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Cost Effective Wastewater Treatment by Natural Adsorbent

Mahmudur Rahman Idris[1], Md. Arifuzzaman[2], Arnob Basak[2], Tonmoy Saha[3] and Jarin Yasmin[4]

[1]Department of Chemistry,
University of Dhaka, Dhaka-1000, BANGLADESH.
[2]Department of Textile Engineering,
Mawlana Bhasani Science and Technology University, Tangail-1902, BANGLADESH.
[3]Department of Wet Process Engineering,
Bangladesh University of Textiles, Dhaka-1208, BANGLADESH.
[4]Department of Textile Engineering,
Southeast University, Dhaka-1213, BANGLADESH.

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ABSTRACT

Today the major environmental concern is the water pollution due to the discharge of colored wastewater from textile industries. This colored wastewater is harmful to human, aquatic life, and ecological sustenance. It is essential to treat this wastewater before discharge into the environment. In this study, we used one of the world's worst weeds water hyacinth (*Eichhornia crassipes*) as an adsorbent. The combination of water hyacinth with coal and bricks can minimize the number of different contaminants present in the wastewater. The textile wastewater was treated with water hyacinth, coal and bricks and then filtered. The study revealed that after treatment of wastewater with water hyacinth, coal and brick, the value of all parameters was reduced than the untreated wastewater. The results indicate that the water hyacinth have a high possibility of being used as a cheap and efficient adsorbent to remove the color and organic contaminants from wastewater of textile industry.

Keywords: Water hyacinth, Adsorbent, Textile wastewater, Coal, brick.

1. INTRODUCTION

Textile industry is very water intensive. In fact only 2.5% of the Earth's water is freshwater and only 0.3% is accessible to humans. So while we may be a 'blue planet', usable water is incredibly scarce in comparison. The fashion industry is a massive consumer and polluter of our fresh water. And one of the biggest culprits is cotton. Despite only occupying 2.4% of the world's cropland, cotton accounts for 24% of the world's insecticide use and 11% of pesticides. Toxic chemicals washing into waterways and entering the ecosystems, is becoming a major source of pollution, especially in developing countries.[1]

Water is used widely throughout the textile processing operations. Almost all dyes and chemicals are applied to textile substrate from water baths. During the pre-treatment, dyeing and finishing process, a certain amount of dye and chemical (2 to 50 percent) does not bind to the inter surface of fiber molecule an as a result residual water is usually returned to our eco-system. The dyeing industry effluents and waste water contains high BOD, COD, TDS and TSS value which is a potential threat for our human life and environment. It is necessary to treat the water and ensure discharge water is free of colors and chemicals. So an environment friendly technology has become a necessity for the textile industry by which we can remove color from waste water. The removal of dyes from waste water using adsorption process is one of them and it has gained paramount importance in industry and environmental protection. An adsorbent can be considered as cheap or low-cost if it is abundant in nature, requires little processing and is a byproduct of waste material from waste industry.[2] The adsorbents used here are water hyacinth, coal and brick.

The goal of water treatment is to remove existing contaminants in water or reduce the concentration of such contaminants so that the water becomes fit for our desired use. In the other words returning water that has been used back into the natural environment without adverse ecological impact.

1.1 Classification of Water Treatment Method

Categories	**Treatment Method**
Physical Method	Adsorption
	Ion exchange
	Membrane filtration
Chemical Method	Coagulation/Flocculation
	Advanced Oxidation process (AOP) : UV (Photochemical), Ozonation based process
Biological Method	Aerobic, Anaerobic, Biofilm based, Fungal Metabolic activities.

From the table we can see that there are various method of waste water treatment. In our project, we worked with adsorption process for the removal of effluents and waste from the water.

1.2 Adsorption

The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. The adsorbing phase is the adsorbent, and the material concentrated at the surface of that phase is the adsorbent. Adsorption is thus different from absorption, a process in which material transferred from one phase to another (e.g. liquid) interpenetrates the second phase to form a solution.[3]

1.3 Factors affecting adsorption include

- The physical and chemical characteristics of the adsorbent, i.e., surface area, pore size, chemical composition
- The physical and chemical characteristics of the adsorbate, i.e., molecular polarity, chemical composition
- The concentration of the adsorbate in the liquid phase (solution)
- The characteristics of the liquid phase, i.e., pH and temperature

1.4 Adsorption mechanisms

Adsorption occurs due to the interactions between ions, molecules and the adsorbent surface. These integrations depend on the types of either ions or molecules and the types of the adsorbent surfaces available. The surfaces are either inorganic or organic and the adsorbents are also either inorganic or organic. Inorganic surfaces are highly polar and in general have a positive or a negative charge. However, organic surfaces can be charged and ranged from strongly polar to non –polar.

