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Performance of Horizontal Roughening Filter in Wastewater Treatment using different Multimedia

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Abstract—*Today, the biggest problem is scarcity of water which is vital for survival of living things, so the different methods are being adopted to recycle the wastewater. Many authors investigated may aspects of the utilization of Filtration techniques in land improvement and environmental management.*
Now, Filtration is one of the oldest and simplest methods of removing those contaminants. So the roughing filters are used as pre-treatment systems prior to sand filtration. Furthermore, roughing filters could reduce organic matters from wastewater. Therefore, roughing filters can be used to polish wastewater before it is discharged to the environment. Roughing filtration can be considered as a major pre-treatment process for waste water. Horizontal roughing filter (HRF) technology is a low cost treatment technology based on physical process to treat wastewater by removing contaminant like BOD, COD, turbidity and suspended solids for a wide range of applications in domestic as well as industrial applications. This paper describes different component of horizontal roughing filter including design parameter and different media such as Granite, Ceramic tiles, charcoal as a filter media. The present study focus on existing types of roughing filter, mechanisms of particle removal and applicability of HRF system for treating wastewater.

Keywords: *Horizontal roughning filter, Wastewater, Multimedia.*

1. INTRODUCTION

Wastewater engineering is that branch of environmental engineering in which the basic principles of science and engineering are applied to solving the issues associated with the treatment and reuse of wastewater.

The ultimate goal of wastewater engineering the protection of public health in a manner commensurate with environmental, economic, social, and political concerns. There are several opportunities for improving wastewater irrigation practices via improved policies, institutional dialogue, and financial mechanisms, which would reduce risks in agriculture. Effluent standards combined with incentives or enforcement can motivate improvements in water management by household and industrial sectors discharging wastewater from point sources. Segregation of chemical pollutants from urban wastewater facilitates treatment and reduces risk. Strengthening institutional capacity and establishing links between water delivery and sanitation sectors through inter-institutional coordination leads to more efficient management of wastewater and risk reduction.

Filtration is one of the oldest and simplest methods of removing those contaminants. Generally, filtration methods include slow sand and rapid sand filtration. Reliable operation for sand filtration is possible when the raw water has low turbidity and low suspended solids. For this reason, when surface waters are highly turbid, ordinary sand filters could not be used effectively. Therefore, the roughing filters are used as pre-treatment systems prior to sand filtration. Furthermore, roughing filters could reduce organic matters from wastewater. Therefore, roughing filters can be used to polish wastewater before it is discharged to the environment.

1.1 Roughing filtration

Filtration is a process for separating suspended impurities from water by passing through porous media. Particle removal is one of the main objectives of filtration. Water supply treatment plants generally use sand filters to produce clear water. Most sand filters have maintenance and operation problems due to lack of pre-treatment system for the reduction of turbidity and suspended solids. Gravel filtration has been used in water treatment since the early 1800s, when it was first used in Scotland to pre-treat water prior to sand filtration. Gravel filtration soon disappeared due to the advent of chemical and mechanical water treatment. However, gravel filtration remerged in the 1970's and 1980's mainly in developing countries, because those roughing filters do not require sophisticated mechanical equipment or the use of chemicals. Roughing filters are the most common type of pre-treatment system, which are used before slow sand filters in order to reduce the raw water turbidity and suspended solids.

Therefore, roughing filtration technology is used as pre-treatment to polish the raw water quality for the improvement of performance of slow sand filtration. But it may be used without slow sand filtration if raw water originates from well protected catchment area and having minor bacteriological contamination. Therefore in rural water supply systems roughing filtration becomes an appropriate technology. Besides that roughing filter can be maintained easily, does not need any chemicals, has long operational time and can be operated and maintained by trained local caretakers.

Wastewater also needs to be treated because it contains bacteria and viruses, some of which can cause diseases to human. Besides, it also contains BOD sources that can deplete oxygen in receiving water resulting in aquatic organisms becoming stressed, suffocate and die. Moreover, it contains high levels of nutrients that are toxic to fish and invertebrates and creates nuisance conditions in the receiving environment. To protect the environment, such kinds of materials have to be removed prior to the water being discharged back to the environment.

Roughing filters can improve the quality of wastewater after treatment. Roughing filters are intended to treat particularly strong or variable organic load. The design of the roughing filter allows high hydraulic loading and high flow rate. The resultant effluent is usually within the normal range for conventional treatment processes.

