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NATURAL ADSORBENTS; AN ECO-FRIENDLY SOLUTION FOR THE REMOVAL OF PH, TDS, DO, BOD & COLOR FROM THE TEXTILE EFFLUENT

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ABSTRACT

The use of different natural adsorbents to eliminate pollutant from textile effluent was studied in this research. Several naturally abundant adsorbents have been used in this work. Two blends of adsorbents made with different natural adsorbents. Blend-1 was made of Plantain Plant bark (Banana), Stem of Water Lilies, coconut fiber/coir and Hartaki. Blend-2 was made of Plantain Plant bark (Banana), Stem of Water Hyacinth, Stalk of an edible root and Dry straw of rice. The textile effluent was prepared and treated with both blends of natural adsorbents. The retention time for both blends of adsorbents was 24 hours. The pH value of the effluent found 12.14 and after 24 hours of treatment with blend-1 found 6.21 & for blend-2 found 8.45. TDS value of the effluent found 3920 before treatment and after treatment found 3440 & 2760 for blend-1 & blend-2 respectively. The DO in the effluent found 3.2 & 2.9 after treating with blend-1 & blend-2 respectively while before treatment DO content of the effluent was 0.8. Both blends of adsorbents showed similar effect (130) on the removal of BOD, while before treatment BOD value was 190. In both case, the color of the effluent turned to brown from its raw color (Black).

KEYWORDS: Textile Wastewater, Natural Adsorbents, pH, TDS, DO, BOD.

I. INTRODUCTION

Apparel is one of the oldest and largest export industries in the world. It is also one of the most global industries because most nations produce for the international textile and apparel market [1].Textiles have been an extremely important part of Bangladesh's economy for a very long time for a number of reasons. Bangladesh is currently one of the world's biggest exporters of ready-made garments with a global market share of about 5% [1-2]. The Bangladesh Garment Manufacturers and Exporters Association have recently set an ambitious target for the textile sector to double its exports and reach $50 billion of exports by 2021. If "business as usual" water demand continues for the textile sector, in particular, this will result in an additional water demand of over 6,750 mega liters per day by 2030 [3].Among the consequences of rapid growth are environmental disorders and pollution problems. Besides other needs the demand of water for industries has increased rapidly and resulted in the generation of a large amount of wastewater containing large number of pollutants [4-5].Wastewater discharged in the environment without treatment, wastewater leads to the breakdown of the ecosystem and creating potential health risks [6].The pollutants in the untreated wastewater need to be removed for the safe disposal into the freshwater bodies [7].The textile materials processing uses a broad variety of chemical substances (detergents, alkali, acids, dyes, surfactants etc.) that contribute to the significant pollution of the environment [8]. Wastewater from the textile industry commonly contains high concentrations of organic and inorganic chemicals and is characterized by high Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), pH, Total Suspended Solids (TSS) values and low Dissolved Oxygen (DO) value as well as strong color [9]. Biological, Physico-chemical and Biochemical plant are mainly used for textile wastewater treatment [10-14]. Because of the low biodegradability of many chemicals and dyes employed in various textile processes; the biological treatment alone is not a very good option [15]. Also, the conventional biological treatment has certain disadvantages such as sludge production, high energy demand and frequent maintenance requirement [16].The physicochemical treatment processes such as coagulation-

