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USING CHEMICAL AND PHYSICAL PARAMETERS TO DEFINE THE QUALITY OF INDUSTRIAL EFFLUENTS (JODHPUR CITY, RAJASTHAN, INDIA)

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ABSTRACT

The paper aims to study the ecological system of industrial effluents, Basni area, at somewhat outskirts area of Jodhpur city. The study was carried out to determine the water quality with some chemical-physical indicators of samples taken monthly, 2001/01-2002/06. The results are discussed based on annual averages and linear inter-correlation matrix between water and soil samples. The results showed that the sediment samples had a close affinity with water samples. The numeric data are mentioned in the text.

INTRODUCTION

The water quality is defined by a set of paprameters or variable, which describe the physical characteristics and the chemical and biological components of the water body (Meybeck, 1990). The high number of parameters normally recommended for water quality diagnosis, as well as the requiremnet of sophisticated and expensive techniques (Branco, 1989) constitute the main limiting factors in the definition of systematic monitoring program of water resources in underdeveloped regions it is highly important to select the minimum nubers of parameters necessary to characterize the sanitary and tropic status of reservoir. The selected the parameters should be measured by simple and low cost techniques.

Large number of chemicals are discharged into the aquatic environment for which there is no direct means of control (USEPA, 1991 and Kinnersley, 1990). The conventional approach to controlling harmful chemicals in the aquatic environment is to use asset of physical-chemical and biochemical parameters (Cronin *et al.* 1991; Trevizo and Nirmalahhandan, 1999).

The Jodhpur city of Thar Desert has immense number of industries, which produce toxic effluents in Jodhpur has emerged as a serious environmental problem of the region. The industries, mostly of textile bleaching, dyeing and printing generate about 60,000-m^3 effluent carrier causing thereby extensive groundwater and surface watre pollution accompanied by land degradation. According to an estimate the chemical load released per day through the effluents is 45-60 tons to Jojari River. This study is thus useful for the definition of protection and preservation measures.

MATERIALS AND METHODS

The study area

The investigations were carried out in a water NULLAH consisting only industrial effluents from the industrial area of Basni, Jodhpur city, India. Looking to the industrial set up of the region, it is gathered that 211 textile units along with 103 stainless steel reerolling mills are the main water polluting industries in Jodhpur. The accomplishment of final products of textile industries comprises chemivcal processes viz., kiering , bleaching, mercerizing, dyeing, printing, carbonization and finishing. The effluents so obtained are highly coloured, turbid and saline and is characterized by high COD and BOD. The effluents thus containing alkalies : caustic soda ash, residual dyes, starch and cellulose, soluble salts mainly of sodium, silicates, oil, fats and waxes and residual chemicals of oxidisable character viz., sulphides, nitrites etc.

Whereas in stainless steel rolling mills, the effluent is generated during pickling process wherein carbon and other surface impurities sustained during annealing and other operations are removed by washing with dilute solution of sulphuric acid and thereafter the sheet is dipped in a mixture of nitric and hydrofluoric acid to regain luster and washed again with pure water. The generated effluent is highly corrosive.

Sampling was undertaken on a monthly basis between January 2000 to June 2001 and sampling was conducted at two stations with different degrees of pollution from the discharge of urban effluent.

Sanitary inspections

At each site a sanitary inspection was performed when the sample was taken. The sanitary inspections followed a standardized format that was adopted from these recommended by WHO (1997), modified forms included questions on composition of effluent coming from the industries, weather they are treated or not, number and type industries etc. The assessment of effluents was undertaken for many sites account for any changes.

Abiotic parameters of water and sediment

The temperature of the water was determined using a thermometer combined with a Nansen sampler. Conductivity and pH was determined by conductivity meter and portable pH meter respectively. APHA(1985) was followed for the nalysis of most of the water quality parameters.S

Sediment samples for different parameters were analyzed according to various methods but the soil was air dried and grounded to pass through a 0.2 mm sieve prior to different estimation. The parameters namely pH, electric conductivity, salinity, total nitrogen, total phosphorous and organic matter were analyzed.

