Assessment of Drinking Water Quality and Efficiency of Water Treatment Plants in Udaipur, Rajasthan

Sangeeta Choudhary[1], Maya Chaudhary[2], Om Prakash Surecha[3], Aniruth Trivedi[4], Hiren Chaplot[5]
[1] Associate Professor, Department of Civil Engineering in Geetanjali Institute of Technical Studies
[2] Assistant Professor, Department of Geology in Mohan Lal Sukhadia University
[3, 4, 5] Students, Department of Civil Engineering in Geetanjali Institute of Technical Studies

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

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

Introduction

Water is as essential for life as air. It has been estimated that two third of human body is constituted of water. Water is absolutely essential not only for survival of human being, but also for animals, plants and all other living beings[1]. It is necessary that the water required for their needs must be good, and it should not contained unwanted impurities or harmful chemical compounds or bacteria in it. Therefore, in order to ensure the availability of sufficient quantity of good quality water[2], 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 are the first and foremost issues that occur as a result of over-exploitation and mismanagement of the city's water resources[3]. Surface water sources serve as major routes for the supply of raw water for processing into potable and general domestic purposes. Water treatment plant should be regularly analyzed 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 in tap water sources of different locations in 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 plants efficiency and drinking water quality assessment from source to household in Udaipur city in Rajasthan, India[8].

Methodology

This study was conducted in Udaipur City, which is located between 23°46' & 25°05' North latitude and 73°09' & 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 efficiency of eleven water treatment plants through testing of water from source of water treatment plants and tap water of 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. Total 45 water samples from Jaisamand Lake, Pichola Lake, Mansi Wakal, Fateh Sagar Lake[2], household taps were obtained for testing of raw water and treated water samples using WHO recommended minimum sample numbers for piped drinking water [5]. The samples were collected with clean, sterile one litre plastic bottles which were rinsed the sample 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 4^0C 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 were calculated using following formula:

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

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

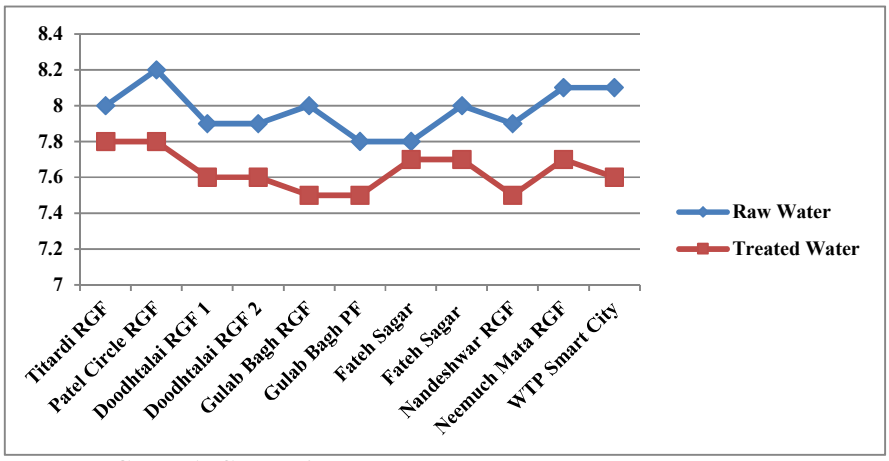
Figure 1: Locations of Water Treatment Plants in Study Area (Udaipur) in Google Earth Map

Results and Discussion

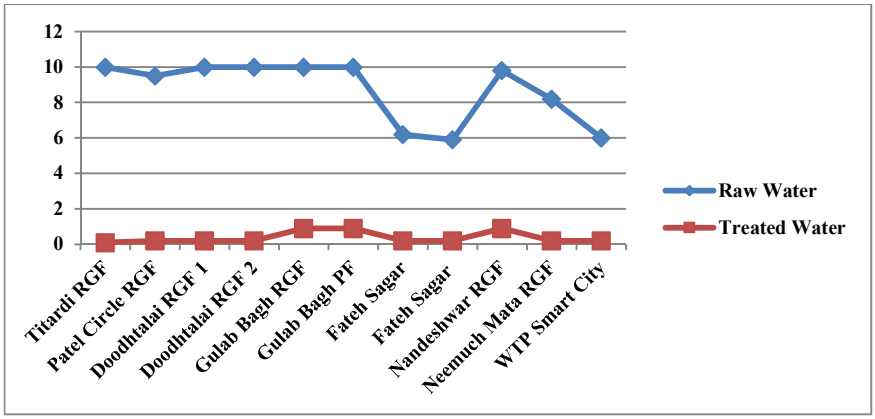
Table 2: Water quality analysis for raw and treated water samples of water treatment plants

