Physicochemical analysis of control and polluted water of Dravyawati River

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Abstract

Around 30 physico-chemical parameters were selected for the observation in the waste water of amanishah nalla. Its water has been found contaminated with the adjoining stream far around regular 47 kilometers stretch. These thirty experimentally observed parameters include pH, Color, Odor , Electrical Conductivity,(EC) (m Mhos), Total Dissolved Solids(mg/l),Total Suspended Solids(mg/l), Total hardness(mg/l),Calcium Hardness(mg/l), Magnesium Hardness(mg/l), Chloride concentration(mg/l), Alkalinity(mg/l),Biological Oxygen Demand(mg/l), Chemical Oxygen Demand(mg/l), Phosphate(mg/l), Sulphate(mg/l), Nitrate(mg/l), Fluoride(mg/l), Potassium(mg/l), Sodium(mg/l), Calcium(mg/l),Magnesium(mg/l), Ammonical Nitrogen(mg/l), Iron(mg/l), Cadmium(mg/l), Chromium(mg/l), Copper(mg/l), Lead(mg/l), Nickel(mg/l). This study reveals higher level of water pollution as above the IS standards which can cause great loss to flora and fauna.

Key words: Parameters, waste water, contamination, stream

Introduction

The Amanishah nalla (Dravyavati river), although a seasonal stream, is of great importance to Sanganer. The nalla gets effluent water (domestic sewage) of jaipur city. Near Sanganer, the Amanishah nalla has deep depression, where the water collects all round the year. This water is used by the Calico Printers and dyers for their cottage industries. The industries release large amount of waste water during printing and dyeing process which is never treated and finally discharged into adjoining nalla. These effluents contain highly toxic dyes, bleaching agents, salts, acid, alkali and heavy metal like Cadmium, Copper, Zinc, Chromium and Iron. This waste water causes ground water pollution besides causing a number of adverse effects on agricultural products, animals and health of people living in that area (Bhargava *et al.,* 1998).

Sanganer town is about 12 km from Jaipur, 26° 49’ latitude and 75° 46’ to 75° 50’ longitudes. The total area is 635 km. out of which 12.9 sq. km comprises of urban area and rest (622.6 sq. km.) is rural area. It is famous

worldwide for its dyeing and printing industries. Most of the industries are situated in the urban area, about 105 small scale, 25 medium scale and 5 large scale textile industries.

A number of factors influence the concentration of heavy metals on and within plants. These factors include climate, atmospheric deposition, the nature of soil on which the plants is grown, application of fertilizers and irrigation with wastewater (Anyanwu *et al*., 2004; Khairiah *et al*., 2004; Itanna, 2002; Madyiwa *et al*., 2002; Denkota and Schmidt, 2000; Frost and Ketchum, 2000). The water of rivers can be polluted by heavy metals which include Pb, Cu, Zn, Fe, Cr, Cd and Hg. The major sources of heavy metals are industrial effluents and indiscriminate disposal of domestic or sewage drainage directed to the rivers untreated or partially treated. Heavy metals, in general, are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to unwanted side effects (Jarup, 2003; Sathawara *et al*., 2004). Lead and cadmium are among the most abundant heavy metals and are particularly toxic.

Wastewater effluents from textile dyeing and printing industries of Sanganer are discharged directly, without any treatment, into Amani Shah Nalla drainage. Textile and dyeing industries of Jaipur is also of ecological concern. Textile effluents in water prevent water uptake by plants, causing harm to osmotic pressure (OP) and interference in metabolism of water flora. (Parivesh, 2002).

Materials and methods

The control sites were Department of Botany, University of Rajasthan (Site-I) and Shikarpura, Sanganer (Site - II) and the polluted sites were Govindpura (Jotadawala), Sanganer (Site - III) and near Shikarpura Flyover, Sanganer (Site-IV) of Amanishah Nalla. The whole experiments were carried out during the period of May 2009 to May 2012. Water samples from control and polluted sites were collected for performing water analysis. Samples (of 500 ml each) were collected in clean polythene bottles at the time when farmers irrigated their crops by polluted water, mostly in morning hours. The groundwater samples of Shikarpura (Sanganer) and Department of Botany were also taken as control samples. They all were further analyzed for different parameters by using established protocols (APHA, AWWA, WEF, 1985).

