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Study on Biodegradation of Textile Effluents by Activated Carbon and Sugarcane Bagasse as Adsorbents

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ABSTRACT

The chemical contamination of water from a wide range of toxic derivatives, in particular heavy metals, aromatic molecules and dyes, is a serious environmental problem owing to their potential human toxicity. New Eco-labels for textile products and tighter restrictions on wastewater discharges are forcing textile wet processors to reuse process water and chemicals. This challenge has prompted intensive research in new advanced treatment technologies. Among all the treatments proposed, bagasse has been reported to be a potential adsorbent for the removal of pollutants or color from the wastewater. The results showed that there is a recent increasing interest in the bagasse(Saccharum Officinarum) of new low-cost, high performance, environment friendly adsorbents used in wastewater treatment[1].

Keywords: Effluent, Temperature, Adsorbent, Biochemical oxygen demand, Chemical oxygen demand, DO, pH, Wastewater, Sugarcane bagasse.

INTRODUCTION

The presence of hazardous wastes in the environment is unavoidable due to a vast array of industrial activities. Unfortunately, the disposal of non-biodegradable inorganic wastes, such as heavy metals and others to aqueous streams is a direct result of these activities[3].

The global demand for textile products is steadily increasing (The Fiber Year Consulting, 2015) a trend likely to continue due population growth and economic development[7]. Meanwhile, the textile industry is facing tremendous environmental and resource challenges. Wet treatment processes (dyeing, finishing, printing, etc.) are major sources of toxic emissions and these raw industrial effluents are the source of wastewater. Waste water treatment is one of the major problems faced by textile manufacturers. Color is the first contaminant to be recognized in the wastewater and has to be removed before discharging into water bodies or on land. The presence of very small amounts of dyes in water (less than 1 ppm for some dyes) is highly visible and affects the aesthetic merit, water transparency and gas solubility in lakes, rivers and other water bodies[4]. Dyes, however, are more difficult to treat because of their synthetic origin and mainly complex aromatic molecular structures.

Therefore, there is a need to develop technologies that can remove toxic pollutants found in wastewaters. Among all the treatments proposed, adsorption is one of the more popular methods for the removal of pollutants from the wastewater. Adsorption is a procedure of choice for treating industrial effluents and a useful tool for protecting the environment. In particular, adsorption on natural polymers and their derivatives are known to remove pollutants from water[2]. The textile wastewater treatment technologies aim at achieving color removal and reduction of Total Dissolved Solids (TDS), Total Suspended Solid (TSS), Total Solid (TS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH correction and increase of Dissolve Oxygen (DO).

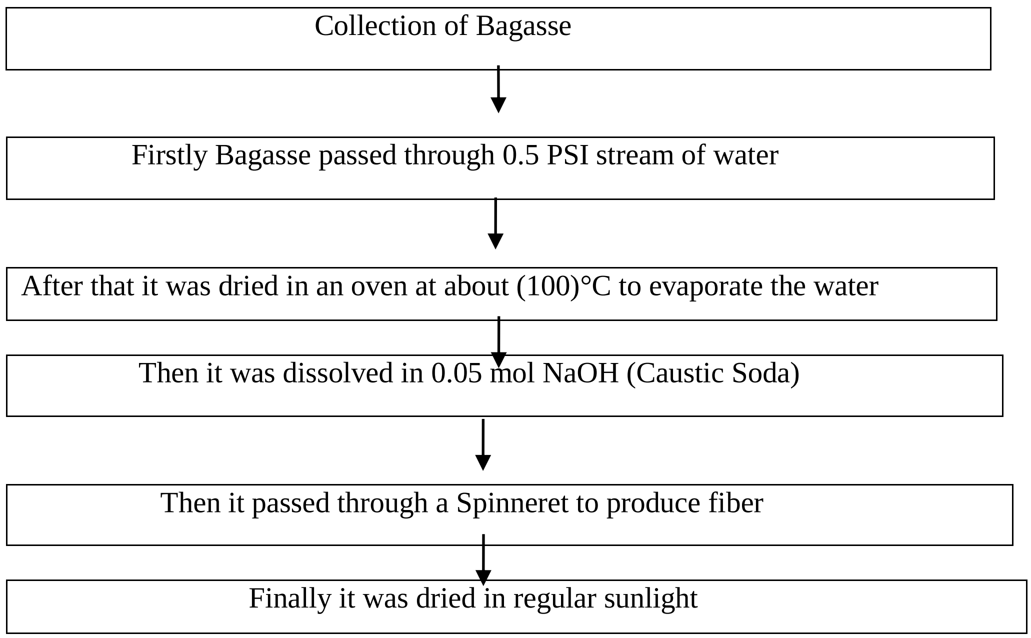
Bagasse are the newly thought adsorbents because of fibrous, low density material with a very wide range of particle sizes and high moisture content with high adsorption capacity and high degree of reactivity[6]. Bagasses are totally new adsorbents for waste water treatment. For that reason I have used these adsorbents for wastewater treatment.