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

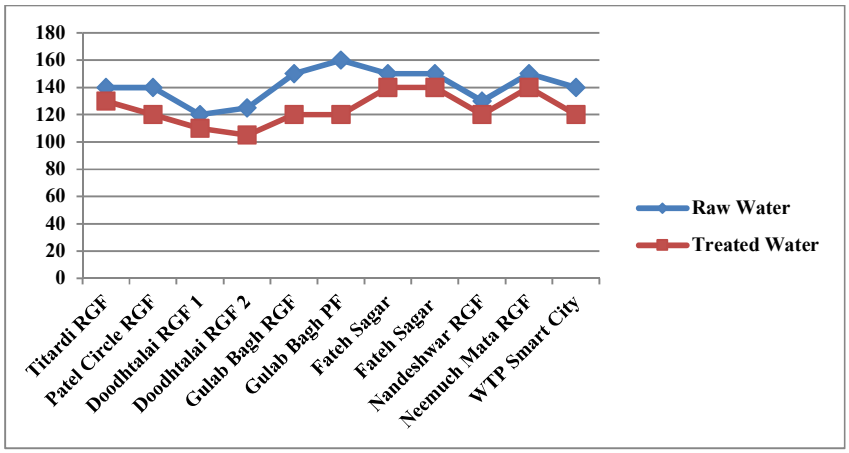
In this study comparison of raw and treated water and removal average efficiencies of water treatment plants were found through results of laboratory testing and graphical representation of the obtained data for eleven water treatment plants as mentioned in table 2. The finding of turbidity in raw water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



Graph 1: Comparison pH between Raw Water and Treated Water

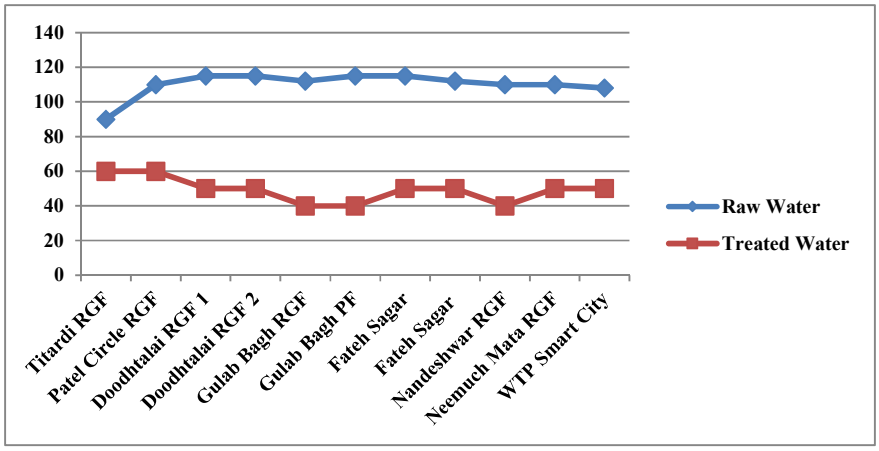


Graph 2: Comparison Turbidity between Raw Water and Treated Water

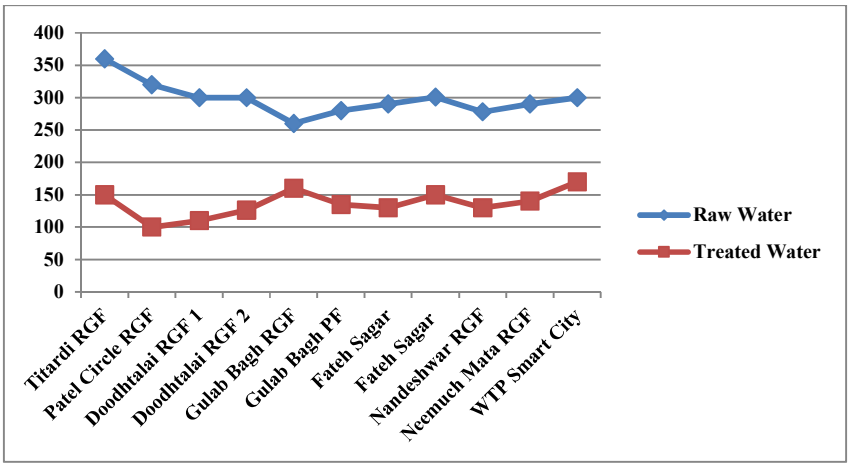


Graph 3: Comparison Alkalinity between Raw Water and Treated Water

The efficiency of treatment plants for selected parameters turbidity, total hardness, chloride, and total dissolve solids (TDS) are found as shown in table 3. Highest average efficiency is 65.84% of Fatehsagar R.G.F. and lowest average efficiency is 54.88% of Titardi RGF. It is found that efficiency of Fatehsagar P.F., Gulab Bagh R.G.F. and Titardi RGF less than 60% and rest of all treatment plant have more than 60% efficiency.

