International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 07 | July-2016 www.irjet.net p-ISSN: 2395-0072

Influence of Pre-detention of Water on Efficiency of Natural Media Filtration

Pallavi U.Pharalad[1], Rajkumar V.Raikar[2]

[1]*PG Scholar, Department of Civil Engineering, KLE Dr. M. S. Sheshgiri College of Engineering and Technology, Belgaum, India*
[2]*Professor, Department of Civil Engineering, KLE Dr. M. S. Sheshgiri College of Engineering and Technology, Belgaum, India-590 008*

Abstract - *This paper presents the experimental results on the pretreatment of surface water by natural media filtration following the detention of water samples. The treatment process considered in the study consisted of detention of sample in four compartments separated by baffle walls of gradually increasing height at selected distances and filtration through natural media filter beds consisting of different sizes. The experiments were carried out in a pilot scale model fabricated of MS sheet and placed at negligible slope. The water sample from Angol Lake of Belgaum city in Karnataka was analyzed during the period of December 2015 to may 2016. The influent flow velocity was kept constant at 0.005 m/s while the inflow concentration, filter bed and filter media were varied. Total 33 experimental trials were studied, which consisted of 6 runs with constant detention period of 2hr-55 min, 6 runs with constant volume of effluent of 30 liters and 21 runs with constant flow rate. The removal efficiency of four water quality parameters EC, TSS, TDS and turbidity were studied. The results show that the optimum removal of EC, TSS, TDS and turbidity were respectively 44%, 21.5%, 57.9% and 91.97% among all experimental runs.*

Key Words: Surface water, Water quality parameters, Filtration, Filter media beds, Detention

1. INTRODUCTION

Surface water is the one of the major natural resources available on the exterior of earth crust such as in lakes, rivers, streams and others. The quantity of water that can be extracted from these sources depends on external conditions of nature like climate change, geology and geographic conditions. Surface water pollution is the contamination of these water bodies. Contamination might be due to natural or anthropogenic activities as rapid increases of urbanization, industrialization, sewage leaks, and agricultural runoff, chemical spills, and others [1]. It can affect biological communities as well as the health of those who depend on surface water sources. Further, the surface water manifests itself in the form of the impairment of quality of water. The effluent which comes out from the agricultural, industrial and domestic is more responsible for the degradation of water quality [2]. Therefore, the regular treatment processes are carried out to reduce the impact of polluted water over an aquatic as well as human life and also increases the sustainable conservation of surface water resources [3].

In this context, many researchers have undertaken the studies on the pre-treatment of surface water and ground water by using various filtration processes in India and in other countries. Peiris et al. [5] used deep bed filtration and membrane bed filtration where filter media used was sand, anthracite, and gravel with different layers of filter bed and found the bacterial removal efficiency of 99%. Delbazi et al. [6] employed fine gravels, coarse gravels and charcoal pieces as filter media and reported that the removal efficiency of turbidity, TSS, TDS was respectively, 89.53%, 91.56% and 62.19%. Atish Kumar and Gidde [7] studied the particle removal efficiency as well as turbidity removal through dual media filtration and obtained turbidity removal of 60-80%. They reported that the advantages of these methods are high removal of bacterial and turbidity. Roughing filtration method was used by Nkwonta and Ochieng [8] and indicated that it is the better suited water treatment process and improves the quality of water through removal of turbidity and solids by75% and 89%, respectively. Hence the investigations on increasing the efficiency of the filtration process are essential to increase the production capacity of filter, reduce the clogging as well as frequency of backwashing. In this perspective, the present study emphasize on effect of detention phenomena of water sample through horizontal flow followed by vertical flow filtration using natural media filter. The water samples of Angol Lake in Belgaum city is used in this case study.