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flocculation, advanced oxidation and electrochemical techniques are effective, quick and compact but are not generally employed due to the associated high chemical and operational costs as well as complex sludge generation [17-18].In addition, chemicals added for wastewater treatment may react together and generate new products with unknown health effects [19]. Generally, depending on the used process and on the wastewater subject to treatment, the technology may be costly economically infeasible and also not eco-friendly, due to the negative impact of its secondary effluent into the environment. Consequently, developing a cost-effective wastewater treatment process remains with extreme importance. In this context, a renewable approach involving application of biomaterials in the removal of pollutants from wastewaters can offer a promising solution [6]. These natural materials should be available, cost-effective and safe for human health and biodegradable [20]. Many researchers reported the potentiality of natural materials for waste water treatment i.e. Aloe-vera [21], cactus[22], Eucalyptus bark [23], Moringo Olifera [24],Wheat Husk [11], tannin [25], water lettuce (Pistia stratiotes) [26], water lilies (Nymphaea spontanea) [26,30], parrot feather (Myriophylhum aquaticum) [26], creeping primrose (Ludwigina palustris) [26], watermint (Mentha aquatic) [26], banana peel [27], Keratin protein[28] , Sugar cane bagasse [29] banana plant bark [30], Water Hyacinth (Eichornia crassipes) [30], Orange Peel [31], Sawdust [32] etc. Previous research shows that single natural adsorbents are not a good choice in the removal of pollutants from textile effluent. For example in case of TDS removal plantain plant (banana) bark could be fruitful rather than water hyacinth, and water lily [30]. That's why we worked with different combination of natural adsorbents. In this study we have worked with some new absorbents i.e. Stalk of an edible root (Colocasia esculenta), Dry straw of rice, coconut fiber/coir Cocos nucifera L., Hartaki (Terminalia Chebula) were used along with previously used Stem of Water Hyacinth (Eichornia crassipes), Stem of Water Lilies (Nymphaea nouchali) and Plantain Plant (Banana) (Musa Sapientum).We have also investigated the effect of different natural adsorbents for textile wastewater treatment & their efficiency on the removal of BOD, DO, TDS, PH and Color. Mixtures of different natural adsorbents were invested to measure their pollutant removal efficiency on textile wastewater. Experiments were done with two different blends of natural adsorbents. These adsorbents are abundant in the nature and can be an eco-friendly & cost-effective way of textile wastewater treatment. The used natural adsorbents have shown a great efficiency in the removal of pollutants from textile wastewater.

Textile Effluent Discharge standard

Wastewater from the textile industry should be considered a serious environmental problem. Despite the use of high-tech equipment and modern technologies, the textile industry is among the highest water-consuming industries and produces a huge amount of wastewater. Water consumption and wastewater generation during the dyeing and finishing of textiles can reach 150– 350 L per kg of the product [33, 34]. The effluent quality of a typical knit dyeing industry & DOE (Directorate of Environment) Bangladesh discharge limits are given below (Table1).

Table 1. Effluent quality of a typical knit dyeing industry with DOE discharge standard

Parameter	Inlet Effluent of Knit Concern Limited, Narayangonj-1400, Bangladesh.	DOE Standards for Waste From Industrial Units or Projects Waste – for Inland Surface Water [35]
pH	10.3	6.5-9
DO(mg/L)	0.1	4.5-8
BOD_5 20°c (mg/L)	281	50
COD (mg/L)	356	200
TDS(mg/L)	3200	2100
TSS(mg/L)	204	150
Temperature(°C)	50	40-45

II. MATERIALS AND METHODS

Collection of natural adsorbent & filtration materials

Plantain Plant Bark (Banana) (Musa Sapientum), coconut fiber/coir Cocos nucifera L., Stem of Water Lilies (Nymphaea nouchali), Hartaki (Terminalia Chebula), Stem of Water Hyacinth (Eichornia crassipes), Stalk of an edible root (Colocasia esculenta), Dry straw of rice were collected from National Institute of Textile Engineering and Research, Nayarhat, Nabinagar & Cantonment area of Savar, Dhaka, Bangladesh. Gravel, Sand, Crumber white stone and Jute were used as a filtration material and collected from NITER.