Table 1: Sources of water pollution at various stages of processing[8]

Process	Possible Pollutants	Nature of Effluent
Desizing	Starch, glucose, PVA, resins, fats and waxes do not exert a high BOD.	Very small volume, high BOD (30-50% of total), PVA.
Kiering	Caustic soda, waxes, soda ash, sodium silicate and fragments of cloth.	Very small, strongly alkaline, dark color, high BOD values (30% of total)
Bleaching	Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids.	Small volume, strongly alkaline, low BOD (5% of total)
Mercerizing	Caustic soda	Small volume, strongly alkaline, low BOD (Less than 1% of total)
Dyeing	Dye stuff, mordant and reducing agents like sulphides, acetic acids and soap	Large volume, strongly colored, fairly high BOD (6% of total)
Printing	Dye, starch, gum oil, china clay, mordants, acids and metallic salts	Very small volume, oily appearances, fairly high BOD.
Finishing	Traces of starch, tallow, salts, special finishes, etc.	Very small volume, less alkaline, low BOD.

Adsorbent preparation:

The bio-adsorbent used for this study was the bagasse which was prepared from the sugarcane of Joypurhat Sugar Mill, Rajshahi, Bangladesh[7].



EXPERIMENTAL

Instruments: Glassware and apparatus, UV-Vis Spectrophotometer, Portable multi-parameter meter, Electronic balance, Vacuum Oven, Magnetic/Hotplate stirrer, Incubator, Refrigerator, Standard flasks, Magnetic Stirrer, Funnel, Beaker, Wash Bottle, Spinneret.

Analytical Procedures:

Determination of physical and chemical characteristics of wastewater:
Dissolved Oxygen (DO):

Dissolved Oxygen in the aquatic habitat is an important requirement for survival. It is the amount of oxygen (O2) available as dissolved form in water. It is one of the most important factors controlling the presence or absence of estuarine species and consumed by bacteria when large amount of organic maters are present in water. Animals and plants require oxygen for respiration—a process critical for basic metabolic processes. It is a water quality parameter. The optimum value for good water quality is 4 to 6 mg/L or ppm. When DO drops below the optimum level the life forms in the water are unable to continue at a normal rate. Dissolved oxygen levels in water depend, in part, on the chemical, physical and biochemical activities occurring in the water. Oxygen has a limited solubility in water directly related to atmospheric pressure and inversely related to water temperature and salinity.

Measurement of DO: Dissolved Oxygen of waste water sample was measured by taking 50 mL of wastewater in a 100 mL beaker and immersing the electrode of portable multi parameter meter (Sessions 153, HACH, USA) into the sample.

Total Suspended Solids (TSS):

Total Suspended Solids (TSS) is the dry-weight of suspended particle that is not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus. It is a water quality parameter used to assess the quality of a specimen of any type of water or water body. It includes a variety of materials such as slit, decaying, plants, animal matter, industrial waste and sewage.

