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Impact of Dyeing Industry Effluent on Groundwater Quality by Water Quality Index and Correlation Analysis

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Abstract

Ground water from Chinnalapatti, TamilNadu, India, was collected from the habitations at the vicinity of dyeing industries to study the impact of dyeing industry effluent on ground water quality. Physico-chemical parameters, namely EC, pH, Total hardness, Ca, Mg, Na, Cl, TDS, Potassium and Sulphate were analyzed and compared with drinking water standard. pH, Ca and Mg were within the desirable and permissible limit of drinking, whereas sulphate, Sodium and Potassium were within the desirable limit only. Water Quality Index was calculated to assess the level of pollution and it is 61, indicating the pollution rate of ground water between slight and moderate. Correlation of various physico-chemical parameters with EC, TDS, and Total hardness was also calculated to establish the nature of relationship between them. EC is positively correlated with sodium, similarly TDS and Total hardness are positively correlated with calcium.

Keywords: Physico-chemical parameters; WQI; Correlation and regression; Water pollution; Standard deviation

Abbreviations: EC: Electrical conductivity; Na: Sodium; Ca: Calcium; Cl: Chloride; Mg: Magnesium; TDS: Total soluble solids; WQI: Water quality index; SPSS: Statistical Package for the Social Sciences; BIS: Bureau of Indian standard

Introduction

Environmental pollution is a global phenomenon because of its adverse effects on human health, plants, animals and exposed materials [1]. Industrialization and urbanization are greatly attributed to the pollution issues. Because, a large number of organic and industrial effluents has been introduced into the environment that has increased water and land pollution problems manifold. Water pollution due to dyeing industry is the matter of great concern since large quantity of effluent is discharged into the water bodies. Central pollution control board has listed the dyeing industry as one of the heavily polluting industries [2]. The dye effluent is highly toxic in nature as it contains high suspended solid, COD, dye and chemicals along with high concentration of heavy metals like Cu, Cd, Zn Ni and Pb. The dye effluent contaminates the surface and ground water, thereby, making it unfit for irrigation and drinking [3]. The dye effluent contains certain chemicals that could be toxic, carcinogenic or mutagenic to living organisms [4]. The study area Chinnalapatti is located in Dindigul district of Tamil Nadu, there are around 80 to100 dyeing units running in the township. Most of the dyeing units discharge the untreated effluent into the land which ultimately pollutes the ground water and makes it unfit for drinking. The main objective of the present investigation was to assess the water quality index of ground water and to interpret the water quality of ground water by a statistical calculation called correlation co-efficient.

Materials and Methods

Study area

Chinnalapatti is a town at Dindigul district of Tamilnadu,India, geographically lies between 10.3000°N latitude and 77.9300°E longitude. The basin is characterized by an undulating topography with hills in the southern parts. The highest elevation in this area is Sirumalai that is 1350m (amsl).Ground water mostly occurs in the weathered as well as in the fractured zones, which are unconfined, semiconfined and confined conditions [5]. These aquifer conditions may change rapidly and vary over a wide range from place to place. The thickness of the weathered/ fractured zone varies even over a small region. The shallow aquifers are in phreatic condition, which may not be a stable source for large demands of ground water, but the deeper aquifers are partly confined, i.e., they are being recharged from the shallow unconfined aquifers through dug – cum bore wells/bore wells [6].

Ground water sampling and analysis

Ground water samples were collected in clean plastic containers 2L capacity from March to December 2012. The samples were immediately transferred to the laboratory and analyzed for various physico-chemical parameters, namely EC, pH, Total Hardness, Ca, Mg, Na, Cl, TDS, Potassium and Sulphate, using standard methods [7]. Mean, standard deviation and correlation study were calculated using SPSS software.

