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Efficiency of Multimedia Pressure Sand Filter for Reducing Turbidity

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ABSTRACT
Surface water when used as source of drinking water has to be treated. There is an urgent need to find effective and economical techniques for water filtration system for public water supply and industrial purpose. Using a graded multimedia the flow rate of the pressure sand filters can be increased and by increasing the flow rate, the area required for the filtration unit can be reduced by two times. In order to carry out the studies a pilot scale model was used with all provision for experimentations and monitoring system. Test runs were carried for the filtration, filtration process monitoring and filter back washing. Filtration rate was carried out at a rate of 490 litres per hour. Raw water modified through mixing the bentonite clay for the desired turbidity was used as the feed water. In this paper the filter runs results for turbidity under pressure variations are discussed.

I. INTRODUCTION

Water is one of the most essential requirements for the human survival. To achieve high quality of potable water, the water has to be given the series of treatment. The surface water and subsurface water are used as the main source of water supply. The main problem in using the surface water as a source of water supply is the higher concentration of the suspended solids, dissolved solids and clay which causes turbidity in water. Filtration process in water treatment is one of the most common methods to reduce clay and suspended solids in water. In filtration process the water is purified by passing the water through the bed of porous media, which causes the retention of clay and suspended matter within it. As the water flows through the filter media particles are deposited on the surface of the granules by interception, diffusion, gravitational settling, inertial impaction force, electrical migration or combination of two are more of these effects. in water treatment process slow sand filter and rapid sand filters are widely used for the removal of suspended solids present in the water. Pressure sand filters are used as the substitute for the rapid sand filters with the difference that they occupy less space for treatment and the driving force required for filtration is obtained by pumping liquid to be filtered.

The media grain size which affects the efficiency of filtration is considered to be an indicator of the size of the particle that could be removed by the media. The finer the media, the smaller the particle size removed and better the quality of the filtration process although, a smaller size filters media requires more frequent cleaning. The effective diameter and uniformity coefficient are the two indicators of the filter media grain size. The media effective diameter is defined as the size of the screen opening which will allow 10% of the total sand sample mass to pass. The uniformity coefficient is the ratio between the screen pores that let pass 60% and 10% of the sand. a uniform sand media has a low uniformity coefficient value while a good graded media is characterised by high uniformity coefficient value. For pressure sand filters a uniformity coefficient value of 2 is recommended although other researchers working with the lower uniformity coefficients suspended matter trapped by the filter decreases with the water flow rate across the filter.

The present study focuses on investigating the effect of the different media combination of media on flow rate and efficiency of the filtration

II. MATERIALS AND METHODOLOGIES

The entire study can be divided into following parts

- Characterization of the filter media
- pilot scale filtration system setup
- pilot scale experimentation on sand media

Characterization of the filter media:

Under this element of the work all the media brought were subjected to sieve analysis in order to find out the effective diameter and uniformity coefficient. For the sieve analysis the following procedure was followed.

A known amount about 2kg of filter media was dried and sieved through a series of nine sieve screens ranging from 00.75 to 20mm pore size decreasing from top to bottom by sieve shaker. Then the material retained on each screen was weighed to determine the weight of retained sand. The sieve analysis results for the sand and the crushed marble are shown in the table

Table 1: sieve size analysis for sand

Sieve size (mm)	Mass retain(kg)	Cumulative wt. retained (kg)	Cumulative wt. retained (%)	Cumulative wt. passing (%)
20	Nil	Nil	Nil	Nil
10	Nil	Nil	Nil	Nil
4.75	Nil	Nil	Nil	Nil
2	0.0075	0.0075	0.367	49.6
1	0.25 95	0.267	13.39	86.61
0.425	1.4515	1.719	86.20	13.8
0.212	0.21 2	1.931	96.86	3.14
0.15	0.0285	1.959	98.29	1.71
0.075	0.0205	1.979	99.2	0.8
Pan	0.0135	1.993	100	0

Table 2: sieve size analysis for crushed marble

Sieve size (mm)	Mass retain(kg)	Cumulative wt. retained (kg)	Cumulative wt. retained (%)	Cumulative wt. passing (%)
20	Nil	Nil	Nil	Nil
10	Nil	Nil	Nil	Nil
4.75	Nil	Nil	Nil	Nil
2	0.010	0.010	0.50	99.5
1	1.631	1.641	82.41	17.59
0.425	0.224	1.865	93.46	6.54
0.212	0.0435	1.908	95.47	4.53
0.15	0.015	1.923	96.48	3.52
0.075	0.021	1.944	97.48	2.52
Pan	0.046	1.990	100	0