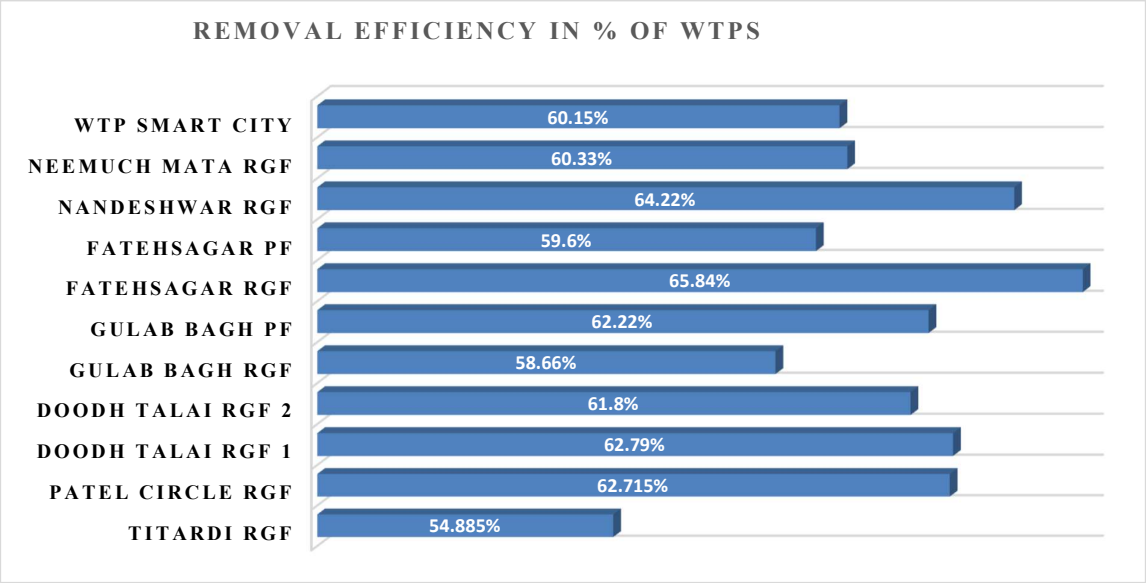


Graph 4: Comparison Chloride between Raw Water and Treated Water



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 quality (< 45 mg/l)[2, 6]. This indicates that the nitrate concentration is not the problem of water in the study area. The total hardness value in water source in this study was below the permissible limit of IS (<300 mg/l).



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)

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
Chloride (mg/l)	110	60	45.45	Chloride (mg/l)	112	50	55.35
TDS (mg/l)	320	100	68.75	TDS (mg/l)	301	150	50.16
			62.715				**59.60**
3. Doodh Talai RGF 1	**Inlet**	**Outlet**	**Removal Efficiency (%)**	**9. Nandeshwar RGF**	**Inlet**	**Outlet**	**Removal Efficiency (%)**

Turbidity (NTU)	10	0.2	98	Turbidity (NTU)	9.8	0.9	90.81
Total Hardness (mg/l)	240	160	33.33	Total Hardness (mg/l)	256	130	49.21
Chloride (mg/l)	115	50	56.52	Chloride (mg/l)	110	40	63.63
TDS (mg/l)	300	110	63.33	TDS (mg/l)	278	130	53.23
			62.79				**64.22**
4. Doodh Talai RGF 2	**Inlet**	**Outlet**	**Removal Efficiency (%)**	**10. Neemuch Mata RGF**	**Inlet**	**Outlet**	**Removal Efficiency (%)**
Turbidity (NTU)	10	0.2	98	Turbidity (NTU)	8.2	0.2	97.56
Total Hardness (mg/l)	245	160	34.69	Total Hardness (mg/l)	240	150	37.50
Chloride (mg/l)	115	50	56.52	Chloride (mg/l)	110	50	54.54
TDS (mg/l)	300	126	58	TDS (mg/l)	290	140	51.72
			61.80				**60.33**
5. Gulab Bagh RGF	**Inlet**	**Outlet**	**Removal Efficiency (%)**	**11. WTP Smart City**	**Inlet**	**Outlet**	**Removal Efficiency (%)**
Turbidity (NTU)	10	0.9	91	Turbidity (NTU)	6	0.2	96.66
Total Hardness (mg/l)	220	130	40.90	Total Hardness (mg/l)	245	130	46.93
Chloride (mg/l)	112	40	64.28	Chloride (mg/l)	108	50	53.70
TDS (mg/l)	260	160	38.46	TDS (mg/l)	300	170	43.33
			58.66				**60.15**