2. EXPERIMENTATION

The experiments were carried out in pilot scale experimental model fabricated with MS sheet of scale ratio 1:1000. The length of the model was 1.5 m, width 0.25 and depth 0.25 m. the model was divided into two parts: detention part and filtration part. Detention part was divided into four compartments of 0.25 m length separated by baffle walls of increasing height in the direction of flow in order provide larger settling time for the sediments at the higher levels. The filtration unit of 0.5 m length followed the detention tank. The experimental setup was placed at negligible slope. The raw water collected from Angol Lake was fed to the filter

through a tank of 100 liter capacity. The effluent was collected in a tank of capacity 35 liters. The raw sample flows horizontally through each compartment. The flow rate was maintained at 0.005m/s throughout. During the flow in each compartment some of the contents settle down. After the fourth compartment the water sample flows through horizontal bed consisted of multiple layers of different media. After the samples infiltrates and passes out of the filter media, it was collected in effluent tank of capacity 35 liters. The filter media consisted of 6 filter material of size 0.3mm, 0.6mm, 1.18mm, 2.36mm, 4.75mm, & 6mm sizes considered with different combination of layers and thickness. Table 1 gives the details of combinations. The water samples were collected after passing through each compartment. That is from each of four compartments and also from the effluent tank. The water samples were tested for EC, TSS, TDS, and Turbidity using BIS: 10500-2013 methods.

Table 1: Filter media with combinations.

Number of bed	Size of filter media grain with combinations
Single bed media of 6 trials	6 mm, 4.75 mm, 2.36 mm, 1.18 mm, 0.600mm, 0.3 mm
Double media bed of 5 trials	6+4.75 mm, 4.75+2.36 mm, 2.36+1.18 mm, 1.18+0.6 mm, and 0.6+0.3 mm.
Three layers of media bed of 4 trials	6+4.75+2.36 mm, 4.75+2.36+1.18 mm, 2.36+1.18+0.6 mm, and 1.18+0.6+0.300 mm.
Four layers of media bed of 3 trials	6+4.75+2.36+1.18 mm, 4.75+2.36+1.18+0.6 mm, and 2.36+1.18+0.6+0.300 mm.
Five layers of media bed of 2 trials	6+4.75+2.36+1.18+0.600 mm, & 4.75+2.36+ 1.18+0.6+0.300 mm.
Six layer of media bed of single trial	6+4.75+2.36+1.18+0.6+0.300 mm.

3. RESULTS AND DISCUSSION

The experimental results of water quality parameters EC, TSS, TDS, and Turbidity are presented. Totally 33 experimental runs were takes with three different conditions. They are: (i) Six filtration runs with constant retention period of 2hr-55 min; (ii) 6 runs of filter operation with constant treated effluent volume of 30 liters; and (iii) 21 experimental trials with constant flow rate at 0.005 m/s varying other parameters. The removal efficiency of these four water parameters are determined and presented here. It was found that the efficiency of natural media filtration depends on the size of the filter media, surface area of the filter bed, dimensions, and depth of the filter bed and flow rate of water through the filter.

Parameter analysis for Constant Retention Period

Fig. 1 shows the variation in percentage removal of water quality parameters such as EC, TDS, TSS and turbidity through single bed filter with various size of filter material under constant retention period of 2hr-55 min. The highest removal efficiency of EC, TDS, TSS and turbidity through detention and single bed filter media having 0.3 mm sand is 35.89%, 17.21%, 52.96% and 89.04%, respectively. This may be due to low porosity of sand as well as surface area of filtration. Hence, the variation presents an increasing removal of water quality parameters with decrease in the grain size of filter material. Similar results were also obtained by Zaidun Naji Abudi [9] who found that 89% of removal of turbidity through filter media size of 0.3 mm.

