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Assessing the Quality of Wastewater for Farming Purpose in and around Various Industrial Areas of Jaipur City, Rajasthan

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The physicochemical properties of domestic and industrial effluents disposed of into 'Amanishah Nala' of Jaipur city, where this water is used for irrigation purpose. The results obtained in the present investigations revealed that the water quality for farming purpose was found to be suitable; however, specific contaminations with special reference to EC, Cl^-, TH, TDS, COD and BOD in wastewater have been observed, which calls for at least primary treatment of wastewater before being used for irrigation.

Key Words: Residual carbonate, Industrial wastes, Water pollution, Sodium absorption ratio.

INTRODUCTION

Due to more industrialization and urbanization, the disposal of city waste, sewage water and industrial effluents are becoming a major problem. In general, sewage effluents of municipal origin contain appreciable amount of plant nutrients and, therefore, its use as a source of irrigation in agriculture is worth consideration[1]. Although, applications of sewage effluents were reported to be beneficial in increasing crop yield and reduce fertilizer requirement[2–7], but some studies showed that metals like Cu, Cd, Cr, etc. enter into the food chain through their application in soil and this ultimately causes health concern significantly[8]. The nitrate and pollution problems in groundwater have also been studied earlier[9, 10].

All the domestic, municipal and industrial wastes are discharged in Amanishah Nala' which is the largest element of drainage system of this city and covers the whole city. The farmers use this water from some parts of Amanishah Nala for growing vegetables and other crops. The structural and functional characteristics of water have to be analyzed, both quantitatively and qualitatively, in order to have a prevalent assessment of the wastewater quality, necessary for judging its appropriateness for farming. Sewage farming is an imperative progress in water resource management.

EXPERIMENTAL

Wastewater samples were collected from eleven different sites from the Amanishah Nala. Samples were collected in sterilized screw-capped polyethylene bottles[11] of one litre capacity, labelled properly and analyzed in the laboratory for

all their physicochemical parameters. Monitoring was done during post-monsoon session (April 2004 to May 2004). The instruments were used in the limit of precise accuracy, chemicals used were of analytical grade and double distilled water was used for preparing solutions for analysis.

Collected water samples were determined as per standard methods[12]. The suitability of wastewater for irrigation was evaluated by using the irrigation water quality indices like % Na, TH, RSC, SAR, EC, TDS, Cl^- and SO_4^{2-} ions. The values of all the parameters considered for suitability determination are shown in in Tables 1 and 2 and classification of wastewater for irrigational uses by various parameters is tabulated in Table-3.

TABLE-1
SUITABILITY OF THE AMANISHAH NALA (JAIPUR CITY) WATER USED FOR IRRIGATION PURPOSE

S. No.	Parameters	Average observed values	CPCB standards	Class of water	Suitability for irrigation
1.	TDS (mg/L)	1102.88	700–2000	II	Good–Injurious
2.	Sulphates (mg/L)	134.35	< 192	I	Excellent–Good
3.	Chlorides (mg/L)	287.35	142–355	II	Good–Injurious
4.	Per cent sodium	43.06	60–75*	I	Excellent–Good
5.	EC (μS/cm)	2569.82	750–2295*	III	Poor–Very Injurious
6.	SAR	4.04		I	Excellent–Good

*United States Salinity Laboratory Standards

TABLE-2
CLASSIFICATION OF IRRIGATED WATER

Parameters	Range	Classification	Parameters	Range	Classification
Sodium (%)	< 20	Excellent	EC (mmho/cm)	< 250	Excellent
	20–40	Good		250–750	Good
	40–60	Permissible		750–2000	Fair
	60–80	Doubtful		2000-3000	Doubtful
	> 80	Unsuitable		> 3000	Unsuitable
SAR	< 10	Excellent	Residual carbonate (RSC)	< 1.25	Excellent
	10–18	Good		1.25–2.50	Good
	18-26	Fair		> 2.50	Poor
	> 26	Poor	Hardness	< 50	Soft
				50–150	Moderately hard
				150–300	Hard
				> 300	Very hard

TABLE-3
CLASSIFICATION OF WASTEWATER FOR IRRIGATIONAL USE BY VARIOUS PARAMETERS

Samples	%Na	SAR	EC	Hardness (as $CaCO_3$)	Residual carbonate (RSC)
E1	Excellent	Excellent	Permissible	Very very hard	Excellent
E2	Excellent	Excellent	Permissible	Very hard	Excellent
E3	Permissible	Excellent	Unsuitable	Very hard	Excellent
E4	Permissible	Excellent	Unsuitable	Very hard	Excellent
E5	Good	Excellent	Doubtful	Very hard	Excellent
E6	Permissible	Excellent	Permissible	Very hard	Excellent
E7	Permissible	Excellent	Doubtful	Very hard	Excellent
E8	Good	Excellent	Permissible	Very hard	Excellent
E9	Permissible	Excellent	Doubtful	Very hard	Excellent
E10	Doubtful	Excellent	Doubtful	Very hard	Excellent
E11	Unsuitable	Good	Doubtful	Very hard	Excellent

RESULTS AND DISCUSSION

The details of outcomes were summarized in Tables 4 and 5. The suitability of wastewater for irrigation depends upon its mineral constituents. More then half of the samples generally ranged between doubtful to unsuitable levels with EC > 2000 μS cm^{-1}. EC values of these effluents ranged between 1376 and 5851 μS cm^{-1} at different locations. Samples were alkaline in reaction with pH values ranging from 7.19–10.04 and were within permissible limits for farming (pH 6–9) except sample E4. Sodium and potassium values ranged from 23.2–364.9 and 7.8–23.4 mg/L, respectively. Small quantities of sodium and potassium are always desirable in irrigation waters. Evaluation of the quality of wastewater on the basis of per cent sodium (% Na) is excellent[13]. Values of % Na varied from 3.97–83.46 and were within permissible limits recommended by USSL standards[14] except samples E10 and E11. Sodium hazard of irrigation water can also be well understood by SAR. The SAR values ranged from 0.37–11.50 and were lying within the standards of USSL (< 10) except E11 but almost all samples were above recommended limit[15] of 3.0 (IS: 3307-1977). Lower the ionic strength of the solution, greater the sodium hazards for a given SAR[16].