Water Quality Index of the collected effluent was calculated to arrive at the level of pollution. The standards for drinking water recommended [8] by BIS for the 10 parameters chosen for the analysis along with the assigned weights [9]. Water Quality Index calculation was carried out as per Harton, as modified by Tiwari [10]. Weights (wi) were assigned to various water parameters which ranged from 1 to 4. According to the role of various parameters on the overall quality of water, the rating scales were fixed. For example, sodium, chloride and sulphate were important parameters in dye industry effluent and hence 4 and 3 were assigned. The other parameters were assigned according to their importance and incidence in irrigation water. Even if they were present, they might not be the ruling factor. Hence they were assigned low weights. The weight (wi) for the ith parameter (i=1,2 .....10 in our case) was calculated. The

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Parameters	Minimum	Maximum	Mean	Std. Deviation
pH	6.2	7.9	7.1	0.522
EC	908	1800	1102.30	254.94
TDS	871	1628	1281.60	297.91
Total Hardness	281	392	320.930	36.27
Calcium	57	92	71.875	11.77
Magnesium	20	44	32.75	6.942
Sodium	4.24	6.34	5.263	0.67
Potassium	0.46	1.70	0.996	0.49
Chloride	210	360	282.18	55.82
Sulphate	82	171	111.375	27.26

Table 1: Physico-chemical quality of Ground water (descriptive statistics).

Substance Characteristic	IS 10500:1991		WHO (1993) Recommendation	Undesirable effect outside the desirable limit	% of Sample exceeding recommended value
	Desirable Limit	Permissible Limit			
pH	.5 to 8.5	No relaxation	8.0	Mucous membrane will be affected	100% within the range of 6.5-.5
Total hardness mg/l	300	600	-	Encrustation in water supply system	62.5% above 300
Chloride mg/l	250	1000	250	Taste, corrosion and palatability are affected	62.5% below and 37.5%
TDS mg/l	500	2000	1000	Palatability decreases gastro intestine affected	31.25% between 500-1000,68.75% above 1000 mg/l
Calcium mg/l	75	200	250	Encrustation in water supply System	62.5% below 75,37.5% between 75-200.
Magnesium mg/l	30	100	50	Encrustation in water supply System	25% >30, 75% >50
Sodium mg/l	-	-	200	-	100% within the range
Potassium mg/l		-	12	-	100% within the range
Sulphate mg/l	200	400	250	Gastro intestine affected	100% within the range

Table 2: Comparisons of water samples with Drinking water.

Salinity Zone	EC(mhos/cm)	No of samples	% of samples
Low	250	0	-
Medium	250-750	0	-
High	750-2250	10	62.5
Very high	2250-5000	6	37.5

Table 3: Classification of Salinity Zone based on Richards [13].

TDS(mg/l)	Class	No of samples	% of samples
<500	Desirable for drinking	0	0
500-1000	Permissible for drinking	5	31.2
1000-3000	Useful for irrigation	11	68.75
>3000	Unfit for drinking and irrigation	0	0

Table 4: Classification of Water based on TDS by Davis and Dewiest [15].

rating scales for the 10-water quality parameters considered here. Each parameter has been divided into 5 intervals according to the ranges. The quality index (qi) is corresponding to each range (varying from 0 to 100) and the extent of pollution corresponding to various value ranges, in descriptive terms.

qi-100-Ideal limit (BIS)

0-Severe value (BIS)

Other ratings, namely qi – 25, 50 and 75 are intermediate scales between ideal and severe values of BIS for irrigation water. The Water Quality Index (WQI) is the aggregate of the multiplication of qi and wi of the ith parameters. Based on WQI value the quality status is assigned, i.e. If WQI is 75-100 the parameters are in "ideal" limit.

Results and Discussion

The minimum, maximum, mean and standard deviation values generated from the analysis of the 16 samples are presented in Table 1. The data was compared with drinking water guidelines of India ISI, WHO [11,12] and tabulated in Table 2. It was observed that pH of ground water was between 6.2 and 7.7 and met drinking water criteria. EC and TDS are important parameters to measure the salinity hazard of water. EC in the present study varies between 908-1800 µhos/cm. As per the classification of water samples by Richards [13] presented in Table 3, 62.5% of samples fell under high salinity range. David Noel et al [14] reported that EC of ground water in Chinnalapatti was 1200 µmhos. TDS values varied between 871-1628 mg/l. Groundwater classification based on TDS given by Davis [15] is presented in Table 4. This table clearly shows that only 31.25% of total samples are permissible for drinking and no samples are desirable for drinking. TDS concentration was high due to the presence of bicarbonates, carbonates, sulphates and chlorides of calcium [16] and TDS value of 500 mg/l is the desirable limit and water containing more than 500 mg/l causes gastrointestinal and irritation [17]. High value of TDS influences the taste, hardness and corrosive property of the water [18]. Chloride in the present study ranged between 210-391 mg/l. 37.5% of samples exceeded the desirable limit of drinking. Calcium and magnesium salts are essential plant nutrients and their concentration play a vital role in reducing sodium hazard [19]. Calcium in the present study varied between 57-92 mg/l Magnesium varied between 20 and 44 mg/l. Mg occurs in lesser concentration than calcium due to the fact that the dissolution of Mg rich minerals is slow process and that Ca is more abundant in the earth crust [20]. All the samples of Ca and Mg were within the desirable and permissible level of drinking as per ISI 1991 and WHO1993 classification of drinking water. Sulphate in the ground water was found in the range 82-171 mg/l. All the samples are within the desirable limit for drinking. Among the Cations Sodium is most dominant in water. In the present study Sodium varied between 4.24 and 6.34 mg/l within the desirable range of drinking. Potassium in the samples ranged between 0.23 and 1.70 mg/l that is within the desirable range of drinking. Total hardness of the samples ranged between 274 and 392 mg/l According to classification of water based on Total hardness proposed by [21]

