DESIGN AND CONSTRUCTION OF AN APPROPIATE SYSTEM FOR THE TREATMENT AND REUSE OF GREY WATER

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ABSTRACT

Due to the increasing rate of population in the world, the demand of fresh water is also increasing. So a balance should be made between the demand of water and its supply. Therefore, wastewater recycling or management is gradually getting importance. Grey water is defined as any kind of domestic waste water, excluding sewage. The aim of this paper is to develop a treatment unit for reusing grey water. To achieve this,one sample of grey water has been collected from Rokeya hall, KUET, Khulna .The characteristics of grey water in terms of different water parameters have been tested. A Treatment unit consisting of a sand filter containing Sylhet sand and a roughing filter containing brick pieces and charcoal has been constructed. After filtration the characteristics of sample have been tested again. Comparing the values of treated grey water with the available permissible values of water reuse, it is found that it can be used for irrigation purpose.

Keywords: *Grey water, Waste water, Laboratory analysis, Treatment unit*

1. INTRODUCTION

Due to the increasing rate of population growth, the demand of fresh water is also increasing all over the world. But the source of fresh water is scarce. So a balance should be made between the demand and the supply of fresh water. Earlier wastewater treatment was popular only in developed countries but nowadays wastewater recycling or management is gradually getting popular in the low and middle income countries too. Appropriate treatment system of wastewater can reduce the scarcity of fresh water. Bangladesh is a South Asian country. The total population in Bangladesh was estimated at 159.9 million people in 2016 (Bangladesh population n.d.). But the area of Bangladesh is 1, 47,570 sq. km. So it can be clearly seen that the availability of fresh water is scarce in terms of vast population. The key concern is to create a proper balance between demand and supply of fresh water. In order to overcome the increasing demand, the concept of treatment and reuse of wastewater is a good solution. Grey water is one kind of wastewater originating from bathtub, shower, washing machine, kitchen sink etc. Grey water can contain large numbers of disease-causing organisms (human pathogens such as bacteria, viruses and protozoa). Grey water can also include a number of contaminants including fats and oils, food scraps, nutrients, salts, sodium, phosphorus, detergents, cleaning products, sunscreens and personal care products. Common tests that are generally conducted to judge the characteristics of grey water are pH, total dissolve solid (TDS), total suspended solid (TSS), color, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), hardness, conductivity (EC), chloride, nitrate, sulfate, total coliform (TC) etc. In this study the parameters tested are conductivity, pH, chloride, hardness, nitrate, TDS, COD, color, sulfate, turbidity, BOD5, TSS etc. The generated amount of grey water depends on the factors such as existing water supply service, number of household members, life style, typical water usage patterns etc. To meet the demand of fresh water for the large number of population, the idea of the treatment of grey water has been developed. The appropriate reuse of grey water largely depends on both the source of grey water and the level of treatment. Septic tank,

constructed wetland and intermittent sand filter are identified as the most suitable processes for decentralized treatment due to the simple operation and maintenance facilities as well as cost effectiveness of these systems (Ahmed and Arora, 2012) A research has been conducted to find out possible treatment method to make the grey water reusable. It has been conducted in the lab of Civil Department of Khulna University of Engineering & Technology.

2. METHODOLOGY

2.1 Study area

KUET campus has been selected as the study area for this research. KUET is situated in Khulna district of Bangladesh. Rokeya Hall of Khulna University of Engineering & Technology (KUET) has been selected to collect sample. Filter has been constructed and sample has been tested in the laboratory of Department of Civil Engineering, KUET. The location of the study area is presented below in the Khulna city map. Aerial view is also shown.