For hydrogen ion concentration the finely sieved air dried sediment sample was mixed with distilled water in the ratio of 1: 5 and pH was determined through filtrate using portable pH meter with a precision of 0.01 and was calibrated with standard buffer solution of 7.0 pH, prior to each sample set. For electric conductivity the sediment was mixed with distilled water in 1: 5 ratio and supernatant solution was used to estimate conductivity by conductivity meter of type MODEL NO C-160-MK II (APHA, 1985). The results were expressed in μS/crn.Salinity was determined by Gypsum requirement method. The micro Kjeldahl method was used for determination of total nitrogen from soil samples. It was also expressed in percentage.Colorimetric method (Strickland and Parsons, 1972) was followed to estimate phosphorous and the measuring unit was mg/gm. And the Walkley and Black (1934) method was followed for the determination of organic carbon.

RESULTS AND DISCUSSION

The wastewater (industrial effluents) causes soil and ground water pollution besides causing a number of adverse effects on agriculture produce animals and health of people living in the neighboring area since it contains waste chemicals and toxic heavy metals. An enormous increase in pollution due to discharge of effluents from industrial units into rivers and lakes is a matter of great concern in developing countries. Developed countries, which have water pollution problem due to industrial proliferation and modernization agricultural technologies are now on the way of combating the problems through improved wastewater treatment technique. But developing countries, with lack of technical known how, weak implementation of environmental policies and with limited financial resources are still facing problems (Sponza.2003).

The results of sanitary inspection revealed that maximum of effluents were discharged untreated .The variety of colors from printing; dyeing and textile industries changed the transparent color of river Jojari. Also the high temperature of effluents affected the aquatic life of the riverine ecosystem.

However, in the present work, we have rationalized the variation of industrial effluents on the basis of 15parameters of effluents and six physical and chemical parameters of sediment, intended as indicators of water quality. These parameters were determined in samples collected at different monitoring stations with monthly frequency, for a total of 18 sampling events. The basic statistics of these experimental data are reported in Table 1 & 2.

The data were analyzed to assess trends in the limnological quality of water or effluent related to various factor in order to develop a better understanding of the causes of pollution. The importance of each factor in causing contamination was tested using statistical models. In addition, the relationships between risk factors and the different indicator bacteria were evaluated. The analysis of data included several relationships that were suspected to be important. The chemical characteristic of industrial wastewater primarily depends upon the factors like nature of industry and raw material used, nature and quality of input chemicals and quality of raw water used.

The temperature of the effluents varied at each site depending upon the heated effluents, which raised the temperatures even in winters. The temperature was thus independent of atmospheric effects and fluctuated in the range of 23.2° C (January, 2001) to 38.5°C (July, 2000) at station A and 24 °C (January, 2000) to 39.5 °C (July 2000) at station B respectively. The variations in between minimum and maximum temperature was found to be 15.3° C and 15.5° C.

The effluents of industrial site showed the extremes of acidic and alkaline

Table 1

Average values of physico-chemical characteristics of industrial effluents

Parameters		Industrial Site	
	Units	A	B
Ambient temperature	(^{0}C)	28.61	29.11
Water temperature	(^{0}C)	30.58	31.24
Electric conductivity	µS/cm	10950	15372
Hydrogen ion concentration	pH	6.32	7.44
Free carbon di-oxide	mg/L	503	141
Carbonate alkalinity	mg/L	24	191
Bicarbonate alkalinity	mg/L	443	411
Salinity (10x-2)	mg/L	163.5	263.6
Calcium hardness	mg/L	214	200
Magnesium hardness	mg/L	138	215
Total hardness	mg/L	804	1118
Nitrate Nitrogen	µgm/L	522	533
Ortho phosphate	µgm/L	74	147
Fluoride	mg/L	3.2	3.5
BOD	mg/L	629	569
COD	mg/L	1045	963

Table 2

Average values of sediments of industrial nullah

Parameters		Industrial site	
	Units	A	B
Electric conductivity	S/cm	18,745	15,400
Hydrogen ion concentration	pH	6.47	7.04
Salinity	mg/gm	8.75	8.64
Total Nitrogen	%	2.85	3.04
Total phosphorus	mg/gm	8.25	12.88
Organic matter	%	8.57	8.63

