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Evaluation of Waste Water Quality Parameters to Assess its Suitability for Irrigation Purpose Around Industrial Localities of Jaipur City

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Abstract

The aim of this study was to assess the wastewater quality for irrigation purpose. The eleven sampling sites of Jaipur city during monsoon season (June—September 2009) were selected for this purpose. The water quality parameters such as pH, EC, TDS, TH, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulfate, fluoride, nitrate, sodium percentage, sodium adsorption ratio were estimated. The analysis revealed that (pH ranged from 7.1—9.3) water was alkaline in nature and EC and TDS in most of samples exceeded the permissible limit suggested by USPH. Similarly F^-, NO_3^-, Cl^-, K^+, Mg^{2+} and Ca^{2+} concentrations also exceeded desirable limits in almost samples. The results from BOD, COD and DO revealed that primary treatment of water is inevitable for irrigation. A characterization of wastewater on the basis of Wilcox diagram exhibited that most of samples fall in C3S1 (high salinity hazard and low alkalinity hazard) and few samples in C4S1 (very high salinity hazard and low alkalinity hazard).
Key words : Wastewater, BOD, COD, DO, Wilcox diagram.

Wastewater pollution has always been a major problem throughout the world. The lack of clean water has always been an issue of environmental concern all over the world. This environmental issue is mainly stressed in developing countries today. The term "wastewater" is a broad, descriptive term. Generally it includes liquids and waterborne solids from domestic, industrial or commercial uses and other waters that have been used (or "fouled") in madn's activities, whose quality has been degraded, and which are discharged to a sewage system. The term "sewage" has been used for many years and generally refers to waters containing only sanitary wastes. However, "sewage" technically denotes any wastewaters which pass through a sewer. Two general categories of wastewaters, not entirely separable, are recognized : domestic wastewaters and industrial wastewaters. Domestic wastewaters originate principally from domestic, household activities but will usually include waters discharged from commercial and business buildings and institutions and wastewater. Surface and storm waters may also be present. Domestic wastewaters are usually of a predictable quality and quantity. Industrial wastewaters, on the other hand, originate from manufacturing processes, are usually of a more variable character, and are often more difficult to treat than domestic wastes. While domestic wastewaters can be dealt with in general terms with respect to character and treatment, industrial wastewaters must be examined on an industry-by-industry basis. Generally we deal primarily with domestic wastewaters. Many studies have been carried out on water quality parameters in India. Singare et al. (1) studied the physico-chemical quality of the industrial wastewater effluent from Gove industrial area of Bhiwandi city of Maharashtra, India and pointed out that as India moves towards stricter regulation of industrial effluents to control water pollution, greater efforts are required to reduce the risk to public health as toxic pollutants which are mainly colorless and odorless are released into the ecosystems. Suheyla and Anagun (2) assessed the water quality observations using cluster analysis and ordinal logistic regression technique. It was concluded that domestic, agricultural and industrial discharges strongly affected the northwest part of the Tahtali dam reservoir. Bhattacharya et al. (3) examined arsenic contamination in rice, wheat, pulses, and vegetables

Table 1. Ionic variation of wastewater in Jaipur city during monsoon season (June—September 2009).

Code	EC	pH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}
W_1	842	8.5	150	51.9	58.2	5.3	8.5	219.5	169.6	226.5	56	2.1
W_2	1545	9.7	63.8	69.8	77.3	7.8	13.7	180.2	361.2	93.5	42.1	1.3
W_3	1090	7.2	70.2	37.1	93.5	9.3	47.5	226.2	277.5	63.6	36.5	1.5
W_4	1040	8.7	84.0	40.5	105.7	11.2	12.6	230.2	340.1	127.0	28	8.2
W_5	2260	8.3	82.2	65.2	30.2	3.6	90.2	243.5	190.2	96.3	29.2	1.3
W_6	2740	7.7	64.1	39.6	80.5	7.9	3.5	178.6	170.8	83.5	18.5	2.4
W_7	3250	7.5	75.2	52.2	36.8	3.8	85.2	227.1	124.3	121.3	43.5	3.5
W_8	1890	7.9	60.5	32.5	56.7	5.2	40.1	217.6	370.3	142.2	67.4	4.1
W_9	1475	8.2	114.5	37.8	93.5	9.2	12.3	324.2	205.3	106.3	56.2	3.1
WA	2340	7.1	62.3	28.5	107.1	10.2	26.3	187.1	196.2	93.5	63.2	1.2
WB	3640	7.8	137.5	42.2	63.9	7.2	35.1	380.2	175.2	66.3	37.2	0.90

