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Performance of Different Low Cost Adsorbents in Removal of Color from Textile Dyeing Wastewater

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Abstract : *The removal of color from the textile dyeing effluents by different low cost adsorbents and other commonly used coagulants were studied in this research. It also presents an assessment of the performance of different adsorbents coagulants in removing color from textile dyeing wastewaters of different colors. Rice Husk, Sugarcane bagasse, Fly Ash, Sawdust, Charcoal and Burnt Coconut Sawdust were used as low cost adsorbents. Ferrouś Sulfate and Alum were used to compare the performance of the low cost adsorbents against the commonly used coagulants, Rice husk, Sugarcane bagasse, Fly Ash and Sawdust did not show any significant color removal. Furthermore they increased the initial color of the sample in many cases. Burnt Coconut Sawdust and Charcoal proved them to be effective in case of several samples. These two adsorbent were also effective in removing odor from an effluent sample. Among the low cost adsorbents used in the research, the Burnt Coconut Sawdust was most effective. The removal color appears to depend on a number of factors, including initial concentration of color, color of effluent, and pH. Alum was more effective in removing color from blue effluent than purple effluent. So, it can be concluded that Burnt Coconut Sawdust could be an effective absorbent to remove color from textile effluents at very low cost.*

Keywords : *Adsorbent, effluent, coagulants, dye, flocculation, oxidation.*

Introduction

One of the major problems concerning textile wastewater is colored effluent. Although color is not included in the Environment Conservation Rules 1997, it is an issue in dye house effluent because unlike other pollutants it is so visible. Reducing color is therefore important for the public image of a factory and international textile buyers are increasingly setting discharge standards for color. Color is widely considered solely an aesthetic pollutant although there are studies currently evaluating aquatic toxicity, photo toxicity, and metal bioavailability for specific dye class. As a result, there has been little regulation of this pollutant. Although its environmental impact may be considered lower than many other pollutants, color is much more readily identifiable by the average citizen. The industry is not mandated to reduce color in the effluent, and doing so typically means significant capital investment in non-process oriented equipment and chemicals. The discharge of colored waste is not only damaging the aesthetic nature of receiving streams but also it may be toxic to aquatic life. In addition, color interferes with the transmission of sunlight into the stream and therefore reduces photosynthetic action. The color in the effluent is mainly due to unfixed dye. The concentration of unused dyes in the effluent depends upon the nature of dyes and dyeing process underway at the time. Inefficiency of dyeing process results in 10-25% of all dye stuffs being lost directly to the wastewater.

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The removal of dye in an economic fashion remains an important problem. Considerable work has been carried out so far on the removal of dye from wastewater. This research work has been done to assess the performance of different low cost adsorbents in removing dye form textile dying wastewater and find out a cost effective process.

Color Removal Techniques

There are various treatment techniques to remove textile wastewater pollution. Biological treatment processes are frequently used to treat textile effluents. These processes are generally efficient for biochemical oxygen demand (BOD) and suspended solids (SS) removal, but they are largely ineffective for removing color from the wastewater because dyes have slow biodegradation rate. Now the treatment technologies recommended meeting color removal requirements are physicochemical treatment operations, including adsorption (Ahmad and Ram, 1992) ozonation (Lin's1993, oxidation (Boon and Tjoon, 2000), chemical precipitation etc. Each has its merits and limitations applied in decolorization treatment operations. But Coagulation-flucculation is the most common chemical treatment method for decolorization (Beulker and Jekel, 1993)

Chemical Precipitation of Colour is the process which depends on the extent to which the soluble color contributing COD can be coagulated and flocculated. The performance depends upon the final floc formation and its setting quality. In case of dyes, Sulphur and dispersed dyes coagulate well but cationic dyes do not coagulate at all, making their removal by coagulation-flocculation method impossible. Acid, direct, vat, mordant and reactive dyes usually coagulate, but the resulting floc is of poor quality and does not settle well. Therefore, for dyes, coagulation-flocculation will yield mediocre results. The negative aspect would be the massive requirement of the coagulant and the formation of several tons of chemical sludge, which has to be dewatered and disposed off.

