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Physicochemical properties of water and heavy metals (Lead and Zinc) in water and sediment of a reservoir and drainage of Jaipur (Rajasthan) – A comparative study

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Abstract
In the present study the physicochemical properties (Temperature, alkalinity, chloride, hardness and dissolved oxygen) of water and heavy metal concentration of two water bodies of Jaipur are compared. Heavy metals (lead and zinc) were detected in water and sediment of Ramgarh reservoir and Amani Shah's drainage of Jaipur. Metals were detected with the help of Atomic absorption spectrophotometer (GBC 902, double beam). In the reservoir the average concentration of lead and zinc was 0.02 µg/ml and 0.22 µg/ml respectively in the water while the average concentration of lead and zinc in the sediment was 3.0 µg/ml and 31.0 µg/ml respectively. While in the Amani Shah's drainage the average concentration of lead and zinc was 0.1 µg/ml and 4.8 µg/ml respectively in the water while the average concentration of lead and zinc in the sediment was 6.5 µg/ml and 43.5 µg/ml respectively. The quality of water of drainage was found more deteriorated than that of the reservoir.

Keywords: Physicochemical property, heavy metals, lead, zinc, water, sediment

Introduction
The water and sediments may become a non-point source and ultimate sink for most of the contaminants. Heavy metals are environmental contaminants. Heavy metals are products, chemical and petrochemical and refining, metalworking, food processing, and textile industry. Heavy metals such as zinc, lead, cadmium, chromium, mercury and copper can cause serious health problems. Virtually all metals, including essential micronutrients, are toxic to aquatic organisms as well as too for human if exposure levels are sufficiently high. Although some metals such as manganese, iron, copper and zinc are essential micro-nutrient, many others such as mercury, cadmium and lead are not required even in small amount by any organism.

Since time immemorial lead is in use in constructing pipe, building materials, paints, solders, ammunitions and casting, wood and cotton preservative, lubricants, oil additives, catalysts, rodent repellants, in storage batteries, in metal products and as gasoline antiknock additives. There are at least 200 minerals having lead (EPA, 1987) [1].The lead may cause colic, constipation, and damage the peripheral nervous system and renal system. In children the lead may damage central nervous system and in sever case may cause coma and death. The low level of lead exposure affects the behaviour and intelligence of children.

Metals can never be totally eliminated once they enter a water body. They remain persistent in sediment and slowly get released causing serious hazards to aquatic life forms as they further move up in the food chain (Campbell and Stokes, 1985) [2]. The water pollution may affect the biochemistry of hydrophytes (Mishra and Jha, 1996) [3]. The metals have a chance of affecting any aquatic ecosystem synergistically of antagonistically when existing in combination with other contamination may cause decrease in biotic diversity (Mathis and Cummings, 1971) [4]. The toxicity of metals may depend on the physical and chemical characteristics of water. The physicochemical properties of water may also indicate the quality of water.

The Ramgarh water reservoir is situated 30 km away from Jaipur City in Northeast direction. Besides being a source of potable water, this water reservoir has economic application such as fish breeding. This water body receives the water from river Bhanganga. The availability of water in this reservoir depends on the rain in its surrounding area and in the vicinity of river.

The anthropological activities and agricultural practices in its catchment area are the main source of pollutants like pesticides and heavy metals. Rajasthan state is not a leading industrial state; there are smaller areas where there is enough concentration of industries to create pollution. One of them is dying industries contributing heavy metal ions to water bodies because of the metal based dyes used. In Jaipur most of these industries have flourished in the Sanganer, which is a suburb of Jaipur. The sewage from these industries is discharged into Amani Shah's drainage. Therefore, there is a probability that effluents from this industry may contain heavy metals. Besides dyeing industries, vehicular traffic may be a source of heavy metal pollutants like lead. The present study was planned to evaluate and to compare the physicochemical properties of water and the heavy mental load in two water bodies.

Materials and Methods

Samples of water and sediment were periodically collected from three sites of Ramgarh reservoir (located 30 kms from Jaipur in Northeast direction); and Amani Shah' drainage (in south city zone of Jaipur) from Oct.96 to Sept.97. One-liter, borosilicate glass bottles were used for collection of water; and samples of bed sediment were collected in polythene zip lock bags and carried to the laboratory.

Temperature (On site determination)-The temperature was determined with the help of thermometer.

pH: The pH was determined with the help of pH meter. (Systronics make) Commercially available buffer tablets, for different pH (9.2, 7.0, 4.1), were used for the preparation of the solution.