in arsenic affected area of West Bengal, India and concluded that concentrations of arsenic in irrigation water, soil, rice, wheat, common vegetables, and pulses, intensively cultivated and consumed by the people of highly arsenic affected.Arsenic concentrations of irrigation water samples were many folds higher than the WHO recommended permissible limit for drinking water. Acharya et al. (4) studied chemical properties of ground water in Bhiloda Taluka region, North Gujarat, India. Banger et al. (5) reported quality of ground water used for irrigation in Ujjain district of Madhya Pradesh, India. Sadashivaiah et al. (6) Studied hydro chemical analysis and evaluation of ground water quality in Tumkur Taluk, Karnataka state, India. Ground water pollution problem in drinking water from various sources in Jaipur and many villages have been carried in our laboratory (7—10).

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Methods

Jaipur (longitude 95° 24′ E; latitude; 27°18′ N), which is located in the eastern part of Rajasthan state, is undergoing rapid urbanization and industrialization. Wastewater samples from eleven sampling station were analyzed during the monsoon season (June—September 2009). Samples were collected in good quality polyethylene bottles of 1-liter capacity. Sampling was carried out without adding any preservatives in rinsed bottles directly for avoiding any contamination and brought to the laboratory. Monitoring was done during the monsoon season (June—September 2009). Only high pure (Anal R grade) chemicals and double distilled water was used for preparing solutions for analysis. Physical parameters like pH; TDS and EC were determined at the site with the help of digital portable water analyzer kit (Model No. : CENTURY–CK–710). BOD and COD were determined with help of titrimetric method. Whereas DO was analyzed with help of Winkler method. For rest of the analysis, water samples were preserved and brought to the laboratory in minimum period of time and were determined following standard methods.

Results and Discussion

Wastewater Chemistry

The pH. The pH values of wastewater varied from 7.1 to 9.7 which indicate that water is slightly alkaline in nature and pH in almost wastewater samples within permissible limit as prescribed by WHO standard (11) (Table 1).

EC. The EC values range from 1,040 to 3,640 μs/cm. The maximum limit of EC in drinking water is prescribed as 1500 μs/cm as per WHO standard. All samples exceeded the desirable limit except (W_1, W_3, W_4 and W_9). The maximum value of EC (3,640 μs/cm) is observed in sample WB (Table 1).

TDS. TDS values ranged from 418 to 1821. The most desired value of TDS is 500 and all samples exceeded desirable limit except sample W_1 (Table 2).

Variation of Ions

The mean concentration of anions was in the

Table 2. Physico-chemical parameters of industrial wastewater of Jaipur city.

Code	TDS	BOD	COD	DO	TH	Na (%)	RSC	SAR
W_1	418	22	84	4.5	588.1	18.33	-7.90	1.40
W_2	742	138	440	4.8	446.3	27.89	-4.48	1.58
W_3	541	72	521	4.3	327.9	39.22	2.04	2.21
W_4	550	55	340	5.2	376.4	39.04	-0.8	2.34
W_5	1095	101	280	5.9	473.5	12.90	-1.1	4.34
W_6	1360	24	76	6.2	430.1	37.25	-0.36	2.01
W_7	1630	40	116	4.4	402.5	20.60	-1.06	0.91
W_8	960	33	92	5.9	284.8	33.30	-1.32	1.63
W_9	702	109	340	6.2	441.4	32.48	-4.39	1.92
WA	1240	125	640	4.9	272.8	50.09	-1.22	3.19
WB	1821	85	309	5.3	516.9	22.82	-1.83	1.28

order bicarbonate > chloride > sulfate > nitrate > fluoride while for cations calcium > sodium > magnesium > potassium (Table 1).