1. pH

pH of water samples were analyzed by digital pH meter (Model No. 161E).

2. Electrical Conductivity (EC)

Electrical conductivity of the sample was determined with the help of digital conductivity meter (Model No. 161E).

3. Total Dissolved Solids (TDS)

Total dissolved solids of the sample were determined with the help of water analysis kit (Model No. 161E).

4. Total Suspended Solids (TSS)

$$TSS(mg/l)=\frac{W_2-W_1\times 1000}{V}$$

Where

W_2 = Final Weight (mg)

W_1 = Initial Weight (mg)

V = Volume of sample (ml)

5. Total Alkalinity

Total alkalinity is the measure of the capacity of water to neutralize a strong acid.

$$PA \text{ as } CaCO_3 \text{ (mg/l)} = \frac{A \times (\text{Normality of HCl}) \times 1000 \times 50}{\text{ml. of sample (Volume)}}$$

$$TA \text{ as } CaCO_3 \text{ (mg/l)} = \frac{B \times (\text{Normality of HCl}) \times 1000 \times 50}{\text{ml. of sample (Volume)}}$$

Where,

A = ml of HCl used with only phenolphthalein

B = ml of total HCl used with phenolphthalein and methyl orange.

PA = Phenolphthalein alkalinity

TA = Total Alkalinity

6. Chloride

$$\text{Chloride (mg/l)}=\frac{(\text{ml}\times N) \text{ of } AgNO_3 \times 1000 \times 35.5}{\text{ml of sample}}$$

7. Total Hardness

$$\text{Hardness as (mg/l) } CaCO_3 = \frac{\text{ml of EDTA used} \times 1000}{\text{ml of sample}}$$

8. Calcium Hardness

It is determined by EDTA titrametric method.

$$\text{Calcium (mg/l)} = \frac{(A-B)\times 1000}{\text{ml of sample}}$$

Where,

A = Volume of EDTA used for sample

B = Volume of EDTA used for blank

9. Magnesium Hardness

Magnesium hardness can be obtained by subtracting the value of calcium hardness from the total hardness.

$$\text{Mg Hardness as } CaCO_3 = \text{Total Hardness} - \text{Calcium Hardness}$$

(a) Ca^{2+} = Calcium hardness × 0.4

(b) Mg^{2+}=Magnesium hardness × 0.244

(AOAC, APHA, AWWA and WPCF, 1985)

10. Fluoride

Fluoride concentration in Water samples were analyzed with the help of Orion Research Ion analyzer model 407 A, fluoride ion selective electrode.

11. Sulphate

Calculated as follows:

$$SO_4^{2-}\ (mg/l) = \frac{mg\ SO_4^{2-} \times 1000}{ml\ of\ sample}$$

12. Nitrate

It is measured by UV spectrophotometric method. Measurement of the ultraviolet absorption at 220 nm enables rapid determination of nitrate.

Calculated as follows:

$$\text{Nitrate N mg/l} = \frac{\text{Net mg nitrate N}}{\text{ml of sample}}$$

NO_3^- mg/l = Nitrate N mg/l × 4.43

13. Phosphate

In acidic condition, orthophosphate reacts with ammonium molybedate to form molybdophosphoric acid. It is further reduced to molybdenum blue by adding reducing agent such as stannous chloride. The intensity of the blue colored complex is measured which is directly proportional to the concentration of phosphate present in the sample.

14. Nitrogen (Ammonia)

Ammonia produces a yellow colored compound when reacted with alkaline Nessler reagent.

15. Sodium and Potassium

Equipment: A flame photometer, with flame accessories.

16. Chemical oxygen Demand (COD)

Apparatus: Reflux apparatus consisting of a flat bottom 250-500 ml capacity flask with ground joint and a condenser with 24/25$ joint.

Calculated COD from the following formula:

$$\text{COD mg/l} = \frac{(a-b)\times N\times 8000}{\text{ml of sample}}$$

Where,
a = ml of FAS for blank
b = ml of FAS for sample
N = normality of FAS

17. Biological Oxygen Demand (BOD)

It is estimated by a bio-assay test, involving measurement of O_2 consumed by bacteria while stabilizing organic matter under aerobic conditions.