Alkalinity: Alkalinity of the sample was estimated by titration with standard sulfuric acid. Titration to pH 8.3 or de-colouration of phenolphthalein indicator indicates complete neutralization of OH and 1/2 of CO3 while to pH 4.5 or sharp change from yellow to pink of methyl orange indicator indicates total alkalinity.

Chloride: Chlorine, in the form of chloride ion (Cl^-) is one of the major inorganic anions in water and wastewater. In potable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. In neutral or slightly alkaline solution potassium chromate can indicate the end point of the silver nitrate titration of chloride. Silver chloride is precipitated quantitatively before red silver chromate is formed.

Hardness: Total hardness is defined as the sum of the calcium and magnesium concentration, both expressed as calcium carbonate, in milligrams per liter. The total hardness of water in the present investigation was determined by EDTA titration method.

Dissolved oxygen: (Azide Modification) - In the present investigation Azide modification method was followed for the determination of dissolved oxygen in the water. The test was based on the addition of divalent ion manganese solution, followed by strong alkali, to the sample in glass-stoppered bottles (300 ml capacity). Dissolved oxygen rapidly oxidizes an equivalent amount of the dispersed divalent manganese hydroxide precipitate to hydroxides of higher valence states. In the presence of iodide ions in the acidic solution, the oxidized manganese reverts to the divalent state, with the liberation of iodine equivalent to the original DO content. The iodine is then titrated with a standard solution of thiosulphate. The titration end point was detected with a starch indicator.

Chemical oxygen demand: Open Reflux Method-In present investigation, the dichromate reflux method has been followed. This method is preferred over procedures using other oxidants because of superior oxidizing ability applicability to a wide variety of samples.

Digestion of samples for Heavy Metal Analysis

The sediment (0.5 gm) were digested in borosilicate glass tube with the addition of nitric acid and perchloric acid (4: 1) by putting the tubes in water bath for 5 - 6 hours or upto clear digestion of sample. After cooling, each sample was diluted upto 10 ml with distilled water and kept in plastic container. The water samples were used directly for analysis. The samples were analyzed by calibrated GBC 902, double beam Atomic Absorption Spectrophotometer (AAS).

Results and Discussion

Physicochemical properties of water

Variation in physicochemical properties of water of Jamawa Ramgarh reservoir and Amani Shah's drain are presented in Table2 and 3 respectively.

Temperature

The maximum mean temperature of Jamawa Ramgarh reservoir was recorded in June, and minimum mean temperature was recorded in December (Table.1.).

However, at Amani Shah's drain the maximum mean temperature was recorded in May and minimum mean temperature was recorded in November during study period (Table.2).

pH

At Jamawa Ramgarh reservoir the pH of water was found to be alkaline throughout the year (Table.1). The maximum alkaline pH (8.3) was recorded in June. It ranged from 7.9 to 8.3. The recorded pH of water of Jamawa Ramgarh Reservoir is in accordance with the findings of Singh and Roy (1995) [5], and Kumar *et al* (1989) [6]. The range of recorded pH may indicate the productive nature of Reservoir. No significant seasonal fluctuation was recorded in pH of water. Kaur *et al* (1996) [7] have also failed to observe any major seasonal fluctuation in pH. Intense algal activity causes the pH to rise sharply as carbon dioxide, present as carbonic acid, is utilized. Algae often raise the pH in surrounding water to as high as 10, at which point calcium carbonate precipitates and often forms a marl layer on the bottom of the lakes.

At Amani Shah's drain it was found to be alkaline throughout the study period (Table.2). It ranged from 6.53 to 8.2. In the high pH range water may harbor some excessive mineral contents.

Alkalinity (Total)

At Jamawa Ramgarh reservoir highest values of alkalinity was recorded in May (Table.1) and lowest in October. Peak values in alkalinity were observed during summer season. However, throughout the study period it was found to be below the acceptable limit of 200 mg/L. Alkalinity of water is acid neutralizing capacity. In the natural water the alkalinity is due to the salts of carbonate, borate, silicate, and phosphate along with hydroxyl ions in the Free State. At Amani Shah's drainage the alkalinity (Table 2.) was found to be above the permissible limit of 200 mg/L during the study period. Todd (1970) [8] has suggested the composition of domestic sewage in which alkalinity was in the range of 50- 200 mg/L.

