# Stormwater Treatment Using Natural Bio-adsorbents

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## Abstract

Stormwater runoff is one of many leading causes of pollution in urban areas. Stormwater runoff contains variety of pollutants including heavy metals, suspended solids, organic carbon, nutrients and hydrocarbon etc. Urban stormwater not only contaminate surface water but also deteriorate soil structure and groundwater quality when infiltrate through ground surface. Hence, efficient treatment of stormwater runoff is crucial to water environment. This paper focuses on the benefits of natural bio-adsorbents for the treatment of urban stormwater to make them suitable for various purposes. A three layered filtration unit using fine sand, coconut coir and activated carbon was prepared for treatment of stormwater collected from road runoff in residential, commercial and industrial areas in Rajshahi City. The characteristics (e.g. alkalinity, pH, total solids, suspended solids, dissolved solids, acidity, conductivity and chemical oxygen demand (COD)) of collected stormwater samples from different locations were determined before and after filtration using standard test method prescribed by APHA. The test results showed that COD, pH, conductivity, turbidity, total dissolved solids, total suspended solids, total solids, alkalinity were removed upto 35.13%, 2.98%, 52.63%, 92.64%, 72.43%, 82.37%,57.25% and 43.45%, respectively. The designed cost-effective filtration unit can be a suitable treatment system where pollution protection and reuse of stormwater is the prime concern.

***Keywords:*** *Stomwater treatment; Bio-adsorbents; Filtration; Water quality; Rajshahi City.*

## 1. Introduction

Water pollution has become one of the crucial problems for the planet in recent years. Water pollution can be defined as defilement of water which mainly occurs because of human actions. Releasing partly treated water or waste water into water bodies can damage the ecosystem (Edokpayi et al. 2017). The problem leading to water pollution is increasing day by day because of increased population, industrialization and urbanization in Bangladesh. Collection, treatment and disposal of domestic and industrial waste water can be very useful. But a better source of water is stormwater. Being a monsoon country, Bangladesh gets a huge amount of rain each year. The average rainfall in Bangladesh is 2000 mm per year while the Rajshahi region receives a rainfall of 1600 per year (Noorunnahar & Hossain, 2019). Rajshahi is situated in Ganges basin. So, Rajshahi receives a little less rain than most other parts of the country. This amount of rain water should be perfectly utilized. Rain water or storm water which is the surface water resulting from heavy rainfall can be the perfect origin of potable water for Bangladesh.

Stormwater is very important resource of easily accessible water all over the world. Steps should be taken to harvest the stormwater and treat them efficiently and effectively. The process should also have to be economical. Pollutants can also discharge into aquatic environment and harm aquatic life. Stormwater treatment can also help prevent these pollutants from entering into aquatic environment. Stormwater can be treated naturally by various WSUD measures like bioretention basin, constructed wetlands, vegetated swales, detention basin etc (Mangangka, 2013). But these are all exercised in the field where maintenance cost is high and treatment plant requires large land area. For the functioning and proper maintenance of the plant, skilled labors are required. Overall the treatment plants are costly affair. Hence, selection of cost effective treatment technology for stormwater treatment is the prime concern.

Adsorption is one of the low cost treatment method that use physical-chemical processes (Montes-Atenas & Valenzuela, 2017). Adsorbents like industrial waste, agricultural products and activated carbon are used to treat stormwater. However, the method requires long time to complete the process and generate large quantity of sludge. Out of available low cost treatment methods for removing contaminations from stormwater, the simplest method is filtration. It is an effective, efficient and economical way to improve water quality. Filtration technology is a physical process which treats water contaminants like COD, color, suspended solids, odor, and turbidity etc (Priyadarsini, 2013). It can be implemented for a vast length of application in both domestic and industrial. Hence, this study has been done on alternate filter media using benefits of natural bio-adsorbents for finding options available to improve water quality. The low cost filter is a household point-of-use water treatment system, and has been identified as a sustainable and suitable water treatment technology in rural remote areas for developing countries. The designed modified intermittently operated multimedia filter is capable of removing pathogens, suspended solids, dissolved solids, BOD, COD and decreasing turbidity levels through physical, physiochemical and biological processes.

## 2. Methodology

### *2.1 Study Area and Sample Collection*

Stormwater from different places can have its own physical and chemical composition. Stormwater samples were collected from two different roads on February, 2021 from Padma Residential Area in Rajshahi City Corporation (Figure 1) based on standard sampling method recommended by Environmental Protection Agency (EPA) (Simpson et al., 2017).


