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Improving the Initial Effluent Quality of a Rapid Sand Filter by Coagulants as Polymer in Back Wash

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Abstract: ***Need of water purification was realized by man in early stages of civilization. So, Central and State Government are making efforts to provide adequate and safe drinking water to the people by constructing water treatment plants in the country. In our country rapid sand filters are used in water treatment plant for filtration process through which fine particles are removed. Filtration process under goes degradation at initial and last phase which affect the initial effluent quality of filtrate after back washing. The rapid sand filter is important unit of water treatment plant which removes the flocs and colloids through filtration. Initial phase in which the colloids are deeply entered in the filter and clogging occurs earlier resulting in frequent back washing. After backwashing filter when rapid sand filter brought back in to normal operation high initial turbidity of filtrate is observed. It is in the form of turbidity spike. To reduce this turbidity spike filter conditioning is essential. The present study is for rapid sand filter conditioning using coagulants as polymer in different percentage during backwashing of rapid sand filter. The optimal dosage as well as corresponding points of application during backwashing will be determined based on laboratory scale studies which found to be improved in initial effluent quality of rapid sand filter.***

Keywords: rapid sand filter, backwashing, coagulants, initial effluent quality.

1. Introduction

The raw water under go different processes in water treatment plant by removing unwanted gases, turbidity and bacteria to converted into potable water. Rapid sand filter is one of the important unit which is removed the flocs and colloids through filtration. The backwashing of the filter is carried out after loss of head is reaches to 2 meter to 2.5 meter and turbidity is greater than 5 NTU. After back washing of the rapid sand filter it under go ripening process , during this process due to remaining of some colloidal within the filter media, first they appear in the form of sudden increase in turbidity which is first turbidity spike after that second sequentially sudden increase in turbidity appear due to remaining of colloidal above the filter media . After back washing due to sequential appearing of remaining colloidal in the form of turbidity spikes which decrease the initial effluent quality before staring normal operation of rapid sand filter. During ripening process the water is waste at beginning some of the water treatment plant till it reach the turbidity up to less than 5 NTU. Some of the water treatment plant it is recirculated but most of the plant it is wasted in India. Literature review*:* The sequential appearing of turbidity spike was studied by Amirtharajah and Westein, (1980) has studded the initial degradation of effluent quality for a granular media filter and its important application for the design and filter operation. Raymond, (1987) has suggested the different coagulants that interact with the particle surface and serving to reduce or eliminate the short range repulsive force that retard the aggregation and deposition. Kelly and Amirtharajah, (1987) has developed the conceptual theory for filter ripening and evaluate the effect of adding coagulants during backwashing of rapid sand filter. James and Amirtharajah, (2003) investigated the technique of extended terminal sub fluidization wash (ETSW) with little or no bed expansion. John, (2003) has developed the theory to improve the initial effluent quality of filtrate by Full Scale West Filter Backwash Water (FBW) by recycling and coagulation. Lin et al. (2011) has studded to improve the initial effluent quality of filtrate by using the three coagulants which are arranged in series with rapid sand filter. Po-Hsun Lin (2011) et.al, Fluidized-bed pretreatment of a rapid sand filter with alum (Al2(SO4)3•14H2O) has been shown to significantly improve performance during the initial portion of filter operation. Po-Hsun Lin (2012),et.al An Alum pretreated filter achieved better than 99.98% removal of an untreated clay suspension (~60 NTU) with filter effluent turbidity below the detection limit of 0.01 NTU. The Scope study is initial effluent quality of rapid sand filter reduce the turbidity of water above the sand media and within the sand media. Reduce the period of ripening of rapid sand filter. The objective of study is to improve the initial effluent quality of rapid sand filter by using various dose of polymer during backwash.