Chloride

The chloride at Jamawa Ramgarh reservoir was found in the range of 21.9 to 80.2 mg/ml. The peak values in chloride were recorded in summer season. (Table.1).The chloride was found below the permissible limit of 200mg/L throughout the study period. The chloride at Amani Shah's drain (Table 2.) was found above the permissible limit of 200 mg/L. It ranged from 198.8 to 528.4 mg/L. Chloride as chloride ions is generally present in natural water. The salty taste produced by chloride depends on the chemical composition of water. It is usually associated with sodium ion. Presence of chlorides above the required acceptable limits can also be used as an indicator of pollution by domestic sewage. In natural surface water the concentration of chlorides is normally low. The chloride concentration in the water of Jamawa Ramgarh Reservoir was in accordance with the study of Chaturvedi *et al* (1996) [9] who found the chloride content in the water of Kolar dam within the acceptable limit. Contrary to these findings the chloride content in the water of Amani Shah's drainage was found to be above the acceptable limit indicating the pollution in water due to domestic sewage.

Hardness (Total)

At Jamawa Ramgarh reservoir the total hardness was ranged from 30.7mg/L to 120.8 mg/L. (Table 1.). The maximum value in hardness was recorded in May, and minimum value was recorded in October. The total hardness was found below the permissible limit throughout the study period. The hardness of water of Amani Shah's drain ranged between 397.0mg/L to 476.2 mg/L (Table 2.) and it was above the permissible limit. The hardness in the water is the measure of capacity of water to react with soap. It is caused by divalent cation, principally calcium and magnesium.

In the present work total hardness of water of Jamawa Ramgarh Reservoir was found to be less than the sum of carbonate and bicarbonate alkalinity. Thus all the observed hardness was carbonate hardness and that was within the required acceptable limit of 200 mg/L. Water of Jamawa Ramgarh Reservoir could thus be considered from soft to moderately hard. However, at Amani Shah's drainage it was found above the acceptable limit throughout the study period and this water may be considered as very hard.

Dissolved Oxygen

The maximum dissolved oxygen in the water of Jamawa Ramgarh reservoir was recorded during winter and from late winter it started declining. The minimum values were recorded in June (Table.1). The dissolved oxygen in the water of Amani Shah's drain was found below the measurable quantity during the study period. Depletion in dissolved oxygen in stagnant water may lead to taste and odor problems and may also create 'red water' problem. In summer the DO in the water of Jamawa Ramgarh water Reservoir was found to be lower in comparison to winter season. The depletion in DO was in accordance with the findings of Chase (1988) [10], who has reported that the warmer the water, the less is the oxygen it can hold. Fresh water at 0 ^{o}C hold 10.2 ml oxygen per liter while water at 24 ^{o}C is saturated at only 6.2 ml oxygen per liter. The summer temperature and decomposition of dead organisms in water may also reduce oxygen where it is used in the process of decomposition. High nutrition loads, especially during periodically warmer periods, increases the respiration rate, hence there is depletion in DO.

The water at Amani Shah's drainage at Sanganer was found to be deficient of DO. The domestic and industrial sewage from the vicinity of Sanganer might have been the main reason for absence of oxygen in water. The water without adequate DO may be considered as wastewater. DO plays a key role in an aquatic system. The DO in streams is an inverse function of the microbial population that in turn is controlled by their food supply, the organic pollutants. Excessive organic pollution causes fish kill by oxygen depletion. Fish kill and odor problems are associated with zero oxygen level.

The quality of Jamawa Ramgarh water Reservoir was markedly deteriorated in summer as the water at the banks turned to a pea soap appearance, which might be due to algae buoyed up by minute oxygen bubbles. Algal blooms may also deplete the DO.

Chemical Oxygen Demand

The chemical oxygen demand in the water of Jamawa Ramgarh reservoir was not studied. However, at Amani Shah's drain the chemical oxygen demand ranged between 952.3 mg/L to 1392mg/L. (Table 2) The water of Amani Shah's drainage may be considered as waste as it required more oxygen to stabilized organic materials.

The extent of sewage discharge, seasonal variation, and geo-chemical nature of land are the main factors responsible for variations in the physicochemical characteristics of the water (Pathak *et al*, 1992) [11]. The values of physicochemical parameters studied of Jamawa Ramgarh Reservoir were found within the required permissible limit. However, at Amani Shah's drainage the quality of water was neither fit for domestic purposes, or for irrigation. Singh and Roy (1995) [5] have found the water of Lake Kawar congenial for the propagation of fauna and flora. Chaturvedi *et al*, 1996 [9] have found the hypolimnic zone of Kolar dam, near Bhopal more polluted than that of surface water on the basis of COD and other parameters.