Powdered activated carbon has a reasonably good color removing capacity when introduced in a separate filtration step than on an 'as is' basis in the physical – chemical or the biological process. High removal rates are seen for cationic, mordant and acid dyes and the removal is moderate for sulphur, dispersed, direct and reactive dyes. Removal rates can be improved by using massive dosages of activated carbon. However, regeneration or reuse of carbon results in steep reduction in performance and the efficiency becomes unpredictable or dependent on massive carbon dosages. The system therefore becomes cost inhibitive, if activated carbon is not regenerated and the disposal of concentrates from regeneration has to be taken care of. Therefore, this option is viable only for effluents with low residual color and is more suitable for companies working with animal or acrylic fibers.

Lab scale studies show that membrane filtration is ideally suited from the viewpoint of water recycling. Ultra filtration achieves complete color removal and a sharp reduction in COD. With membranes, clogging represents a major drawback and would require a prior filtration stage for the coagulated effluent. The results are excellent as it yields non colored water that could either be recycled back to the process or discharged in the water bodies. This advantage is offset by the formation of a heavily loaded concentrate which needs further treatment and careful land filling. Furthermore, due to the prohibitive costs involved, this technique is more suited for units with low effluent volume.

In a subsequent biological post treatment, newly formed degradable compounds are effectively removed with high efficiency. Biological post treatment is necessary as it entails much lower costs than by a far reaching oxidation without additional biological treatment. Generally, Powerful oxidants such as ozone are applied at high rates and cause destructive oxidation with aromatic ring cleavage leading to decolorization of the effluent. Color removal is generally effective and fairly rapid using ozone. Ozone dosages are determined based on the total color and residual COD to be removed. Use of Ozone is ideal as it allows as effluent with no color, low COD suitable for discharge into the environment, by destroying the COD, leaving no residues such as concentrates or sludge, to be disposed off. It is again, the class of dye determines its behavior. Dispersed and vat dyes are difficult to treat and ozone is not the correct or efficient solution to treat these dyes even at higher concentrations. Generally speaking, advanced treatment processes such as those mentioned above, may be optionally applied either before or after biological effluent treatment. For all purposes, proven from our industrial experiences, it may be safely stated that unless partial flows can be successfully treated, Oxidation stages inserted after the biological treatment are more economical and effective.

Performance of Different Coagulants in Removing Color

A coagulant is a chemical used to effectively separate fine particles that cause pollution form water. Minute particles that do not readily separate from water can be separated by coagulating them into easily separated flocs. Coagulants are roughly divided into inorganic coagulants and organic coagulants.

Inorganic Coagulants

There are various inorganic coagulants which can be used as coagulants such as ferric sulfate II, ferric chloride and sulfate III, lime and inorganic polymer floccules.

Organic Coagulants

Organic coagulants including poly electrolytes, synthetic polymers and natural polymers can also be used for coagulation process (Beulker and Jekel, 1993). Polymers with initial monomers such as carboxyl or amino are called poly electrolytes. Different types of poly electrolyte are used as coagulant aids recently. Poly electrolyte has huge molecules with a high molecular weight which has a high ionization power. It produces a large amount of ions in water and shows the properties of both polymers and electrolytes. Polyamphotypes, anionic and cationic poly electrolytes are some types of poly electrolytes. The most practical benefit of poly electrolytes is the formation of massive flocs. These massive flocs speed up the flocs setting velocity, reduce the expenses of decolorization and also decrease settled sludge volume. However, the use of poly electrolytes may have some problems.

Method of Assessing Performance of Different Low Cost Adsorbents in Removing Color

In this research along with chemical coagulants, performance of several agricultural by-products and some low cost products are observed in removing color form textile dyeing effluent which was collected from different sources.

The names of used adsorbents are Rice husk, Sugarcane bagasse, Saw Dust, Fly ash,Charcoal, Burnt coconut saw dust, Alum and Ferrous sulfate.