Table 3

Linear inter correlation matrix for different physico-chemical parameters of waters in industrial site

Para-meter		TEM	EC	pH	SAL	T.H.	CA^{2+}	MG^{2+}	PO_4	NO_3	COD	F
TEM	A	1	-0.08	-0.29	0.48	0.10	0.411	-0.07	0.223	-0.71	0.18	-0.01
	B	1	-0.03	-0.26	0.31	0.20	-0.02	0.19	0.013	-0.47	-0.27	-0.27
EC	A		1	-0.31	0.14	0.30	-0.06	0.421	0.12	0.31	-0.19	-0.27
	B		1	0.23	0.17	-0.14	0.136	-0.14	0.60	0.487	.008	-0.12
pH	A			1	-0.05	-0.63	-0.65	-0.49	-0.08	-0.03	0.076	0.39
	B			1	0.09	-0.50	0.04	-0.53	0.31	0.102	-0.05	-0.03
SAL	A				1	0.11	0.50	-0.07	-0.11	-0.2	0.425	-0.04
	B				1	0.29	0.33	0.26	0.11	0.067	-0.2	-0.18
T.H.	A					1	0.57	0.94	-0.01	0.03	0.085	-0.72
	B					1	0.49	0.98	-0.19	-0.1	0.091	-0.38
CA^{2+}	A						1	0.34	-0.09	-0.13	0.401	-0.19
	B						1	0.42	0.015	0.13	0.301	0.07
MG^{2+}	A							1	0.015	0.13	0.301	0.076
	B							1	-0.18	-0.11	0.14	-0.11
PO_4	A								1	-0.23	0.99	-0.07
	B								1	-0.56	-0.07	-0.23
NO_3	A									1	-0.37	-0.05
	B									1	-0.23	-0.17
COD	A										1	-0.13
	B										1	0.21
F	A											1
	B											1

Significance of 0.050% level of significance (0.468) significance of 0.010% level of significance (0.590)

Table 4

Linear inter-correlation matrix for different abiotic parameters of sediment samples

Parameter		pH	EC	TP	OM	SAL	TN
pH	A	1	-0.49	0.11	0.12	0.01	0.13
	B	1	0.18	0.14	-0.21	-0.53	0.27
EC	A		1	-0.05	0.25	0.02	-0.15
	B		1	-0.09	-0.29	0.26	0.54
TP	A			1	0.34	0.21	0.29
	B			1	-0.47	-0.20	0.39
OM	A				1	0.12	-0.05
	B				1	0.29	-0.38
SAL	A					1	-0.09
	B					1	0.04
TN	A						1
	B						1

range, with the outcome of various chemicals disposed off. The pH ranged from 2.0 (August 2000) to 10.0 (January, 2000) at station A and 2.6 (April, 2000) to 9.5 (January, 2000) at station B respectively. The average values were6.32 and 7.44 respectively. The acidic nature of effluents may be linked to the acidic nature of chemicals used in the industries. According to a report on the industrial effluents of Jodhpur city by Gupta *et al.* (1998), the pH value varied from 8.6 to 10.1 and 2.2 to 10.1 as determined by GWD(1995) and NEERI(1997)

The conductively also showed aberrant changes and ranged from 1400 µS/cm (January 2000) to 67000 µS/cm (November, 2000) and 1300 µS /cm (August, 2000) to 93,OOO µS/cm (November, 2000) at station A and B respectively. Due to arid climate and high evaporation rate the salinity of the flowing effluent goes on increasing in relation to distance downstream. It thus showed the variations in the range of 81.25 X 10^{-2} (September, 2000) to 318.47 > 10^{-2} (July, 2000) and 83.77-10^{-2} (April, 2001) to 503.8 x 10^{-2} (August, 2000) at respective stations. The carbonate alkalinity at industrial site fluctuated from 50-800 mg/L and similar range has been mentioned by Gupta *et al.* (1998) in the industrial effluents of Jodhpur city [72-742 mg/L, GWD (1995)]. The average values for free carbon di-oxide, carbonate alkalinity and bicarbonate alkalinity are mentioned in Table 1.