2. Materials and Methods

2.1 Materials

The required size of anthracite sand was obtained by sieve analysis. After sieving the sand was washed thoroughly with a water to remove all traces of residual compound. The specific gravity of sand was 2.65. b)D10 = 0.46 mm c) D60 = 0.78 mm d) Coefficient of uniformity = 1.69 .The coarser gravel supporting material is used in equal four layer with varying diameter 5mm to 50 mm at bottom of filter . The Water Treatment Plant Sludge (WTPS**)** was collected from underflow of the sedimentation tank in slurry form from Miraj water treatment plant. Alum is the coagulant used in plant and sludge basically consists of hydroxide flocs. To make it suitable and easy for dosing, it was first sun dried for 48 hrs to ensure complete removal of water content. After this, dried sludge was ground to a fine powder of approximately less than 150 µm. The specific gravity of sludge was determined by Pycnometer method and found to be 1.36. The dried WTP sludge dosage was given in terms of

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g/L. A range from 6 g/L to 16 g/L in multiples of 2 gm/L was used in the study. The polymer MAXSLOC-T (high density cationic polymer provided by Thermax, Pune) was used for the experiments. 0.5 ppm to 1 ppm strength polymer solution was used.

2.2 Methods

Design of rapid sand filter as a lab scale model. Coagulant dosage is decided by using Jar test. Turbidity is measured in NTU , Head loss is measured by piezometer , Flow is measurement by rotameter and volumetric method. Rate of filtration is maintained 5m/hr and backwashing velocity was 36 m/hour. Surface area of Filter is 78.5 cm^2 . The expansion of sand was 40 % with backwashing rate of 36m/hr. The stock solution was prepared by diluting 1 gram white granular powder of polymer in 1000 ml of distilled water. The polymer dosage was represented in terms of mg/L.

2.3 Experimental Procedure

The experiments of conventional coagulation and flocculation were conducted using jar test apparatus. The following procedure was followed for conventional coagulation and flocculation. Conventional Coagulation:1 L of the tap water sample was taken in each jar of jar-test apparatus. Then stirring of raw wastewater in the beakers was initiated and pre-determined dosage of coagulant was added in each jar. The water was rapidly stirred at 160 rpm for 1 minute after the addition of coagulant .The slow mixing was done at the speed of 10-20 rpm for 15 minutes. The jars were carefully removed and the contents were allowed to settle for 30 minutes. The supernatant from the each jar was collected for analysis without disturbing settled solids. 1 L of the tap water was taken in each jar of jar-test apparatus. Then stirring of raw wastewater in the beakers was initiated and pre-determined dosage of coagulant was added in each jar. The wastewater was rapidly stirred at 300 rpm for 2 minute immediately after the addition of coagulant, then an appropriate dose of polymer were given in each jar and content were further stirred for 1 minute. The water was then allowed to settle for 5 minutes and the supernatant from the each jar was collected for analysis without disturbing settled solids.

Prepare a stock solution of the chemical(s). All results of the jar tests are in parts per million or milligrams per liter. (1 ppm = 1 mg/L). Raw and coagulated-flocculated-settled water samples were analyzed for pH, turbidity and alkalinity according to the procedures described in standard methods (APHA, 1998). The pH was measured using pH meter. Turbidity for water samples was measured using a Hach 2100 series turbid meter and measured in NTU. Alkalinity was determined by titration procedure. The results obtained were used during the backwashing of rapid sand filter. The lab scale model of rapid sand filter was as shown in figure:1. For the each run the following parameters were monitored: loss of head during normal operation with respect to time, filtrate rate at the normal operation and during ripening period, turbidity during normal operation, during back washing, and during ripening period. For the each run at the end of back washing the polymer dose was injected. All the observations were recorded in tabular form to obtain the graphs.