Measurement of TSS: TSS can be measured by gravimetric (with an evaporation dish) or calculated by multiplying a conductivity value by an empirical factor. The water sample is filtered through a pre weighted filter (10µm). The reduce retain on the filter which is dried in an oven at 103-105ºC until the weight of the filter paper no longer changes. The increase in the weight of the filter represents total suspended solid. By using following formula TSS can be calculated,

$$\text{TSS, mg /L} = \frac{(\text{A}-\text{B})\text{X } 1000}{\text{Volume of Sample,ml}}$$

Where:

A = weight of filter + dried residue, mg, and

B = weight of filter, mg

Total Dissolved Solids (TDS):

Total Dissolved Solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. These are solids in water that can pass through a filter usually with a pore sizes of (0.45-2.0) µm. TDS includes Cl^-,F^-,I^-,Ca^{2+} and complex ions.

Measurement of TDS: The water sample is filtered and then the filtrate is evaporated in a pre weighted dish (porcelain) and dried in an oven at 180ºC temperature until the weight of the dish no longer changes. The increase in the weight of the dish represents total dissolved solid.

Biological Oxygen Demand (BOD):

Biochemical Oxygen Demand (BOD, also called Biological Oxygen Demand) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The first step in measuring BOD is to obtain equal volumes of water from the area to be tested and dilute each specimen with a known volume of distilled water which has been thoroughly shaken to ensure oxygen saturation. The determination of DO of a sample before and after five days incubation at 20°C is the basic of BOD determination.

Chemical Oxygen Demand (COD): In environmental chemistry, COD is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution[5].

The Chemical Oxygen Demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. The basis for the COD test is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic condition. A blank sample is created by adding all reagents (e.g. acid and oxidizing agent) to a volume of distilled water. COD is measured for both the water and blank samples and the two are compared. The oxygen demand in the blank sample is subtracted from the COD for the original sample to ensure a true measurement of organic matter.

$$\text{COD, mg/L} = \frac{(A-B) \times M \times 8000}{\text{Volume of Sample,ml}}$$

Where:
A = mL of titrant used for sample
B = mL of titrant used for blank
M = normality of ferrous ammonium sulfate

pH:

pH is a logarithmic scale used to specify the acidity or basicity of an aqueous solution. Measurements of pH are important in agronomy, medicine, chemistry, water treatment, and many other applications. pH is a measure of how acidic or basic (alka-line) a solution is. It measures the hydrogen ion (H+) activity in a solution, and is expressed as a negative logarithm. It carried out by digital pH meter.

Parameter of Water	Temp. of Sample (°C)	Before the Test (Mg/L)		After the Test (Mg/L)		Standard value inland surface water(9) (Mg/L)	Test Method (APHA)
		Activated Carbon	**Bagasse**	**Activated Carbon**	**Bagasse**		
BOD	27	120	98	56	45.4	50	4500.O
COD	27	245	992	176	310	200	5220.B
DO	27	0.09	6.8	2.76	9.2	4.5	-----
TSS	27	600	220	95	125	150	2540.D
TDS	27	4287	3224	1759	2080	6.9	4500-H+ B
pH	27	9.8	11	7.5	7	4.5	-----

RESULT AND DISCUSSION

In Bangladesh aspect, we know that, Bangladesh is a growing economic developing country and passing a crucial time for developing the infrastructures and treatment plants for textile toxic waste and other industrial hazardous pollutants, where industrial toxic waste can be treated with suitable bio adsorbent to get the harmless water for us and as well as aquatic life[4]. So far, many textile effluent treatment methods have been worked out such as coagulation and / or flocculation, membranes (microfiltration, nanofiltration and reverse osmosis), adsorbents (silica, clays, granular activated carbon, peanut husk), oxidation (Fenton-reagent, photocatalyis, advanced oxidation processes, ozonation) and biological treatments (aerobic and anaerobic)[8]. But most of these methods are not natural for this reason they are not easy to use and can be harmful. These methods materials are not so much available and cost effective.