Figure 1. Study areas and sampling locations

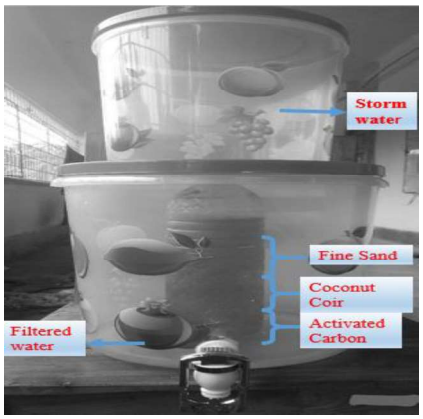


Figure 2. Multimedia filtration unit

### *2.2 Design of Filtration Unit*

A multimedia filtration unit was designed using three different filter media for this study. The filter unit was developed using a plastic bottle for filter's unit body, fine sand, coconut coir and activated carbon as filter media (Figure 2). For the protection of filter media 25mm thickness of cotton was used after the last layer of the bottle. The entrance and discharging area was very small so the rate of water passing through the filter media was very low. Available local materials were used to develop the filter unit.

### *2.3 Laboratory Testing*

The physical and chemical parameters such as turbidity, conductivity, pH, alkalinity, total solids, total dissolved solids and total suspended solids, chemical oxygen demand were tested after collection of samples from different study locations. Then the sample was filtered through the designed filter unit as shown in Figure 2. After filtration all the parameters were tested again to determine the performances of designed filter unit. The testing was taken place at the Environmental Engineering Laboratory of Rajshahi University of Engineering & Technology based on the standard test method recommended by APHA 2017. The stormwater quality characteristics need to be maintained within the allowable limit for the purpose of irrigation if the properties are beyond the limit recommended by Food and Agricultural Organization, FAO 1994.

## 3. Results and Discussions

The tested water quality parameters before and after filtration are compared with standard guideline and discussed in Figures 3-11. The values of pH found for all samples are well under the allowable limit. The tolerable value of pH is between 5.5 to 9.0 for irrigation and discharge (FAO 1994. Water quality for agriculture). The value of pH of the two samples is 6.70 and 6.75 respectively (Figure 3). Therefore, the water maintains bearable pH, and little acidic. In a similar study on wastewater treatment, the pH range was about 6.5-7.5 (Brownlee, 2004). After filtration, the pH value modified up to 2.6% as shown in Figure 4.

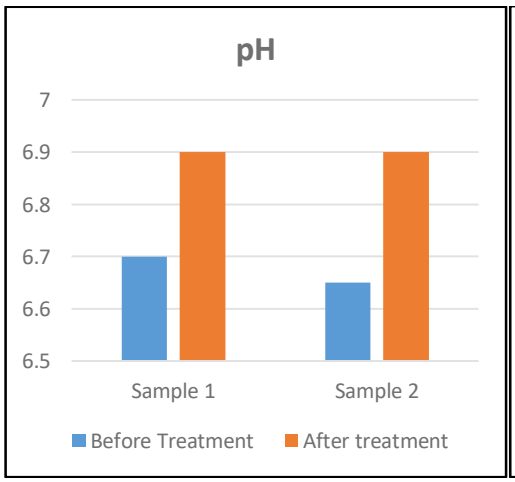


Figure 3. Variation of pH value

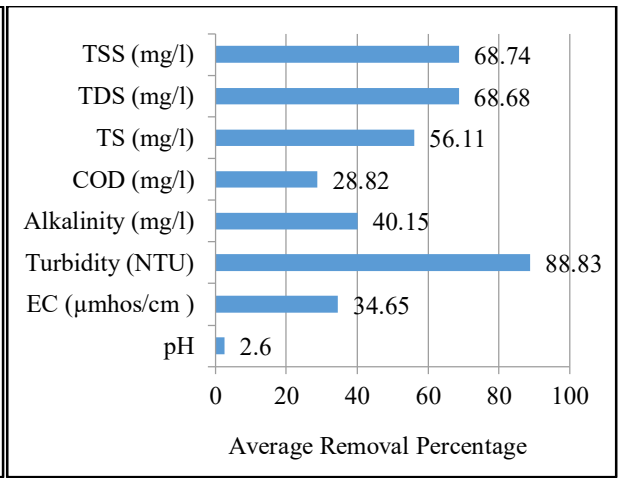


Figure 4. Average removal percentages

Conductivity of a substance can be termed as the ability or power to conduct or transmit heat, electricity or sound. Figure 5 shows the variation of electrical conductivity (EC) of