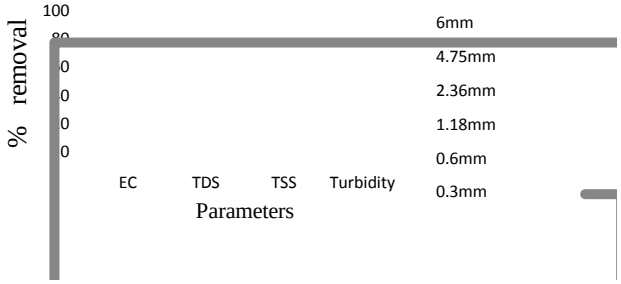

Fig. 1. Variation of percentage removal of water quality parameters with different grain size of filter media of single bed under constant retention time

Parameter analysis for Constant volume of Effluent

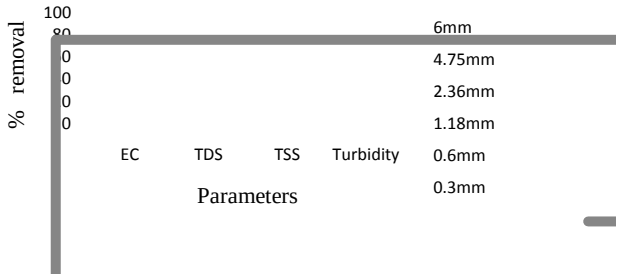

Fig. 2. Variation of percentage removal of water quality parameters with different grain size of filter media of single bed under constant effluent volume

Fig. 2 presents the variation in percentage removal of water quality parameters such as EC, TDS, TSS and turbidity through single bed filter with various size of filter material under constant volume of effluent of 30 liters. It is seen that the maximum removal efficiency of EC, TDS, TSS and turbidity were obtained through detention and filter media of 0.3 mm size is respectively, 38.43%, 17.86%,

Filter media size	Parameters	Compartments				Filter	Total % removal
		1	2	3	4		
Single bed of 0.3mm	EC	8.74	10.4	2.54	1.39	3.66	26.75
	TDS	0.04	0.03	0.28	0.069	0.09	0.51
	TSS	3.5	2.3	3.8	1.15	0.77	11.5
	Turbidity	4.3	7.3	20.2	9.50	12.33	53.6
Duel bed of 0.6+0.3 mm	EC	1.4	2.68	6.85	8.69	8.63	28.24
	TDS	0.07	0.178	0.147	0.089	0.11	0.59
	TSS	2.89	3.5	1.50	0.99	5.01	13.89
	Turbidity	40.1	4.28	2.52	2.57	14.82	64.3
Three layer bed of 1.18+0.6+0.3mm	EC	1.4	4.51	3.43	15.3	4.6	29.1
	TDS	0.2	0.09	0.12	0.09	0.4	0.87
	TSS	10.7	5.7	2.87	0.00	2.16	21.44
	Turbidity	20.1	12.8	4.88	18.4	9.31	65.43
Four layer bed of 2.36+1.18+0.6+0.3 mm	EC	0.06	0.05	0.577	3.86	29.74	31.33
	TDS	0.45	0.24	0.28	0.66	0.44	7.8
	TSS	1.29	4.52	8.39	9.7	8.38	40.8
	Turbidity	32.7	9.71	9.36	5.75	15.2	62.02
Five layer bed of 4.75+2.36+1.18+0.6+0.3 mm	EC	4.69	8.15	7.81	16.1	1.44	38.1
	TDS	0.33	1.15	2.84	1.05	2.07	7.43
	TSS	4.5	7.9	11.8	8.2	9.1	41.5
	Turbidity	33.3	0.7	2.64	0.23	32.44	69.35
Six layer bed of 6+4.75ss+2.36+1.18+0.6+0.3 mm	EC	16.4	3.7	0.97	10.1	7.64	38.72
	TDS	1.8	1.31	3.15	4.42	0.58	11.2
	TSS	21.8	6.63	9.38	3.13	6.25	47.9
	Turbidity	28.6	9.22	10.1	12.1	9.77	69.68

56.25% and 91.2%. It may be due to decrease in ion concentration by their low porosity and surface area of filter bed. Hence, it can be shown that the increase in grain size results in decrease of removal of turbidity.