Our research findings will help to find out the suitable adsorbent which can be used as large scale commercial effluent treatment plant. Sugarcane Bagasse (SCB) is a product with a large area of cultivation in Bangladesh, even all over the world. It is mainly composed of cellulose, hemicelluloses and lignin, allowing its use as a potential adsorbent. The aim of this work was to establish the feasibility of using SCB as an alternative, potential, wide spread presence materials, environment friendly, easy to use, harmless and low-cost adsorbent for the removal of textile wastewater effluent. These results suggest SCB is a promising alternative and optimal solution of a non-conventional adsorbent that could be applied for treating wastewater and dyes effluent[9].

Graphical Representation of analytical data:

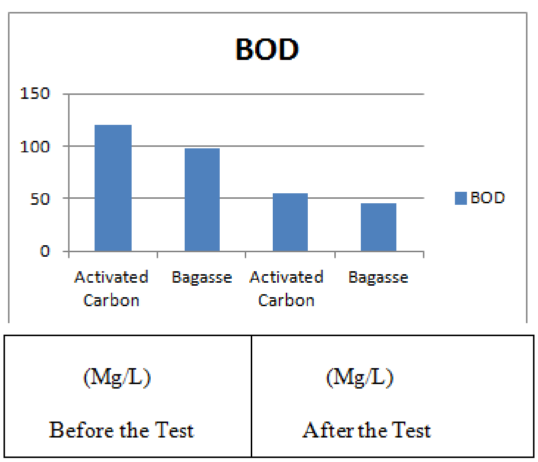


Fig (a)-Comparative graph of BOD analysis (Before and after treatment by the Activated Carbon and Bagasse)

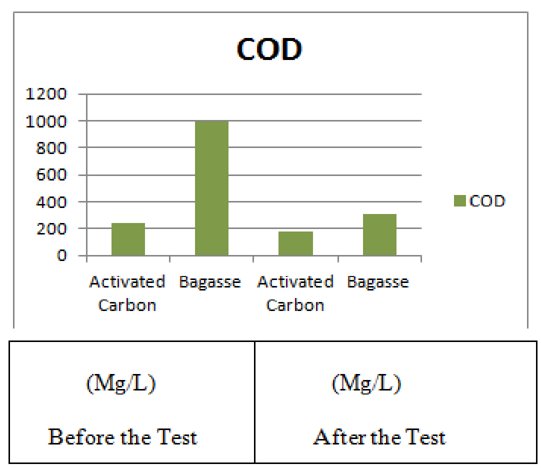


Fig (b)-Comparative graph of COD analysis (Before and after treatment by the Activated Carbon and Bagasse)

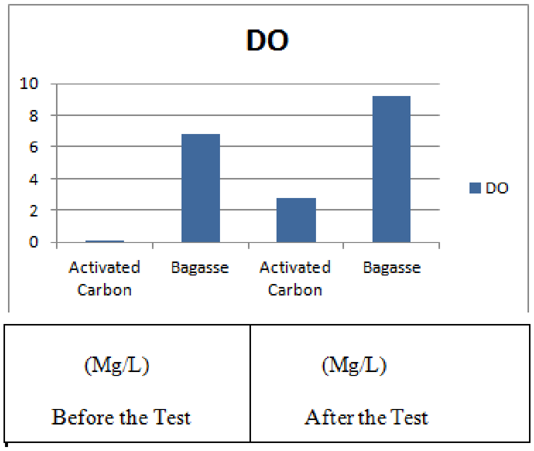


Fig (c)-Comparative graph of DO analysis (Before and after treatment by Activated Carbon and Bagasse)

