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(Research Article)

Assessment of secondary treated water quality through water quality index

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Abstract

The solution to all water challenges like water scarcity, unaccounted water loss or safe disposal of wastewater lies in wastewater treatment and reuse of treated water. To meet the sustainable water management practices, sewage treatment plants (STPs) are being installed for domestic wastewater treatment in new developing residential colonies. This research paper evaluates the water quality of sewage treatment plant operating on extended aeration process with average inflow of 400 KLD functioning in a residential colony, Ridhi Sidhi Enclave, Sri Ganganagar. This assessment will help to decide if the emanating is under cut-off points given by CPCB. The results indicated that average value of COD (144±14.77), TA (194.8±26.21) and TDS (532.7±38.20) are higher than permissible limits of FAO or BIS limits of drinking water but within limits of EPA standards of inland surface water. Average BOD values (51.7mg/l±6.7) are higher than permissible limits of FAO and inland surface waters standards (30mg/l). Regarding overall water quality, present study indicated that STP undertaken for study is capable of producing good to moderately good quality effluent at different times of sampling with respect to physicochemical parameters and there is a need of continuous monitoring of treated water quality.

Keywords: Wastewater treatment; Secondary treated water; Physicochemical; WWQI; Water management

1. Introduction

All living organisms depend on water for their day-to-day activities. Average daily consumption of water in residences, apartment houses for drinking, cooking, washing, bathing and other household activities is 135 lpcd. [1] This water is taken from rivers, lakes or from underground water. After use it gets contaminated and is called wastewater or sewage. About 80% of water used comes out of the houses in the form of wastewater. Industries and other economic activities also generate a lot of wastewaters. Population growth, industrialisation, urbanisation and economic activities have increased water demand enormously. As the water consumption increases, the wastewater production and pollution load increases accordingly. Improper and unplanned disposal of wastewater made it a nuisance and cause of environmental pollution. In lack of proper sewage system, every type of wastewater is disposed of into road drains or even directly on roads, thereby creating unhygienic conditions. Ultimately, it enters in water receiving bodies and results in degradation of water quality. If water quality is not maintained, it is not only environmental issue, but the commercial and recreational values of water resources also degrade drastically [2]. Potential harm of various wastes to the environment and public health can be minimized or possibly eliminated if the wastes are properly managed. Depending on composition, sewage water requires specialized treatment. As on date, emphasis is made on creating facilities for collection, conveyance and treatment of domestic wastewater. Domestic wastewater after treatment is a potential resource to meet the non-potable requirements. It will help in conserving raw water resources like groundwater and surface water [3]Various studies on potential of treated wastewater for irrigation lead to the conclusion of safe use for a particular group of crops and require regular monitoring [4],[5],[6]. Sewage composition is highly influenced by biotic and abiotic factors [7]. Depending on locality, the sewage water is variably contaminated and polluted and requires treatment accordingly [8], [9] Sewage treatment plants are a way to eliminate various pollutants

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from civil wastewater that primarily contains domestic sewage and sewage from commercial and industrial activities. STP's operate on physical, chemical and biological cycles to dispose of foreign substances from raw sewage. Governments have made it mandatory to install wastewater treatment systems within the boundaries for a cleaner environment and sustainable water management system [10] The STP located in a residential colony, Ridhi-Sidhi Enclave, Sri Ganganagar 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 in construction work and to irrigate parks in the colony. The present study is aimed to evaluate the functioning of this stp (RS STP) in terms of wastewater quality index (WWQI) of treated water.

2. Experimental section

To study the treated water quality parameters of sewage treatment plant (RS STP), measurements were made for a period of one year from February 2020 to January 2021. The present paper focuses on evaluation of wastewater quality index (WWQI) from measured physicochemical parameters. To assess the level of treatment, sampling of secondary treated water as per standard procedure was done from this site. Good quality narrow mouth screw-capped water bottles of two litre capacity made of polypropylene were used to collect the samples. Before sample collection bottles were rinsed thrice with water to be sampled and then filled completely to avoid any air bubble Methods of Sampling and Test (Physical and Chemical) for water & wastewater [11],[12]. Composite method of sampling was adopted for the research work [13], [14]. Sampling was done in the morning and evening time. Temperature, pH and DO were noted in the field at the time of sampling. For other parameters, the samples were refrigerated immediately and then mixed. The detailed analysis of all the composite samples was carried out using standard methods given in 'Standard Methods for the Examination of Water and Wastewater' 23rd Edition- 2017 prepared and published jointly [15]. Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Hardness (TH), Total Alkalinity (TA), Total Dissolved Solids (TDS), Sodium (Na+), Potassium (K+), Calcium (Ca+2), Magnesium (Mg+2), Nitrate (NO3-), Sulphate (SO4-2), Chloride (Cl-), Fluoride (F-) were measured for the present study and Waste Water Quality Index (WWQI) was calculated using these equations:

$$WWQI = \sum q_iW_i / \sum W_i \quad \ldots\ldots (1)$$

Where, Wi is unit weight for the ith parameter

$$W_i = k/S_i \quad \ldots\ldots (2)$$

$$q_i = 100\,(V_i - V_{i0}) / (S_i - V_{i0}) \quad \ldots\ldots (3)$$

Si 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) & Vi is measured value of the ith parameter in water sample, Vi0 is the ideal value of this parameter in pure water and Since in general, the ideal value, Vi0 = 0 for most parameters. Equation (2) assumes that simple form for these parameters

$$\text{Therefore } q_i = 100\,(V_i/S_i) \quad \ldots\ldots (4)$$

3. Results and discussions

The measured physicochemical parameters data is presented in table-1. Average value of pH (7.35±0.19), EC (886.6±116.3), TH (186.7±21.35), measured cations and anions- Na+ (86.90±8.95), K+ (8.88±0.4), NO3-(4.16±1.31), SO42- (56.95±5.44), Cl- (72.43±5.19), F- (0.31±0.02), Ca2+ (38.90±3.77), and Mg2+ (21.71±3.12) are within permissible limits of irrigation water (Tolerance limits of inland surface waters, Class-E.[16]. High levels of Na+ in summer season indicate more pollution load of domestic sewage or less efficient treatment that may cause harm to sensitive plant watering of the parks. The changes in these parameters in different samples are contributed to changes in atmospheric temperature and less efficient treatment process at times. Data indicates that average value of COD (144±14.77), TA (194.8±26.21) and TDS (532.7±38.20) are higher than permissible limits of FAO or BIS limits of drinking water but within limits of EPA standards of inland surface water [17]. Average BOD values (51.7mg/l±6.7) are higher than permissible limits of FAO and inland surface waters standards (30mg/l) [18]. The high values in pre monsoon season are attributed to higher biological activity and the availability of much waste for degradation due to less efficient treatment. The wastewater of this site includes domestic sewage water and wastewater from various café and restaurants located in the colony. The organic waste is the major component of the sewage and high levels of BOD indicate insufficient biological treatment.