Parameter analysis for Constant flow rate of filter

The experimental results on the percentage removal of water quality parameters (EC, TSS, TDS and turbidity) by detention in various compartments and through horizontal filter with single to multi-layered media under constant flow rate of 0.005 m/s are furnished in Table 2 and presented in Fig.3 to Fig. 8. Table 2 presents the percentage removal of water quality parameters with different size of media having single bed and multiple bed media filters indicating the minimum and maximum removal efficiency values in each compartment of detention and through the filter, These are the average values of the water quality parameters tested at every one hour interval following parameter analysis procedure prescribed by BIS: 10500-2013.

Table 1. Percentage removal of water quality parameters with different size of single bed filters media to multimedia filers

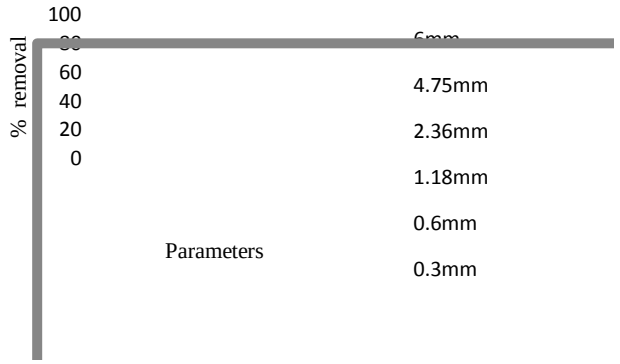

Fig. 3. Reduction of water quality parameters at different stages with single bed filter media

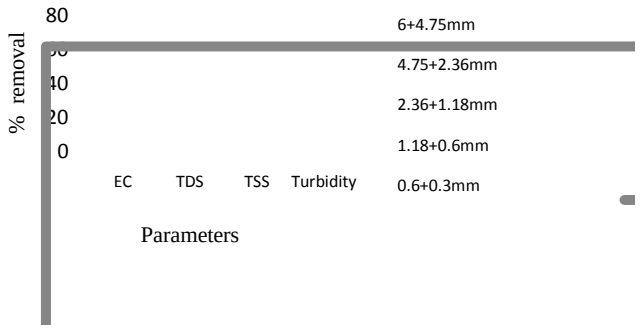

Fig. 4. Reduction of water quality parameters at different stages with double bed filter media

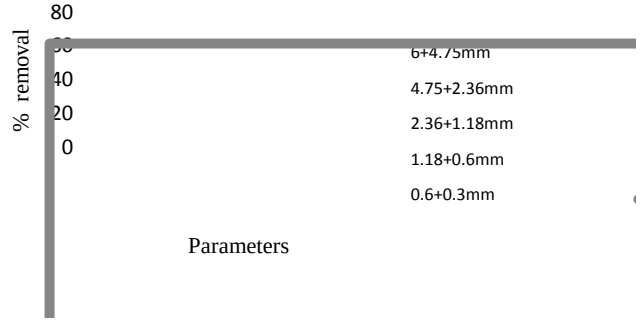

Fig. 5. Reduction of water quality parameters at different stages with three layer bed filter media

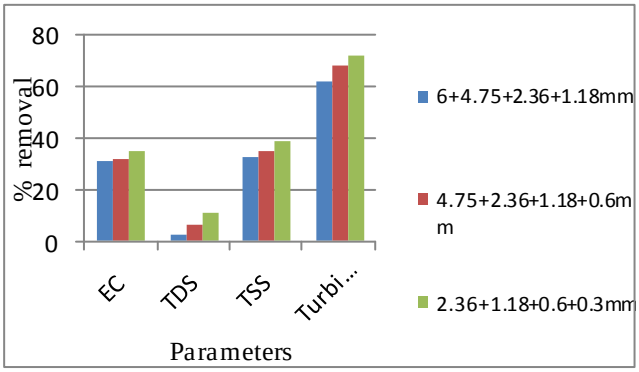

Fig. 6. Reduction of water quality parameters at different stages with four layer bed filter media