Sugarcane bagasse and rice husk are the agricultural by –product found in abundant amount in Bangladesh. They were collected from the Bazidpur sugermill and ricemill respectively. Sawdust and charcoal were collected from the nearby sawmill and restaurant respectively. They are used in the form they were obtained. The collected coconut sawdust was simply burnt to obtain the burnt coconut sawdust. Fly ash is a residue that results from the combustion of coal in power plants. The advantages of color removal by using fly ash over the other chemical treatment methods are its abundance and its easy availability, which makes it a strong choice in the investigation of an economic way of color removal. Other advantage is that it could easily be solidified after the pollutants are adsorbed because it contains pozzolanic particles that react with lime in the presence of water, forming cementation. Fly ash was obtained from a cement factory. The method used in removing color from textile dyeing effluent is coagulation-flocculation. The followed process in the environmental lab comprises the following steps:

Step 1: Take 500 ml well –mixed waste effluent in a 1000 ml container.
Step 2: Add a coagulant material in required amount in the container

Step 3: Rapid mixing at 45 rpm for 1 min and slow mixing at 25 rpm for 14 min in flocculator (SW6)

Step 4: Keep the sample undisturbed for 15 minutes for removing the flocs by settling.

Step 5: Measure color with HACH spectrophotometer (DR 4000) after filtering the sample.

Results and Discussion

The results obtained from the tests with different combination of textile dyeing wastewater sample and coagulants are presented here in tabular form. Bar charts are used to show the % removal of color achieved using different coagulants in varying dose and also with varying pH. Table 5.1 shows the description of samples used.

Table 1: Description of the Samples Used

Sampl e no.	Color description	Initial color (Pt –Co unit)	Initial pH	Source
1	Light blue	103	6.2	A Textile industry
2	Blackish green	3120	4	A Textile industry
3	Blackish blue	299	7	Modern Industry
4	Dense Blue	2380	10.3	Ring shine Industry
5	Moderate Red	584	8.1	Ring shine Industry
6.	Blue	765	10	Ring shine Industry
7.	Moderate Purple	153	5.3	Ring shine Industry

** The name of the industries are not disclosed*

Removal of Color using Fly Ash

Table-2: Results of color removal from sample 1 with Fly Ash (*Initial color:103 Pt-Co.unit)*

Serial No.	Fly Ash Dose(g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	2	7	130	Light blue	Substantial Increase in color
2	4	7	143	Light blue	Substantial Increase in color
3	8	7	150	Light blue	Substantial Increase in color
4	12	7	180	Light blue	Substantial Increase in color

Table-3: Result of color removal focus sample 5 with Fly Ash

Serial No.	Fly Ash Dose(g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	4	10	750	Blue	Insignificant removal
2	8	10	800	Blue	No removal
3	12	10	810	Light blue	No removal
4	16	10	785	Light blue	No removal
5	20	10	930	Lighter blue	No removal

**Initial color: 765 Pt-Co. Units*

Removal of Color using Rise Husk

Rice husk is an agricultural by-product found in a large amount in the rice mill as Bangladesh is an agricultural country. So it will cost-effective if it can be used in removing color efficiently

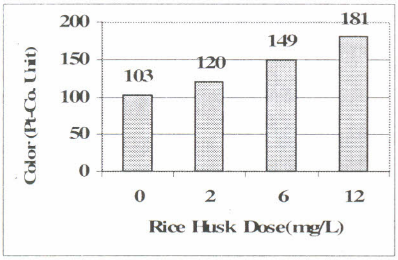
Table-4: Result of color at different doses of Rice Husk (Sample-4)

Sl No.	Dose Rice Husk (g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	2	7	120	No change in color	Increase in color
2	6	7	149	No change in color	Increase in color
3	12	7	181	No change in color	Increase in color

Table5: Result of color at removal by Rice Husk (Sample-4)

Sl No.	Dose Rice Husk(g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	4	10.3	2070	No change in color	13
2	12	10.3	2200	No change in color	7.6
3	16	10.3	2300	No change in color	3.4
4	20	10.3	2310	No change in color	2.94
5	40	10.3	2305	No change in color	3.2

** Initial color: 2380 Pt-Co. units*



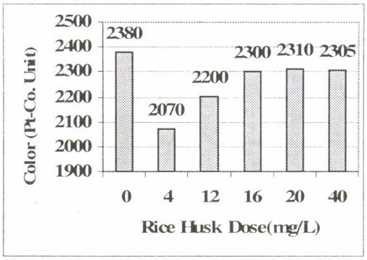


Fig 1: Results of color removal from (a) sample-1 and (b) sample- 4 with Rice Husk

Color Removal using Sugercane Bagasse

Sugarcane Bagasse is a low cost material easily available and was used as coagulant in color removal test.

