IJMRSET

e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 5, Issue 9, September 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.54

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International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54| Monthly, Peer Reviewed & Referred Journal|

| Volume 5, Issue 9, September 2022 |

| DOI:10.15680/IJMRSET.2022.0509025|

A Comparative Study on Descriptive Data of Water Quality of Sewage Treatment Plants

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ABSTRACT: In the present study, secondary treated water quality of two sewage treatment plants was assessed and examined with 16 physicochemical parameters for a period of one year from February 2020 to January 2021. Descriptive statistical data was used to compare the water quality and classification of the study sites in terms of water quality. WWQI (waste water quality index) was calculated using measured parameters to determine the overall quality of secondary treated wastewater of both STPs. According to water quality criteria, water quality of RS STP is better and more stable than C1FC STP. Higher WWQI values in pre-monsoon season require dilution of treated water prior to reuse. This study is crucial to know the water treatment process characteristics and pollutant levels of treatment plants upon various time scales, necessary to improve the state of the art of the treatment process.

KEY WORDS: Sewage treatment plant, treated wastewater, water quality, waste water quality index.

I. INTRODUCTION

Water quality and quantity is very important part of human life and the living world. As population increases in urban areas, increased domestic and industrial activities result in huge water consumption and lead to more volumes of wastewater. This wastewater if not discharged properly, leads to water pollution that poses serious threats to public and environment health. The use of wastewater helps to close the loop between water supply and wastewater disposal [1], [2]. Wastewater reuse is considered economically interesting in all parts of the world. Reuse is considered viable in developed countries for reasons like the application of strict standards and the use of expensive technology including economic incentives. By contrast, in developing countries partially treated or untreated wastewater use to produce goods and beneficially recycle nutrients makes reuse attractive [3], [4]. Although different but both approaches converge as wastewater is being considered as a resource. Government's noble project of sewage treatment plant (STP) has flourished in too many cities to comply with the discharge standards. Operation and maintenance of existing plants and sewage pumping stations is a much-neglected field, as nearly 39% plants do not comply with the general standards prescribed under the Environmental Protection Rules for discharge into streams. [5]. It requires continuous monitoring of the effluent of wastewater treatment plants (WWTPs) to ensure smooth operation, adjustment to prescribed legislative requirements and safety of the receiving water. [6]. If wastewater treatment schemes are properly managed, have high potential to reduce waste production and improve environmental health [8]. The treatment of wastewater for reuse and disposal is particularly important for water scarce states like Rajasthan, Maharashtra, and other states in India where water availability is highly critical. The downstream area of Sri Ganganagar and Hanumangarh cities face water scarcity as they are not having any regular water supply. Sewage treatment plants near downstream areas can be a regular source of non-potable water use. Two sewage treatment plants, one public and other installed in residential colony of Sri Ganganagar were undertaken for evaluating quality of treated wastewater and exploring possibilities of "new water reuse". These are: Chak 1 F Chhoti (C1FC) STP, Sri Ganganagar and Ridhi-Sidhi (RS) STP, Sri Ganganagar. The C1FC STP, located in Chak 1F Chhoti, is 10 MLD STP with a technique of SBR (sequential batch reactor) started by UIT, Sriganganagar in 2018. The RS STP located in residential colony, Ridhi-Sidhi Enclave is established in 2008 with capacity of 400 KLD. Domestic sewage of the colony is collected in raw water storage tank from there it flows through aeration tank, recirculation tank, chlorination tank, passes through sand and carbon filters and used to irrigate parks.

II. MATERIALS & METHODOLOGY

The secondary treated wastewater samples were collected from Chak 1F Chhoti area of STP (C1FC STP) and Ridhi-Sidhi colony STP (RS STP) Sri Ganganagar. Composite sampling on every site was done fortnightly in morning and evening for a period of one year from February 2020 to January 2021. The sample bottles were well cleaned and rinsed twice with the sample water. The collected samples were analyzed for 16 physico-chemical parameters- temperature, pH, electrical conductance (EC), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total alkalinity

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(TA), total hardness (TH), total dissolved solids (TDS), chloride, sulphate, nitrate, sodium, potassium, magnesium, fluoride and calcium as per standard methods. Temperature and pH were measured at the sampling site. DO fixation was performed at the location itself by adding Manganese sulphate and Alkaline KI solution and samples were stored at 4°C for determining other parameters.