TH(mg/l)	Water type	No of samples	% of samples
0-75	Soft	-	-
75-150	Moderately hard	-	-
150-300	Hard	6	37.5
>300	Very hard	10	62.5

Table 5: Classification of Water based on hardness [21].

S. No	Parameters	Values (BIS)	Rating (pi)	Unit weight	Product (piwi)
1	pH	7.39	100	0.04	4
2	Electrical Conductivity (µmhos/cm)	2,250	0	0.09	0
3	Total Dissolved Solids (mg/l)	2,100	0	0.09	0
4	Chloride (mg/l)	350	0	0.18	0
5	Total Hardness (mg/l)	300	100	0.04	4
6	Sodium (meq/l)	40	100	0.09	9
7	Potassium (meq/l)	2	100	0.18	18
8	Calcium (meq/l)	20	100	0.13	13
9	Magnesium(meq/l)	5	0	0.04	0
10	Sulphate(mg/l)	200	100	0.18	13
Total Water Quality Index					61

Table 6: Water Quality Index (WQI) of the Groundwater Samples.

	pH	EC	Ca	Mg	Na	K	Cl	SO	TH	TDS
pH	1									
EC	4.72	1								
Ca	-17.8	0.39	1							
Mg	-15.7	0.43	0.25	1						
Na	-2.04	0.69	-0.33	-251	1					
K	-80.97	-0.42	0.08	0.09	0.04	1				
Cl	-8.73	0.0002	-2.21	-0.46	-0.23	0.41	1			
SO	-8.90	0.37	0.21	0.32	-0.16	-0.62	0.23	1		
TH	-2.61	-0.28	0.41	0.82	-0.14	0.40	-0.40	0.39	1	
TDS	-12.48	-0.021	0.58	-0.17	-27.88	-0.64	-0.08	-0.13	-0.12	1

Table 7: Correlation Matrix.

presented in Table 5, 62.5% of samples are very hard water type. The Water Quality Index (WQI) of the ground water was 61 that indicates the pollution level between slight and moderate and presented in Table 6.

Correlation analysis

Correlation coefficient analysis is useful for interpreting groundwater quality data and relating them to specific hydro geological processes. The correlation of EC, TDS and Total hardness with different constituents of 16 water samples has been calculated and correlation matrix is represented in Table 7. There existed significant positive correlation of EC with pH r=4.72 and sodium r=0.69, TDS with calcium r=0.58 and Total hardness with calcium r=0.41 and potassium r=0.40 (Figures 1-5). However, significant negative correlation of EC with chloride r=0.0002, TDS with EC r=0.021 and Total hardness with EC r=-0.28. These results indicate that pH sodium and magnesium shows major contribution than other physico-chemical constituents towards causing salinity in ground water. Cyanobacterial species were isolated from textile industry effluent and identified as *Anabaena variabilis, Oscillatoria salina, Nostoc muscorum* and *Lyngbya majuscula*i.

