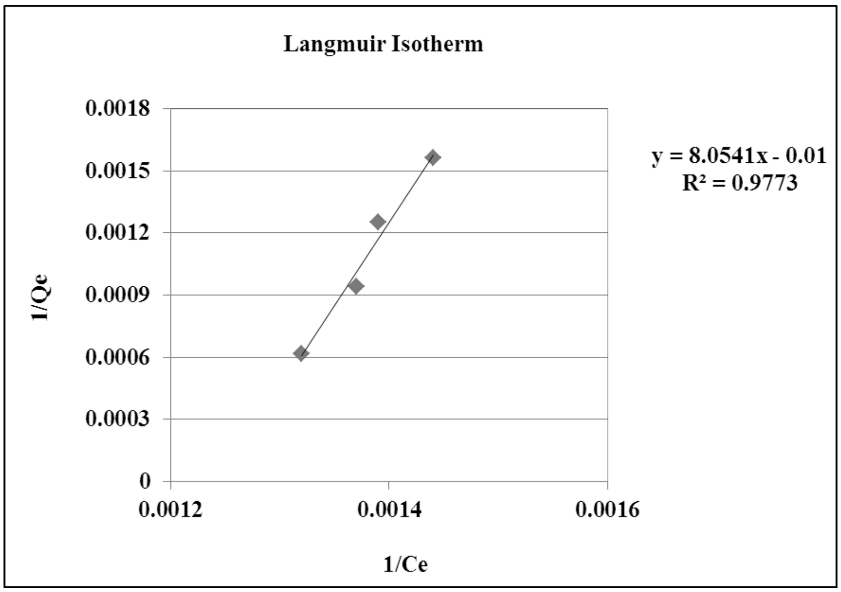

Figure 3.4: Graphical Representation of Langmuir Isotherm

Putting the value from the graph on the isotherm equation following data are obtained. The graph formed a straight line which indicates that the system fits the isotherm. Table 3.9 shows the value obtained from Langmuir Isotherm.

Table 3.8: Value obtained from Langmuir Isotherm

Langmuir Isotherm			
Qe_{max} (g/L)	**b**	**K_L**	**R^2**
561.8	1.242E(-3)	100	0.9773

3.5.1 Freundlich Isotherm

The equilibrium adsorption isotherms are of fundamental importance in the design of adsorption systems. The equilibrium adsorption data could be satisfactory by the Freudlich isotherm

$$Qe = KFCe^{(1/n)} \qquad \textbf{(3)}$$

Where, Qe = amount of dye adsorbed on the adsorbent (g/L)
Ce = dye concentration at equilibrium (g/L)
n and K_F = Langmuir constants
The constant K_F, partition coefficient in equilibrium is positively related to the extent of degree of adsorption, while then constant ‘n’ provides a rough estimation of the intensity of adsorption. A linear form of the Freundlich expression will yield the constants K_F and n hence:

$$Log\ (Qe) = log\ (KF) + (1/n)\ log\ (Ce) \qquad (4)$$

Table 3.9: Experimental data

Log Qe	Log Ce
3.209	2.878
3.026	2.864
2.902	2.856
2.806	2.842

The experimental data from table 3.10 were plotted in the figure 4.6 and the obtained equation from the graph is compared to the y=mx + c equation. The plots of Log Qe against Log Ce (figure 4.6), is showed. The formation of straight line indicates that the system fits the Freundlich Isotherm.