Mg^{2+}. The Mg^{2+} concentration varied from 28.2 to 69.8 mg/, the desirable value of Mg^{2+} is 50 mg/L; four samples (W_1, W_2, W_5 and W_7) exceeded the desirable limit (Table 1).

Ca^{2+}. The Ca^{2+} value varied from 60.5 to 150 mg/liter. Six samples (W_1, W_4, W_5, W_7, W_9 W_B) exceeded the desirable (75 mg/liter) limit (Table 1).

Na^+ and K^+. Sodium values were ranging from 30.2 to 107.1 mg/liter. Potassium values were ranging from 3.6 to 11.2 mg/liter. In all the analyzed samples sodium and potassium values were in permissible limit as per WHO standard (Table 1).

CO_3^{2-} and HCO_3^-. The carbonate content ranged between 3.5 to 126 mg/liter, whereas bicarbonate content ranged 178.6 to 380.2 mg/liter. All the values of carbonate and bicarbonate were in permissible limit (Table 1).

Cl^-. Chloride values varied from 124.3 to 370.3 mg/liter. The desirable limit of Cl^- for wastewater is specified as 250 mg/liter; hence three samples (W_2, W_4 and W_8) exceeded the desirable limit (Table 1).

SO_4^{2-}. The concentration of sulphate ranged from 63.6 to 226.5 mg/liter and all the samples below the permissible (400 mg/liter) limit as per WHO standard (Table 1).

F^-. Fluoride value varied from 0.82 to 4.1 mg/liter. Five samples (W_1, W_6, W_7, W_8 and W_9) exceeded the permissible limit (1.5 mg/liter) based on WHO standard (Table 1).

NO_3^-. Nitrate values varied from 18.5 to 67.4 mg/liter. Four samples (W_1, W_8, W_9 and WA) exceed the standard desirable limit of 45 mg/liter as per WHO norms (Table 1).

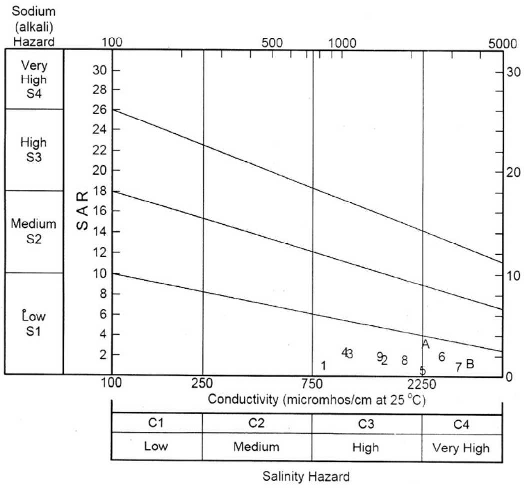

Figure 1. Wilcox diagram.

Irrigation Water Quality

A classification system to evaluate the suitability of water for irrigation use was developed by US salinity laboratory (12). The suitability of wastewater for irrigation purposes depends upon its mineral constituents. The general criteria for judging the quality are : Total salt concentration as measured by EC; relative proportion of sodium to other principal cations as expressed by SAR. EC is a good measure of salinity hazard to crops. Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil. According to Wilcox classification (13) the wastewater in the study part are ranging between good to permissible for irrigation uses.

SAR is important parameters for determining the suitability of wastewater for irrigation because it is a measure of alkali/sodium hazard to crops. SAR can be estimated by the formula :

$$SAR = (Na^+) / \sqrt{[(Ca^{2+}) + (Mg^{2+}) / 2}$$

Where all the concentrations are expressed in meq./liter.

Table 3. Classification of wastewater for irrigational use by various parameters.