Calculated as follow:

$$\text{BOD mg/l} = \frac{\text{Sample (0 day DO - 3}^{rd}\text{ day DO)-blank (0 day DO - 3}^{rd}\text{ day DO)}\times 100}{\text{ml of sample}}$$

18. Heavy metal analysis in water samples

Heavy metals viz. zinc, iron, cadmium, copper, chromium and lead were determined by Atomic absorption spectrophotometer. Cd, Cr, Co, Fe, Pb and Zn were determined by direct aspiration into air acetylene flame by AAS.

$$\text{Element (mg/l)} = C \times \text{d.f.}$$

Where,
C = absorbance

d.f. = dilution factor

Results & discussion

30 physico-chemical parameters were analyzed in the waters of control sites as well as of polluted sites. Control and polluted water samples were analyzed by assessing average values for the following 23 parameters as given in Table 1. Indian standards (IS) for discharge of environmental pollutant effluents into land for irrigation suggested in Pollution Control Acts, Rules and Notifications issued and published by Central Pollution Control Board are presented in Table 2. Indian standard specifications for drinking water are summarized in Table 3.

In polluted water samples studied here amount of total solids, Ca, Mg, alkalinity, COD, ammonical nitrogen, phosphate, nitrate, fluoride, and sodium and heavy metals like Zn, Fe, Cd and Pb were found in higher concentrations than in the control samples. Out of 30 parameters studied in polluted water samples, 14 parameters showed the higher amounts than the standard limit as suggested by IS.

Water of experimental sites was alkaline and the pH showed the level approximately equal to the permissible limits (6.5-8.5). Water sample from polluted site IV showed the highest EC i.e. 8.97 m mhos while Control site I showed lowest values of EC i.e. 0.59 m mhos. TDS in control and polluted water samples were observed in the range of 353 mg/l - 5533 mg/l and all exceeded the permissible limits. Suspended solids in all samples (of both control and polluted water) were in the range of between 175 mg/l–968.33 mg/l.

Total hardness of water samples ranged from 210 mg/1 to 511.33 mg/l calcium hardness ranged between 115 mg/1 – 248.93 mg/l. Similarly the values of magnesium hardness varied between 95 mg/1-324.06 mg/l. Calcium as Ca^{2+} of water samples were found to be between the ranges of 39 mg/l – 104.64 mg/l. In control and polluted water samples, Mg^{2+} concentration varied between 19.92 mg/l - 81.792 mg/l.

Higher Cl^{-} concentration was estimated in polluted water samples (334.5 mg/l to 427.83 mg/l) than the controls (44 mg/l). Alkalinity was also higher in polluted waters (468.33 mg/l and 522 mg/l) as compared to controls (74 mg/l and 248 mg/l). BOD of all samples ranged between 3.0 mg/l – 19.35 mg/l. COD in control sample was approximately 4.8 mg/l while in polluted water samples, ranged between 148.92 mg/l to 196.33 mg/l. All samples exceeded the standard limit.

In polluted water samples phosphate was found in the range of 3.46 mg/l to 4.76 mg/l and all water samples exceeded the standard limit suggested by CPCB. In control and polluted water samples, sulphate ranged between 4.05 mg/l to 90.058 mg/l, all samples are within the stipulated limit suggested by IS and CPCB. Concentration of nitrates in ground water samples of control sites exceeded the standard limit (45 mg/l). Nitrate in polluted water samples ranged between 18.353 mg/l to 19.103 mg/l. Fluoride in ground

water samples ranged between 0.91mg/l to 1.31 mg/l (desirable limit = max 1.5 mg/l). In polluted water samples, fluoride was found to be in the range of 1.533 mg/l to 2.736 mg/l. All samples of Nalla water exceeded the standard limit of nitrates and fluoride suggested by CPCB for discharge of effluent into land for irrigation. Na, Ammonical Nitrogen and oil and grease were not traceable in control samples. Potassium in control site samples was 0.5 and 0.9 mg/l while in polluted samples it ranged between 49.16 mg/l to 83.33 mg/l. Sodium in Nalla water was in the range of 296.33 mg/l to 314.73mg/l, which exceeded the recommended guide line value (200 mg/l). Ammonical nitrogen in polluted samples ranged between 23 mg/l to 24.66 mg/l. Oil and Grease in polluted water samples was in the range of 10.193 mg/l to 11.223 mg/l.