The concentration of nitrate -Nitrogen in effluent waters reached a maximum of 2192,22 µgm/L (January, 2001) and 2307.6 µgm/L (January, 2001) at respective stations and than decreased on average by 98.01% and 99.3% age respectively. The concentration of ortho-phosphates in effluents reached a maximum value of 255 µgm/L and 475 µgm/L and a minimum value of 6.25 µgm/L and 12 µgm/L. Untreated wastewaters have high COD [average-629 mg/lt and 569 mg/L and BOD5 (average 1045mg/L and963 mg/L). Precise analysis of wastewaters demonstrated that high COD and BOD correlate with industrial technology. They contain residues of solvents, detergents and numerous primary, and secondary plant substances, which are released due to extraction process. The maximum COD values of wastewaters were 983 mg/L and 966 mg/L and the minimum 228 mg/L and 210 mg/L, while the maximum BOD was 1243 mg/L and 1334mg/L and minimum 295 mg/L and 365 mg/L. The average BOD: N: P ratio (14.3:7.1:1 and 6.5:3.6:1) is indicative of typical industrial wastewater in which nitrogen and phosphorus should be limiting for the efficient reduction of BOD.

Sediment results

The hydrogen ion concentration values of the sediment samples showed acidic condition due to the constant out flowing acidic effluents. At station A, it varied from 2.9 (August, 2000) to 8.9 (February, 2000) and at station B it was 2,2 (April, 2000) to 8.4 (January, 2000) and the average values of each of the stations was 6.47 and 7.04 respectively. However Bhatt and Joshi (2000) reported low pH (6.21 to 6.46) from soil samples affected by discharge of thermal power plants. The conductivity in the sediment was not as high as waters of industrial effluents. It varied from 1200 µS/cm (February. 2000) to 31000 µS/cm (August, 2000) at station A and 1200 µS/cm (May, 2000) to 21000 µS/cm (February, 2001) at station B. Shrivastava (1977) reported electric conductivity of soil samples at Varanasi in the range of 0.3 to 4.5 mmhos/cm. The salinity was due to the presence of various salts of chemical effluents. It varied from 7.31 mg/gm (January, 2000) to 12.05 mg/gm (April, 2000) at station B and the average values were 8.75 mg/gm and 8.46 mg/gm respectively. Total nitrogen in sediments varied from 0.53% (April, 2000) to 4.5% (January, 2001) at station A and from 0.52% (April, 2000) to 4.65% (January, 2001) at station B with the average values of 2.12% 2.09% .The total phosphorus fluctuated from 3.1 mg/gm (February, 2001) to 16.5 mg/gm (May, 2001) at station A and 6.0 mg/gm (April, 2000) to 15.25 mg/gm (September, 2000) at station B. Organic matter in the sediments varied from 6.15%(May, 2000) to 11.25%(May, 2001) and 6.45% (October, 2000) to 9.85% (May, 2000) at both the stations.

Effluent flow and process of regeneration

Natural regeneration is an important property of flowing water. After entry into rivers, the effluent flows to a considerable distance downstream and remains in dynamic contact with river sediments and atmosphere and thus undergoes various physico-chemical interactions like aeration, sedimentation, oxidation, ion exchange and adsorption. This helps in alleviating pollution load primarily of organic nature to a certain extent and creates conditions conducive for survival of aquatic life.

The studies carried out here, showed dissipation of many impurities of non-conservative nature like turbidity, BOD, COD and build up of dissolved oxygen during traverse of effluents downstream. The effect is much pronounced in monsoon period when the effluents get diluted with dissolved oxygen enriched rainwater and has turbulent flow at many places .It is seen that the oxygen build up to the saturation level takes place within a distance of 10 km during monsoon period and 30 to 40 km during dry period. The bioactivities enhanced by solar energy also help in consumption of organic matter and reduces the turbidity in flowing effluent.

Finally we can conclude that in the effluents, the degree of influence of given parameter on another may be the result of multiple integrating factors, sometimes known by the term" Confusion factors".

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