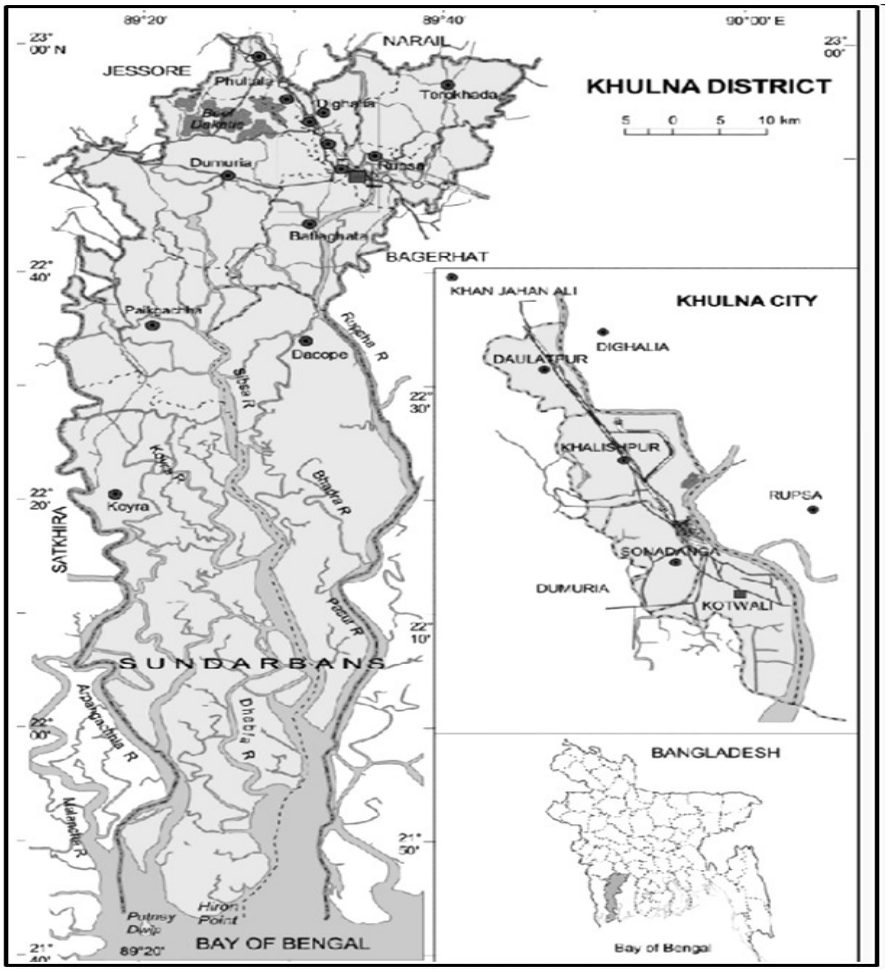

Figure 1: Khulna District (Map of Khulna n.d.).

2.2 Collection of Grey Water

Only one sample of grey water has been collected. It has been collected from tank in a plastic bottle from Rokeya hall, KUET, Khulna. The treatment method of grey water largely depends on the collected sample of grey water.

Figure 2: Sample of grey water

2.3 Arrangement of filter media

Filtration mechanism has been applied to treat the water. The filter which has been constructed in the lab for this study purpose consists of two parts. One is sand filter and another is roughing filter. Sand filter is one kind of simple filter containing sand. This filter is relatively inexpensive to build, but do require highly skilled operators. Roughing filter consists of one to three compartments in which gravels of different sizes are arranged. In this filter the portion which is known as sand filter contains 6" thick layer of Sylhet sand. And the portion which is known as roughing filter contains three layers. First layer contains 1.5" thick layer of brick pieces (size 0.5"-1"). Second layer contains 1.5" thick layer of brick pieces (size 1"-1.5"). Last layer contains 2" thick layers of charcoal. The function of sand, brick pieces and charcoal are to remove and retain contaminants. Various filter media with varying thickness has been adopted with a view to checking the effectiveness of the filter. It takes few seconds to run the filter, About 2 litres of influent can be treated at one time.