1.1.1 Classification of Filter

The two criteria for filter classification are size of filter media and rate of filtration. Rapid sand filter and slow sand filter are different from intake filter and roughing filter according to their filter media size. The coarse filter media and the low flow rates applied to roughing filtration.

Table 1.1.1: Elucidates the differences of filter material sizes and flow rates of each

Characteristics	intake filtration	roughing filtration	rapid sand filtration	Slow sand filtration
filter material size (mm)	6 - 40	4 - 25	0.5 - 2	0.15 - 1
filtration rate (m/h)	2 - 5	0.3 - 1.5	5 - 15	0.1 - 0.2

1.1.2 Types of Roughing Filters

Roughing filters are classified by their flow patterns in the reactor system.

1. Horizontal flow roughing filters
2. Vertical flow roughning filters

1.1.2.1 Horizontal flow roughing filters

The main advantages of horizontal roughing filters are unlimited filter length and simple layout. Horizontal roughing filters have a large silt storage capacity. Solids settle on top of the filter medium surface and grow to small heaps of loose aggregates with progressive filtration time. Part of the small heaps will drift towards the filter bottom as soon as they become unstable. This drift regenerates filter efficiency at the top and slowly silts the filter from bottom to top. Horizontal-flow roughing filters also react less sensitively to filtration rate changes, as clusters of suspended solids will drift towards the filter bottom or be retained by the subsequent filter layers. Horizontal-flow roughing filters are thus less susceptible than vertical-flow filters to solid breakthroughs caused by flow rate changes. However, they may react more sensitively to short circuits induced by a variable raw water temperature. The inlet and outlet structures were flow-control installations required to maintain a certain water level and flow along the filter as well as to establish an even flow distribution along and across the filter. The filter bed was composed of three filter medium packs of different sizes. The filter medium was placed in separate compartments starting with the coarsest to the finest, in the direction of flow and operated in series.

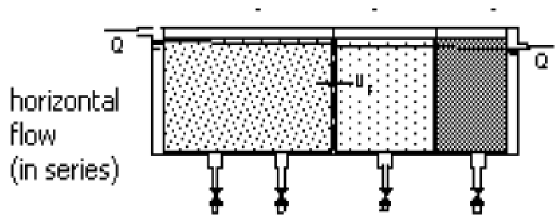

Figure 1.1.2.1: Shows the diagrammatic representation of Horizontal flow Roughing Filters

1.1.2.2 Vertical flow roughing filters

Wastewater is applied to the surface and then drains vertically down through the filter layers towards a drainage system at the bottom. Vertical-flow roughing filters operate either as down flow or up flow filters. They are hence either supplied by inflowing water at the filter top or at the filter bottom. The height of a vertical filter bed is generally limited to 1.0-2.0 m as higher height increases the construction cost of the walls and foundation. The vertical flow roughing filters incorporates a simple self cleaning mechanism and occupies minimal floor space when compared to horizontal flow roughing filters. Vertical-flow roughing filters usually consist of three filter units arranged in series and the water to be treated flows in sequence through the three filter compartments filled with coarse, medium and fine filter material. To prevent algal growth over media for that it cover by a layer of stone often experienced in pre-treated water exposed to the sun. Drainage facilities, consisting in perforated pipes or a false filter bottom system are installed to drain the filter water from bottom.

Finally, pipes or special inlet and outlet compartments are required to convey the water through the subsequent three filter units. In a vertical filter the settled deposits drift downward in both compartments. As a result the deposits accumulate within the first few centimetres from the inlet. This was visually observed in the first compartment with larger grains.

2. MULTI - MEDIA FILTER

Multi – media Filter refers to a filter vessel which utilizes three or more different media as opposed to a "sand filter" that typically uses one grade of sand alone as the filtration media. Multi-media filters for multimedia filtration typically have three layers, consisting of anthracite, sand and garnet. These are often the media of choice because of the differences in mass between the materials. Garnet is by far the heaviest per unit volume, sand is intermediate while anthracite is the lightest filtration media. The idea behind using these three media of differing densities is that anthracite media, with the largest particle size, will stratify on top following backwash while the intermediate size media (sand) will settle in the middle and garnet, the heaviest but having the smallest particle diameter, will settle to the bottom.