Heavy Metals

In water

Lead was detected in 40 percent (Table 4.) of water samples of Jamawa Ramgarh water Reservoir with average of 0.021 μg/ml. The monthly variation in the concentration of lead in the water is presented in the Table 3. Forstner and Wittman (1979) [12] have reported that the concentration of soluble lead in uncontaminated fresh water is generally 3.0 μg/L with background concentration in the range of 5-50 μg /L. However, in the present investigation much higher concentrations of lead in water were recorded in the water of Amani, s shah drainage (Table 3). This high concentration may be due to the combustion of gasoline on roads near the water bodies. The results are in accordance with the study of Panday and Das (1980) [13] who revealed high concentration in water of Lake in Nanital respectively. The level of lead in water was found to be higher than the level recommended by Indian Standard Institution (ISI, 1982) [14]. The criteria laid down for lead level in aquatic life protection (EPA, 1987) [1] ranges from 1.3 to 7.7 μg/L. the value above than this range may adversely affect the growth of aquatic species.

The zinc concentration in the water of Amani Shah's drainage was higher than that of Jamawa Ramgarh water Reservoir (Table 4). The higher concentration in the drainage may be attributed to anthropogenic activities in its vicinity. At Amani Shah's drainage, in Jan. the zinc concentration was exceeding the value (15 ppm) (Table 5.) recommended by Indian Standard Institute (ISI, 1982) [14] for inland surface water.

Table 1: Physicochemical properties of water of Jamawa Ramgarh Reservoir.

	Oct.	Nov.	Dec.	Jan	Feb.	Mar	Apr.	May	Jun.	Jul.	Sept.
Temperature(^{0}C)	23.2	22.8	18.8	20.3	21	20.3	28.3	26.2	31.6	27	29.6
pH	7.9	8.2	8.2	8.1	8.1	7.9	8	8.3	8.1	7.9	8
Alkalinity(mg/l)	60.8	123	114.8	142.66	117.33	131.4	161.4	211	182	146.66	120.8
Chloride(mg/l)	29.5	21.96	40.18	39.27	34.38	26.83	29.08	54.98	65.7	80.23	50.4
Hardness(mg/l)	30.67	72.66	82.6	86.6	107.6	108.8	119	120.8	93.8	117	88.8
DO(mg/l)	9.57	12.8	12.76	13.8	12.4	7.9	9.68	5.84	5.03	5.9	12.09

Table 2: Physicochemical properties of water of Amani Shah's Drainage**.**

	Nov.	Dec.	Jan.	Mar.	Apr.	May.
Alkalinity (mg/l)	324.6	99.13	460	379.2	421.33	480.8
Chloride (mg/l)	198.98	188.2	528.4	239.7	246.17	290.96
Hardness (mg/l)	397.06	460.8	413.06	463.73	430.2	476.2
COD (mg/l)	NC	1392	1354.6	952.3	960.3	978.6
Acidity (mg/l)	ND	ND	128	ND	ND	ND
Temperature(0^0c)	19	19.83	20	25	27.66	30.56
pH	7.83	7.9	6.53	8.2	8.26	7.7
DO	ND	ND	128	ND	ND	ND

Table 3: Heavy Metals in water and sediment of Jamawa Ramagarh Reservoir

MONTHS→		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.
Water(µg/ml)											
Lead	Mean	0	0.007	0.059	0.013	0.0526	0.01	0	0.011	0.01	0.049
	±SEM	0	0.005	0.048	0.011	0.01	0.008	0	0.008	0.008	0.032
Zinc	Mean	0.109	0.187	0.187	0.489	0.078	0.009	0	0.188	0.265	0.25
	±SEM	0.089	0.152	0.152	0.392	0.064	0.007	0	0.079	0.096	0.11
Sediment(µg/mg)											
Lead	Mean	0.015	1.595	0.565	3.05	5.32	12.2	2.26	2.06	0.99	2.91
	±SEM	0.01	0.505	0.251	0.162	0.353	5	0.367	0.24	0.035	1.36
Zinc	Mean	2.9	2.15	4.75	5.25	174.4	10.54	5.47	97.71	3.12	4.12
	±SEM	0.55	1.03	0.657	0.304	27.01	7.452	0.459	25.96	0.33	0.438

Table 4: Summary of Heavy Metal in water and sediment of Jamawa Ramgarh reservoir and Amani Shah's Drainage.