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Table 2. Different types of Natural Adsorbents & Filtration Material used

Natural Adsorbents Used		Filtration Material Used
Plantain Plant Bark	coconut fiber/coir	Gravel
		
Stem of Water Lilies	Hartaki	Crumber white stone
		
Stem of Water Hyacinth	Stalk of an edible root	Sand
		
Dry straw of rice		Jute
		

Preparation of Textile Effluent

A typical textile dyeing effluent was prepared in the wet processing laboratory of NITER in open bath system. All of the reagents used were available in the laboratory & the below recipe was followed;

- ✓ Reactive Dye (Remazol Black) - 2% owf
- ✓ Salt- 40 gm/l
- ✓ Alkali-20 gm/l
- ✓ Sequestering agent-1.0 gm/l
- ✓ Anti-creasing agent-0.5 gm/l
- ✓ Antifoaming agent-1.0 gm/l
- ✓ Wetting agent-0.5 gm/l
- ✓ M:L-1:20
- ✓ Temp.- 600C
- ✓ Time- 40 min

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Determination of p^H

The pH values of the effluent were measured in two steps; firstly the pH of the prepared effluent measured & then pH of the effluent after treated with natural adsorbents. For the measurement of pH in wastewater, a pocket-sized pH meter (HI2211, Hanna Instruments, Italy) was used. The method followed; ISO 10523:2008. Before the measurement, pH meter has been calibrated by three buffer solutions (pH 4.01, pH 7.01 and pH10.01) as per suggested method in operation manual of the manufacturer.

Measurement of p^H

Determination of TDS

Total Dissolved Solids (TDS) values of the prepared effluent & the effluent treated with natural adsorbents were measured. For the measurement of TDS in wastewater, a pocket-sized TDS meter (HI 96302, Hanna Instruments, Italy) with a range of 100 / 1000 ppm was used. The TDS meter has been calibrated by a standard solution (1382 mg/L) as per operation manual of the manufacturer.

Measurement of TDS

Determination of DO

The Dissolved Oxygen (DO) of the prepared effluent & the treated effluent were measured. For the measurement of DO, A DO meter (YK22DO, Lutron Electronic Enterprise Co., Ltd., Taiwan) with a range 0 to 20.0 mg/L was used. Before the measurement, DO meter has been calibrated as per the suggested method in operation manual of the manufacturer. During calibration, the display of the meter showed 20.9.

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Measurement of DO

Determination of BOD₅

The BOD in the effluent carried out by the measurement of the dissolved oxygen content of the samples before and after 5 days of incubation at 20°C.

III. RESULTS AND DISCUSSION

Plantain Plant Bark (Banana) (Musa Sapientum), coconut fiber/coir (Cocos nucifera L.), Stem of Water Lilies (Nymphaea nouchali), Hartaki (Terminalia Chebula), Stem of Water Hyacinth (Eichornia crassipes), Stalk of an edible root (Colocasia esculenta) and Dry straw of rice, these natural adsorbents are divided into two groups i.e. blend-1 & blend-2. The prepared textile effluent was treated separately with these two blends of natural adsorbents for 24 hours.

Treatment of textile effluent with natural adsorbents

The effects of natural adsorbents on the different parameters of the effluent are given in the following table.

Table 3. Effect of Different natural absorbents on effluent quality

Parameter	**Prepared Effluent**	**Retention time**	**Blend -1** (Plantain Plant Bark + coconut fiber/coir + Stem of Water Lilies + Hartaki)	**Blend-2** (Plantain Plant Bark + Stem of Water Hyacinth + Stalk of an edible root + Dry straw of rice)
pH	12.14	24 Hours	6.21	8.45
TDS	3920	24 Hours	3440	2760
DO	0.8	24 Hours	3.2	2.9
BOD	190	24 Hours	130	130
Color	Black	24 Hours	Brown	Brown