Table-6: Removal of Color by Sugarcane Bagasse (**Initial color: 103Pt-Co. unit)*

Serial No.	Dose Bagasse (g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	2	7	135	Light Blue	Increase in color
2	6	7	165	Light Blue	Increase in color
3	12	7	211	Light Blue	Increase in color

Color Removal using Charcoal

Table-7: Result of Color Removal by Charcoal (Sample-3)

Serial No.	Dose Charcoal(g/l)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal	Odor Removal
1	8	7	281	Blackish blue	6	No odor
2	12	7	275	Blackish blue	8	No Odor
3	16	7	239	Light Medium blue	20.1	Odor

** Initial color: 299 Pt-Co. units*

Table-8: Result of Color Removal by Charcoal from Sample-6

Serial No.	Dose Charcoal(g/I)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	8	9.9	725	No change	5.9
2	12	9.9	675	No change	12.3
3	14	9.9	670	No change	13.0
4	16	9.9	640	No change	16.9

* *Initial color: 765 Pt-Co. units*

Removal of color using burnt coconut sawdust

Table-9: Result of Color Removal of Sample-3 by Burnt Coconut Sawdust

Serial No.	Dose (g/I)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	8	7	147	Light blackish watery blue	50.8
2	12	7	148	Light blackish watery blue	50.5
3	16	7	175	Blackish watery blue	41.5

* *Initial color: 299 Pt-Co. unit*

Table -10 Results of Color Removal of Sample-4 by Burnt Coconut Sawdust

Serial No.	Dose (g/I)	Final pH	Final Color (Pt-Co Unit)	Visual observation of color	Percent Removal
1	4	10.3	2105	Blackish watery	11.6
2	8	10.3	1710	Same	28.2
3	12	10.3	1645	Same	30.9
4	16	10.3	1435	Lighter Blackish Watery	39.7
5	20	10.3	1435	Lighter Blackish Watery	39.7

* *Initial color: 2380 Pt-Co. Units*

Table-11: Result of Color Removal by Burnt Coconut Sawdust from Sample-6

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	12	10.3	670	Blackish Watery	13
2	16	10.3	535	Transparent	30.5
3	20	10.3	525	More Transparent	32.8
4	24	10.3	535	Transparent	30.5

Table-12: Result of Color at Different Doses of Burnt Coconut Sawdust

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	12	11.3	75	Lightest Watery	51
2	16	11.3	77	Lightest Watery	49.7
3	20	11.3	109	Lighter Watery	28.8
4	24	11.3	135	Light Watery	11.8

Table-13: Removal of Color Using Burnt Coconut Sawdust at Different pH

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	12	7	19	Almost Clear	87.58
2	12	9	10	Almost Clear	93.46
3	12	10	64	Almost Clear	58.2
4	12	14	69	Almost Clear	54.9

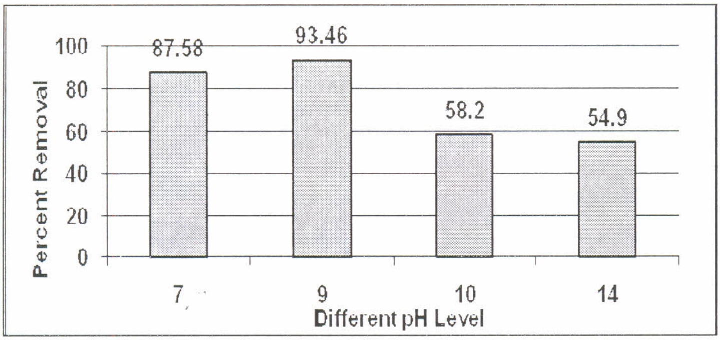


Fig-2: Removal of Color from Sample 7 Using Burnt Coconut Sawdust at Different pH

Removal of Color using Alum

Table-13: Color Removal from Sample 5 at Different Doses of Alum

Serial No	Dose (g/l)	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	200	494	No Considerable Change	15.4
2	300	476	No Considerable Change	18.5
3	400	324	No Considerable Change	44.5
4	500	204	No Considerable Change	65.1

* *Initial color of 584 Pt-Co units*

Table-14: Removal of Color at a Fixed Dose of Alum at Different pH

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	500	7	330	Light Red	43.5
2	500	8	294	Light Red	49.7
3	500	9	231	Lighter Red	60.44
4	500	10	335	Light Red	42.64
5	500	11	272	Light Red	53.42