1.5 Discussion about Basic Water quality Parameter

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. The most common water quality parameter is given below:

- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD
- Chemical Oxygen Demand (COD)
- Total Dissolved Solids (TDS)
- Total Suspended Solid (TSS)
- pH.

1.6 Dissolved Oxygen (DO)

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. Animals and plants require oxygen for respiration—a process critical for basic metabolic processes. In addition to its use in respiration, oxygen is needed to aid in decomposition. An integral part of an estuary's ecological cycle is the breakdown of organic matter.[4]

1.7 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand or Biological Oxygen Demand, is a measurement of the amount of dissolved oxygen (DO) that is used by aerobic microorganisms when decomposing organic matter in water. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment.[5]

1.8 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is the amount of oxygen consumed by the organic compounds and inorganic matter which were oxidized in water. [6] Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels.

1.9 Total Dissolved Solids (TDS)

TDS can be either defined as the residue left after filtration and drying at a constant temperature or as the electrochemical conductance that originates from disassociated ions in solution.[7]

1.10 Total Suspended Solid (TSS)

TSS is one of the method defined analytes. There is no specific chemical formula for a total suspended solid. Quite simply put, TSS is anything that is captured by filtering the sample aliquot through a specific pore size filter. Suspended solids can range from particles of silt or sediment to pieces of plant material such as leaves or stems. Even insect larvae and eggs can fall in the general category of TSS. High amounts of TSS can lead to an esthetically displeasing appearance of a body of water. Either the color or overall turbidity of the water will be negatively impacted.[8]

1.11 Potential of Hydrogen (pH)

pH is a measure of a solution's acidity. In water, small numbers of water molecules (H_2O) will break apart or disassociate into hydrogen ions (H+) and hydroxide ions (OH-). pH is measured on a logarithmic scale between 1 and 14.

2. MATERIALS

2.1 Hyacinth

Water hyacinth is a prolific free floating aquatic macrohpyte found in tropical and subtropical parts of the earth. Mainly the water hyacinths growing in pond or river which length is 30-40 cm. The effects of pollutants from textile wastewater on the anatomy of the plant were studied.[9]

Chemical Composition of Hyacinth

Organs	Cellulose	Hemicelluloses	Lignin	Other
Leaf	15.42 ± 0.08	29.75 ± 0.15	9.79 ± 0.06	45.04 ± 0.29
Stem	17.14 ± 0.12	21.82 ± 0.06	8.01 ± 0.07	53.03 ± 0.25
Whole Plant	18.07 ± 0.20	28.21 ± 0.11	7.03 ± 0.09	46.69 ± 0.40

2.2 Coal

This is an ultra long burning solid fuel, and the only one that can be used in a wood burner as it burns in the same way as wood with a secondary air supply. It can be used with wood or briquettes or on its own. The Wood Coal is made from lignite and is very long burning so suitable for overnight uses.

Chemical Composition of Coal

It can be used as a substrate for the application of various chemicals to improve the adsorptive capacity for some inorganic (and problematic organic) compounds such as hydrogen sulfide (H_2S), ammonia (NH_3), formaldehyde (HCOH), mercury (Hg) and radioactive iodine). This property is known as chemisorptions.

2.3 Brick

A brick is building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units laid in mortar. Here we used the brick as a adsorbent. Because it molecular structure contain various type of pores.

3. METHODOLOGY

The adsorption experiment were carried out in a beaker. The amount of textile effluent taken was 500ml and tested in a beaker. Bio-sorption studies were carried out in 1000ml beaker by mixing 25gm (15gm hyacinth, 5gm coal, 5gm brick) with 500 ml of effluent, at room temperature and contact time 8 hours. The sample solution was stirred in a time interval of two hours each using a glass stirrer. After the desired contact period for each batch experiment, the adsorbent treated and untreated effluent were analyzed for pH, TSS (Total suspended solids), TDS (Total dissolved solids), BOD (Biological oxygen demand), COD (chemical oxygen demand), DO (dissolved oxygen).

4. RESULTS AND DISCUSSION

Following table represents the physiochemical characteristics of wastewater, wastewater treated with adsorbent and surface water.

Parameter of Water	Temperature of Sample (0C)	Value Before Treatment (mg/L)	Value After Treatment (mg/L)	Standard Value (mg/L)	Removal Efficiency (%)	Test Method (APHA)
COD	28	343	72.5	200	78.86 %	5220.B
DO	28	0.15	7.33	4.5-8	97.95 % ↑	5220.B
BOD	28	1207.5	163	50	86.50 %	4500.O
TSS	28	800	120	150	85 %	Gravimetric
TDS	28	3000	2200	2300	26.67 %	Gravimetric
pH	28	8	9.5	6-9	15.78 % ↑	2540.C

4.1 Effect of COD

Normally COD test shows the oxygen equivalent of the organic matter that can be oxidized by using a strong oxidizing agent e.g. K_2CrO_7 in acidic solution. In wastewater, the value of COD was 343 mg/L. We observed that COD decreased with time and was 72.5 mg/L at the end. The COD removal efficiency was 78.86%.