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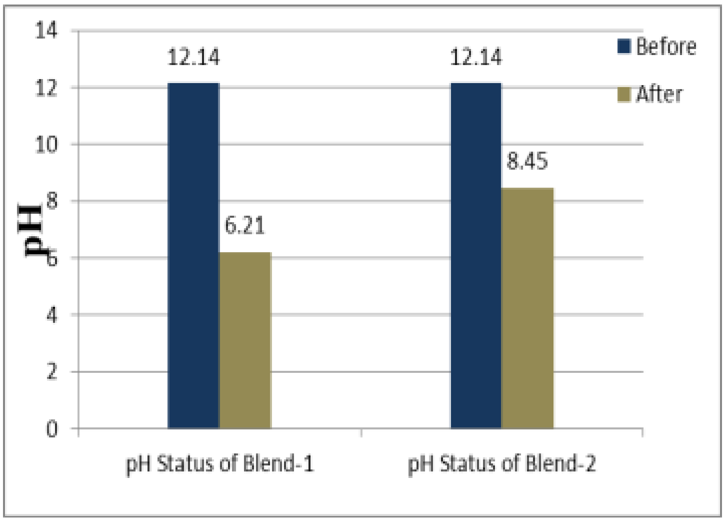
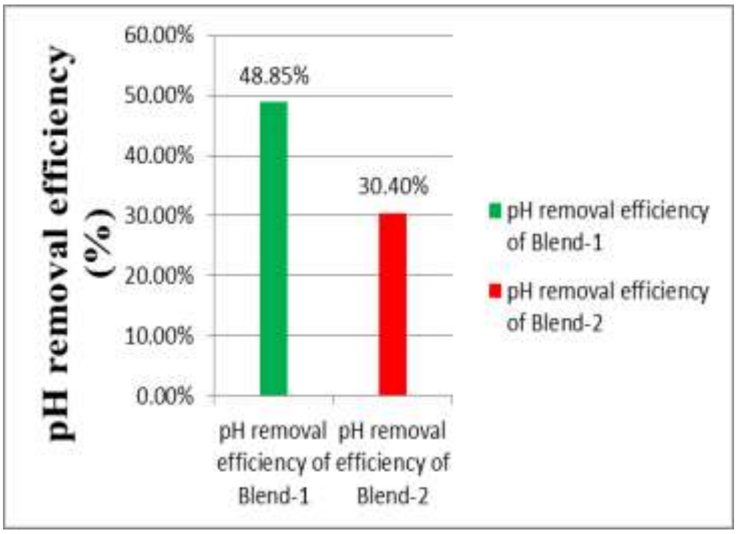
P^H Status

The pH value indicates the nature of the effluent whether it is acidic or basic. The most of the metals become soluble in water at low pH and insoluble at high pH. The low or high strength of the pH in the effluent can affect the quality of clean water and alters the rate of biological reaction with the survival of various microorganisms. The strength of the pH also alters the soil permeability which results in contaminating underground water resources [36, 37].



pH status of Effluent before & after application of natural adsorbents

The application of natural adsorbents shows a great result in minimizing the pH value of the effluent. The pH value of the prepared effluent found 12.14 which were highly alkaline and not suitable for discharge to the environment. After 24 hour retention time blend-1 of adsorbents show great influence over pH minimization rather than blend-2.



pH removal efficiency of Blend-1 & Blend-2

After treating the prepared effluent with -1 of adsorbents pH value found 6.21. For mixture-2 of adsorbents pH value found 8.45 after 24 hours. So, in case of pH removal blend-1 shows greater efficiency (48.85%) than blend-2 (30.40%).