Table 1 Physico-Chemical Parameters of RS STP, Sri Ganganagar

Sample	Month	Temp.	pH	EC	COD	BOD	TH	TA	TDS	Na^{+}	K^{+}	Ca^{+2}	Mg^{+2}	NO_3^{-}	SO_4^{-2}	Cl^{-}	F^{-}	CO_3^{-}	HCO_3^{-}
RS1	February (1)	17.5	7.3	870	138.0	53.8	192	210	510	90	8.5	40.0	22.4	4.0	58.0	78	0.26	0	210
RS2	February (2)	18.2	7.2	745	126.0	49.0	174	196	418	88	8.2	38.0	19.2	3.0	56.0	68	0.30	0	196
RS3	March (1)	21.1	7.3	820	152.0	60.8	192	226	492	92	8.9	40.4	22.1	4.0	62.0	72	0.32	0	226
RS4	March (2)	22.3	7.5	980	160.0	62.0	198	246	576	98	8.7	40.0	23.8	5.4	66.0	77	0.30	0	246
RS5	May (2)	25.8	7.9	1280	182.0	68.6	258	270	605	102	9.7	51.2	31.6	8.2	68.0	80	0.35	0	270
RS6	June (1)	27.5	7.5	1080	164.0	54.4	168	173	576	90	8.8	36.0	19.0	6.0	63.0	71	0.30	0	173
RS7	June (2)	27.9	7.3	970	140.0	48.6	162	165	546	82	8.2	34.8	18.2	5.5	60.0	68	0.31	0	165
RS8	July (1)	27.3	7.2	920	116.0	40.3	152	162	532	77	8.5	34.8	15.8	3.0	62.0	64	0.32	0	162
RS9	July (2)	26.6	7	870	118.0	44.0	160	168	560	72	8.6	32.0	19.4	4.2	58.0	65	0.33	0	168
RS10	August (1)	25.2	7.2	842	154.0	54.0	172	187	512	68	9.0	38.0	18.0	3.0	54.0	68	0.30	0	187
RS11	August (2)	25	7.1	868	140.0	48.4	177	190	543	82	9.4	36.0	21.1	4.6	58.0	73	0.31	0	190
RS12	September (1)	23.9	7.3	890	138.0	42.0	184	195	564	85	9.5	37.6	21.9	3.0	50.0	75	0.30	0	195
RS13	September (2)	23.4	7.4	860	142.0	53.4	188	210	516	80	9.2	40.0	21.4	4.0	46.0	68	0.28	0	210
RS14	October (1)	22.7	7.3	810	145.0	48.5	192	182	508	74	9.3	39.2	22.8	3.0	52.0	64	0.30	0	182
RS15	October (2)	22.1	7.4	832	140.0	51.4	186	176	520	93	8.8	38.4	21.9	3.4	54.0	72	0.30	0	176
RS16	November (1)	20.6	7.5	850	152.0	54.4	196	190	540	95	9.0	42.4	21.9	4.0	56.0	75	0.26	0	190
RS17	November (2)	18.9	7.6	876	146.0	52.8	192	188	556	97	8.7	39.2	22.8	3.0	59.0	78	0.28	0	188
RS18	December (1)	17.3	7.4	820	144.0	48.7	188	184	528	92	8.6	37.6	22.8	3.0	53.0	72	0.30	0	184
RS19	December (2)	16.8	7.2	780	135.0	45.0	193	195	510	87	8.8	39.2	23.1	4.0	50.0	74	0.32	0	195
RS20	January (1)	14.6	7.3	810	142.0	50.4	195	192	528	89	8.9	40.0	23.1	4.0	54.0	78	0.34	0	192
RS21	January (2)	15.6	7.4	846	150.0	55.6	202	186	548	92	9.1	42.0	23.6	5.0	57.0	81	0.33	0	186

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

Table 2 Wastewater Quality Index (WWQI) of RS STP, SriGanganagar

Parameter	IS-2296 (Si)	Unit Wt (Wi)	RS1 (qi Wi)	RS2 (qi Wi)	RS3 (qi Wi)	RS4 (qi Wi)	RS5 (qi Wi)	RS6 (qi Wi)	RS7 (qi Wi)	RS8 (qi Wi)	RS9 (qi Wi)	RS10 (qi Wi)	RS11 (qi Wi)	RS12 (qi Wi)	RS13 (qi Wi)	RS14 (qi Wi)	RS15 (qi Wi)	RS16 (qi Wi)	RS17 (qi Wi)	RS18 (qi Wi)	RS19 (qi Wi)	RS20 (qi Wi)	RS21 (qi Wi)
Temp.	25	0.0400	2.80	2.912	3.376	3.568	4.128	4.400	4.464	4.368	4.256	4.032	4.000	3.824	3.744	3.632	3.536	3.296	3.024	2.768	2.688	2.336	2.496
pH	8.5	0.1176	2.35	1.569	2.353	3.922	7.059	3.922	2.353	1.569	0.000	1.569	0.784	2.353	3.137	2.353	3.137	3.922	4.706	3.137	1.569	2.353	3.137
EC	2250	0.0004	0.02	0.015	0.016	0.019	0.025	0.021	0.019	0.018	0.017	0.017	0.017	0.018	0.017	0.016	0.016	0.017	0.017	0.016	0.015	0.016	0.017
COD	100	0.0100	1.38	1.260	1.520	1.600	1.820	1.640	1.400	1.160	1.180	1.540	1.400	1.380	1.420	1.450	1.400	1.520	1.460	1.440	1.350	1.420	1.500
BOD	10	0.1000	53.80	49.000	60.800	62.000	68.600	54.400	48.600	40.300	44.000	54.000	48.400	42.000	53.400	48.500	51.400	54.400	52.800	48.700	45.00	50.40	55.60
TH	300	0.0033	0.21	0.193	0.213	0.220	0.287	0.187	0.180	0.169	0.178	0.191	0.197	0.204	0.209	0.213	0.207	0.218	0.213	0.209	0.214	0.217	0.224
TA	200	0.0050	0.53	0.490	0.565	0.615	0.675	0.433	0.413	0.405	0.420	0.468	0.475	0.488	0.525	0.455	0.440	0.475	0.470	0.460	0.488	0.480	0.465
TDS	500	0.0020	0.20	0.167	0.197	0.230	0.242	0.230	0.218	0.213	0.224	0.205	0.217	0.226	0.206	0.203	0.208	0.216	0.222	0.211	0.204	0.211	0.219
Na^{+}	200	0.0050	0.23	0.220	0.230	0.245	0.255	0.225	0.205	0.193	0.180	0.170	0.205	0.213	0.200	0.185	0.233	0.238	0.243	0.230	0.218	0.223	0.230
K^{+}	15	0.0667	3.78	3.644	3.956	3.867	4.311	3.911	3.644	3.778	3.822	4.000	4.178	4.222	4.089	4.133	3.911	4.000	3.867	3.822	3.911	3.956	4.044
Ca^{2+}	75	0.0133	0.71	0.676	0.718	0.711	0.910	0.640	0.619	0.619	0.569	0.676	0.640	0.668	0.711	0.697	0.683	0.754	0.697	0.668	0.697	0.711	0.747
Mg^{2+}	30	0.0333	2.49	2.133	2.456	2.644	3.511	2.111	2.022	1.756	2.156	2.000	2.344	2.433	2.378	2.533	2.433	2.433	2.533	2.533	2.567	2.567	2.622
NO_3^{-}	50	0.0200	0.16	0.120	0.160	0.216	0.328	0.240	0.220	0.120	0.168	0.120	0.184	0.120	0.160	0.120	0.136	0.160	0.120	0.120	0.160	0.160	0.200