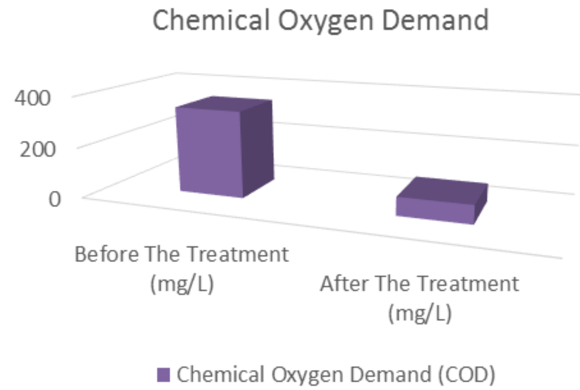

Figure 1 Change in COD level

4.2 Effect of DO

It is the actual amount of Oxygen (O_2) dissolved in water. Before treated with adsorbent DO value was 0.15 mg/L. After the treatment DO increase and was 7.33 at the end. Increased efficiency of DO was 97.95%.

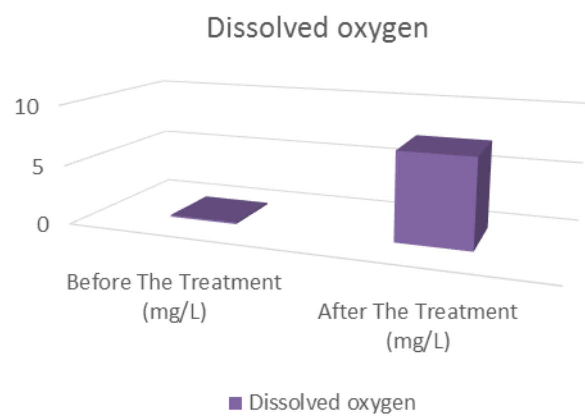

Figure 2 Change in DO level

4.3 Effect of BOD

The BOD indicates the content of oxygen needed to decompose organic compounds in waste water by bacteria. Initial value of BOD in wastewater was 1207.5 mg/L and it was 163 after treated with adsorbent. Here the BOD removal efficiency was 86.50%.

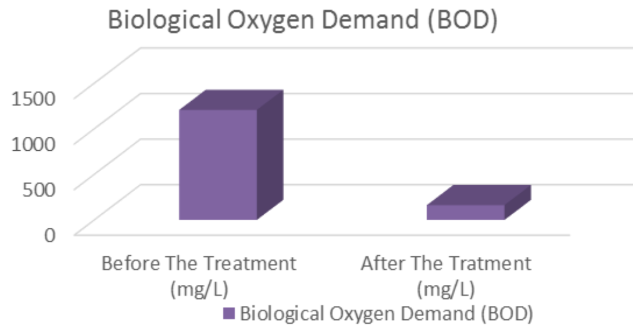

Figure 3 Change in BOD level

4.4 Effect of TSS

TSS is the amount of suspended solids which cannot pass through a filter paper usually with a pore size (0.45-2.0) µm.The wastewater which was collected contains 800 mg/L TSS. After treating the water by the adsorbent, it affected the TSS value (120 mg/L) in a suitable range.

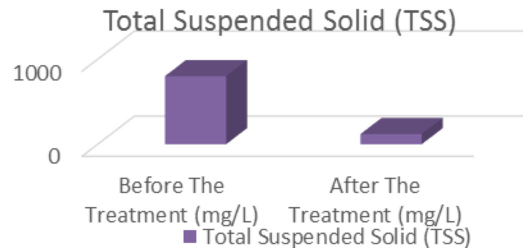

Figure 4 Change in TSS level

4.5 Effect of TDS

It is the total amount of filterable solid that can pass through a filter paper usually pore size of (0.45-2.0) µm. It was determined by the Gravimetric method. At first, we weighted a dry beaker and 50 ml of wastewater was filtered by the filter. Then the solution was evaporated & dried in at 180^0C by an oven and weighted the beaker with residue. The value of TDS of wastewater was 3000mg/L and after treated with adsorbent it was 2200mg/L.