Parameters	Range	Water class	Samples
Na (%)	<20%	Excellent	W_1, W_5
	20—40%	Good	W_2, W_3, W_4, W_6, W_7, W_8, W_9, WB
	40—60%	Permissible	WA
	60—80%	Doubtful	–
	>80%	Unsuitable	–
EC (μS/cm)	0—250	Good	–
	251—750	Permissible	–
	751—2,250	Doubtful	W_1, W_2, W_3, W_4, W_8, W_9
	>2,250	Unsuitable	W_5, W_6, W_7, WA, WB
RSC	<1.25	Good	–
	1.25—2.5	Doubtful	W_1
	>2.5	Unsuitable	–
SAR	<10	Low sodium water (S1)	W_1, W_2, W_3, W_4, W_5, W_6, W_7, W_8, W_9, WA, WB
	18	Medium sodium water (S2)	–
	18—26	High sodium water (S3)	–
	26	Very high sodium water (S4)	–
T H	<75	Soft	–
	75—150	Moderately hard	–
	150—300	Hard	WA, W_8
	>300	Very hard	W_1, W_2, W_3, W_4, W_5, W_6, W_7, W_9, WB

SAR values ranged from 0.91 to 3.19 (Table 2). This exhibited low sodium wastewater. The analytical data plotted on the US salinity diagram (14) illustrated that most of samples (W_1, W_2, W_3, W_4, W_5, W_8 and W_9) fall in C3S1 (high salinity hazard and low alkalinity hazard) and few sample (WA, WB, W_6 and W_7) in C4S1 (very high salinity hazard and low alkalinity hazard), hence wastewater can be used for irrigation in almost all types of soil with little danger of exchangeable sodium (Fig. 1).

Na Percent. The sodium in irrigation water is usually expressed in percent Na. Indian standards maximum of 60% sodium is permissible for irrigation water. Na can be determined by using the formula

$$\text{Na (\%)} = \frac{(Na^+ + K^+)\ 100}{Ca^{2+} + Ng^{2+} + Na^+ + K^+}$$

Where all the ionic concentrations were expressed in mili-equivalents per liter.

The value of Na (%) varied from 12.90 to 50.09 (Table 2). Two samples (W_1 and W_5) fall in excellent category, eight samples (W_2, W_3, W_4, W_7, W_8, W_9 and WB) fall in good category while one sample (WA) in permissible category (Table 2).

RSC. RSC has been calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose and has been determined by the formula :

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

Where the concentrations are reported in meq/liter.

The classification of irrigation water according to the RSC values is presented in (Table 2). Sample (W_3) was in doubtful category. For rest of samples RSC values were found nil.

Total Hardness (TH). The total hardness in ppm was determined by following equation :

$$TH\ (ppm) = 2.497\ Ca^{2+} + 4.115\ Mg^{2+}$$

Water hardness caused primarily by the presence of cations such as calcium and magnesium and anions such as carbonate, bicarbonate, chloride and sulphate water. The total hardness varies between 272.8 to 588.1 mg/liter (Table 2). According to Sawyer and McCarthy's (13) classification for hardness two samples (W_8 and WA) fall under hard class and remaining samples fall under very hard class of water samples (Table 3).

BOD. BOD values ranged from 22 to 138 mg/liter (Table 2). Four samples (W_2, W_5, W_9 and WA) fall in doubt category (Table 3). The BOD range suggested that primary treatment of water required before being used in farming.

COD. COD values ranged from 76 to 640 mg/liter (Table 2). All the samples exceeded the permissible limit by USPH; the COD range also indicated inevitably primary treatment.

DO. DO values were recorded in the range of 4.3 to 6.2 mg/liter (Table 2). All the samples were within permissible limits recommended by USPH standards.