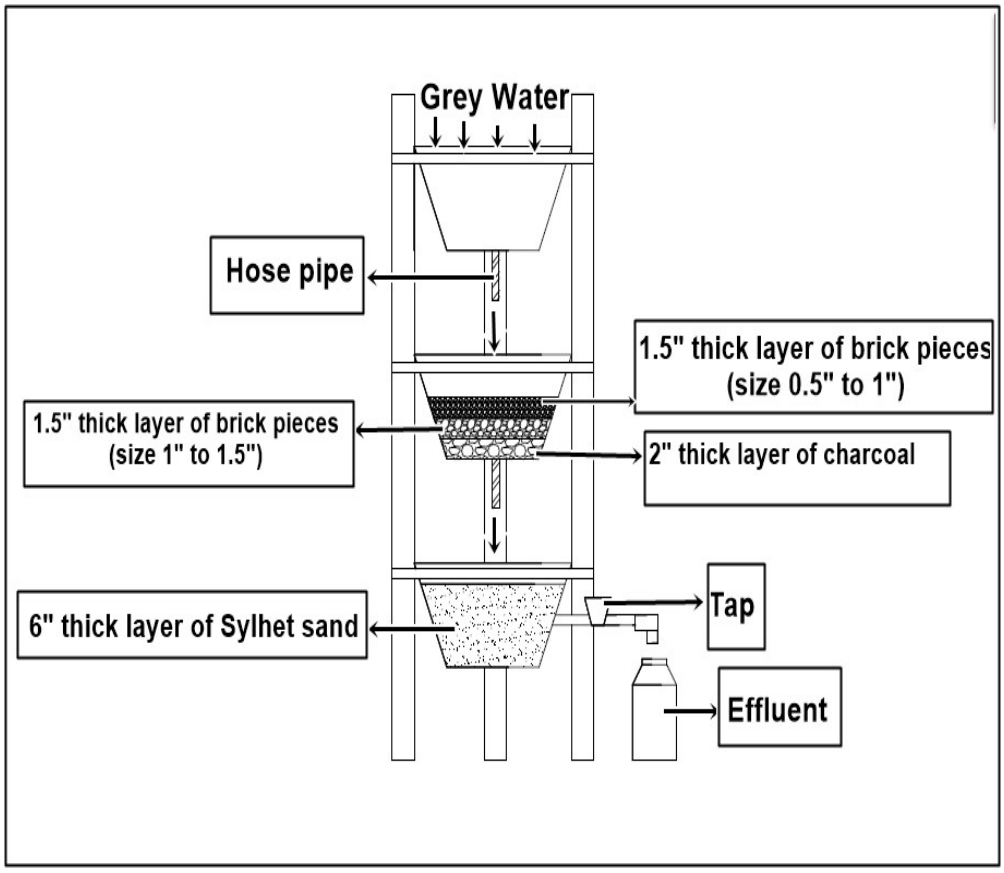

Figure 3: Linear representation of filter

Figure 4: Constructed filter

2.4 Laboratory Analysis

In the laboratory, total 11 parameters have been determined for the sample before and after the treatment. After that the values of treated water have been compared with the permissible values of reusing. Measurement of pH is carried out either by calorimetrical or by electrometrical method. The electrometric method is more accurate but expensive and calorimetric method is less accurate but cheap. Here electrometric method has been used. Pure water does not have any color. The color of water is tested either by color compactor or

by spectrometer. Here it is done by spectrometer. Turbidity is a measure of the cloudiness or murkiness of water due to suspended particles. The standard method for turbidity test needs Nephelometry and Jackson turbiditimeter. Here it is conducted by nephelometry method. Conductivity indicates the presence of ions within the water. Conductivity has been measured electrochemically. In laboratory Biochemical Oxygen Demand (BOD) is measured by DO meter. For the determination of chemical oxygen demand (COD), $K_2Cr_2O_7$ is taken in pipette and ferrion indicator is used as reagent and then titration is conducted until reddish color forms. Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). Here chloride was determined by Mohr method. Sulfate in water was measured electrochemically by using a spectrometer. Nitrate in water was also measured electrochemically by using a spectrometer. The total dissolved solid content in water is obtained by specific conductance measurement.