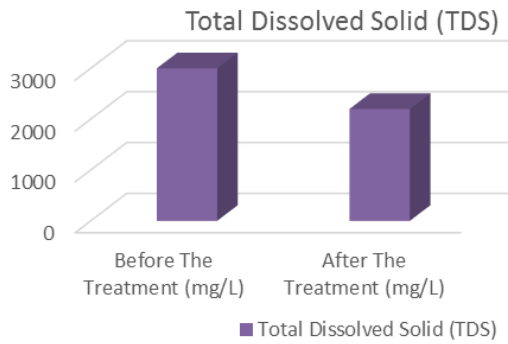

Figure 5 Change in TDS level

4.6 Effect of pH

pH is a measure of hydrogen ion concentration or more precisely the hydrogen ion activity. Initially the pH was 8. Since we wanted to get adjustable color of water so we use the Calcium Carbonate ($CaCO_3$). Which increase the value of pH. Which was (pH=9.5).

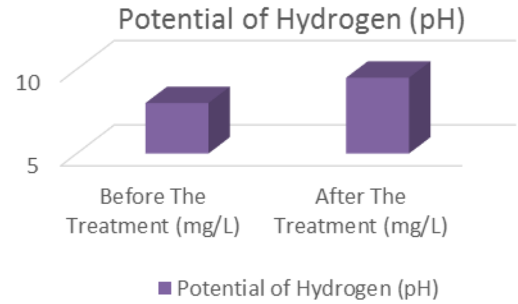

Figure 6 Change in pH level

4.7 Comparison among Standard water, Wastewater and Treated Water

Following diagram shows the comparison analysis among standard inland water, textile wastewater and textile wastewater treated with adsorbent.

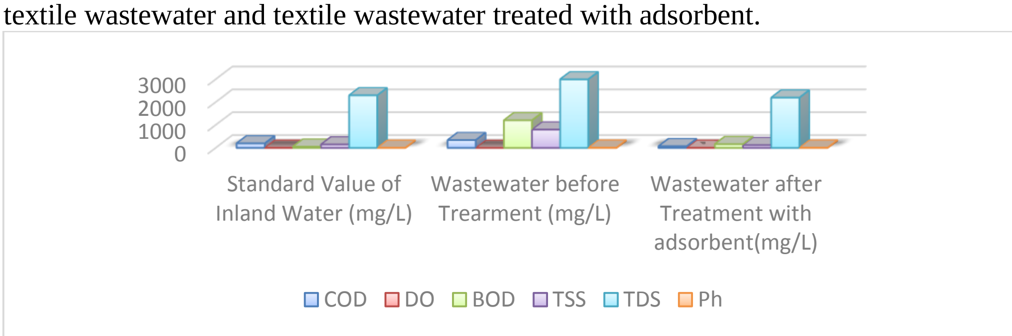

Figure 7 Effect of adsorbent on different parameter

4.8 Change in percentage of different parameter after the treatment

Following diagram shows the change in percentage of different parameter after treatment of textile wastewater with adsorbent.

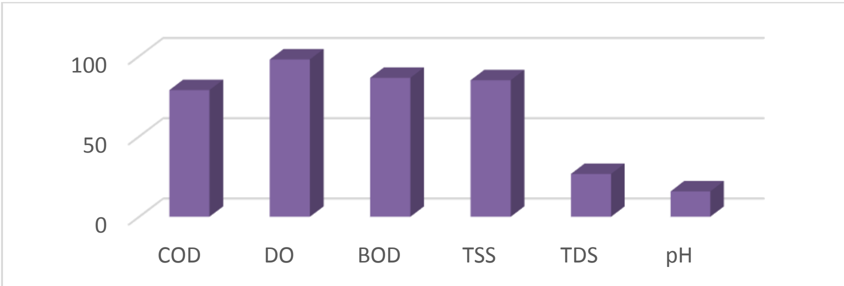

Figure 8 Change in percentage of different parameter

By considering all the result of water quality parameter it is cleared that adsorbent (Water Hyacinth, Coal, Bricks) and Calcium Carbonate are effective removal for COD, BOD, TSS, TDS of waste water. The above result showed that these adsorbents are highly suitable for treatment of waste water.

5. CONCLUSION

The study showed that water hyacinth (*Eichhornia crassipes)*, coal, and brick were efficient in reducing BOD, COD, TDS, and TSS of the textile wastewater and as well as increase the dissolved oxygen remarkably. Current research has demonstrated the possibility to adopt a sustainable and environmentally friendly approach to the treatment of wastewater with the water plant Eichhornia. This study also reveals that the adsorption increases with increase in retention time and depends on the height of the adsorbent used in the adsorption column. As water hyacinth is world's worst weeds and it is impossible to eradicate from waterways, they can be used widely as a low-cost adsorbent to remove color and heavy metals from textile wastewater, and can also improve profitability.

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