Conclusion

EC of water samples 2 and 14 have high salinity. Other samples also have high EC values unfit for drinking. Though the variation is less it is worth mentioning that the reason behind this may be continuous discharge of the chemicals and salts along with dyes from industries. Very high level of Total hardness gives an alarm to the future utility of ground water for drinking and irrigation purpose. No water samples are desirable for drinking as per the classification of water based on TDS by Davis and Dewiest. The ground water contamination of the investigated sites was due to dyeing industrial discharge of the effluent onto the land from Chinnalapatti town. Other geological factors such as soil porosity,

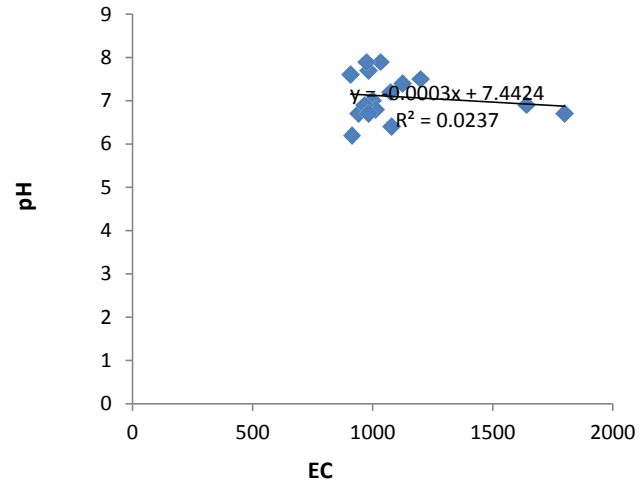

Figure 1: EC with pH r = 4.72.

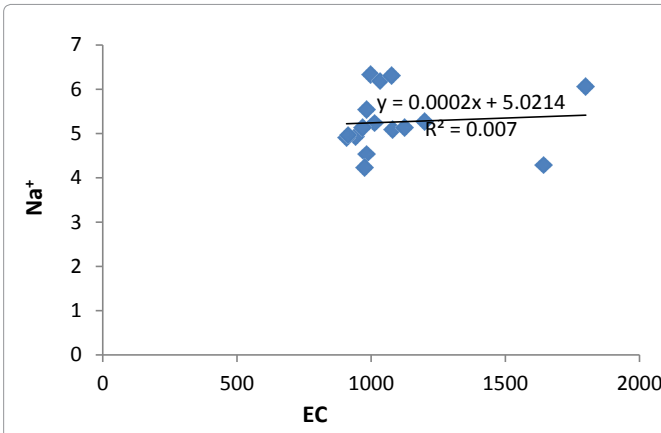

Figure 2: EC with sodium r = 0.69.

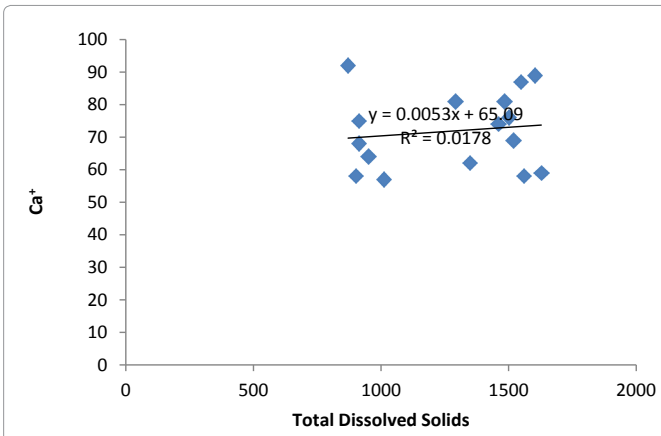

Figure 3: TDS with calcium r = 0.58.

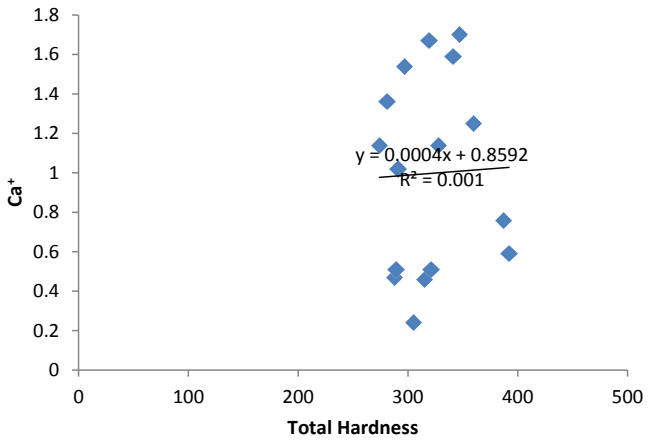

Figure 4: Total hardness with calcium r = 0.41.