Table-15: Color Removal from Sample-6 at Different Doses of Alum

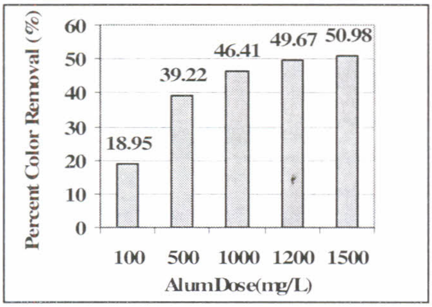
Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	100	9	620	No Change	18.95
2	500	9	465	No Change	39.22
3	1000	9	410	No Change	46.41
4	1200	9	385	Lighter Blue	49.67
5	1500	9	375	Lighter Blue	50.98

**Initial color 765 Pt-Co. units*

Table-16: Removal of Color from Sample 7 at Different Doses of Alum

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	100	9	136	Pink	11.11
2	500	9	120	Pink	21.6
3	1000	9	116	Pink	24.2
4	1200	9	113	Pink	26.14
5	1500	9	119	Dense Pink	22.22

** Initial color 153 Pt-Co. Units.*



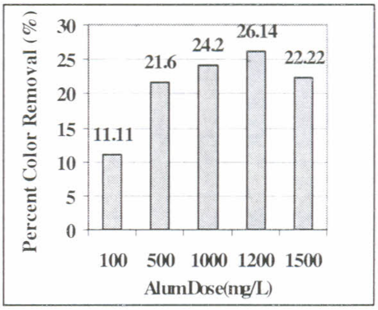


Fig-3: Removal of Color from (a) Sample-6 and (b) Sample 7 at Different Doses of Alum

Removal of Color using Ferrous Sulfate

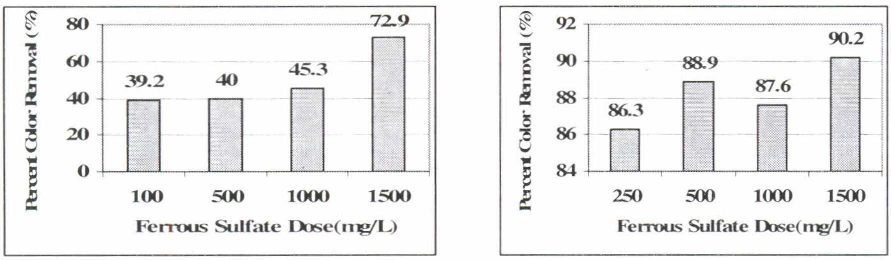
Ferrous Sulfate is also a commonly used coagulant in textile dyeing industry which is used along with lime/NaOH solution. The Results of Sample-6 and Sample-7 with Ferrous Sulfate is as below.

Table-17: Color Removal from Sample 6 at Different Doses of Ferrous Sulfate

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	100	11	465	Light Blue	39.2
2	500	11	300	Light Blue	40
3	1000	11	419	Lightest Blue	45.3
4	1500	11	207	Almost No Color	72.9

Table-18: Removal of Color from Sample 7 at Different Doses of Ferrous Sulfate

Serial No	Dose (g/l)	Final pH	Final Color (Pt-Co Unit)	Observation of Visual Color	Percent Removal
1	250	11	21	Almost Clear	86.3
2	500	11	17	Almost Clear	88.9
3	1000	11	19	Almost Clear	87.6
4	1500	11	15	Almost Clear	90.2



(a) (b)

Fig-4: Color Removal from (a) Sample 6 and (b) Sample 7 at Different Doses of Ferrous sulfate

Comparison between Low Cost Adsorbents and Commonly Used Coagulants

A comparison between low cost adsorbents such as Burnt Coconut Sawdust and usually used coagulants i.e. Alum and Ferrous Sulfate is done here to sort out a deduction.