Concentration of Zn ranged between 0.021 mg/l to 5.373 mg/l. Fe concentration was 0.69 mg/l at site II. Fe was found in the range of 6.783 mg/l to 9.080 mg/l. Cadmium and Chromium were not found in the ground water samples of control sites. Whereas in polluted water samples, it was in the range of 1.40 mg/l to 1.43 mg/l. Cr in polluted water samples at site III and site IV were 2.3 mg/l and 2.366 mg/l respectively, which exceeded the desirable limit (0.1 mg/l). Pb was in higher concentration in Nalla water samples and ranged between 0.4 mg/l to 6.36 mg/l. Zn, Fe, Cd, Cr and Pb concentration in polluted water samples exceeded the standard limit suggested by CPCB.

Table 1: Physicochemical analysis of Control and polluted water of Dravyawati river

Parameters	Control water		Dravyawati River Water	
	Site-I	Site-II	Site-III	Site-IV
1. pH	8.21	8.57	8.03	8.10
2. Color	Colorless	Colorless	Grayish Brown	Grayish Black
3. Odour	Odourless	Odourless	Strong Odour	Strong Odour
4. Electrical Conductivity (EC) (m Mhos)	0.59	1.51	8.89	8.97
5. Total Dissolved Solids(mg/l)	353	997	5464	5533
6. Total Suspended Solids(mg/l)	175	540	968.33	843.33
7. Total Hardness(mg/l)	270	210	476.66	571.33
8. Calcium Hardness(mg/l)	160	115	225.93	248.93
9. Magnesium Hardness(mg/l)	120	95	261.23	324.06
10. Chloride Concentration(mg/l)	44	44	334.5	427.83
11. Alkalinity(mg/l)	74	248	468.33	522
12. Biological Oxygen Demand(mg/l)	3.00	3.70	14.22	12.45
13. Chemical Oxygen Demand(mg/l)	4.90	4.80	196.33	148.92
14. Phosphate(mg/l)	0.60	0.80	3.46	4.76
15. Sulphate(mg/l)	11	4.050	87.523	90.058
16. Nitrate(mg/l)	50.010	58.560	18.353	19.103
17. Fluoride(mg/l)	1.310	0.910	1.553	2.736
18. Potassium(mg/l)	0.50	0.90	49.16	83.33
19. Sodium(mg/l)	0.00	0.00	314.73	296.33
20. Calcium(mg/l)	65	39	96.17	104.64
21. Magnesium(mg/l)	28.840	19.920	61	81.792
22. Ammonical Nitrogen(mg/l)	0.0	0.0	23	24.66
23. Oil and Grease(mg/l)	0.0	0.0	11.223	10.193
24. Zinc(mg/l)	0.0	0.021	5.373	3.976
25. Iron(mg/l)	0.0	0.690	9.080	6.783
26. Cadmium(mg/l)	0.0	0.0	1.43	1.40
27. Chromium(mg/l)	0.0	0.0	2.300	2.366
28. Copper(mg/l)	0.0	0.0	0.0	0.0
29. Lead(mg/l)	0.0	0.40	6.31	6.36
30. Nickel(mg/l)	0.0	0.0	0.0	0.0

Table 2: Indian Standards for industrial and sewage effluents discharge (IS: 2490-1982)

