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Mini Review Paper

Performance of Horizontal Roughing Filters for Wastewater: A review

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Abstract

Horizontal roughing filter (HRF) technology is a low cost treatment technology based on physical process to treat wastewater by removing contaminant like COD, BOD, turbidity and suspended solids for a wide range of applications in domestic as well as industrial applications. This article describes different component of horizontal roughing filter including design parameter. This paper intends to provide an overall vision of Horizontal roughing filter technology as an alternative method for treating wastewater in different Industrial applications. The present review focus on existing types of roughing filter, mechanisms of particle removal and applicability of HRF system for treating wastewater

Key Words: Sedimentation, wastewater treatment, particle removal, types of hrf, application of HRF.

Introduction

Water supplies continue to decrease because of resource depletion and pollution, whilst demand is also rising fastest because of rapid growth population, industrialisation, mechanisation and urbanisation Industrial pollution is one of the problems presently facing the entire world and several efforts are being vigorously pursued to control it. If untreated wastewater is discharged into natural water courses, it can cause public health and environmental problems.

Previous studies have shown gravel roughing filtration to be an effective and reliable method for removing suspended solids. Roughing filters are simple, efficient and inexpensive wastewater pre-treatment technology compared to the conventional system[1]. This is in terms of technical labour requirement, daily operation, maintenance costs and treatment efficiency and effectiveness. Roughing filters are used primarily as pre-treatment for filter systems that may not be able to tolerate high turbidity or suspended solids in the source of wastewater. Roughing filters are mostly used to separate fine solids from the water that are only partly or not retained at all by stilling basin or sedimentation tanks for suspensions with particulates that do not readily settle, roughing filtration provides superior treatment to basic sedimentation methods[2] and represents an attractive alternative to more costly conventional coagulation methods. Successful modifications include the design concept and process capabilities for roughing filter can achieve better treatment quality.

Types of roughing filters: Roughing filters are classified by their flow patterns in the reactor system. These include flow of roughing filters down flow roughing filters and horizontal roughing filters. A typical roughing filter consists of a series of graded gravel beds, with the first bed having the coarsest material and the final bed having the finest material. Typical roughing filters have gravel of different sizes in different number of compartments.

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[3]. 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[2]. 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.

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.

Roughing Filter Design Parameters; Filter media: Media types commonly used in roughing filtration are quartz sands and gravels but can be replaced by any clean, insoluble, and mechanically resistant material. Previous work showed that the effect of surface porosity and roughness of filter media on particle removal efficiency in roughing filtration was insignificant compared to the size and shape of macro pores in the filter (Lin et. al., 2006). Gravel is the commonly used filter media although a few studies have investigated other media. One HRF field study completed by the Blue Nile Health Project experimented with broken burnt bricks. The results from these performance tests showed that exchanging gravel for palm fibre in the first compartment improved the suspended matter removal by 28%[2]. The use of multiple grades of filter media in a roughing filter promotes the penetration of particles throughout the filter bed and takes advantage of the large storage capacities offered by larger media and high removal efficiencies offered by small media. The size of filter media decreases successively in the direction of water flow, and ideally the uniformity of filter media fractions is maximised to increase filter pore space (storage capacity) and aid in filter cleaning[4].

Filtration rate: Filtration rate also dominate treatment removal efficiency. Good removal in roughing filters is best achieved with low filtration rate[4], because low filtration rates are critical to retain particles that are gravitationally deposited to the surface of the media. While as pretreatments used for removal of iron and manganese were able to operate at filtration rates of 1.5 - 3 m/h. Researchers reported that horizontal flow roughing filter is capable of removing metals like iron, manganese, turbidity and colour at a filtration rate of 1.8 m/h[3]. Coarse particles penetrate deeper into the bed and these will cause decrease in filter efficiency, whereas at 1 m/h there was good distribution of solids loading throughout the bed. Previous study suggested that normal filtration rate of horizontal roughing filters is between 0.3 and 1.5 m/h.

Hydraulic Retention Time (HRT): Sedimentation process play important role for filtration mechanism in roughing filtration and various studies have shown that improved removal efficiencies are correlated to slower hydraulic loading rates when flow in laminar. Operation of roughing filters under laminar flow conditions is essential to maximise removal efficiencies. Flow conditions are described by the Reynold's number, which can be calculated through a porous medium by the following equation[2].

$Re = (Vd_c) / \nu$

Where, V = hydraulic loading rate (m/s), d_c = collector (media) diameter (m), ν = kinematic viscosity = 1.004×10^{-6} m^2/s at 20°C

Filter length: To increases the removal efficiencies of filter which are directly correlated to longer filter lengths. However, incremental removal efficiencies tend to decrease with increasing filter length due to the preferential removal of larger particles early in the filter[2]. The rate of decline is dependent on filter design variables and the size and nature of particles in suspension. By using different media and sizes that could lead to meeting shorter filtration rate compared with long filter packed with one media size.