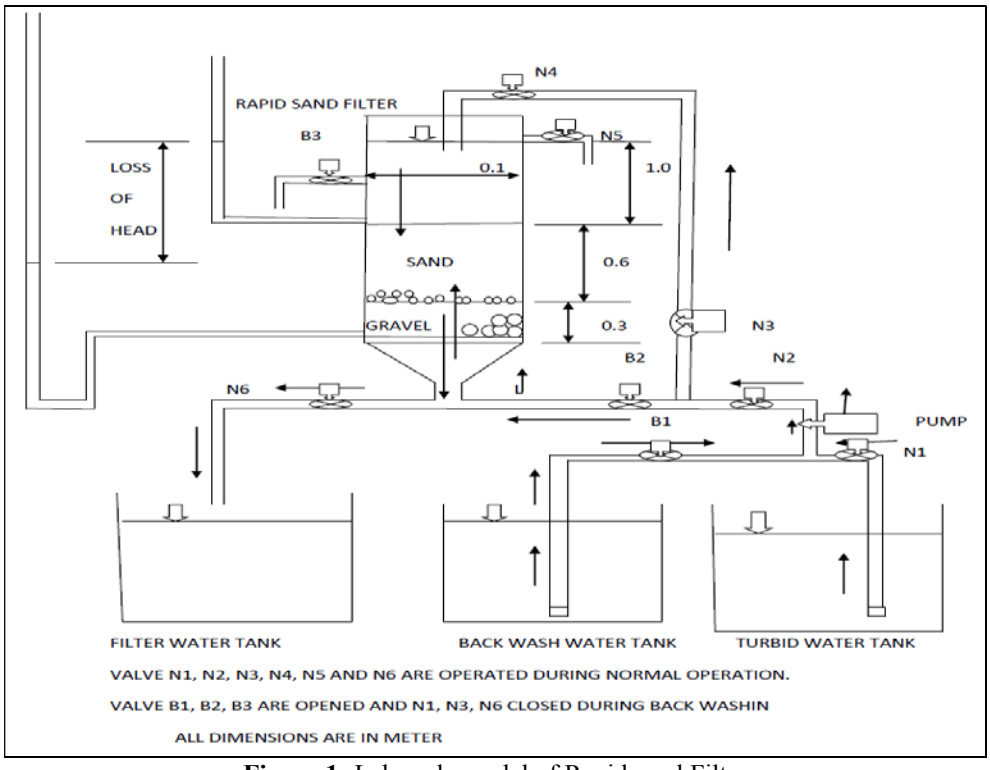


Figure 1: Lab scale model of Rapid sand Filter

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3. Results and Discussions

For Filter run observation (with and without coagulants in back washing):Normal operation of Rapid sand filter, Backwashing of Rapid sand filter, Ripening of Rapid sand filter Normal operation of Rapid Sand Filter :

Table 1: Loss of head during normal operation:

Time in Minute	Normal Run-1 (Loss of Head) in meter	Polymer:1ml Run-2(Loss of Head) in meter	Poymer:2ml Run-3 (Loss of Head) in meter	Polymer:3ml Run-4 (Loss of Head) in mete
0	0.29	0.32	0.3	0.29
15	0.3	0.32	0.3	0.29
30	0.3	0.32	0.3	0.29
45	0.35	0.32	0.3	0.29
60	0.4	0.32	0.3	0.29
75	0.45	0.32	0.3	0.3
90	0.46	0.32	0.3	0.3
105	0.47	0.39	0.33	0.35
120	0.49	0.43	0.35	0.39
135	0.51	0.48	0.39	0.41
150	0.55	0.53	0.44	0.46
165	0.56	0.57	0.49	0.49
180	0.58	0.62	0.55	0.53
195	0.6	0.65	0.59	0.57
210	0.62	0.69	0.63	0.61
225	0.65	0.71	0.67	0.65
240	0.71	0.76	0.69	0.69
255	0.71	0.79	0.73	0.71
270	0.71	0.84	0.79	0.75
285	0.71	0.84	0.85	0.79

Table 2: Back washing of Rapid sand filter:

Time in minute	Normal Run-1 B1 Turbidity in NTU	Poymer-1ml Run-2 B2 Turbidity in NTU	Poymer-2ml Run-3 B3 Turbidity in NTU	Poymer-3ml Run-4 B4 Turbidity in NTU
0	200	109	39.9	38.1
1	150	45.51	33.4	40
2	145	34.7	28.3	38.1
3	142	23.9	20.4	34.2
4	140	23	15.5	28.3
5	137	17.1	13.2	25.4
6	107	16.5	12.7	20.3
7	99.6	13.2	12.1	19.3
8	97.7	11	11.4	12.3
9	74	11.7	11.3	12.4
10	70.4	11.9	11.1	11.6
11	68.4	17.85	16.65	17.4
13	46.2	13.92	12.15	13.39
14	46	12.13	11.32	12
15	38.32	7.14	6.66	6.96