Table-19: Different Coagulants/Adsorbents Performance Chart

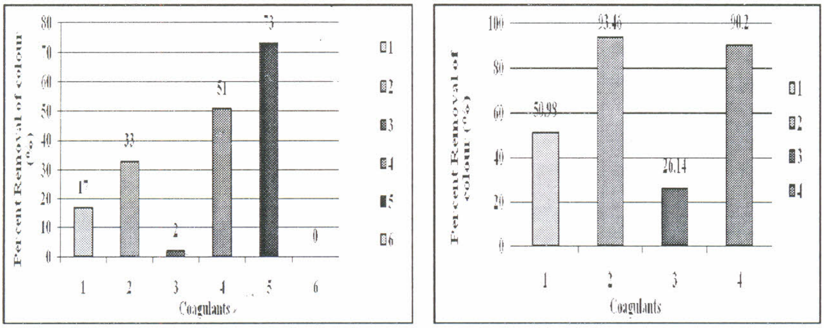
Coagulants	Sample No	% Removal
Rice Husk	1	0
	2	21
	3	0
	4	13
Sugarcane Bagasse	1	0
Sawdust	6	0
FlyAsh	1	0
	6	2
Charcoal	1	0
	3	20
	6	17
Burnt Coconut Sawdust	1	15
	3	51
	4	40
	6	33
Alum	5	61
	6	51
Ferrous Sulfate	5	73

Table-20: Highest Removal of Color from Sample 6 for Different Coagulants

Ser	Coagulant	Highest % color Removal
1	Charcoal	17
2	Burnt Coconut Sawdust	33
3	Fly ash	2
4	Alum	51
5	Ferrous Sulfate	73
6	Sawdust	0

Table-21: Highest Removal of Color from Sample 7 for Different Coagulants

Ser No	Coagulant	% Color Removal
1	Burnt Coconut Sawdust	50.98
2	Burnt Coconut Sawdust with varying pH	93.46
3	Alum	26.14
4	Ferrous Sulfate	90.2



(a) (b)

Fig-5: Highest Removal of Color from (a) Sample 6 and (b) Sample 7 for Different Coagulants

From the above tables and graphical presentations it is evident that Burnt Coconut Sawdust is not so good compared to the common adsorbents for Sample-6. But For Sample-7, Burnt Coconut Sawdust appears to be the most efficient coagulant with highest removal of 93.46% over 90.2%. So for waste effluent having low initial color Burnt Coconut Sawdust performs as very effective adsorbents, especially if pH is adjusted at optimum level.

Comparison of Behavior of Two Different Colored Waste with Same Coagulants

For Ferrous sulfate, Blue and Purple waste show almost identical behavior, though for purple waste the removal efficiency is 90.2%, where for blue waste it is 73%. For Coconut Sawdust highest removal is achieved at 12g/L for purple waste and at 20g/L for Blue waste.

Table-22: Performance of Burnt Coconut Sawdust in removing color from Blue and Purple colored Wastes

Sample No	Coagulants Dose (g/l)	% Removal of Color		Visual Color After Setting		pH After Mixing Coagulants	
		Blue Waste	Purple Waste	Blue Waste	Purple Waste	Blue Waste	Purple Waste
1	12	12.98	50.98	Blackish Watery	Lightest watery	10.3	11.3
2	16	30.52	49.67	Lighter Watery	Lighter Watery	10.3	11.3
3	20	32.82	28.88	Lightest watery	Light Watery	10.3	11.3
4	24	30.52	11.8	Blackish Watery	Blackish Watery	10.3	11.3

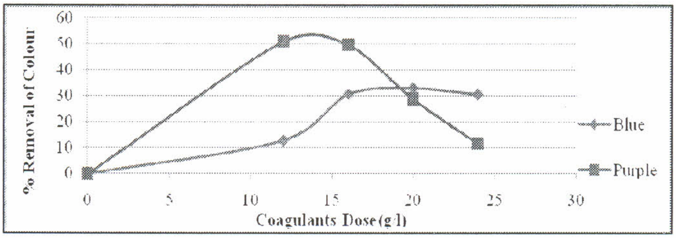


Fig-6 Performance of Burnt Coconut Sawdust in Removing Color from Blue and Purple Colored Waste

Table-23: Performance of Ferrous Sulfate in removing color from Blue and Purple colored Wastes

Sample No	Coagulants Dose (mg/l)	% Removal of Color		Visual Color After Setting		pH After Mixing Coagulants	
		Blue Waste	Purple Waste	Blue Waste	Purple Waste	Blue Waste	Purple Waste
1	250	32.68	86.27	Blackish Watery	Light Greenish	11	11
2	500	60.78	88.89	Lighter Watery	Lighter Greenish	11	11
3	1000	45.26	87.58	Lightest watery	Medium Greenish	11	11
4	1500	72.93	90.2	Blackish Watery	Dense Greenish	11	11

