Performance Evaluation of Urban Water Treatment Plant

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Abstract: ***Sustained supply of safe and potable water is of paramount significance in promotion of health and well being of the people. It is commonly observed in most of the conventional WTP in urban area are unable to perform this task. The common problem along with the unacceptable quality is inadequate amount of supply due to rapidly growing population and industrialization. Because of the variations in type, nature and concentration of impurities in river water and also due to seasonal variation in the raw water quality no single theory or design approach can be used universally for all water treatment plants and every treatment plant should be considered as a unique case before designing and deciding the different unit processes and operations to be used to treat the water. Unfortunately without much of such analysis most of the WTP are following same process train. Such practice is resulting in above mentioned problems. When the study regarding the performance evaluation of any existing WTP has to be made, criteria for performance evaluation and correct interpretation of the results obtained is very essential to arrive on correct problem identification and measures to be implemented in further work. The authors have visited and studied a plant in detail with respect to various processes followed and the effect of treatments provided. The paper throws light on the method and criteria used for the performance evaluation of conventional WTP and its findings. The authors also discuss the importance of characterization of media used in rapid sand filter beds.***

Keywords: Performance evaluation, turbidity, pH, hardness, alkalinity, acidity, filter media

1. Introduction

Sustained supply of safe and potable water is of paramount significance in promotion of health and well being of the people. It is commonly observed in most of the conventional WTP in urban area are unable to perform this task. The common problem along with the unacceptable quality is inadequate amount of supply due to rapidly growing population and industrialization. Because of the variations in type, nature and concentration of impurities in river water and also due to seasonal variation in the raw water quality no single theory or design approach can be used universally for all water treatment plants and every treatment plant should be considered as a unique case before designing and deciding the different unit processes and operations to be used to treat the water. Unfortunately without much of such analysis most of the WTP are following same process train. The current paper focuses on one such study made. The selected WTP is located in fast growing urban area and facing the problem of inadequate supply besides of unsatisfactory treated water quality as well as operation and maintenance. The different units provided in the WTP are cascade aerator followed by flash mixer, clariflocculetors, rapid sand filters, chlorinator, underground sump and finally main balancing reservoir respectively.

Performance evaluation of the existing WTP was difficult task. Right from the deciding the method for sampling, criteria for performance evaluation and correct interpretation of the results obtained was very essential to arrive on correct problem identification and measures to be implemented in further work.

2. Methodology Adopted for Performance Analysis

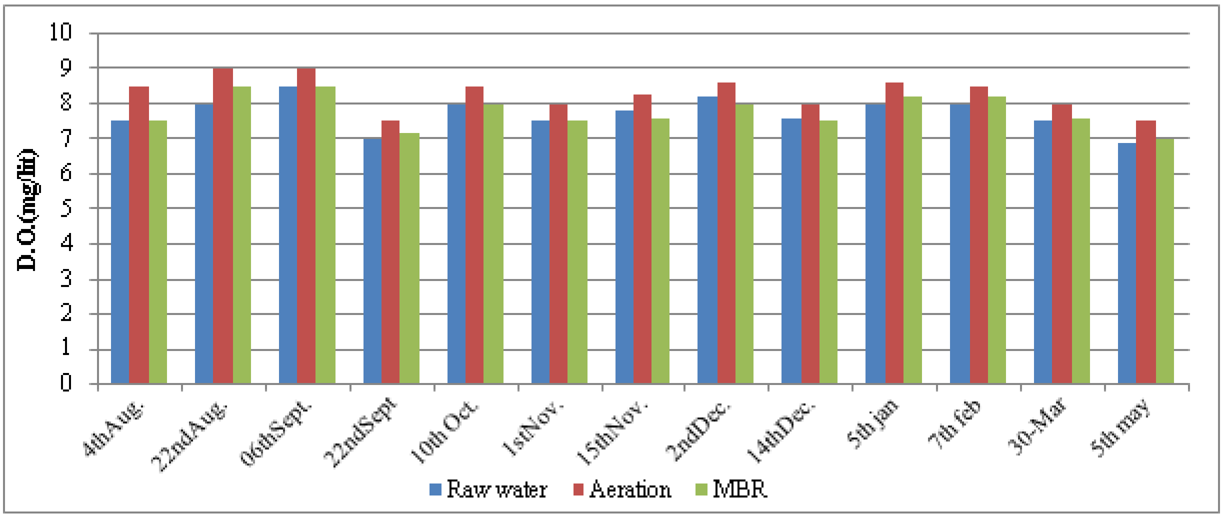
Grab sampling was used to collect the representative samples. The different parameters used for evaluation were Dissolved oxygen (DO), turbidity, pH, hardness, acidity, alkalinity and free chlorine. Total thirteen sampling were done. Few parameters mentioned above were not assessed in few initial samplings.

Various characteristics like turbidity, pH, hardness, and alkalinity of raw water, after aeration fountain i.e. at the entry of WTP, after clariflocculator, after filtration, after chlorination, at underground sump and at main balancing reservoir were measured. In case of DO the assessment was done for samples collected before aeration fountain i.e. at the entry of WTP, after aeration and that of at MBR. While in case of acidity the assessment was done for samples collected before aeration fountain i.e. at the entry of WTP and after aeration.

Parameters used for the characterization of filter media were specific gravity, effective size and coefficient of uniformity. The acid test for weight loss was also conducted.

3. Results and Discussion

1. D.O. -

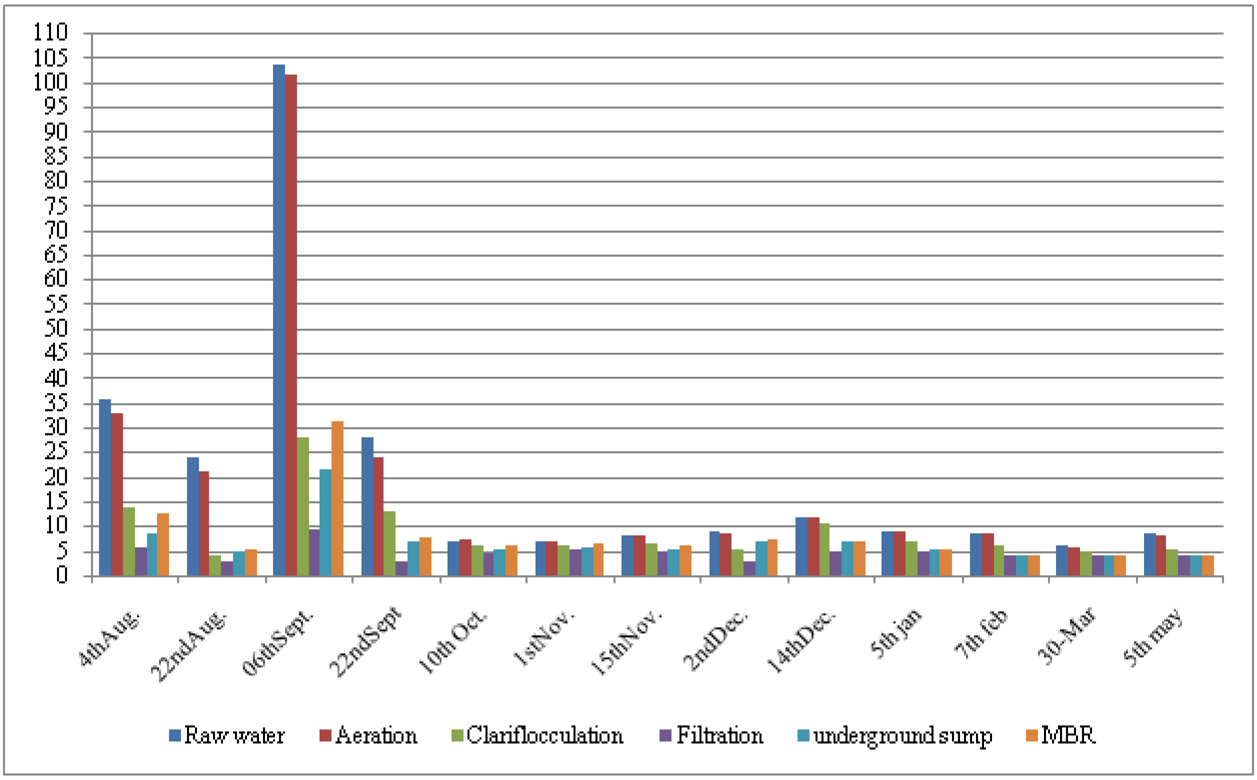


Graph showing variation in D.O.

From the observations it was concluded that, the raw water had good DO content. The DO content was increased after aeration but in MBR the DO content was again decreased. The decrease in DO may be due to the oxidation of present organic matter in underground sump and MBR. This was an indication of improper housekeeping. The MBR as well as underground sump needed immediate cleaning.

2. Turbidity

The turbidity in monsoon period is generally high as compared to the other part of the year, same thing was observed during the sampling. The turbidity measured at various stages shows that the turbidity of raw water varies between 104 NTU (on next a day of flood occurred) to 6 NTU (in pre-monsoon period). The efficiency of turbidity removal of clariflocculator was observed between ***80.24% and 19.45%.***while the efficiency of filter was observed between***78.08% and 26.53%.*** Higher values were observed during high turbid raw water to be treated while lower values were observed during lower turbid raw water to be treated. Over all turbidity removal by clariflocculator and filter was observed between ***90.92% and 40.16%.***

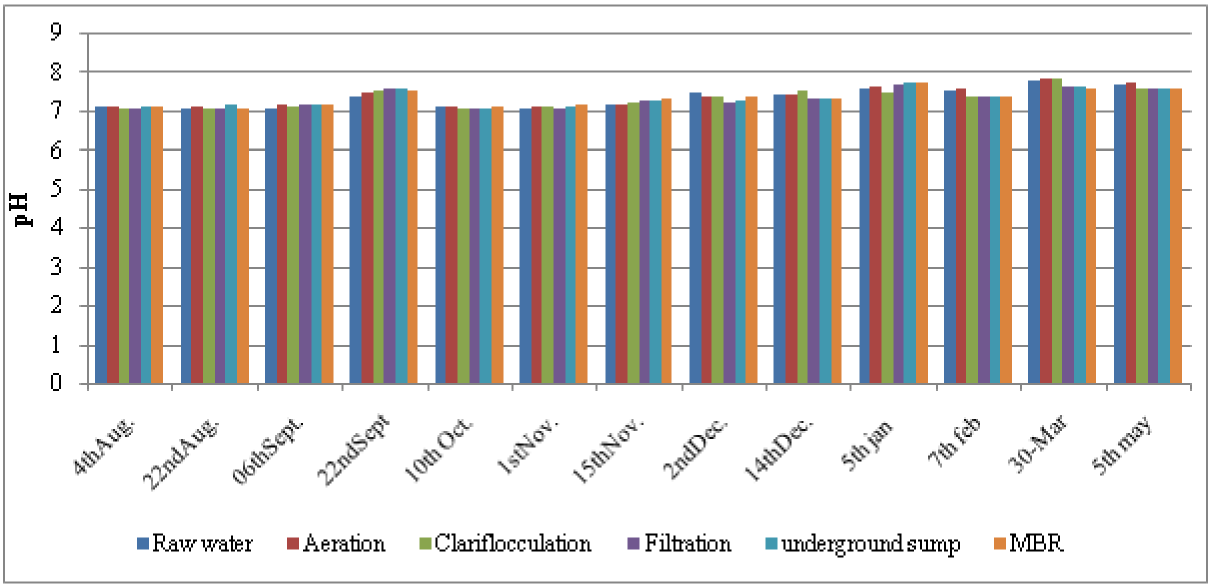


Graph showing turbidity of water at various stages of purification

The graph also shows that the turbidity of the treated water stored in main balancing reservoir is much higher than it was after filtration. The probable reason for this can be the high ripening period of filter beds.

3. pH

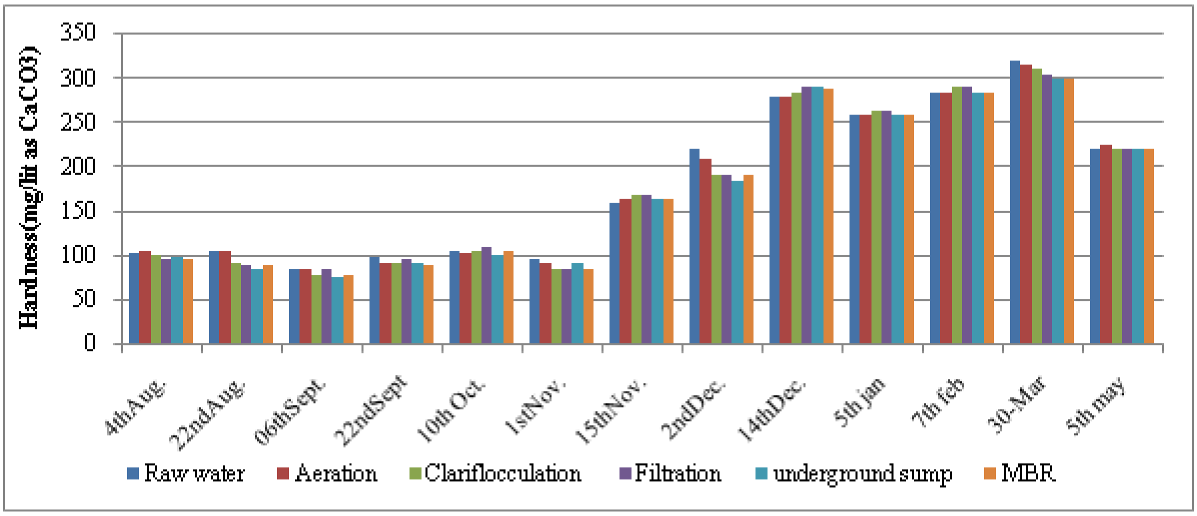
pH of raw water as well as water during the purification process and after treatment is about 7. No issue regarding the pH of water has been observed. pH after coagulation is generally lowered, due to consumption of alkalinity. But such thing was not observed constantly. This was an indication of poor performance of the process of coagulation.



Graph showing pH of water at various stages of purification

4. Hardness

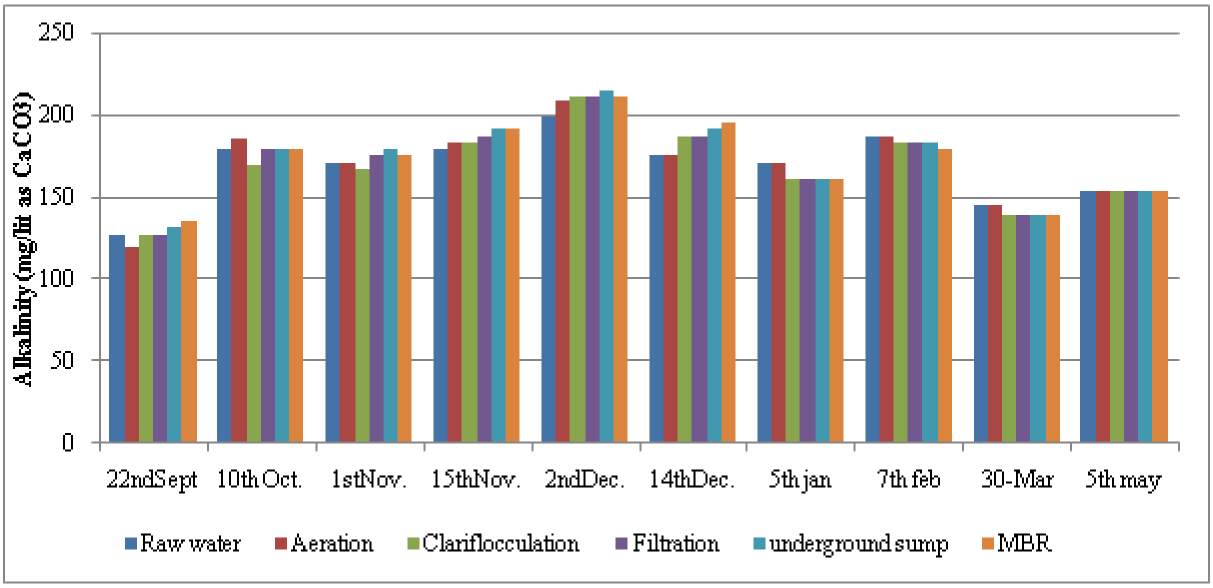
The hardness of raw water was observed between 97 mg / l as $CaCO_3$ and 320 mg/l as $CaCO_3$. The hardness of raw water was observed between 90 mg / l as $CaCO_3$ (during the monsoon period) and 300 mg / l as $CaCO_3$ (during pre-monsoon period). The maximum desirable limit for the hardness is 300 mg/lit as $CaCO_3$. The supplied water was almost crossing the higher limit. The water supplied particularly in pre-monsoon period was observed to be very hard, which was demanding the need of water softening facility to be included in the currently followed process train.