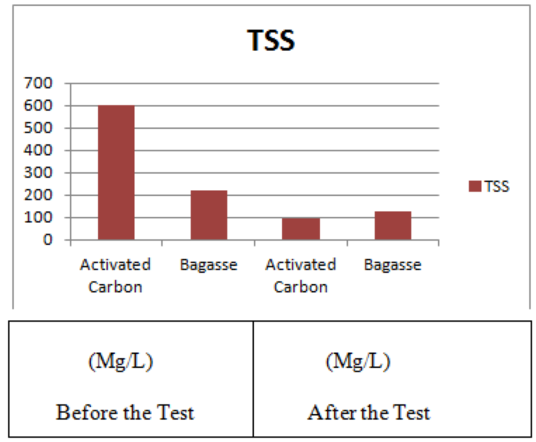


Fig (d)-Comparative graph of TSS analysis (Before and after treatment by Activated Carbon and Bagasse)

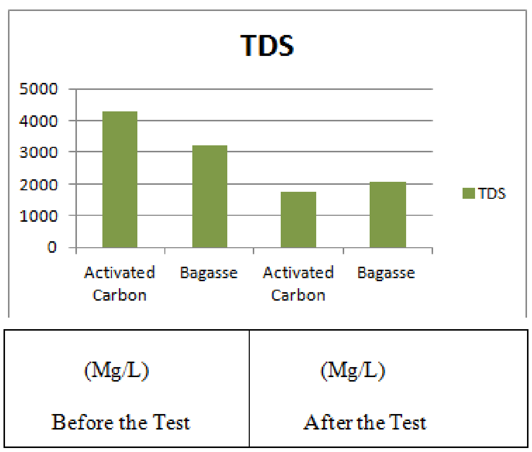


Fig (e)-Comparative graph of TDS analysis (Before and after treatment by Activated Carbon and Bagasse)

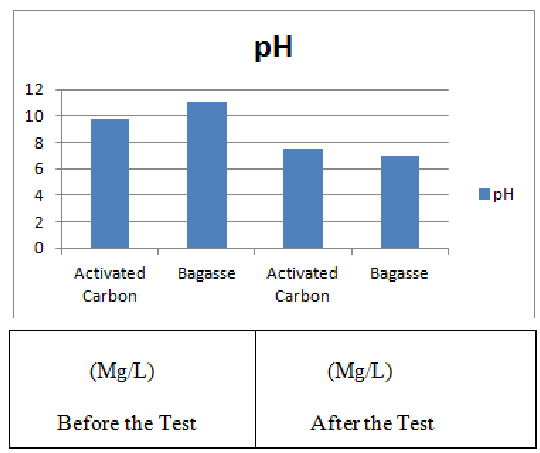


Fig (f)-Comparative graph of pH analysis (Before and after treatment by Activated Carbon and Bagasse)

From the above result it is clearly shown that pH, BOD, COD, TDS, TSS has reduced and DO has increased which is remarkable. It was found from the graph that the removal of dyes by Bagasse adsorbents increases with an increase in the adsorbent dosage.

CONCLUSION

In this research work, the removal percentage of reactive dyes from the textile waste water was carried out by the application of bio adsorbents (Bagasse). Bagasse is effective in removing the dissolved organic matter from the textile wastewater. When the initial pH is 7, initial concentration is 0.5 PSI, temperature is 100°C and dissolved in 0.05 mol NaOH then the maximum amount of the reactive dyes adsorbed by bagasse. The test showed that bagasse was the most efficient in reducing BOD, COD, TDS and TSS of the effluent sample and as well as increase the DO remarkably. De colorizations process is not specific and depends upon many factors. The factors which favor the selection of Bagasses are its low cost, widespread presence and organic composition which shows strong affinity for some selected dyes. In spite of the scarcity of consistent cost information, the widespread uses of low cost adsorbents in industries for wastewater treatment applications today are strongly recommended due to their local availability, technical feasibility, engineering applicability, and cost effectiveness. Although there are lots of adsorbents, if low-cost adsorbents perform well in removing heavy metals and colors, bagasse can be adopted and widely used in industries not only to minimize cost inefficiency, but also improve profitability.

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