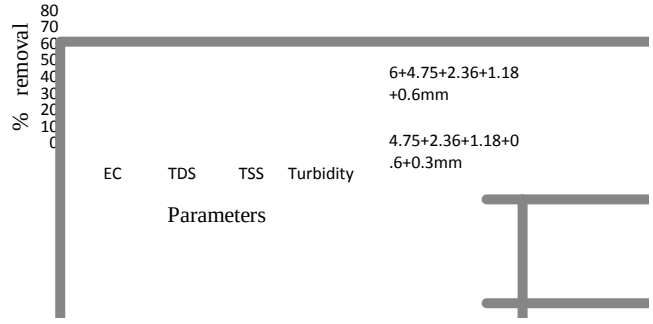

Fig. 7. Reduction of water quality parameters at different stages with four layer bed filter media

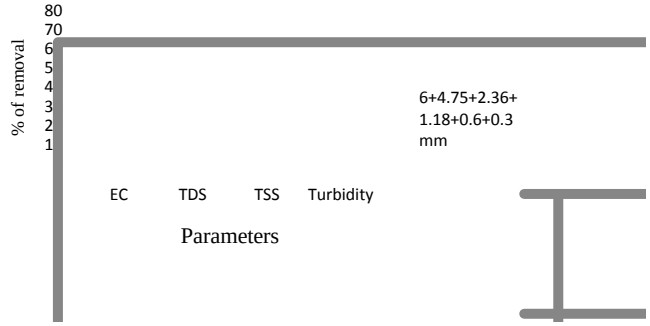

Fig. 8. Reduction of water quality parameters at different stages with four layer bed filter media

The percentage reduction in water quality parameters EC, TDS, TSS and turbidity through four compartments of detention tank separated by baffle walls and through different single bed filter consisting of 6mm, 4mm, 2.36mm, 1.18mm, 0.6mm and 0.3mm media is presented in Fig. 3. It is found that the total removal through detention and filter in 0.3mm media is given highest removal efficiency of EC, TDS, TSS and turbidity respectively by 44%, 21.5%, 57.9% and 91.97%. Zaidun Naji Abudi [9] also found that the percentage removal of turbidity with 0.35 mm size sand filter media as 89%, which is comparable with present study showing 91.97% removal of turbidity with 0.3 mm size filter media. Similarly, high efficiency of water quality parameters are reduced through four compartments along with dual media filter consisting of 0.6 mm+0.3 mm media as shown in Fig. 4. The total removal of EC, TDS, TSS and turbidity is 37.8%, 11.2%, 44.8%, and 74.38%, respectively. In case of three layered filter beds along with detention, the maximum removal of EC, TDS, TSS and turbidity is obtained in case of 1.18mm+0.6mm+0.3mm media and the respective values are 35.22%, 10.45%, 36%, and 72.93% as illustrated in Fig. 5.

Fig. 6 illustrates the reduction in water quality parameters EC, TDS, TSS and turbidity through different four layer bed filters were examined at every one hour interval. It is found that the total removal through detention and filter with 2.36mm + 1.18mm + 0.6mm + 0.3 mm media is 35.05% of EC, 10.52% of TDS, 38.63% of TSS and 72.16% of turbidity. Further in case of five layered and six layered beds of filters run were carried out and the reduction of water quality parameters through respective multimedia filters was examined and the results are presented in Fig. 7 and Fig. 8, respectively. It is found that the total removal efficiency of EC, TDS, TSS and turbidity in five layer bed of 4.75mm + 2.36mm + 1.18mm + 0.6mm + 0.3 mm is 39.02%, 8.36%, 43.8%, and 69.96% and with six layered bed of 6mm + 4.75mm + 2.36mm + 1.18mm + 0.6mm + 0.3 mm media the respective removal efficiency of EC, TDS, TSS and turbidity is 38.72%, 11.2%, 47.9%, and 69.68%.