SO4-2	400	0.0025	0.04	0.035	0.039	0.041	0.043	0.039	0.038	0.039	0.036	0.034	0.036	0.031	0.029	0.033	0.034	0.035	0.037	0.033	0.031	0.034	0.036
Cl-	250	0.0040	0.12	0.109	0.115	0.123	0.128	0.114	0.109	0.102	0.104	0.109	0.117	0.120	0.109	0.102	0.115	0.120	0.125	0.115	0.118	0.125	0.130
F-	1.5	0.6667	11.56	13.333	14.222	13.333	15.556	13.333	13.778	14.222	14.667	13.333	13.778	13.333	12.444	13.333	13.333	11.556	12.444	13.333	14.22	15.11	14.66
∑Wi		1.0899																					
∑qiWi			80.37	75.88	90.94	93.36	107.88	85.85	78.28	69.03	71.98	82.46	76.97	71.63	82.78	77.96	81.22	83.36	82.98	77.80	73.45	80.32	86.33
WWQI = ∑qiWi / ∑Wi			73.74	69.62	83.43	85.65	98.98	78.76	71.82	63.33	66.04	75.66	70.62	65.72	75.95	71.53	74.52	76.48	76.13	71.38	67.39	73.69	79.21

However, samples exhibit relatively low variability of COD and BOD around mean values indicating sewage of almost uniform pollution load. Chemical parameters do not follow any seasonal trend as they are affected by nature of discharges in wastewater and the treatment process efficiency. WWQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, poor, etc.) for reporting to management and the public in a consistent manner [19]. It enables rapid assessment of water reuse for agricultural or recreational purpose as well as for comparing different wastewater treatment sequences [20,21]. The WWQI values ranging from 63.33 to 98.98 (table-2) are of class II category with average value 74.8 that is indicative of overall good quality of treated water in terms of physicochemical parameters [22] (table-3). WWQI was significantly higher during pre-monsoon sampling period. In pre-monsoon high atmospheric temperature of this area causes more evaporation resulting in concentration rise of WWQI determining parameters.

Table 3 Water Quality Index

WQI	Class	Water Quality
<50	I	Excellent
50-100	II	Good
100-200	III	Poor
200-300	IV	Very Poor
>300	V	Unsuitable

4. Conclusions

Data reveals that average value of COD, TA and TDS are higher than permissible BIS limits of drinking water but within limits of EPA standards of inland surface water. Average BOD values are higher than permissible limits of FAO and inland surface waters. Chemical parameters do not follow any seasonal trend as they are affected by nature of discharges in wastewater and the treatment process efficiency. The water quality gets deteriorated at different times due to atmospheric conditions or improper treatment processes. The WWQI values ranging from 63.33 to 98.98 indicate that RS STP undertaken for present study is producing water of overall good quality in terms of physicochemical parameters. The reclaimed water can be used only for non-potable purpose like landscape irrigation and construction activities. Regular monitoring of treatment process will contribute a lot to sustainable water management.

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