3. RESULTS AND DISCUSSIONS

3.1 Results of the characteristics tests of grey water before and after the treatment

For collected sample of grey water, values of pH, Color, Turbidity, Conductivity, BOD, COD, Chloride, Sulfate, Nitrate, TDS, TSS before treatment were 7.32, 1065 Pt-Co, 26.1 NTU, 4.78 µS/cm, 201.5 mg/L, 1230 mg/L, 1980 mg/L, 56 mg/L, 4.5 mg/L, 3260 mg/L, 325 mg/L respectively and after treatment the values of pH, Color, Turbidity, Conductivity, BOD. COD, Chloride, Sulfate, Nitrate, TDS, TSS are 7.80, 290 Pt-Co, 11 NTU, 3.56 µS/cm, 112.84 mg/L, 110 mg/L, 535 mg/L, 80 mg/L, 0.44 mg/L, 299 mg/L, 95 mg/L respectively. Comparing the values of treated grey water with the available permissible values of water reuse, it is found that it can be used for irrigation purpose. After treatment the liquid is waste water, as it is not suitable for drinking purpose. The permissible values for irrigation are taken from different sources. The permissible limits of pH, BOD, COD, Chloride, Sulfate, TDS, TSS for irrigation are 6.5-8.4, 50 NTU, 2000 µS/cm, 110 mg/L, 150 mg/L, 2000 mg/L, 250 mg/L, 100 mg/L, 500 mg/L, 100 mg/L respectively for irrigation (Islam, 2012) .The permissible limits of Conductivity, Turbidity are 2000 µS/cm, 50 NTU for irrigation (Sultana, 2015).

Table 1: Tabular from of Results

Water Quality Parameter	Unit	BD Standard for drinking (ECR'97)	Irrigation Permissible Limit	Values Before Treatment	Values After Treatment
pH	-	6.5-8.5	6.5-8.4	7.32	7.80
Color	Pt-CO	15	-	1065	290
Turbidity	NTU	10	50	26.1	11
Conductivity	µs/cm	-	2000	4.78	3.56
BOD	mg/L	.2	110	201.5	110
COD	mg/L	-	150	1230	112.84
Chloride (Cl^-)	mg/L	150-600	2000	1980	1535
Sulfate ($SO4^{2-}$)	mg/L	200	250	56	80
Nitrate (NO_3^-)	mg/L	10	100	4.5	.44
Total Dissolved Solid	mg/L	1000	500	3260	299
Total Suspended Solid	mg/L	10	100	325	95

3.2 Graphical Representation of Results

The values of different types of pH changes slightly after the filtration. The value of pH slightly increased. This is because the sand filter may contain some alkalinity. The treated values are within the limit. Grey water contains high turbidity, but after filtration in roughing filter the turbidity is found less, and it is within the limit for the use in irrigation. After the treatment, the value of conductivity is decreased, the value of conductivity is within the standard limit for irrigation. After filtration the value of nitrate is decreased because of the roughing filter.

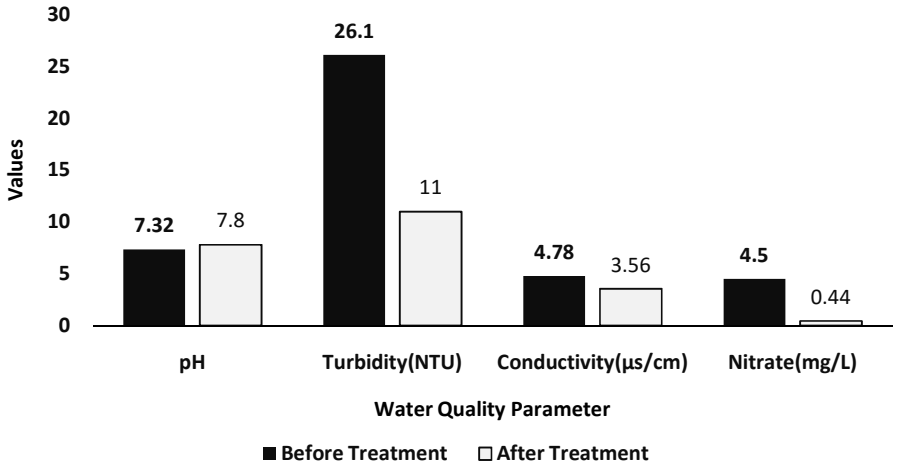

Figure 6: The variations of pH, Turbidity, Conductivity, Nitrate before and after treatment

The value of BOD is significantly reduced in the roughing filter, as large chain of organic can not pass through the small pore of aggregate. The value of COD is significantly reduced in the roughing filter. The value of chloride after treatment is found within the reusable limit. The value of sulfate increases after treatment, it may be because of the supply water which is used for the treatment contains lot of sulphate.