Particle Removal Mechanism of Roughing Filters: Suspended Particles in wastewater may be removed in roughing filters by one of three mechanisms. These include: surface filtration, straining filtration, and Physico-chemical filtration. Filtration is defined as the process of removing suspended solids from a fluid by passing it through a porous. The filtration process can also be classified according to the location where the deposits are retained: surface filtration and deep bed filtration.

In surface or cake filtration the bed consists of small size grains and most of the deposits are retained on and in the top layer. Due to the potential presence of small-sized particles in raw surface water, sedimentation and adhesion to media particles, not mechanical straining, are the main filtration process in roughing filter. Fine particles do not normally have long enough residence times in a settling basin to overcome a large settling distance. However, the presence of the media decreases the settling distance and allows fine particles to adhere to a sticky bio-film that has formed on the surface of the media. Removal of suspended solids in RF requires laminar flow. A sticky organic film on the surface of the media or in the pores retains the suspended solids by mass-particle attractions through the van der Waals forces and electrostatic forces between charged particles[2].

Advantages of roughing filters: 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, Roughing filter 90% reduction, 90-99% reduction in coliforms, and Suitable technology for rural setting – uses local material

Disadvantages of roughing filters: Colour removal is fair to poor and in some cases it requires a large area of land for effective treatment. It can handle only relatively low strength wastes compared to conventional methods. It also can handle only very low organic loads compared to conventional treatment methods such as activated sludge process. Cannot treat stable colloidal suspension needs coagulant and Needs to clean filter. HRF has advantage of being able to tackle relatively high raw water turbidity, whilst at the same time offering long filter run time.

Conclusion

HRF can be used effectively to treat different types of wastewater and it designed in such way to get benefit of the removal of particle as well as microbes. Having the capability of simultaneous sedimentation and filtration, horizontal-flow rough filtration is an applicable alternative for supplying drinking water. Highest percentage removal was obtained for the filtration velocities below 1.5 m/h for color and turbidity, and below 2 m/h for algae removal. Field-scale experiments show that filter length does not provide a significant effect on the percentage reduction of algae count, color and turbidity. Achieved results in previous study shows that roughing filtration may be considered as efficient pre-treatment process increase surface water is used as water supply for treatment. But this can be achieved best result for wastewater, if applied to appropriate source waste and when designed and operated properly.

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References

1. Onyeka Nkwonta and George Ochieng, Roughing filter for water pre-treatment technology in developing countries: A review, *International Journal of Physical Sciences,* **4(9),** 455-463 (**2010**)
2. Wegelin M., Surface water treatment by roughing filters. A design, construction and Operation manual, Swiss Federal Institute for Environmental Science and Technology (EAWAG) and Department Water and Sanitation in Developing Countries (SANDEC), **(1996)**
3. Dastanaie J., Use of horizontal roughing filtration in drinking water treatment, *Int. J. Sci. Technol,* **4(3),** 379-382 (**2007**)
4. Boller M., Filter mechanisms in roughing filters, *J. Water Supply Res. Technol. Aqua,* **42(3**), 174-85 **(1993)**
5. Clarke B.A., Lloyd B.J., Crompton J.L. and Major I.P., Cleaning of up flow gravel prefilters in Multi-stage filtration water treatment plants, in Advances in Slow Sand and Alternative Biological Filtration, ed **(1996)**
6. Collins M.R., Westersmund C.M., Cole J.O. and Roccaro J.V., Evaluation of roughing filtration design variables, American Water Works Association Research Foundation and American Water Works Association **(1994)**
7. Dome S., How to estimate and design the filter run duration of a horizontal flow roughing filter, Thammasat, *Int. J. Sci. Technol,* **5(2), (2000)**
8. Mahvi A.H., Performance of a DHRF system in treatment of highly turbid water, *Iranian J. Environ, Health Sci. Eng.,* **1(1**), 1-4 **(2004)**
9. Mukhopadhay B. and Majumder M., Verification of filter efficiency of horizontal roughing filter by wegelin design criteria and artificial neural Network, Copernius publication **(2008)**
10. Ochieng G.M. and Otieno F.A.O., Performance of different filter media against conventional water treatment system, *Watersa,* **30 (2004)**
11. Ochieng G.M. and Otieno F.A.O., Verification of wegelin design criteria for horizontal flow roughing filters with alternative filter materials, *Watersa,* **32 (2006)**
12. Pacini V., Removal of iron and manganese using biological roughing up flow filtration technology, *Water Res,* **399,** 4463-4475 **(2005)**
13. Rooklidge S.J. and Ketchum K.L., Calcite amended horizontal roughing filtration for clay turbidity removal, *J. Water Supply Res. Technol,* **5(6),** 333-342, **(2002)**
14. Metcalf and eddy, Wastewater Engineering **(2003)**

Table-1
Typical media grades used in roughing filtration

Roughing filter description	Filter Media Size (mm)		
	1st fraction	2nd fraction	3rd fraction
Coarser	24 – 16	18 – 12	12 – 8
Normal	18 – 12	12 – 8	4 – 8
Fine	12 – 8	8 – 4	4 – 2