The carbonate contents ranged between 6.3–297.6 whereas bicarbonate ranged from 6.7–604.9 mg/L which was marginal. In waters having high concentration of bicarbonate there is a tendency for calcium and magnesium to precipitate as carbonates. To qualify this effect an experiential parameter termed as residual sodium carbonate (RSC) was used[17]. All samples were found to have nil RSC values. Chloride values varied from 124.6–754.3 mg/L, chloride was at toxic level in all samples except E2, E5 and E8 on the basis of maximum permissible limit for irrigation[15] (IS: 3307-1977). Similarly, SO_4^{2-} values varied from 24.6–295.7 mg/L

and they were also higher than the tolerance limit (10–14 mg/L) for irrigation purpose[15] (IS: 3307-1977). Ca^{2+} hardness values varied from 17.8– 252.4 mg/L; values of Mg^{2+} hardness ranged from 16.3–333.4 mg/L and total hardness (TH) values varied from 111–2002 mg/L; all samples were of very hard quality.

TABLE-4
IONIC VARIATIONS IN INDUSTRIAL WASTEWATER OF JAIPUR CITY

Site and source	EC	pH	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	F^-	NO_3^-
E1	1720	7.36	38.3	11.3	252.4	333.4	209.2	211.5	6.3	6.7	2.0	52
E2	1376	7.19	23.2	19.6	63.9	43.6	124.6	118.4	42.5	354.6	0.7	82
E3	3556	7.51	135.7	13.5	51.2	58.7	239.7	138.4	236.1	32.5	1.6	97
E4	5851	10.04	167.6	23.4	73.5	60.1	754.3	94.9	297.6	24.8	1.3	35
E5	2208	7.26	116.1	17.4	139.3	37.8	178.9	146.7	10.4	604.9	2.1	49
E6	1613	7.41	144.5	7.8	94.1	23.5	205.4	120.8	39.1	315.6	0.8	234
E7	2356	7.48	164.5	12.6	93.5	47.2	314.6	295.7	100.5	287.4	1.2	59
E8	1578	8.33	113.9	16.5	86.7	37.3	198.7	65.7	35.2	408.5	0.2	47
E9	2662	8.15	213.8	16.8	75.6	58.9	287.9	24.6	114.8	428.9	2.9	43
E10	2635	8.01	364.9	9.7	58.2	36.6	375.8	125.8	124.2	415.7	7.2	5
E11	2713	7.23	279.1	6.9	17.8	16.3	271.8	135.4	151.9	561.8	8.9	234

Note: All values are in mg/L except pH and EC.

TABLE-5
PHYSICO-CHEMICAL PARAMETERS OF INDUSTRIAL WASTEWATER OF JAIPUR CITY

Site and source	TH	TDS	DO	BOD	COD	% Na	SAR
E1	2002	1117.7	4.2	124	684	3.97	0.37
E2	339	695.1	5.2	51	274	12.18	0.55
E3	369	986.6	5.2	192	1241	43.29	3.07
E4	431	1518.8	6.0	75	516	44.18	3.51
E5	503	998.1	6.4	135	827	32.46	2.25
E6	331	1027.0	5.2	238	1509	47.93	3.45
E7	427	1231.3	5.7	42	294	44.64	3.46
E8	370	805.2	5.1	31	213	38.79	2.58
E9	431	1049.8	4.9	46	331	50.68	4.48
E10	296	1308.0	5.3	104	751	72.03	9.23
E11	111	1394.1	5.4	127	940	83.46	11.50

Note: All values are in mg/L except %Na and SAR.

Nitrate values varied between 5–334 mg/L; all sample had marginal value but samples E6 and E11 had very high nitrate concentration (234 mg/L). Fluoride values varied from 0.20–8.90 mg/L. Total dissolved solids (TDS) values varied from 695.1–1518.8 mg/L. Sample E4 was beyond the maximum recommended limit (1500 mg/L) for land irrigation[18].

The DO values were recorded in the range of 4.2–6.4 mg/L; they all were within permissible limits recommended by USPH standards. BOD and COD

values varied from 31–238 mg/L and 213–1509 mg/L; in all the studied samples COD values were higher than the prescribed limits but BOD values of samples E1, E3, E5, E6, E10 and E11 had BOD content above 100 mg/L.

It is concluded that the water samples have salt load (EC) in between 1376–5851 $\mu S\ cm^{-1}$. The BOD and COD of all samples–were above the IS standards and might cause problems in the long run. The long-term application of these wastewaters may enlarge heavy metals to significant levels that will finally enter into the vegetation grown on such soil. Generally, the average application rate of wastewater per unit area is in excess of normally permissible application rates in any properly managed irrigation system. Therefore, industrial effluents, if treated properly to reduce BOD, COD and salt load and used judiciously, can provide an alternate source of water for farming.

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