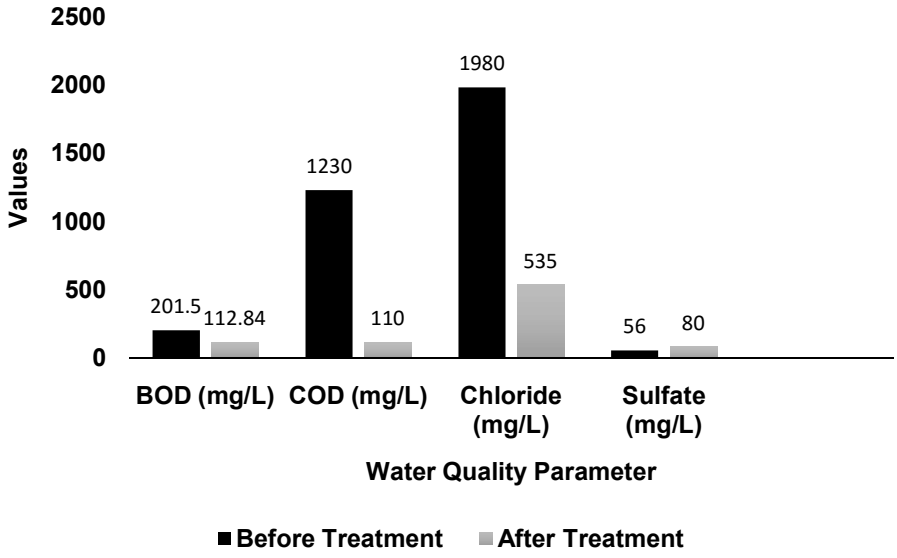

Figure 7: The variations of BOD, COD, Chloride, and Sulfate before and after treatment

The color is removed in roughing filter, as it is absorbed by brick chips. The TDS value decreased after treatment TDS was mostly removed by sand filter. The value of TSS is also increased.

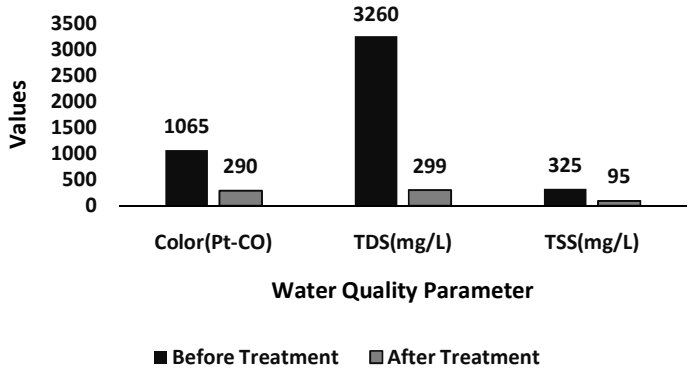

Figure 8: The variations of color, TDS, TSS before and after treatment

4. CONCLUSIONS

Different characteristics of grey water in terms of eleven different water parameters have been tested by collecting sample of grey water. A treatment filter has been constructed. The filter has two parts. One part contains Sylhet sand another contains different size of brick pieces and charcoal. After the treatment the water parameters have been tested again. The removal efficiency of color, BOD, COD, TDS, TSS etc have been observed. Comparing the parameters of treated grey water with the available standard values, it has been decided whether it can be reused or not. Most of the parameters are found to satisfy the permissible limit for the reuse in irrigation, but this treated grey water is not suitable for drinking. This treated can be applied directly to the soil. However, root crops which are eaten should not be watered with this water. Treated grey water can be used on flat area. Finally a treatment unit has been proposed.

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