Table 1: Standard methods adopted for analysis

S. No.	Parameter	Method	Page No.
1	Temperature	Lab & field method	2550 B2-74
2	pH	Electrometric method	4500-H^+ B4-95
3	Electrical Conductivity (EC)	Laboratory method	2510 B2-58
4	Chemical Oxygen Demand (COD)	Titrimetric method	5220 C5-20
5	Biochemical Oxygen Demand (BOD)	5-Day BOD test	5210 B5-6
6	Total Hardness (TH)	EDTA Titrimetric method	2340 C2-48
7	Total Alkalinity (TA)	Titration method	2320 B2-36
8	Total Dissolved Solids (TDS)	Dried at 180°C	2540 C2-69
9	Sodium (Na^+)	Flame photometric method	3500-Na, B3-69
10	Potassium (K^+)	Flame photometric method	3500-K, B3-89
11	Calcium (Ca^{+2})	EDTA Titrimetric method	3500-Ca, B3-69
12	Magnesium (Mg^{+2})	Calculation method	3500-Mg, B3-86
13	Nitrate (NO_3^-)	UV-Spectrophotometric method	4500- NO_3^- B4-127
14	Sulphate (SO_4^{-2})	UV-Spectrophotometric method	4500- SO_4^{-2} B4-127
15	Chloride (Cl^-)	Argentometric method	4500-Cl^-, B4-75
16	Fluoride (F^-)	Ion-Selective Electrode method	4500-F^-, B4-89

***All parameters are expressed in mg/L except Temp., pH and EC.**
Temp. is expressed in ◦C. EC is expressed in µmhos/cm.

For sampling and testing, the procedure described in standard methods [9] were adopted. All the reagents used were AR grade and double distilled water was used for solution preparation. To study the composite influence of measured parameters and make the data interpretation easier, Waste Water Quality Index (WWQI) was used to discuss the treated water quality. WWQI was computed from measured parameters following these steps (Ramakrishna et al.)[145]

(a) The weights for various water quality parameters are assumed to be inversely proportional to the standards for the corresponding parameters:

$W_i = k/S_i$……………….(1)

Where, W_i is unit weight for the i^{th} parameter, S_i refers to acceptable limit as given in Indian standard (IS- 2296) and k is constant of proportionality (k is assumed unity for the sake of simplicity)

(b) Calculation of the quality rating, q_i for each of the water quality parameters used in the index

$q_i = 100 (V_i - V_{10}) / (S_i - V_{10})$……………….(2)

Where, V_i is measured value of the i^{th} parameter in water sample, V_{10} is the ideal value of this parameter in pure water and
Since in general, the ideal value, V_{10} = 0 for most parameters. Equation (2) assumes that simple form for these parameters

$q_i = 100 (V_i/S_i)$ ………………………..(3)

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The above two equations ensure that $q_i = 0$ if the i^{th} parameter is totally absent in the water sample and $q_i = 100$, if amount of this parameter is just equal to its permissible value S_i. But for pH the ideal values is 7.0 (for neutral water) and the permissible value is 8.5.

So the equation $q_i = 100(V_i - V_{10})/(S_i - V_{10})$ can be written as

$q_{pH} = 100(V_{pH} - 7.0)/ (8.5 - 7.0)$ ……………….(4)

(c) Aggregation of these sub-indices into the overall index.

$WWQI = \sum q_iW_i / \sum W_i$……………….(5)

III. RESULT & DISCUSSIONS

In the present study, 16 physicochemical parameters of water quality from two sites: Chak 1 F Chhoti (C1FC) STP, Sri Ganganagar and Ridhi-Sidhi (RS) STP, Sri Ganganagar were determined. The average values, standard deviation and coefficient of variance of measured parameters are given in Table-1. Temperature exhibited 19.0% variability within samples throughout the year in different seasons for both sites. pH represents an important characteristic of water in evaluating the acid-base balance of water [10]. (pH = 7 is neutral, pH 7 is acidic and pH 7 is alkaline or basic). Variability within samples for pH was 2.6% for RS STP and 3.2% for C1FC STP with average value 7.3 and 7.4 respectively and is within permissible limits of 6.5 – 8.5 (BIS 10500). pH value for both the STP's under study is higher in pre-monsoon season than the post monsoon because of discharges like soaps and detergents added to the sewage gets concentrated in the dry season. [11] reported the alkaline pH (8.25 ±0.12 & 8.4±0.08) in summer season in river Yamuna. The mean pH values recorded for both the sampling points were within the CPCB public sewers limits of between 6.5 and 8.5 for wastewater to be discharged into the environment [12]. These changes are contributed to changes in atmospheric temperature, microbial decomposition due to less efficient treatment process. The standard deviation and within sample variability of EC, COD, BOD, TH, TDS, K^+, SO_4^{-2}, Cl^- was lower for RS STP than C1FC STP (Table-2) indicating sewage of more uniform pollution load. RS STP is run in residential colony, so, wastewater composition as well treated water composition variation is low. The variation is particularly in summer season, when maximum temperature of this region reaches upto 45°C and water gets concentrated due to high rate of evaporation. On the other hand, C1FC STP gets domestic, commercial as well industrial sewage from different areas of the city and is of quite non-uniform composition. Hence, more coefficient of variation is observed in treated water as well.

In the study area, average EC values of all water samples were found within the permissible limits of BIS standards (2250 µS cm^{-1}). However, according to classification of irrigation water, most of the samples of C1FC (100%) and RS (95%) fall under medium hazard category and such water use requires some management. Average COD values of C1FC (146.2 mg/l) and RS (144 mg/l) STP'S are higher than permissible limits of [13] (100mg/l) but within limits of 250mg/l of inland surface waters [14].