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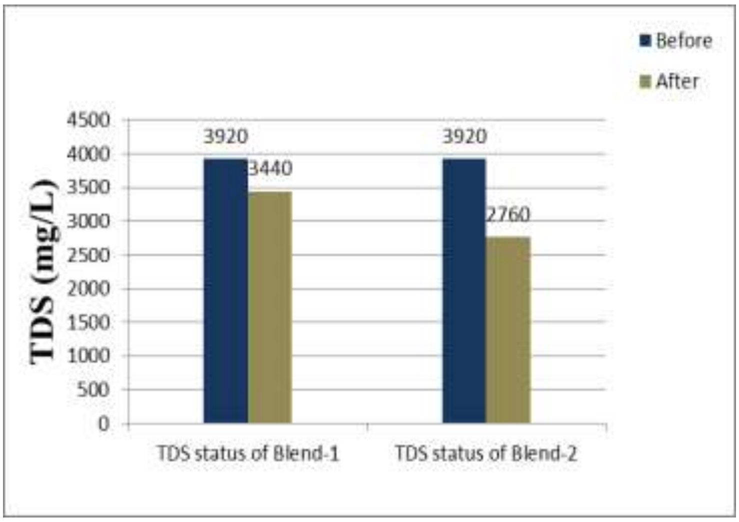
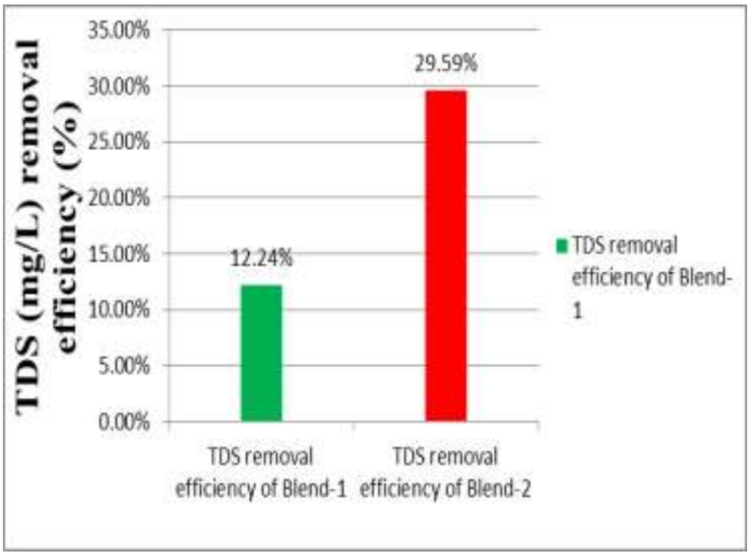
TDS (mg/L) status

The Total Dissolved Solids (TDS) is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants [30].The high TDS value of water not recommended for drinking and irrigation purposes as it may cause salinity problem.



TDS (mg/L) status of Effluent before & after application of natural adsorbents

A mixture of different adsorbents could be fruitful for removing TDS from textile effluent. TDS value of the prepared effluent found 3920 which represent the presence of a high contaminant in the effluent. After 24 hours of retention time, blend-2 of adsorbents shows great influence over TDS minimization than blend-1.



TDS removal efficiency of Blend-1 & Blend-2

After treating the prepared effluent for 24 hours with blend-1 of absorbents found 3440 and for blend-2 of absorbents TDS of the effluent found 2760. The TDS removal efficiency of blend-2 (29.59%) was much higher than the removal efficiency of blend-1(12.24%).

DO (mg/L) Status

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality [39].

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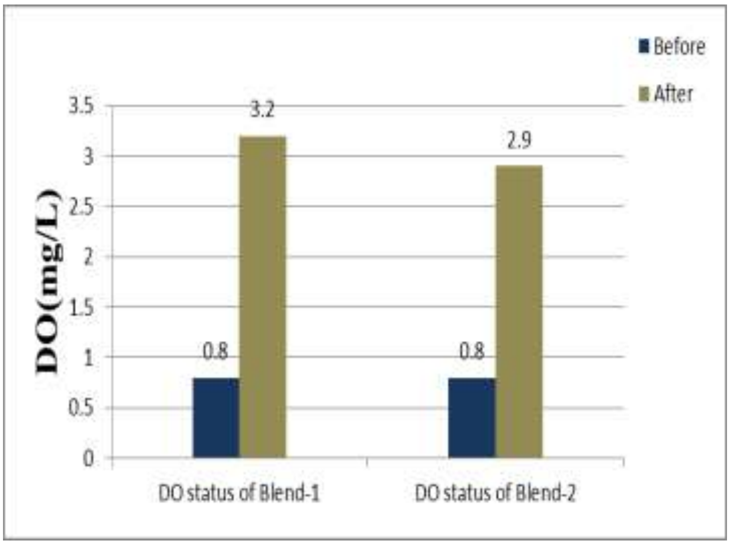
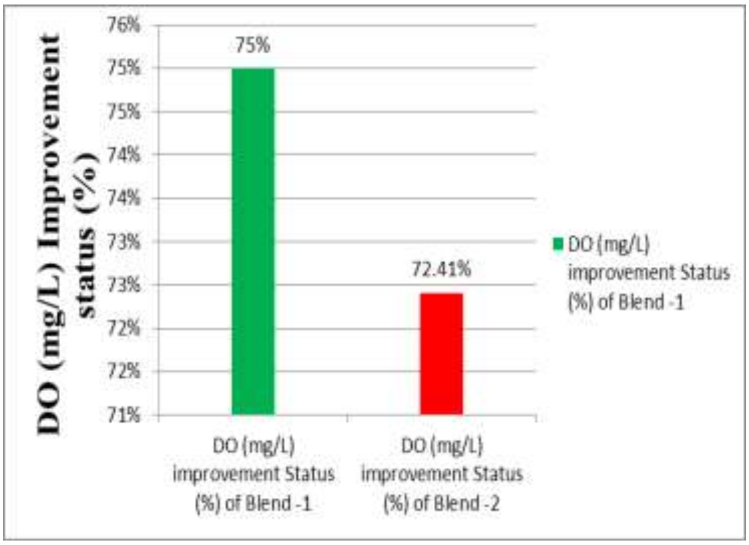