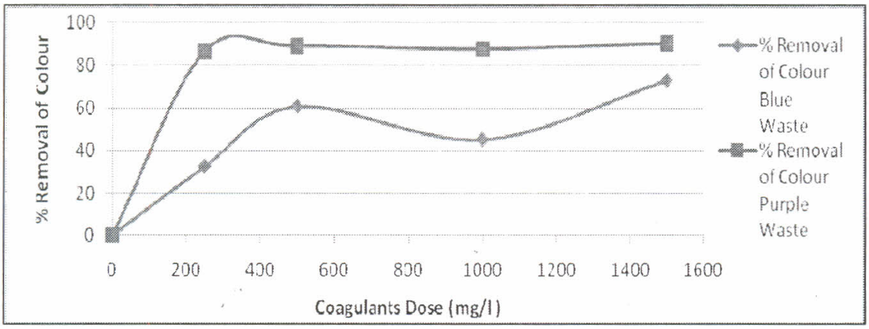


Fig-7: Performance of Ferrous Sulfate in Removing Color from Blue and Purple Colored Wastes

Findings

The Major findings obtained from the research work are presented below:

- Rice husk, Sugarcane Bagasse, Fly ash and Sawdust did not show any significant result in removing color. Furthermore they increased the initial color of the sample in many cases.
- Burnt Coconut Sawdust and Charcoal proved them to be effective in case of several samples and in some cases its performance was compared to Alum and Ferrous Sulfate.
- Burnt Coconut Sawdust was found to be effective in removing color in cases of almost all samples.
- Burnt Coconut Sawdust showed greater removal up to 93.5% if the pH can be adjusted at 9. In comparison to that in case of Ferrous sulfate, removal was achieved 90.2% at pH 11.
- The color composition of the textile dyeing wastewater and pH affect the performance of the coagulants. Burnt coconut sawdust showed 50.8% color removal in case of blue sample, but the % removal increased up to 93.5% while pH was adjusted at 9.
- The initial value of color also has a significant impact on the efficiency of the coagulant. The efficiency of burnt coconut sawdust increased with the decrease in the initial value of color.
- Burnt Coconut Sawdust also produced small amount of residue as compared with that produced by Alum and Ferrous Sulfate.

So, it can be concluded that burnt coconut sawdust could be an effective adsorbent to remove color at a very low cost.

As Burnt Coconut Sawdust and Charcoal show better result in removing color from the textile dyeing wastewater, further study should be made with these adsorbents with adequate knowledge in the field of organic chemistry.

References

1. Ahmad, M.N., Ram, R.N.(1992). Removal of basic dye from wastewater using silica as adsorbent. Environ. Pollut.,77-79.
2. Bennet, D.H., Reeser, D. (1988). Pretreatment of CTMP effluent by lime to reduce sulfite and color. Environmental conference Charleston, S.c.,199-207.
3. Beulker, S., Jekel, M. (1993). Precipitation and coagulation of organic substance and color from industrial wastewater. Water. Sci. Technol., 28:193-199.
4. Bisschops, I. and Spanjers, H. (2003). Literature Review on Textile wastewater Characterization. Environment Technology 24, 1399-1411.
5. Boon Hai Tan, A.K., Tjoon Tow Teng, A.K., Mohammad Omar, A.K. (2000). Removal of Dyes and industrial dye wastes by magnesium chloride. Water. Res.,34(2):507-601.
5. Dziubek, A.M., Kowal, A.L. (1983). Water treatment by coagulation and adsorption with Dolomite. Chemistry for protection of environment. In proceedings of an International Conference, Toulouse,France.,205.
6. Government of the People's Republic of Bangladesh (2000). The Environment Conservation Rules 1997, (unofficial translation), Ministry of Environment and Forests, Dhaka.
7. Lin, S.H., Lin, C.M. (1993). Treatment of textile waste effluents by ozonation and chemical coagulation. Water. Res.,27:1743.
8. Modified version based on Hettige, M. and Brandon, C. 1997. 'Industrial Pollution in Bangladesh: A Detailed Analysis', The World Bank, Workshop Discussion Draft. [M Aminul Islam]
9. Rahman, A. (1997). Characteristics of Major industrial pollutants in Bangladesh, M. Engg. Project report, Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka