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Valuation of Drinking Water Excellence and Efficiency of Water Treatment Plants in Udaipur, Rajasthan

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Abstract: There is a requirement to assess the performance of water treatment plants for the proper treatment of raw water. Percentage removal efficiency is used to determine the performance of the plant and assess how much contamination was removed. This study was carried out to determine the efficiency of eleven water treatment plants in Udaipur through the testing of water from the source of water treatment plants and tap water from the respective treatment plants in Udaipur. The highest average efficiency is 65.84% of Fatehsagar RGF, and the lowest average efficiency is 54.88% of Titardi RGF. It was found that the efficiency of Fatehsagar P.F., Gulab Bagh R.G.F., and Titardi RGF was less than 60%, and the rest of the treatment plants had more than 60% efficiency. In this study, comparisons of raw and treated water and removal average efficiencies of water treatment plants were also found through results of laboratory testing and a graphical representation of the obtained data for eleven water treatment plants. The finding of turbidity in the raw water sources of Fateh Sagar RGF, Fateh Sagar PF, Nandeshwar, Neemach Mata, and WTP Smart City was relatively higher than 5 NTU, which is a desirable limit as per Indian standard drinking water specifications.

Keywords: Water Quality, Water Treatment Plant, Efficiency, Raw Water, Treated Water

1. Introduction

Water is as essential for life as air. It has been estimated that two-thirds of the human body is composed of water. Water is absolutely essential not only for the survival of human beings but also for animals, plants, and all other living beings [1]. It is necessary that the water required for

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their needs be good, and it should not contain unwanted impurities, harmful chemical compounds, or bacteria. Therefore, in order to ensure the availability of a sufficient quantity of good-quality water [2], it is necessary to plan and build suitable water supply schemes. The growing urbanization trend has directly given rise to contamination of fresh water and scarcity of water resources, which are the first and foremost issues that occur as a result of overexploitation and mismanagement of the city's water resources [3]. Surface water sources serve as major routes for the supply of raw water for processing for potable and general domestic purposes. Water treatment plants should be regularly analyzed to determine the plant's water treatment performance and ensure systems are operating with the most efficient equipment and technology. When water treatment plants are not operating efficiently, it can be extremely costly [4, 5]. The combination of inefficient and older pumping and process equipment, combined with outdated water management practices, can result in higher operating costs and lower revenue collected, which can negatively impact a treatment plant's bottom line. Although there was some routine quality assessment of tap water sources in different locations in the city [6, 7], little attention is being given to drinking water quality issues and quantity by water supply agencies. The aim of this study is to evaluate treatment plant efficiency and drinking water quality assessment from source to household in Udaipur city in Rajasthan, India [8].

2. Methodology

This study was conducted in Udaipur City, which is located between 23°46' and 25°05' North latitude and 73°09' and 74°35' East longitude, covering an area of 13419 sq. km. Presently, there are eleven water treatment plants for water supply [6], as shown in Figure 1. This study was carried out in January 2023 for the efficiency of eleven water treatment plants through testing of water from the source of water treatment plants and tap water of the respective treatment plants in Udaipur, as mentioned in Table 1. Capacity, year of construction, and raw water sources of water treatment plants are also mentioned in this same table. A total of 45 water samples from Jaisamand Lake, Pichola Lake, Mansi Wakal, and Fateh Sagar Lake [2] were obtained for testing of raw and treated water samples using the WHO recommended minimum sample numbers for piped drinking water [5]. The samples were collected in clean, sterile one-liter plastic bottles, which were rinsed before being filled. In order to minimize drastic changes in the physiochemical characteristics of water samples between the time of sample collection and analysis [9], the water samples were preserved by cooling to 40 °C using ice packs. The physio-chemical tests included the determination of pH, turbidity, alkalinity, total hardness, chloride, nitrate, TDS, and fluoride [10, 11]. The overall efficiency of the treatment plants was calculated using the following formula:

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$$\text{Removal efficiency (\%)} = \frac{\text{Inlet concentration} - \text{effluent concentration}}{\text{inlet concentration}} \times 100$$

There are following eleven water treatment plants in Udaipur city with the capacity and year of construction of the plants are also mentioned in table 1.

Table 1: Details of Water Treatment Plants in Udaipur City

S. No.	Name of WTP	Capacity (MLD)	Year of Construction	Raw Water Source
1	Teetardi RGF	13.5	2007	Jaisamand Lake
2	Patel Circle RGF	7.57	1997	Pichola Lake
3	Doodhtalai RGF	13.62	1976	
4	Doodhtalai RGF	2.85	1996	
5	Gulab Bagh RGF	4.54	1968	
6	Gulab Bagh PF	2.27	1968	
7	Fatehsagar RGF	2.27	1970	Mansi Wakal
8	Fatehsagar PF	1.72	1968	
9	Nandeshwar RGF	23.35	2007-08	Fateh Sagar Lake
10	Neemuch Mata RGF	11.35	1996	
11	WTP Smart City	23.7	2023	Pichola Lake

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Figure 1: Locations of Water Treatment Plants in Study Area (Udaipur) in Google Earth Map

1. Results and Discussion

Table 2: Water quality analysis for raw and treated water samples of water treatment plants

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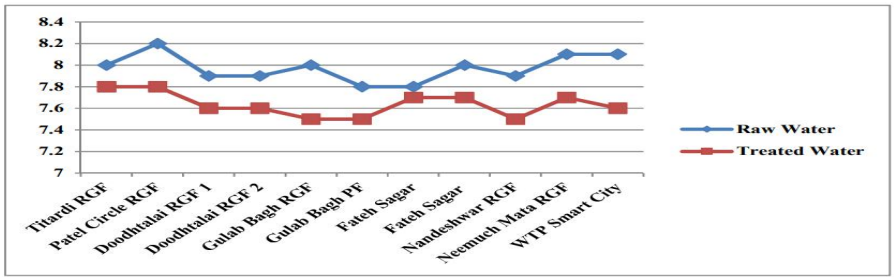
Source	Source & Location	pH	Turbidity (NTU)	Alkalinity (mg/l)	Total Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	TDS (mg/l)	Fluoride (mg/l)
R. W.	Titardi RGF	8	10	140	225	90	2	360	0.2
T.W.		7.8	0.1	130	160	60	2	150	0.2
R.W.	Patel Circle RGF	8.2	9.5	140	245	110	3	320	0.3
T. W.		7.8	0.2	120	150	60	3	100	0.3
R.W.	Doodhtalai RGF 1	7.9	10	120	240	115	3	300	0.3
T. W.		7.6	0.2	110	160	50	3	110	0.3
R.W.	Doodhtalai RGF 2	7.9	10	125	245	115	3	300	0.3
T.W.		7.6	0.2	105	160	50	3	126	0.3
R.W.	Gulab Bagh RGF	8	10	150	220	112	2	260	0.2
T. W.		7.5	0.9	120	130	40	3	160	0.3
R.W.	Gulab Bagh PF	7.8	10	160	220	115	3	280	0.3
T.W.		7.5	0.9	120	130	40	3	135	0.3
R.W.	Fateh Sagar RGF	7.8	6.2	150	255	115	2	290	0.3
T.W.		7.7	0.2	140	150	50	2	130	0.3
R.W.	Fateh Sagar PF	8	5.9	150	248	112	2	301	0.3
T. W.		7.7	0.2	140	150	50	2	150	0.3
R.W.	Nandeshwar RGF	7.9	9.8	130	256	110	3	278	0.3
T.W.		7.5	0.9	120	130	40	3	130	0.3
R.W.	Neemuch Mata RGF	8.1	8.2	150	240	110	2	290	0.3
T. W.		7.7	0.2	140	150	50	2	140	0.3
R. W.	WTP Smart City	8.1	6	140	245	108	2	300	0.2
T.W.		7.6	0.2	120	130	50	2	170	0.2

In this study, comparisons of raw and treated water and removal average efficiencies of water treatment plants were found through results of laboratory testing and a graphical representation of the obtained data for eleven water treatment plants, as mentioned in Table 2. The finding of turbidity in the raw water sources of Fateh Sagar RGF, Fateh Sagar PF, Nandeshwar, Neemach Mata, and WTP Smart City [12, 13] was relatively higher than 5 NTU, which is a desirable limit as per Indian standard drinking water specifications [14, 15].



Graph 1: Comparison pH between Raw Water and Treated Water

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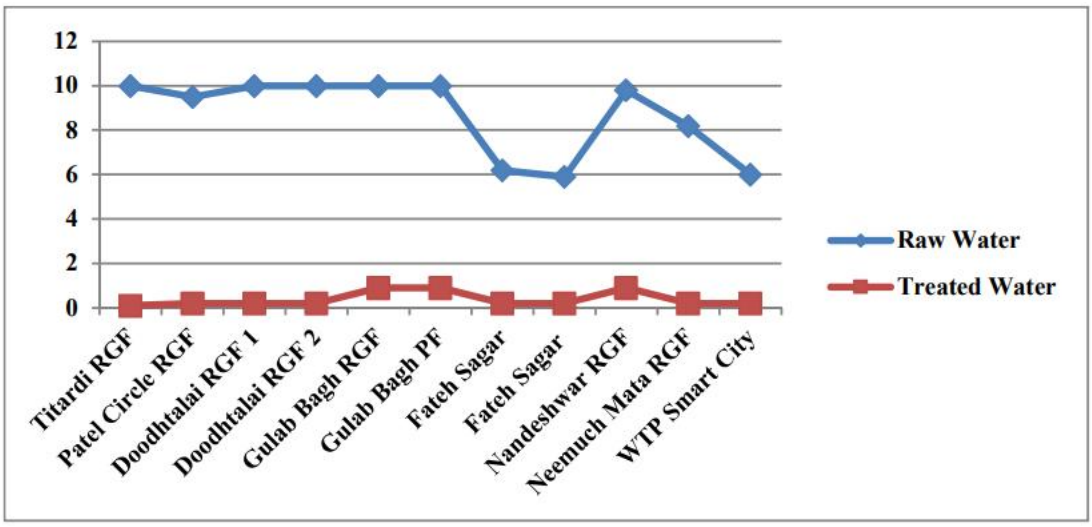
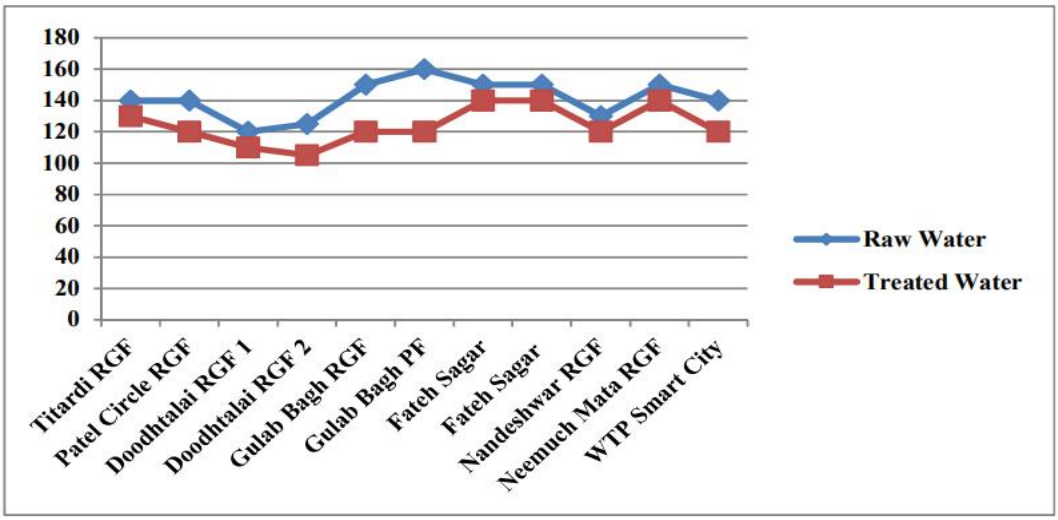


Graph 2: Comparison Turbidity between Raw Water and Treated Water



Graph 3: Comparison Alkalinity between Raw Water and Treated Water

The efficiency of treatment plants for selected parameters (turbidity, total hardness, chloride, and total dissolved solids) is found as shown in Table 3. The highest average efficiency is 65.84% of Fatehsagar R.G.F., and the lowest average efficiency is 54.88% of Titardi RGF. It was found that the efficiency of Fatehsagar P.F., Gulab Bagh R.G.F., and Titardi RGF was less than 60%, and the rest othe treatment plants had more than 60%

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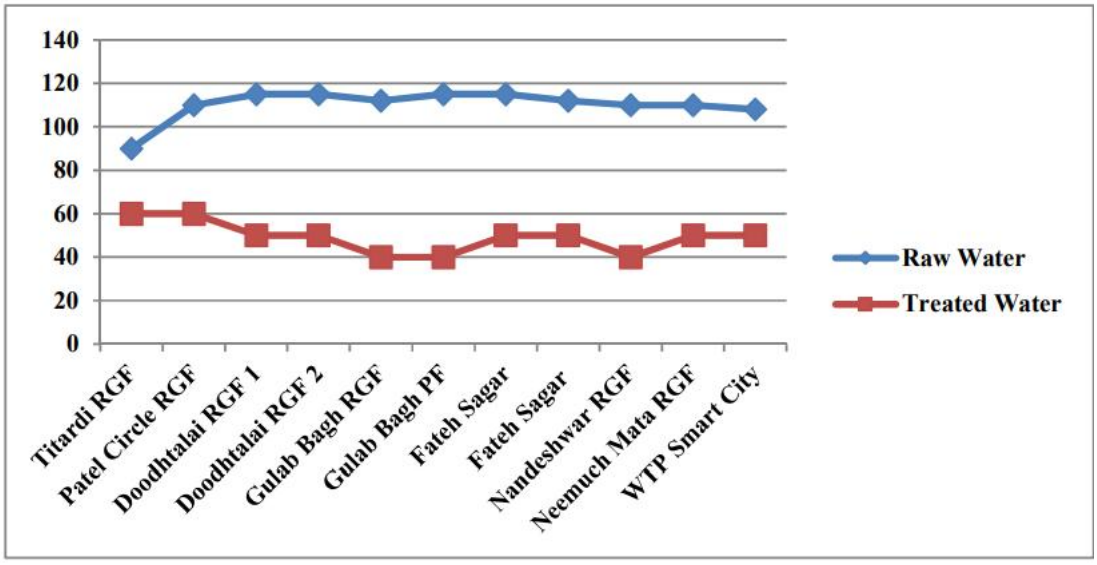
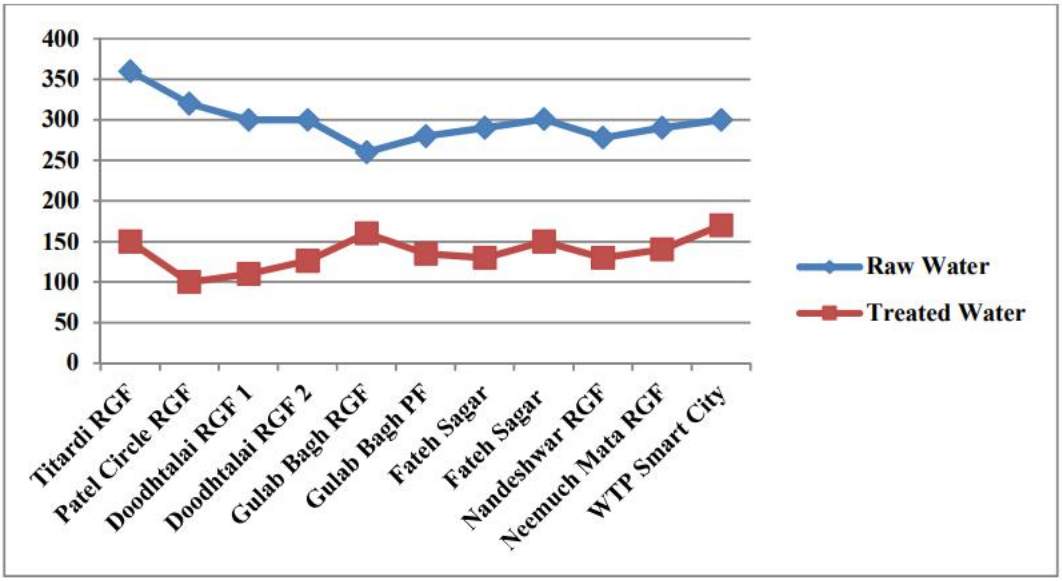
efficiency.



Graph 4: Comparison Chloride between Raw Water and Treated Water



Graph 5: Comparison TDS between Raw Water and Treated Water

Figure 6 shows the average removal efficiency of water treatment plants in Udaipur. The nitrate level of the water sources [6] was much less than the permissible limit of IS for drinking water

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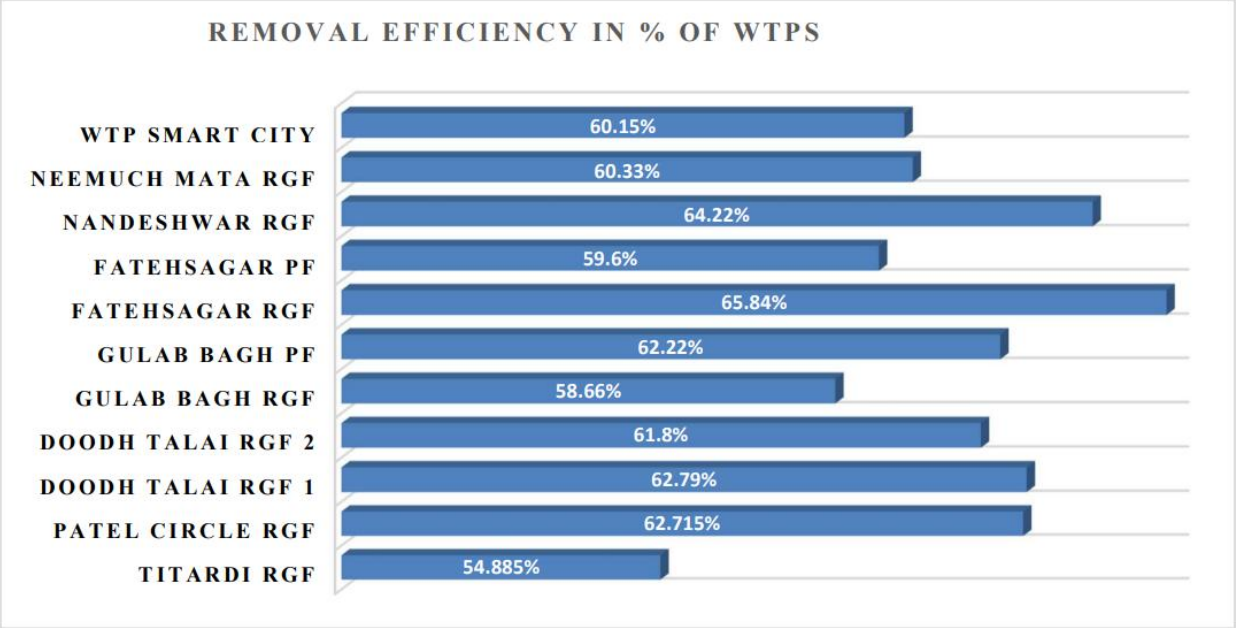
quality (< 45 mg/l) [2, 6]. This indicates that the nitrate concentration is not a problem with the water in the study area. The total hardness value of the water source in this study was below the permissible limit of IS.



Graph 6: Comparison of Removal Efficiency in % of WTPS in Udaipur

Table 3: Water Treatment Plant Efficiency for selected parameters in Udaipur City, Rajasthan (January 2023)

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Name of WTP/ Parameters	Inlet	Outlet	Removal Efficiency (%)	Name of WTP/ Parameters	Inlet	Outlet	Removal Efficiency (%)
1. Titardi RGF				**7. Fatehsagar RGF**			
Turbidity (NTU)	10	0.1	99	Turbidity (NTU)	6.2	0.2	96.77
Total Hardness (mg/l)	225	160	28.88	Total Hardness (mg/l)	255	150	54.90
Chloride (mg/l)	90	60	33.33	Chloride (mg/l)	115	50	56.52
TDS (mg/l)	360	150	58.33	TDS (mg/l)	290	130	55.17
			54.885				**65.84**
2. Patel Circle RGF	**Inlet**	**Outlet**	**Removal Efficiency (%)**	**8. Fatehsagar PF**	**Inlet**	**Outlet**	**Removal Efficiency (%)**
Turbidity (NTU)	9.5	0.2	97.89	Turbidity (NTU)	5.9	0.2	96.61
Total Hardness (mg/l)	245	150	38.77	Total Hardness (mg/l)	248	158	36.29

3. Conclusion

The efficiency of a water treatment plant is a necessity for evaluating the performance of the plant. There are various methods for increasing water treatment plant efficiency. It is required to access and analyze the data in order to evaluate infrastructure performance and determine what changes are required to further increase efficiency. Water treatment plant managers should examine their water management procedures on a regular basis to ensure that the facility is working efficiently, reducing energy costs.

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