4. CONCLUSIONS

The following conclusions can be drawn from the experimental results carried out on natural media filtration for pre-treatment of surface water:

1. In natural media filter, suspended solids and turbidity were reduced throughout the filter media by using various filter media and filter beds.
2. The performance of horizontal flow detention along with vertical flow filter media has better performance than the conventional filter in removing the turbidity at high percentage and suspended solids with shorter retention period of filter run.
3. The removal efficiency of filter bed with 0.3 mm grain under constant flow rate of 0.005m/s and constant effluent volume of 30 liters is 38.43% of EC, 56.25% of TSS, 17.86% of TDS, and 91.2% of turbidity.
4. The removal efficiency of filter bed of 0.3 mm of grain size with constant flow rate of 0.005 m/s and constant total detention period of 2hr-55min is 35.39% of EC, 17.21% of TDS, 52.96% of TSS and 89.04% of turbidity.
5. Filtration runs with single bed filter media of 0.3 mm with variations in effluent volume and detention time resulted in higher removal efficiency than the other experimental runs having multi-bed filters. The efficiency for removal of EC, TDS, TSS and Turbidity with single bed filtration with 0.3 mm media size is

44%, 21.5%, 57.9% and 90.97%, respectively. Hence, finer the filter media, greater is the removal efficiency.

6. The filtration process following the detention of water sample reduce the load on the filter beds as the TDS is removed considerably by detention. This further reduces the frequency of backwashing of filters and enhances the overall efficiency of the filters.

REFERENCES

1 Hoorman J., Hone T., Sudman T. J., Dirksen T., Iles J., and Islam K. R. "Agricultural Impacts on Lake and stream water quality in Grand Lake St. Marys, Western ohio". Journal of water, Air and Soil pollution, 2008, Vol. 193, pp. 309-322.

2 Mohamed Ateia, M. Nasr, C. Yoshimura, and M. Fujii. "Organic matter removal from saline agricultural drainage waste water using a moving bed biofilm reactor". Journal of water science and Technology. 2015, Vol.8, Issue 78, pp. 1327-1333.

3 A. Bhattacharyya, A. Mazumdar, P. K. Roy, and A. Sarkar. "Conservation life cycle assessment of carbon flow through Harvested wood products". Journal of Ecology, Environment and Conservation. 2013, Vol.19, Issue 4, pp.275-290

4 C. Visvanathan, D. R. I. B. Werellagama, and R. Ben Aim. "Surface Water Pretreatment Using Floating Media Filter". Journal of Environmental Engineering, 1996, Vol. 122, Issue 1, pp. 25-33.

5 P. Peiris, J. Bailey, H. Ngo, and S. Vigneswaran**.** "Bacterial Removal from Secondary Sewage Effluent by a Combined Down flow Floating Medium Flocculator/Pre-Filter and Sand Filter". Journal of Engineering and material science, August 1998, vol. 5, pp. 193-200.

6 Delbazi, N., Ahmadi, M. M., Takdastan A., and Jaafarzade, N. "Comparison of Mono Layer Filter (Sand), Dual Media Filter (Anthracite and Leca) and Performance in Removal of Organic Matter and Turbidity". Iranian Journal of Health and Environment, 2011, Vol.4, pp. 301-312.

7 Atish Kumar, and Milind R, Gidde. "Design and Study of Low Cost Household Drinking Water Treatment Process for Rural Area". International Journal of Science and Technology, 2014, Vol. 2, Issue 5, pp. 21-29.

8 Onyeka Nkwonta, and George Ochieng. "Roughing Filter for Water Pre-Treatment Technology in Developing Countries". Journal of Environmental Engineering, 2009, Vol. 3, Issue 9, pp. 13-17.

9 Zaidun Naji Abudu. "The Effect of Sand Filter Characteristics on Removal Efficiency of Organic Matter from Grey Water". Journal of Science, 2011, Vol. 4, Issue 2, pp.143-156.

BIOGRAPHIES

Pallavi U.P : Postgraduate student, Department of civil engineering KLE Dr. M. S. Sheshgiri College of Engineering and Technology, Belagavi, India