Multi-media filters are filled with a variety of media in order of increasing size, for example, fine sand, coarse sand, gravel, stone, and wood chips to a total depth of 0.75 m to 1 m. The inlet is provided at the top so that the filtered water is collected through outlet in the bottom. This filter media arrangement allows the largest dirt particles to be removed near the top of the media bed with the smaller and smaller dirt particles being retained deeper and deeper in the media. This allows much longer filter run times between backwash and much more efficient dirt or turbidity removal. Sand filters typically remove particles down to 25-50 microns while a well-operated multi-media filter may remove particles from 10-25 microns.

3. FACTORS AFFECTING REMOVAL IN ROUGHING FILTERS

The major parameters that affected suspended solids removal by roughing filters were filter media size, filtration rate and bed depth. The filter media size is an important variable. An increased efficiency in the treatment has been observed with decreasing filter media size, which indicates the importance of straining. Higher removals can be obtained due to smaller interstices between smaller media, as well as the larger surface area available, which allow more adsorption. A smaller size of filter media will have a larger total surface area available for biofilms to grow on, and therefore more biofilm can be exposed to raw water. Therefore, removal efficiency increases. The empty space or pore size within a filter medium is important for determining the right filter size and efficiency. Pore size is a measure of how much of the medium consists of empty space. The filter efficiency depends on the ratio of filter media surface area to its volume, which means total specific surface area (SSA) per cubic metre. Despite this enormous SSA, sand would make a poor filter medium because the small particle size would soon lead to blockages. Because of the dense packing, any flow through the sand would be very slow. Therefore despite its massive surface area, the volume of water that could be treated per hour would actually be quite small

For a medium such as gravel, it is larger in size and less in SSA that would make it less prone to blocking. Special media such as filter matting, plastic or sintered glass, have both a large SSA and a generous void space. In fact, many of them are more than 90% void or empty space. This makes blockage almost impossible.

Filtration rate also has a significant influence on the particle removal. Many reports described that good removals in the roughing filters were achieved at low filtration rates. It is attributable that low filtration rates give support to retain particles that are gravitationally deposited to the upper side of filter media. It is important to have laminar flow conditions.

3.1 Advantages of Roughning filter

Conventional system is quite demanding in chemical use, energy input and mechanical parts as well as skilled manpower that are often unavailable. But roughing filters do not require chemical use, and mechanical parts. Due to high operating cost of conventional treatment technology compare to that HRF posing cheapest technology.

Remove solid matter from water more effectively by reducing sedimentation distance. Intake filter 50-70% reduction in solid content, roughning filter 90% reduction, 90-99% reduction in coliforms, and suitable technology for rural using different multimedia.

4. MATERIALS AND METHODS

The model was fabricated with GI sheet and consists of three reactors placed in series with the total reactor volume 25 liters. The model is based on the principle of attached growth system. The wastewater was fed into the inlet chamber having the dimension as 60 x 20 x 25 cms. The first reactor is 20 x 20 x 25 cms in dimension and having the down flow movement. The second reactor is 20 x 20 x 25 cms in dimension and having the up flow movement. The third reactor is 20 x 20 x 25 cms in dimension and having the down flow movement. The collecting chamber is followed by the third reactor having the dimensions 15 x 30 x 40 cms. The inlet level was at 35 cms from the bottom of the tank and the outlet level was placed at 15 cms from the bottom of the tank.

5. RESULT AND DISCUSSIONS

Practical experiences with horizontal roughning filter

Table no. 5.1

SR. NO	PARAMETERS	INFLUENT	EFFLUENT	% REMOVAL
1	PH	6.942	7.108	-
2	TURBIDITY (NTU)	150	18	88
3	BOD (mg/l)	210	74	65.25
4	COD (mg/l)	538.36	114.21	78.78

Wastewater contains a variety of inorganic and organic substances from domestic sources. The wastewater parameters namely BOD, COD, TURBIDITY and pH were analyzed. The procedure followed for calculating the parameters are the standardized methods.

6. CONCLUSION

HRF can be used effectively to treat different types of wastewater and it designed in such a way to get benefit of the removal of particle. It can be also performed by using different combinations of microbial growth process. Performance of system can be extended to find out the different parameters such as nutrients, minerals, micro-organism *etc.* present in the treated wastewater.

By improving the design and minimizing the construction cost this technique of treatment of waste water can be effectively used in rural area of country as it does not require energy for operation also its maintenance and operating cost is negligible.

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