stormwater before and after filtration. The value of EC for one of the samples is above permissible limit that is 2250 µmhos/cm while the second sample has a conductivity value well under the permissible limit recommended by FAO. After filtration both samples reached within the acceptable limit for irrigation. Then maximum removal of EC is about 52.63% and the average is 34.65% (Figure 4). So, the water is tolerable and its effect in the pollution of stormwater is insignificant. Similar study on conductivity measurements for controlling municipal wastewater treatment showed the maximum removal of conductivity was about 23% (Levlin, 2014).

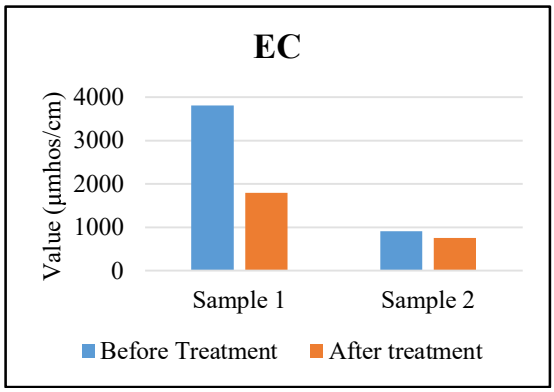


Figure 5. Variation of EC

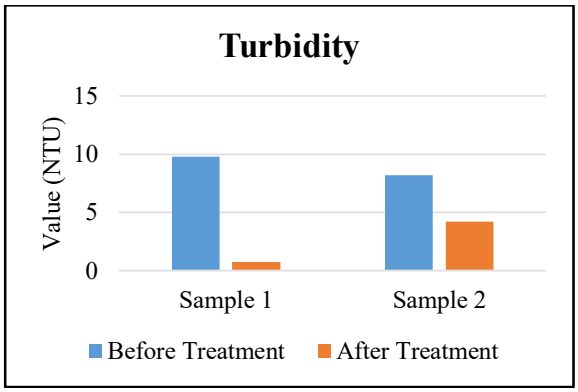


Figure 6. Variation of Turbidity

Turbidity is the amount of particulate that is suspended in water. It is a measurement of the point at which the water becomes opaque because of the presence of suspended particles. As the amount of total suspended solids in the water increases, the water becomes more the opaque. Thus turbidity becomes higher. EUTECH INSTRUMENTS Turbidimeter-TN-600 was used in the experiment. Figure 6 shows the turbidity of stormwater before and after treatment. Maximum permissible limit for turbidity is 35 NTU. The values of turbidity found for the sample was below 35 NTU. The maximum removal of turbidity was found 92.64% where the average is 88.83% (Figure 4). In another study on water treatment where it was tried to remove turbidity and bacteria from the waste water and the maximum removal was about 85% (Ramavandi, 2014).

Alkalinity can be defined as the capability of an aqueous solution to neutralize an acid. Figure 7 shows the variation of alkalinity of stormwater before and after treatment. The highest permissible limit is 600 mg/l. The values of alkalinity found for all samples are well within the permissible limit. The maximum removal is about 43.45% and average is 40.15% (Figure 4). In a similar study on wastewater treatment, the maximum removal of alkalinity was about 37.95%. The study was done on sand intermittent filtration technology for safer domestic sewage treatment (Prasad et al., 2006).

The chemical oxygen demand can be described as the quantity of oxygen which is needed for oxidizing unstable materials in a sample with the help of potassium permanganate in an acidic solution. Figure 8 shows the Chemical Oxygen Demand (COD) variation of stormwater before and after treatment. The value of COD was below the permissible limit and the maximum removal of COD was 35.13%. The average removal rate is 28.82% (Figure 4). Permissible limit for COD is 120 mg/l. In the study of Coconut shell-activated carbon for filtration the removal of COD was 53% (Ratnoji and Singh, 2014).