Graph showing variations in hardness of water at various stages of purification

5. Alkalinity

The alkalinity of raw water was observed to be between 128 mg / l as $CaCO_3$ and 200 mg/l as $CaCO_3$. During the process of coagulation the alkalinity is consumed, but no such phenomenon was observed continuously, indicating the problem in the process of coagulation. It was desirable to add polyelectrolyte along with alum for better coagulation.



Graph showing alkalinity of water at various stages of purification

6. Acidity

Table 1: Removal of Acidity

Sample no.	*Date*	*Acidity mg/lit as $CaCO_3$ before aeration*	*Acidity mg/lit as $CaCO_3$ after aeration*	*% removal of Acidity*
1	15th Nov.	72	44	38.88
2	2nd Dec.	64	40	43.75
3	14th Dec.	68	40	41.18
4	05th Jan.	60	40	33.33
5	7th Feb.	56	36	35.71
6	30th Mar.	52	32	38.46
7	05th May	52	36	34.61

From the observation it was clear that, after aeration the acidity was reduced and so as the CO_2. This was a desirable thing.

7. Free Chlorine:

Table 2: free chlorine content after chlorination and in MBR

Sample no.	*Date*	*Free chlorine after chlorination*	*Free chlorine in MBR*
1	04th Aug.	1.0ppm	0.5 ppm
.2	22nd Aug.	1.0 ppm	0.5 ppm
3	06th Sept.	1.5 ppm	1.0 ppm
.4	22nd Sept.	1.0 ppm	0.5 ppm
5	10th Oct.	1.0 ppm	1.5 ppm
6	01st Nov.	2.0 ppm	1.5 ppm
7	15th Nov.	2.0 ppm	1.5 ppm
8	2nd Dec.	1.5ppm	1.0ppm
9	14th Dec.	2.5 ppm	2.0ppm
10	05th Jan.	2.5 ppm	2.0ppm
11	7th Feb.	2.5 ppm	2.0ppm
12	30th Mar.	2.5 ppm	2.0ppm
13	05th May	2.5 ppm	2.0ppm

8. Characterization of Sand Beds

Table 3: properties of sand used as filter media

	Effective size (mm)	Coeff. Of uniformity	Specific gravity	Voids ratio	Acid test Wt. loss (%)
Bed 1	0.95	2.379	2.22	0.432	3.8
Bed 2	0.94	2.074	2.325	0.339	3.1
Bed3	0.84	2.304	2.307	0.325	2.5
Bed 4	0.94	2.234	2.21	0.426	3.0

The standards for filter media sand are…

a. Effective size = 0.45 to 0.55 mm,
b. Coeff. of uniformity =1.65,
c. Acid test wt. loss = 5% (maximum).

Highest size of particle found in the sand bed…..5 mm

4. Conclusions

1) Increase in DO and decrease in acidity of water was indicating the proper working of aeration fountain.
2) The DO content was increased after aeration but in MBR the DO content was again decreased. The decrease in DO may be due to the oxidation of present organic matter in the form of settled solids in underground sump and MBR. Similar conclusion can be drawn by observed variation in free chlorine. Immediate cleaning of underground sump and MBR was needed.
3) In case of high turbid water the clariflocculator and filter in combination were failed to produce a satisfactory results.
4) Performance of the process of coagulation was very poor, as the alum was not added as per need. Proper testing of water per day to finalizing the dose of alum has to be practiced for proper working of flocculation and clarification.
5) The chlorination process was not practiced with proper care. The amount of residual chlorine was not monitored.
6) The need of water softening facility particularly in pre monsoon period was felt, demanding such process to be included in process train and practiced.

7) Higher effective size of sand and higher coefficient of uniformity in filter bed has affected the performance. Higher effective size generally deteriorates the effluent quality while the higher coefficient of uniformity reduced the filtration rate.
8) Effective size of sand in all beds was higher than required while coefficient of uniformity was more than the limit specified. The sand used was not suitable and either had to be replaced or at least blended with new sand to achieve proper effective size and coefficient of uniformity.
9) The highest size of particles in sand bed was about 5 mm. which was an indication that the particles from gravel bed were also mixed with the sand indicating practice of higher backwashing rate.

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