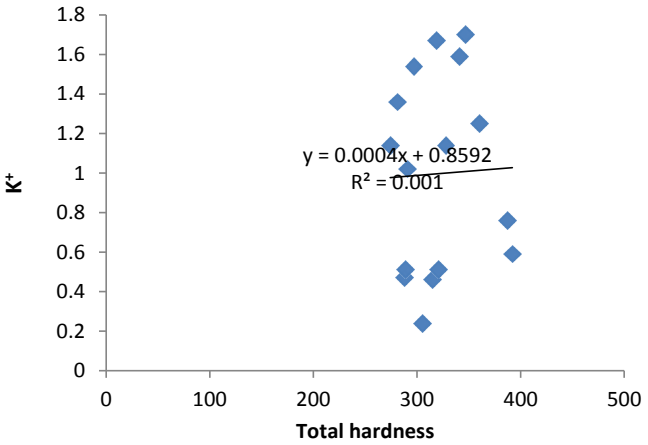

Figure 5: Total hardness with potassium r = 0.40.

permeability and the nature of rocks are also attributed to the ground water pollution. EC is positively correlated with sodium. Similarly TDS and Total hardness are positively correlated with calcium. Therefore it is inferred that enriched caustic soda and sodium chloride salts are added excessively during the dyeing process.

References

1. Irshad A, Ali S, Jan MR (1997) Physico-chemical studies of industrial pollutants. Environ. Poll. Islamabad, Pakistan.
2. CPCB (Central Pollution Control Board) (1990) Minimal National standards: Dye and Dye
3. Intermediate industry, Comprehensive Industry Document. Series: COINS/34/1990 (2007).
4. Mathur N, Bhatnagar P (2007) Mutagenicity assessment of textile dyes from Sanganer
5. (Rajasthan) J Environ Biol 28: 123-126.
6. Suzuki T, Tinolei S, Kurunczi L, Dietze U, Schuuirmann G (2001) Correlation of aerobic biodegradability of sulfonated azo dye with the chemical structure. Chemosphere 45: 1-9.
7. Mondal NC, Singh VS (2004) A new approach to delineate the groundwater recharge zone in hard rock terrain. Cur Sci 87: 658–662.
8. Mondal NC, Saxena VK, Singh VS (2005) Assessment of groundwater pollution due to tannery industries in and around Dindigul, Tamilnadu, India. Environ Geol 48: 149–157.
9. American Public Health Association (1998) Standard methods for the examination of Water and waste water. Washington DC
10. Trivedy RK (1988) Organic source effects and treatment. IndianJ.Env.Prot.8: 362- 371.
11. Punmia BC (1977) Water supply engineering, standard book house. New Delhi, India.
12. Tiwari TN, Misra N (1985) Preliminary assignment of water quality index to major indian rivers. Indian J. Environ. Protection.5: 276-279.
13. ISI (Indian Standards Institution) (1991). Indian standard Specification for drinking water, IS 10500.
14. WHO (World Health Organization) (1993). Guidelines for drinking water quality, 2nd (edn).
15. Richards LA (1954) Diagnosis and improvement of saline and alkaline soils. In USDA Handbook. U.S Salinity laboratory Staff.
16. David Noel S, Rajan MR (2012) Assessment of dye industry effluent for irrigation and its impact on ground water quality at Chinnalapatti. J.Ecotoxicol Envron.Monit. 22: 395-399.
17. 15. Davis SN, De Wiest RJ (1966) Hydrogeology. New York: Wiley. .
18. Deepali S, Sapna P, Srivastava VS (2001) Groundwater quality at tribal town; Nandurbar (Maharashtra). Indian J. Environ. Ecoplan. 5: 475-479.
19. Jain CK, Kumar CP, Sharma MK (2003) Ground water qualities of Ghatapraba command Area, Karnataka. Indian J. Environ. Ecoplan. 7: 251-262.
20. Subhadra Devi G, Barbaddha SB, Hazel D, Dolly C (2003) Physico-chemical characteristics of drinking water at Velsao Goa. J. Environ. Monit. 13: 203-209.
21. Basavarajan D, Narayana J, Puttaiah (2008) Irrigation water quality assessment of Anjanapura reservoir. Indian J. Environ. Protection. 29: 145-151.
22. Varadarajan N, Purandara BK (2003) Environment and conservation 9: 253-262.
23. Sawyer CN, McCarty PL (1967) Chemistry for sanitary engineers (2ndedn). New York: McGraw-Hill Education.