Conclusion

It is concluded that the water samples had salt load (EC values ranged from 1,040 to 3,640 µs/cm). The BOD and COD of all the samples were above the IS parameters and might cause problems in the long run. F^-, NO_3^-, Cl^-, K^+, Na^+, Mg^{2+} and Ca^{2+} concentrations exceeded desirable limits in almost samples. The US salinity diagram (12) illustrated that most of samples (W_1, W_2, W_3, W_4, W_5, W_8 and W_9) fall in C3S1 (high salinity hazard and low alkalinity hazard) and few samples (WA, WB, W_6 and W_7) in C4S1 (very high salinity hazard and low alkalinity hazard), hence wastewater can be used for irrigation in almost all types of soil with little danger of exchangeable sodium. The long-term application of these wastewaters may enhance heavy metals to significant levels that will finally enter into the vegetations and crops grown in these areas. In general, the average practice of wastewater per unit area is in excess of normally permissible effluents. If the industrial effluents are treated properly to decrease the levels of BOD, COD and salt load it will definitely provide an alternate source of water for agricultural purpose (15).

References

1. Singare P. U., R. S. Lokhande and A. G. Jagtap. 2010. Study of physico-chemical quality of the industrial waste water effluent from Gove industrial area of Bhiwandi City of Maharashtra, India. *Interdiscipl. Environm. Rev.* 11 : 263—273.
2. Suheyla Y. and A. Sermet Anagun. 2010. Assessment of water quality observation stations using cluster analysis and ordinal logistic regression technique. *Int. J. Environ. and Poll.* 42 : 344—358.
3. Bhattacharya P., A. C. Samal, J. Majumdar and S. C. Santra. 2010. Arsenic contamination in rice, wheat, pulses, and vegetables : A study in an arsenic affected area of West Bengal, India. *water. Air, & Soil Poll.* 213 : 3—13.
4. Acharya G. D., M. V. Hathi, A. D. Patel and K. C. Parmar. 2008. Chemical properties of groundwater in Bhiloda Taluka region, North Gujarat, India. *E-J. Chem.* 5 : 792—796.
5. Banger K. S., S. C. Tiwari, S. K. Verma and U. R. Khandkarss. 2008. Quality of ground water used for irrigation in Ujjann district of Madhya Pradesh. *Ind. J. Environ. Sci. and Engg.* 50 : 179—186.
6. Sadashivaiah C., C. R. Ramakrishnaiah and G. Ranganna. 2008. Hydro-chemical analysis and evaluation of ground water quality in Tumkur Taluk, Karnataka state. India. *Int. J. Environ. Res. Pub. Hlth.* 5 : 158—164.
7. Sharma S. and C. P. Singh Chandel. 2008. Studies on physico-chemical parameters of ground water of samber block of Jaipur district. *Poll. Res.* 27 : 671—677.
8. Tank D. K. and C. P. Singh Chandel. 2009. *A hydro-chemical elucidation of the groundwater composition under domestic and irrigated land in Jaipur city.* Environ. Monit. Assess. DOI10.1007/s10661-009-09857.
9. Tatawat R. K. and C. P. Singh Chandel. 2007. Quality of ground water of Jaipur city, Rajasthan (India) and its suitability for domestic and irrigation purpose. *Appl. Ecol. and Environ. Res.* 5 : 79—88.
10. Tailor G. S. and C. P. Singh Chandel. 2010. Environmental Appraisements of physico-chemical parameter of groundwater in Malpura block, Tonk district, Rajasthan, India. *Environ. Ecol.* 28 : 2136—2140.
11. WHO. 1994. International standards for drinking water. WHO, Geneva.
12. US. Salinity Laboratory. 1954. *Diagnosis and improvement of saline and alkali soils*. US Dep. Agric., Washington DC, USA.
13. Sawyer G. N. and D. L. McCarthy. 1967. Chemistry of sanitary engineers, Mc Graw Hill, New York, USA. 518 pp.
14. Richards L. A. 1954. *Diagnosis and improvement of saline alkali soil : Agriculture*. Volume 160. Handbook 60. US Dep. Agric., Washington UC, UAS.
15. Shakir M. S., M. Ahmed and M. A. Khan. 2002. Irrigational quality of under ground water in Kasur district. Asian J. Pl. Sci. 1 : 53—54.