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Table 3: Ripening period of Rapid sand filter

Time in Minute	Normal Run-1 Ri1 Turbidity in NTU	Poymer-1ml Run-2 Ri2 Turbidity in NTU	Poymer-2ml Run-3Ri3 Turbidity in NTU	Poymer-3ml Run-4 Ri4 Turbidity in NTU
0	4.47	3.21	2.17	1.63
0.5	4.22	3.96	7.81	2.13
1	3.19	6.99	8.35	2.46
1.5	7.79	7.5	9.78	3.5
2	17.41	8.53	7.62	4.24
2.5	18.1	6.1	6.1	5.65
3	15.4	2.37	5.23	3.12
3.5	20.4	3.06	3.28	3.02
4	16.2	3.27	3.01	3.02
4.5	12.3	2.98	3.01	3.02
5	9.5	2.98	3.01	3.02
6	7.6	2.98	3.01	3.02
6.5	7.62	2.98	3.01	3.02
7	7.61	2.98	3.01	3.02
7.5	6.5	2.98	3.01	3.02
8	5.5	2.98	3.01	3.02
8.5	3.9	2.98	3.01	3.02
9	3.2	2.98	3.01	3.02
9.5	2.2	2.98	3.01	3.02
10	2.2	2.98	3.01	3.02