Pilots scale filtration systems :
The pilot scale study requires the following facility setup. the specification of the laboratory scale model are shown in the table below:

- A pressure filtration system
- A pump with the necessary flow control
- Raw water tank for preparing, storing and dosing of the desired turbid water
- Butterfly valve
- Back wash water tank
- Pump with piping and regulators for pumping the back wash water through the filter media
- Pressure and differential pressure monitoring system.

Table 3: specification of lab scale model

Sl. No.	item description	design specification
1	Type of valve	Vertical pressure vessel with the manual butterfly valve
2	Material	FRP
3	Size of the vessel	137cm Diameter
4	Flow rate	0.49cub m/hr
5	Operating pressure	2-2.5 kg/ sq cm
6	Filtration velodity	10m/hr
7	Filtration area	0.049sq.m
8	Total bed depth	900m
9	Type of filter media	River sand with pebbles and gravels as media
10	Depth of fine sand	700mm

11	Effective size of fine aggregate	0.36mm
12	Bulk density of sand	1250-1550 kg/cub m
13	Quantity of sand	49kg
14	Back washing	the pressure difference in the inlet and outlet pressure gauges is 0.8 kg/sqcm
15	Back wash duration	15-20minutes
16	Back wash mode	Pressure
17	Back wash velocity	50m/hr
18	Design flow	10cub m/hr

Raw water preparation:

Bentonite clay was mixed with water in a container. It was then transferred to the raw water tank and agitated continuously for the whole of the experimental duration using mechanical agitators so as to maintain the turbidity of 20-40NTU.

Filtration runs:

The manual butterfly valve was set at filtration mode before starting the pump, the tank water is thoroughly mixed to get the uniform quality of water. The flow rate was set to 490lt/hr. the uniform flow rate was maintained throughout the experiment then the water was allowed to enter into the filter media. Inlet and outlet samples were collected at the regular interval during the experiment to monitor the filter. Differential pressure at different points and the overall pressure built up were recorded at regular intervals.

Back washing of filter:

When the pressure differences at both the inlet and outlet pressure gauges was 0.8 kg/sqcm. filter was back washed. Back washing was done at the rate five times of filtration. Butterfly valve was setup at backwash mode. Back washing was done for 15-20minutes.

III. RESULTS AND DISCUSSION:

Characterization of the filter media:

Characterization of the filter media used in Pilot scale experiment obtained from sieve analysis is shown in the table

Table 4: D_{10}, D_{60} and uniformity coefficient for sand and crushed marble analysed

Media	D_{10}	D_{60}	D_{60}/D_{10},
sand	0.3 6	0.76	2.1
crushed marble	0 .7	2.1	2

PILOT SCALE EXPERIMENTATION:

Table 5: pressure filter media experiment results:

Sl. No.	Start time	Stop time	Duration	Pressure (kg/sqcm)		Turbidity		
				Inlet	Outlet	Inlet	Outlet	% removal
1	2:30 PM	3:00 PM	0	0.80	0.70	22.2	3.14	85.85
			15	0.80	0.75	21.5	0.61	97.16
			30	0.75	0.75	22.5	0.51	97.73
2.	3:45 PM	4:15PM	0	0.80	0.70	23 .3	0.67	97.12
			15	0.85	0.80	22.5	0.66	97.06
			30	0.80	0.75	17.5	0.57	97.17

The pressure filter with river sand as media was run at the rate of 490lt/hr with turbidity created through addition of bentonite clay; the inlet turbidity was maintained at the range of 20-40 NTU. Pressure media filter run results obtained from such experimentation and monitoring are given in the table above. The test results show that the pressure filter media was effective in reducing the turbidity of the waste water. The media need to be back washed when the pressure difference in the inlet and outlet pressure gauges is 0.8 kg/sqcm. The back washing was found to be done at the rate of 50m/hr. total time required for back washing was found to be 15 to 20 minutes. The total amount of the water required for back washing was 0.408 m^3.

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