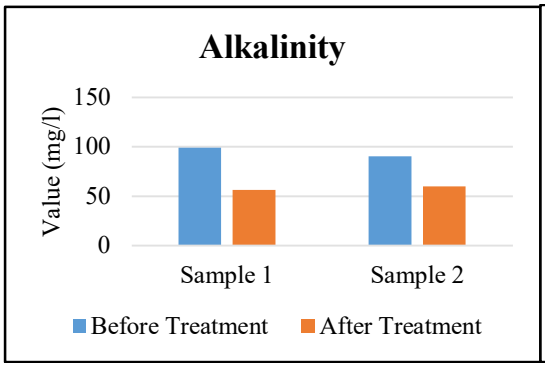


Figure 7. Variation of Alkalinity

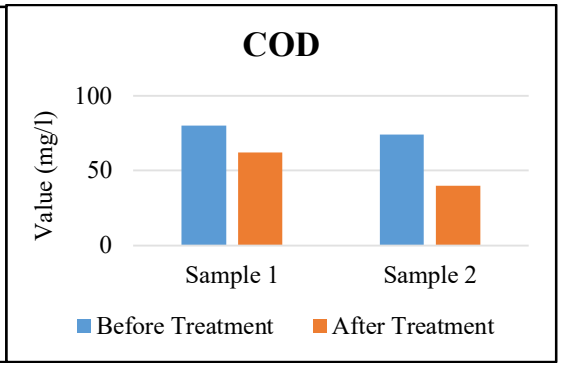


Figure 8. Variation of COD

Figure 9 shows the variation of total solids (TS) of stormwater for before and after treatment. The maximum permissible limit of total dissolved solid (TDS) is 2000 mg/l. The maximum allowable limit of total suspended solid (TSS) is 100 mg/l for direct discharge into natural water bodies and 200 mg/l for use in irrigation. The maximum removal of TS was found 57.25% and average is 54.97% (Figure 4).

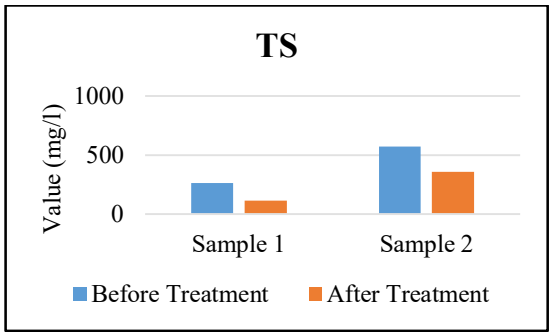


Figure 9. Variation of TS

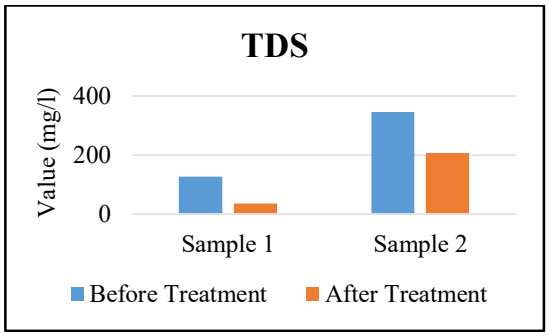


Figure 10. Variation of TDS

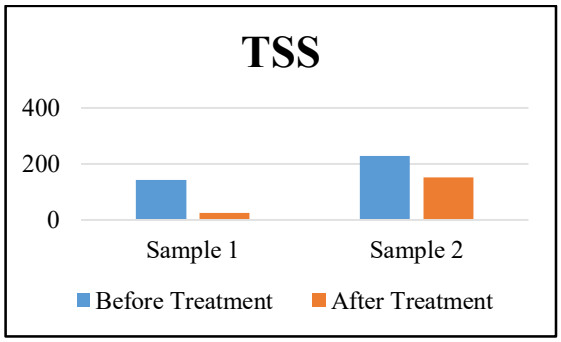


Figure 11. Variation of TSS

The maximum removal of TDS is about 72.43% and average is about 68.68%. In case of total suspended solid maximum removal is about 82.37% and average is about 68.74%. In a similar study on wastewater treatment, the maximum removal of TDS and TSS was 20.26% and 72% respectively (Wahid et al., 2015).

## 4. Conclusions

In this study, a filtration unit was designed using three filter media's for investing the performance of pollutants removal from stormwater collected from road runoff. Most of the characteristics of stormwater were well within the allowable limit in both before and after treatment. Conductivity and TSS were above the permissible limit before treatment but after treatment were under the permissible limit. The filtration unit was found to be productive for treatment of stormwater for potential use in irrigation during dry season. So, there is a substantial opportunity by using more than three layers, expanding their length and increasing their contact time with filter media which will increase the performance of filter media.

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