DO (mg/L) status of Effluent before & after application of natural adsorbents

The DO value of the prepared effluent found 0.8, which is very low and not suitable for aquatic life. The application of natural adsorbents can improve the DO value. After 24 hours of treating with natural adsorbents the value of DO improved significantly.



DO removal efficiency of Blend-1 & Blend-2

DO value of the effluent improved to 3.2 from 0.8 in case of blend-1. For blend-2 DO improved to 2.9 from 0.8 after 24 hours. In case of improving DO content in the effluent, blend-1 shows greater efficiency (75%) over the efficiency (72.41%) of blend-2.

BOD_5 (mg/L) Status

The BOD (Biological Oxygen Demand) is due to the presence of organic contaminants of textile effluents in water bodies. The low or nil BOD shows good quality water, whereas a high BOD indicates the water is highly contaminated. The increase in BOD leads to microbial oxygen demand causes reducing DO which may induce hypoxia conditions with subsequent adverse effects on aquatic biota [38].

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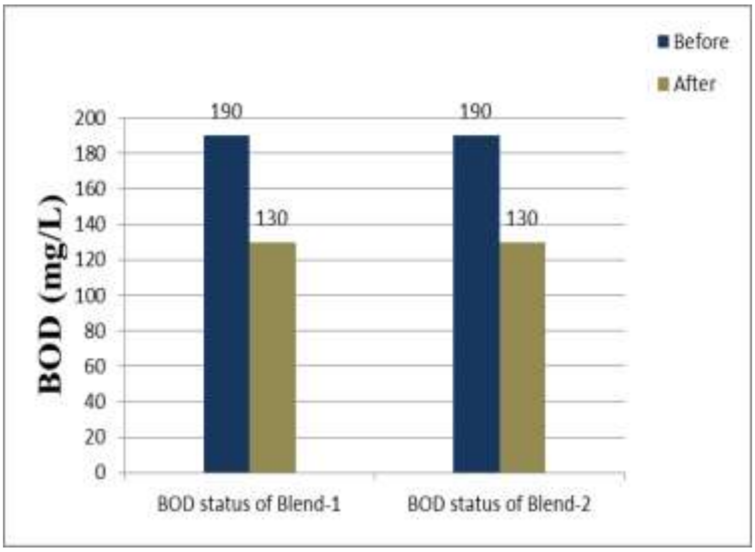
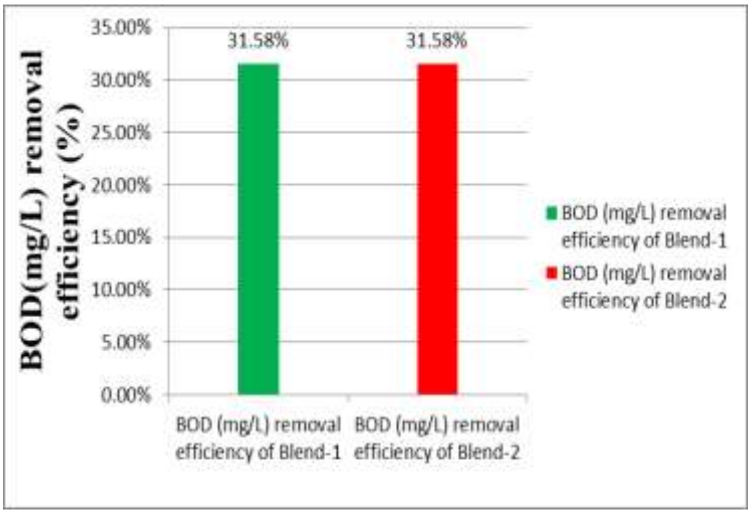