S.No.	Parameters	Standards for discharge into		
		Inland surface	Public Sewers	Land for irrigation
1.	Color and odour	Should be totally colourless,odourless		
2.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
3.	Suspended solids (mg/l) Max.	100	600	200
4.	Dissolved Solids (Inorganic) (mg/l) Max.	2100	2100	2100
5.	Chloride (as Cl) (mg/l) Max.	1000	1000	600
6.	Total residual chlorine, (mg/l) Max.	1.0	-	-
7.	Biochemical Oxygen Demand (5 days at 20 C) (mg/l) Max.	30	350	100
8.	Chemical oxygen demand, (mg/l) Max.	250	-	-
9.	Dissolved Phosphate(as P), (mg/l) Max.	5.0	-	-
10.	Sulphate (as SO4), (mg/l) Max.	1000	1000	1000
11.	Nitrate Nitrogen(mg/l)	10	-	-
12.	Fluoride (as F) (mg/l) Max.	2.0	15	-
13.	Percent Sodium (Max.)	-	-	60
14.	Oil and grease, (mg/l) Max.	10	20	10
15.	Ammonical Nitrogen (as N), (mg/l) Max.	50	50	-
16.	Arsenic (as As), (mg/l) Max.	0.2	0.2	0.2
17.	Mercury (as Hg), (mg/l) Max.	0.01	0.01	-
18.	Lead (as Pb), (mg/l) Max.	0.1	1.0	-
19.	Cadmium, (mg/l) Max.	2.0	1.0	-
20.	Total chromium (mg/l) Max.	2.0	2.0	-
21.	Copper(mg/l) Max.	3.0	3.0	-
22.	Zinc, (mg/l) Max.	5.0	15	-
23.	Nickel, (mg/l) Max.	3.0	3.0	-
24	Iron, (mg/l) Max.	3 mg/l	3mg/l	-

Source: Pollution Control Acts, Rules and Notification issued there under published by Central Pollution Control Board, Sept., 2001, P.381
www.cpcb.nic.in [GSR801 (E), EPA, 1986, dated Dec.31, 1993]

Table 3: Indian Standards (IS) Specifications for drinking water IS: 10500, 1992 (Reaffirmed 1993)

S. No.	Parameters	IS:10500 Requirement (Desirable limit)	Undesirable effect outside the desirable limit	IS:10500 Permissible limit in the absence of alternate source
1.	pH	6.5-8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation
2.	Colour (Hazen units) Max.	5	Above 5 consumer acceptance decreases	25
3.	Odour	-	-	-
4.	Total hardness as CaCO3(mg/l,Max)	300	Encrustation in water supply structure and adverse effects on domestic use	600
5.	Calcium as Ca (mg/l,Max)	75	-do-	200
6.	Magnesium as Mg (mg/l,Max)	30	-do-	100
7.	Dissolved solids(mg/l,Max)	500	Beyond this palatability decreases and may cause gastro intestinal irritation	2000
8.	Alkalinity	200	Beyond this limit taste becomes unpleasant	600
9.	Chlorides(as Cl) (mg/l,Max)	250	Beyond this limit taste, corrosion and palatability are affected	1000
10.	Sulphate (as SO4) (mg/l,Max)	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400
11.	Nitrate (as NO4) (mg/l,Max)	45	Beyond this methanemoglobinemia takes place	100
12.	Fluoride (as F) (mg/l,Max)	1	Fluoride may be kept as low as possible. High fluoride may causes fluorosis	1.5
13.	Iron(as Fe)	0.30	Beyond this limit taste/appearance are affected,	1.0

S. No.	Parameters	IS:10500 Requirement (Desirable limit)	Undesirable effect outside the desirable limit	IS:10500 Permissible limit in the absence of alternate source
	(mg/l,Max)		has adverse effect on domestic uses and promotes iron bacteria	
14.	Zinc(as Zn) (mg/l,Max)	5	Beyond this it can cause astringent taste and an opalescence in water	15
15.	Lead(as Pb) (mg/l,Max)	0.05	Beyond this, the water becomes toxic	No relaxation
16.	Copper (as Cu) (mg/l,Max)	0.05	Astringent taste, discoloration and corrosion of pipes, fittings and utensils will be caused beyond this limit	1.5
17.	Cadmium(as Cd) (mg/l,Max)	0.01	Beyond this, the water becomes toxic	No relaxation
18.	Chromium(as Cr6+)(mg/l,Max)	0/05	May be carcinogenic above this limit	No relaxation
19.	Arsenic(as As) (mg/l,Max)	0.05	Beyond this, the water becomes toxic	No relaxation
20.	Mercury (as Hg)(mg/l,Max)	0.001	Beyond this, the water becomes toxic	No relaxation
21.	Residual Free Chlorine (mg/l,Max)	0.20	-	-

Conclusion

The results were compared among the values experimentally determined from control and polluted sites. The results showed alarming hike when cross checked with IS standard values, thus concluded for causing toxicity and bears social impact.

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