Table 2 : Water Quality Data for Study Sites – SriGanganagar

Para meter	C1FC STP, SriGanganagar				RS STP, SriGanganagar			
	RANGE	AVG	STDEV	CV (%)	RANGE	AVG	STDEV	CV (%)
Temp.	14.6 - 28.1	22.08	4.20	19.02	14.6 - 27.9	21.92	4.16	18.97
pH	7.1 - 8.1	7.42	0.24	3.24	7 - 7.9	7.35	0.19	2.60
EC	800 - 2180	1328.48	395.29	29.75	745 - 1280	886.62	116.33	13.12
COD	96 - 188	146.24	26.93	18.42	116 - 182	144.00	14.77	10.26
BOD	32 - 75	57.40	13.55	23.61	40.3 - 68.6	51.72	6.69	12.94

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TH	154 - 308	203.57	33.67	16.54	152 - 258	186.71	21.35	11.43
TA	272 - 460	358.19	48.79	13.62	162 - 270	194.81	26.21	13.46
TDS	420 - 770	601.33	93.26	15.51	418 - 605	532.76	38.20	7.17
Na^+	61 - 98	84.71	9.52	11.24	68 - 102	86.90	8.95	10.30
K^+	7.9 - 10.7	8.62	0.70	8.09	8.2 - 9.7	8.88	0.40	4.46
Ca^{+2}	35.4 - 51.8	42.61	4.13	9.70	32 - 51.2	38.90	3.77	9.69
Mg^{+2}	15.2 - 26.3	19.47	3.11	15.99	15.8 - 31.6	21.71	3.12	14.36
NO_3^-	6 - 12	8.76	1.51	17.27	3 - 8.2	4.16	1.31	31.41
SO_4^{-2}	60 - 97	77.33	10.94	14.15	46 - 68	56.95	5.44	9.56
Cl^-	58 - 105	81.29	14.64	18.01	64 - 81	72.43	5.19	7.17
F^-	0.34 - 0.48	0.39	0.04	9.99	0.26 - 0.35	0.31	0.02	7.59
WWQI	58.49-104.21	84.29	13.38	15.86	63.33-98.98	74.80	7.88	10.53

Average BOD values of C1FC (57.4mg/l) and RS (51.7mg/l) STP'S are higher than permissible limits of FAO and inland surface waters standards (30mg/l) [13]. The higher values of BOD are attained by the higher biological activity and the availability of much waste for degradation [15], which might be the result of untreated sewage, solid and industrial waste discharge [16]. [17] recorded COD and BOD values 94 mg/l and 28.55 mg/l respectively in the treated dairy effluent. According to [18] classification, most of the samples of C1FC (95%) and RS (100%) are of hard nature and such water use requires some management. Desirable limit of total hardness (TH) for irrigation water is 150 mg/L. TH more than this may cause white deposition on soil and plant foliage and can also damage to irrigation equipment [19]. Hardness caused by bicarbonate ions can influence soil, thereby indirectly affecting plant health [20]. All the samples were exceeding the limit of 150 mg/l as $CaCO_3$ hardness, so require dilution before application. C1FC (358.1mg/l) STP recorded higher average total alkalinity (TA) values than acceptable limits of 200 mg/l [21] but lower than [22] standard. Higher TA than standard values may be attributed to the high amounts of anionic surfactants and alkalis associated with commonly used domestic detergents which are carried by domestic effluents into the sewage treatment plants. Proper functioning of treatment units is required to regulate TA values. [23]. In the present study, it is found average TDS values for C1FC (601.3) and RS STP (532.7) are higher than prescribed BIS standard of drinking water but are within limits for irrigation and reuse purposes [12]. According to [24] classification of irrigation water, treated water of C1FC and RS may cause medium hazard to sensitive crops and should be used with some management. Calculated average values of WWQI, 84.4 (C1FC) and 74.8 (RS) are indicative of overall good quality of treated water in terms of physicochemical parameters [25]. WWQI was significantly higher during pre-monsoon sampling period in both treatment plants. In pre-monsoon high atmospheric temperature of this area causes more evaporation resulting in concentration rise of WWQI determining parameters and need of dilution for reuse of such water.

IV. CONCLUSION

The within sample variability data shown by coefficient of variance (CV) was lower for RS STP than C1FC STP indicating sewage of uniform pollution load in residential colony in comparison to public STP. WWQI was calculated using measured parameters to determine the overall quality of secondary treated wastewater of both STPs. Regarding water quality, present study indicated that STPs undertaken for study can produce good to moderately good quality effluent with respect to physio-chemical parameters and need continuous monitoring of treated water quality. Based on

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these results and analysis of water samples, it is recommended to use water only after dilution for specific usage like irrigation or reuse to prevent adverse plant and public health effects.

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