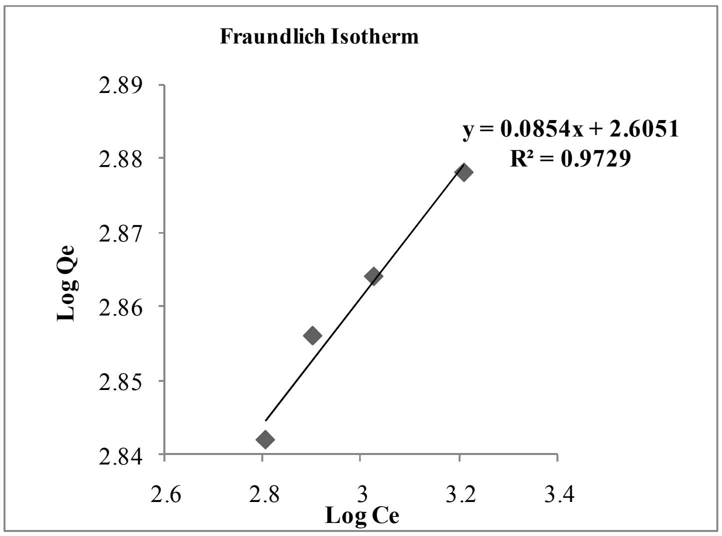

Figure 3.5: Graphical Representation of Freundlich Isotherm

Putting the value from the graph on the isotherm equation following data are obtained from table 3.11.

Table 3.10: Value obtained from Freundlich Isotherm

Freundlich Isotherm			
Qe_{max} (g/L)	**1/n**	**K_F**	**R^2**
707.51	0.085	402.81	0.9729

So adsorption capacity can be explained by Langmuir Isotherm as the value of R^2> value of R^2 of Freundlich Isotherm.

4. CONCLUSIONS

Conventional technologies to treat textile wastewater include various combinations of biological, physical, and chemical methods, but this method requires low costs and easily available. Treatment processes based on adsorption can be eco-friendly if the pollutants are mineralized afterwards. A combination methods involving adsorption followed by biological metabolism and disinfection has been advocated. This proposed treatment process for textile effluent in Dhaka involves the following steps. After the physical treatment, dyes are adsorbed by the orange and banana peels. Microbial life from the water would be destroyed by sunlight in the next phase. The treated water at this stage can be discharged in the surface.

- Orange and Banana peels can be used as adsorbent to remove the dyes from textile effluent.
- The removal efficiency for both the bio adsorbent is obtained and maximum removal efficiency is 90% of color from textile wastewater.
- For maximum removal, dose should be applied 2.5g (ratio 1:1) at neutral pH and normal room temperature. And 90% removal efficiency is obtained at 60 min.

REFERENCES

Somasekhara Reddy, M.C. (2006). "Removal of direct dye from aqueous solutions with an adsorbent made from tamarind fruit shell, an agricultural solid waste" Journal of scientific & industrial research vol.65, pp 443-446.

Saha, Papita. (2010). "Assessment on the removal of methylene blue dye using tamarind fruit shell as bio sorbent." Springer science+business media b.v., 213, pg(287–299).

Sharma, P. (2010). "COD reduction and colour removal of simulated textile mill wastewater by mixed bacterial consortium" Rasayan .j. chem.vol 3, no.4, 731-735, issn-0974-1496.

Mane, R.S. Bhusari, V.N. (2012). "Removal of Colour (dyes) from textile effluent by adsorption using Orange and Banana peel." International Journal of Engineering Research and Applications (IJERA), Vol. 2, Issue 3.

Khan, T. (2004). " Removal of some basicdyes from artificial textile wastewater by adsorption on Akash kinari coal" journal of scientific and industrial research, vol 63 pp(355-364).

Theivarasu, M.S. (2011). "Cocoa shell as adsorbent for the removal of methylene blue from aqueous solution: kinetic and equilibrium study" universal journal of environmental research and technology, vol-i, 70-78.

Velmurugan, P., Rathina, K., Dhinakaran V. (2011)."Dye removal from aqueous solution using low cost adsorbent" International Journal of Environmental Sciences, volume 1 no.7,pg 1492- 1503.

Yavuz, ö., Aydin, H. (2006). "Removal of direct dyes from aqueous solution using various Adsorbents", Polish Journal of Environmental Studies, vol. 15, no. 1, 155-161.