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Efficiency of Slow Sand Filter in Wastewater Treatment

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Abstract—Slow sand filtration is a technology that has been used for potable water filtration for hundreds of years. It is a process well-suited for small, rural communities since it does not require a high degree of operator skill or attention. As its name implies, slow sand filtration is used to filter water at very slow rates. The typical filtration rate is at least fifty times slower than for rapid rate filtration. Due to this slow rate of filtration, a large land area is required for the filtration basins. No chemical addition is required for proper filtration operation. Particle removal is accomplished primarily through biological processes that provide treatment. The biological activity is located primarily in the top surface of the filter known as the "schmutzdecke," although recent research has indicated that biological processes throughout the depth of the filter bed may also influence particle removal. A "ripening" period from several weeks to several months is necessary for the biological organisms to mature in a new slow sand filter. Slow sand filters are not backwashed like rapid rate filters, but are instead scraped or harrowed periodically when head loss reaches 3 - 4 feet across the filter bed.

Index Terms— Filtration, Headloss, Schmutzdecke, ripening, scraped,

1. INTRODUCTION

Slow sand filtration is a technology that has been used for potable water filtration for hundreds of years. It is a process well-suited for small, rural communities since it does not require a high degree of operator skill or attention. As its name implies, slow sand filtration is used to filter water at very slow rates. The typical filtration rate is at least fifty times slower than for rapid rate filtration. Due to this slow rate of filtration, a large land area is required for the filtration basins. Small communities that have plenty of available land are often good candidates for slow sand filtration. Slow sand is a relatively simple filtration process. No chemical addition is required for proper filtration operation. Particle removal is accomplished primarily through biological processes that provide treatment. The biological activity is located primarily in the top surface of the filter known as the "schmutzdecke," although recent research has indicated that biological processes throughout the depth of the filter bed may also influence particle removal.

A "ripening" period from several weeks to several months is necessary for the biological organisms to mature in a new slow sand filter. Slow sand filters are not backwashed like rapid rate filters, but are instead scraped or harrowed periodically when headloss reaches 3 - 4 feet across the filter bed. Typically slow sand filters must be scraped or harrowed every 1 - 12 months depending on water quality. Some facilities with very high water quality can experience even longer filter runs. During scraping, the top 1/8 – 1/2 inch of sand is removed from the filter bed. Eventually, after years of operation, the sand layer must be replaced to restore the depth of the filter bed. In some cases, filters are harrowed to break up the top layer of material and reduce headloss through the filter. Sand is not removed when filters are harrowed, but the top layer of organic material is broken up and floated off the surface of the filter bed using flow up through and across the filter surface. After a filter is scraped or harrowed, the filtered water is typically sent to waste for a period of 1 - 7 days to allow the biological population in the filter to reestablish.

The mechanisms of purification vary depending on the type of filter. Proper choice of the filter depth, sand type, sand size and filtration rate affects the pollutant removal performance and purification efficiency of the sand filter (Abudi, 2011).

The biological activity is enhanced with increasing filter depths. Microorganisms and other suspended particles have to travel more through the sand, thus, a

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higher removal efficiency is expected at higher sand depths (Ellis, 1984). The use of slow sand filter to remove bacteria from contaminated groundwater has been an attractive option as a filter system in both developed and developing countries especially in rural communities due to its low cost, ease of operation and maintainance (Nassar & Hajjaj, 2013; Logsdon et al., 2002). Using sand filter for water treatment offers unique advantage for solving water shortage problem. Though the technology is cheap and simple, it is not widely used in the Philippines, perhaps due to lack of expertise for the maintenance and operations of such kind of treatment. With the growing population in the Philippines especially in the urban and suburban areas, potable water demand will increase inevitably and slow sand filtration may address the concern. Moreover, access to safe drinking water is one of the first priorities following a disaster in a local community (Loo et al., 2012). An evaluation of the use of local sand for slow filtration and its eventual use in local water districts for water treatment is an important contribution to water demand of the local population. Thus, this study aimed to investigate the efficiency of slow sand filter in purifying well water using Achenkovil River sand as the filter medium. Turbidity and pH tests were done on water sample before and after the filtration process to determine the percent efficiency of the slow sand filter to reduce turbidity and pH.