BOD$_5$ (mg/L) status of Effluent before & after application of natural adsorbents

The mixture of different natural adsorbents can reduce BOD from textile effluent successfully. The BOD value of prepared effluent found 190 which is quite high and should be reduced before discharging to the environment.



BOD$_5$ removal efficiency of Blend-1 & Blend-2

After treating with different natural adsorbents BOD of the effluent found 130. Both of the mixture of adsorbents seems similar in the removal of BOD. In the case of both blend-1 & blend-2 removal efficiency found 31.58%.

Color Status

In the case of color removal both of the blend of different natural adsorbents has shown a remarkable result. According to the observation, after treating with a different blend of natural adsorbents the color effluent changed to brown from dark black. But the second blend of adsorbents with plantain plant bark, the stem of water hyacinth, a stalk of an edible root & dry straw of rice has shown better color removal efficiency than the mixture of plantain plant bark, coconut fiber/coir, the stem of water lilies and hartaki.

IV. CONCLUSION

Currently in Bangladesh, the textile wastewater is one of the major sources of pollution. The type of this wastewater has the characteristics of higher value of pollutants i.e. pH, TDS, DO, BOD and color, Complex composition, large emission, widely distributed and difficult degradation. The treatment of textile wastewater before disposal into the environment is important and ensures safety to the environment without affecting the quality of water of lakes, rivers etc. But the main barrier to the treatment of textile wastewater is high cost. The use of an economic method will play an important role in minimizing environmental pollution associated with untreated polluted textile wastewater. The use of natural adsorbents in the treatment of textile wastewater could be an eco-friendly solution. Natural adsorbents are abundant, environmentally friendly, adaptable and biodegradable. This paper deals with the investigation of pollutants i.e. pH, TDS, DO, BOD & Color removal efficiency of different natural adsorbents. The used natural adsorbents were divided in two groups, Plantain Plant Bark (Banana), coconut fiber/coir, Stem of Water Lilies, Hartaki were used for blend-1 and Plantain Plant Bark (Banana), Stem of Water Hyacinth, Stalk of an edible root and Dry straw of rice were used for blend-2. Both blends of natural adsorbents could be useful for the removal of pollutants from textile wastewater. The pH removal efficiency (48.85%), TDS removal efficiency (12.24%), DO improvement efficiency (75%) & BOD removal efficiency (31.58%) for blend-1. But considering all experiment results i.e. removal of pH (30.40%), removal of TDS (29.59%), improvement of DO content (72.41%), removal of BOD (31.58%) and color, it could be concluded that the treatment of textile effluent with blend-2 (Plantain Plant Bark (Banana), Stem of Water Hyacinth, Stalk of an edible root and Dry straw of rice) could be more fruitful than blend-1. In both case the color of the effluent changed from Dark black to brown. But the blend-2 has shown better color removal efficiency than blend-1. The question remains in the area that how poisoned natural adsorbents would be managed. Anaerobic digestion of natural adsorbents could be the best and economic solution. Bio gas generated from anaerobic digestion of these poisoned natural adsorbents could be a renewable & sustainable solution in meeting constantly increasing energy demands of the textile sector.

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