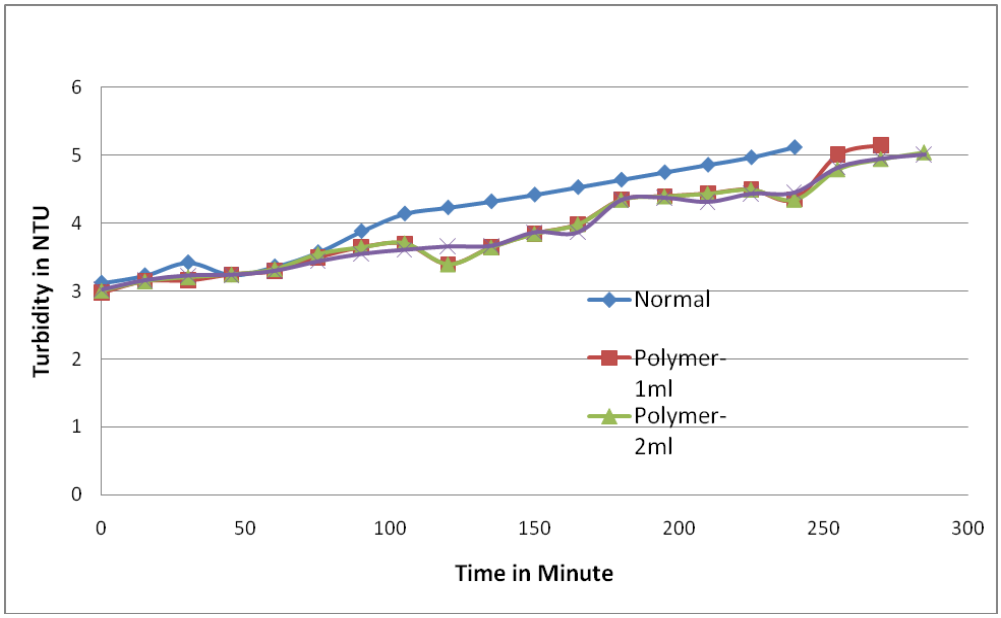


Figure 2: Loss of head during normal operation

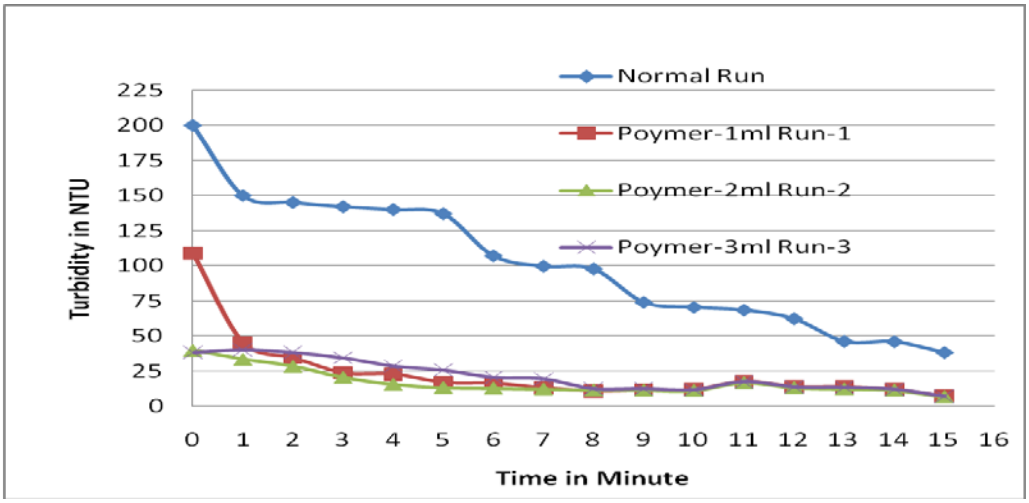


Figure 3: Back washing of Rapid sand filter

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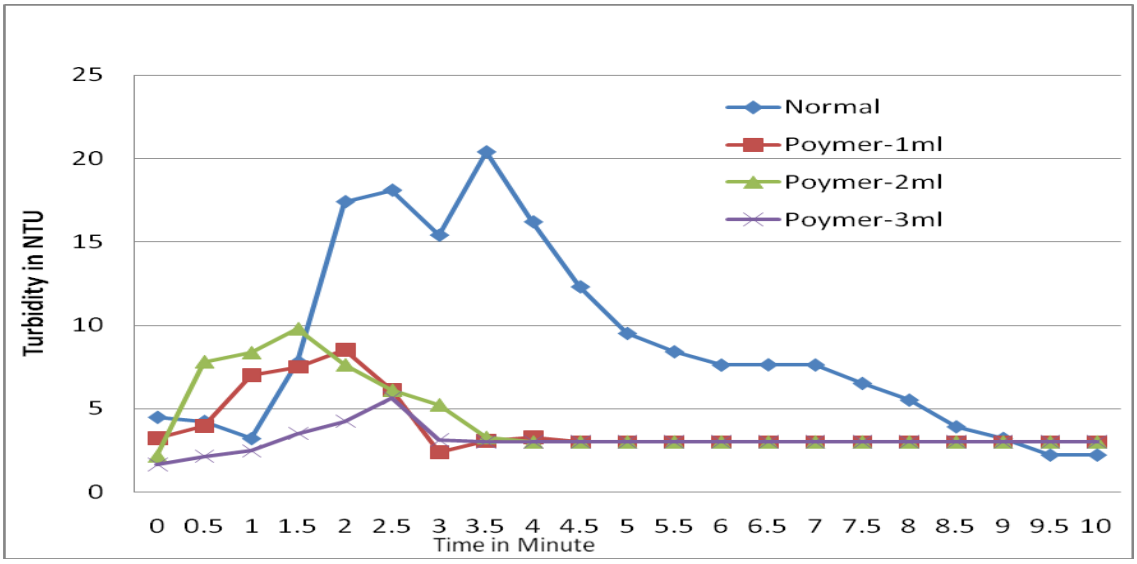


Figure 4: Ripening of Rapid sand filters

4. Conclusion

Initial quality of filtered water was improved by using various coagulants during back washing i.e. there was reduction in ripening period. It was found that there is overall reduction in output turbidity during the filter runs, also by using various coagulants during back washing. It was found that there no significant impact on head loss development pattern due using coagulants during back washing. 60% to 70% improvement in effluent quality by using polymer in backwashing was observed.

5. Scope of Work

The research work further can be studied by using different type of coagulants

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