2. OBJECTIVES

The objectives of this study were as follows:

1. To determine the suitability of slow sand filtration for treating water from a particular water source.
2. To determine the effectiveness of the slow sand filtration process at removing turbidity from the raw water source

3. MATERIALS REQUIRED

1. Filter basins can be constructed using concrete or earthen berm construction. For very small systems (<25 gpm), basins can be constructed from alternative materials such as polyethylene or fiberglass tanks.

2. An inlet to provide uniform flow rate

3. Coarse gravel was used to make the under drain medium

4. The media grains are sorted and measured through a series of mechanical sieves. The grains should be relatively uniform in size to prevent clogging. "Effective size" and "uniformity coefficient" are measurements used to express these characteristics. Effective sizes for sand filter media range from 0.3 mm to 3 mm in diameter.

5. Slow sand filters may be provided with either inlet or outlet flow control. Inlet flow control can provide either constant rate or declining rate filtration.

6. An outlet to drain the treated water

4. METHODS OF OPERATION

Slow sand filters work through the formation of a gelatinous layer (or biofilm) called the hypogeal layer or *Schmutzdecke* in the top few millimetres of the fine sand layer. The *Schmutzdecke* is formed in the first 10- 20 days of operation and consist of bacteria, fungi, protozoa, rotifer and a range of aquatic insect larvae. As an epigeal biofilm ages, more algae tend to develop and larger organisms like bryozoa, snails and Annelid worms. The surface biofilm is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. As water passes through the hypogeal layer, particles of foreign matter are trapped in the mucilaginous matrix and soluble organic material is adsorbed. The contaminants are metabolised by the bacteria, fungi and protozoa. The water produced from an exemplary slow sand filter is of excellent quality.

Slow sand filters slowly lose their performance as the biofilm thickens and thereby reduces the rate of flow through the filter. Eventually, it is necessary to refurbish the filter. Two methods are commonly used to do this. In the first, the top few millimetres of fine sand is scraped off to expose a new layer of clean sand. Water is then decanted back into the filter and re-circulated for a few hours to allow a new biofilm to develop. The filter is then filled to full volume and brought back into service. The second method, sometimes called wet harrowing, involves lowering the water level to just above the hypogeal layer, stirring the sand; thus precipitating any solids held in that layer and allowing the remaining water to wash through the sand. The filter column is then filled to full capacity and brought back into service. Wet harrowing can allow the filter to be brought back into service more quickly.

In this pilot test, initially the turbidity, pH and electrical conductivity of the water were measured. Then the water was allowed to pass through the inlet using an IV apparatus that regulates the flow rate at 3.82 x 10^(-7) m^3/sec. The water was allowed to flow through the bed at a constant rate and the retention time was about 12

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minutes and 21 seconds. The filtered water is collected in a beaker using the hose pipe fitted at the bottom of the filter. Finally the turbidity, pH and electrical conductivity of the filtered water is found

5. RESULTS AND DISCUSSION

It was observed that the reduction of turbidity, pH, and electrical conductivity increases at a flow rate of $3.82 \times 10^{-7}\ m^3/sec$. For the wastewater treated, initial turbidity was 14 NTU and pH was 8.5. The retention time was 12 minutes and 21 seconds respectively. The results show that there occurs a notable reduction in the turbidity, pH and electrical conductivity of the wastewater treated.

Parameters analysed	Initial	Final	% Reduction Efficiency
Turbidity (NTU)	14	02	86
pH	8.5	7.2	-
Electrical conductivity (µS/cm)	386	85.7	77

Table 5.1: EFFICIENCY IN THE REDUCTION

6. CONCLUSION

It was observed that the reduction efficiency of turbidity is about 70% and the reduction in pH and electrical conductivity is also noticeable. Thus it can be concluded that the slow sand filter is efficient in treating wastewater from a particular source.

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