6. Gulab Bagh PF	**Inlet**	**Outlet**	**Removal Efficiency (%)**
Turbidity (NTU)	10	0.9	91
Total Hardness (mg/l)	220	130	40.90
Chloride (mg/l)	115	40	65.21
TDS (mg/l)	280	135	51.78
			62.22

Conclusion

Efficiency of Water Treatment Plant is necessity for evaluate the performance of the plant. There are various methods for increasing water treatment plant efficiency. It is required to access and analyse 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 regular basis to ensure that the facility is working efficiently, reducing energy costs.

Acknowledgment

This work is done under the MOU between Civil Department, GITS and Department of Geology, MLSU. The authors appreciate the laboratory assistants of Civil Department, GITS for their technical support and assistance during experimental works. The authors are also very grateful to all the staff of water treatment plant authorities of Udaipur city.

References

1. A. M. Wolde, K.J., G. M. Woldearegay, and K. D. Tullu, *Quality and safety of municipal drinking water in Addis Ababa City, Ethiopia.* Environmental Health and Preventive Medicine, 2020. **25**(1): p. 9-6.
2. Choudhary, S. and J. Sharma, *Surface Water Quality Trends and Regression Model through SPSS in Udaipur, Rajasthan.* International Advanced Research Journal in Science, Engineering and Technology, 2021. **8**(10): p. 153-160.
3. Choudhary, S., H. Shrimali, and J. Shrimali. *Techno-Managerial Phases and Challenges in Development andImplementation of Smart City Udaipur*. in *4th International Conference on Emerging Trends in Multi-Disciplinary Research, -2023*. 2023. https://www.researchgate.net/publication/370402952_Techno ….
4. Sisay, T., A. Beyene, and E. Alemayehu, *Assessment of drinking water quality and treatment plant efficiency in southwest Ethiopia.* J Environ Sci, 2017. **3**(3): p. 208-12.
5. Desye, B., et al., *Efficiency of treatment plant and drinking water quality assessment from source to household, gondar city, Northwest Ethiopia.* Journal of Environmental and Public Health, 2021. **2021**: p. 1-8.
6. Choudhary, S., et al. *GIS Mapping for Distribution of Ground Water Quality in Udaipur*. in *IOP Conference Series: Earth and Environmental Science*. 2022. IOP Publishing.
7. Choudhary, S., et al., *Development of Rain Water Harvesting System through National Highway Profiles by Using GIS and Field Survey.* Available at SSRN 3348303, 2019.
8. Daud, M., et al., *Drinking water quality status and contamination in Pakistan.* BioMed research international, 2017. **2017**.
9. Ojha, S. and S. Choudhary, *QUALITATIVE ANALYSIS OF SOCIO-ENVIRONMENTAL FACTORS OF SAND MINING ON MITHRI TRIBUTARY OF LUNI RIVER AT KOSANA, PIPAR JODHPUR DISTRICT OF RAJASTHAN.* International Research Journal of Environmental Sciences, 2017. **6**(10): p. 22-31.
10. Organization, W.H. and WHO., *Guidelines for drinking-water quality*. Vol. 1. 2004: World Health Organization.
11. Li, P. and J. Wu, *Drinking water quality and public health.* Exposure and Health, 2019. **11**(2): p. 73-79.
12. Choudhary, S., et al., *Requirements of Solid Waste Management System in Savina Vegetable Market at Smart City Udaipur in Rajasthan.* International Journal of Engineering and Advanced Technology (IJEAT), 2020. **9**(3S): p. 26-29.
13. Choudhary, S., et al., *Requirements and Planning of Badliya Village for converting it into Smart Village Category in Banswara, Rajasthan.* International Journal of Engineering and Advanced Technology (IJEAT), 2020. **9**(3S): p. 40-44.
14. Werkneh, A.A., et al., *Physico-chemical analysis of drinking water quality at Jigjiga City, Ethiopia.* American Journal of Environmental Protection, 2015. **4**(1): p. 29-32.
15. Organization, W.H., *WHO global water, sanitation and hygiene: annual report 2020.* 2022.