Heavy metals (µg/ml)			**Mean ±SEM**	**Range**	**% occurrence**	**Time when maximum Quantity Reported**
WATER	Lead	1	0.021 ± 0.007	ND-0.179	40	December
		2	0.116 ± 0.04	ND-0.7	89	December
	Zinc	1	0.228 ± 0.070	ND-1.45	54	January
		2	4.87 ± 3.54	ND-61.6	85	March
SEDIMENT	Lead	1	3.4 ± 0.914	ND-19.28	95	May
		2	6.54 ± 1.2	1.12-20.54	100	March
	Zinc	1	31.04	ND-212.6	95	February
		2	43.48 ± 14.3	5.92-196.6	100	March
	1. Jamawa Ramgarh water Reservoir. 2. Amani Shah's drainage.					

Table 5: Heavy metals in Water and sediment of Amani Shah's drainage

MONTHS→		Nov.	Dec.	Jan.	Mar.	Apr.	May.
Water(µg/ml)							
Lead	Mean	0.092	0.26	0.04	0.046	0.09	0.153
	±SEM	0.02	0.17	0.003	0.015	0.009	0.12
zinc	Mean	0.058	0.6	0.189	28.05	0.109	0.249
	±SEM	0.01	0.2	0.08	14.65	0.03	0.188
Sediment(µg/mg)							
Lead	Mean	9.53	8.36	5.9	9.37	2.87	2.94
	±SEM	3.30	0.33	1.37	4.72	0.73	0.58
zinc	Mean	22.5	29.75	119.76	69.7	7.66	11.5
	±SEM	6.14	2.84	39.65	50.98	0.82	1.71

In Sediment

Lead and Zinc were also detected in the sediment of Jamawa Ramgarh water Reservoir and Amani Shah's drainage. The levels of both the metals were found maximum in sediments (Table 4). The variation in concentration may be attributed to anthropological activities in their vicinity. The lead and zinc concentration in the sediment of Jamawa Ramgarh Reservoir were not in the categories of moderate or polluted level. The mean concentration of lead in sediment was 3.0 ppm (DW), while that of zinc was 31.0 ppm (DW). This concentration may be considered as background concentration in sediments. The levels of heavy metals in the sediment cannot be considered polluted or moderately polluted because the levels were below the permissible limit. However, the sediment of Amani Shah's drainage was found to be moderately polluted during January as in this month zinc level was maximum (194 ppm) compared to other study months. The bioavailability of these metals is influenced by physico-chemical interaction of the system (Dicks and Allen, 1983) [15]. Thapalia *et al* (2015) [16] have found the lake and reservoir were affected by zinc from vehicle related sources on the basis of zinc isotope studied. Nishumara and Kumagai (1982) [17] have revealed that polluted sediments as the primary source of fish contamination in most of the aquatic system. The levels of metals in sediments may reflect the nature of overlying water and also the level of metal contamination in the organisms inhabiting the sediment water interface.

The levels of zinc concentration in sediment are in accordance with the findings of Friant (1979) [18], Barman and Lal (1994) [19], and Ganapathy and Pillai (1975) [20]. The level of zinc can be considered as normal, according to the range suggested EPA and safe to aquatic biota sμggested by Elder and Mattraw (1984) [21].

Lead concentration in the sediment can be considered safe as it ranged within the permissible limit and even safe for aquatic biota (Elder and Mattraw, 1984) [21]. Lead level in the sediment is in accordance with the study of Barman and Lal (1994) [19], Pheiffer (1972) [22], Moore and Sutherland (1981) [23], and Mathis and Cummings (1973) [4]. The concentration of heavy metal in water and sediment may depend on the physicochemical characteristics of water and sediment. The soil retention capacity of lead and zinc depends upon the pH of the soil (Harter, 1982) [24] and this capacity increases above pH 7.0 to 7.5. The extent of absorption, of lead and zinc by bed sediment, increases with the increase of pH of solution (Jain and Ram, 1997, Jain *et al* 2005) [25, 26]. The industrial and anthropogenic activity in the river catchment area of reservoir and drainage may be a major source of heavy metal to the water bodies (Suthar et. al. 2009) [27].

Conclusion

Metals enter in the ecosystem in a relatively non-toxic form and become intrinsic components of the environment in such a way that it is difficult to remove them from the environment. The heavy metals like lead and zinc were found in water and sediment of reservoir and drainage. However, its concentration was more in water and sediment of drainage than reservoir. Therefore, the presence of lead and zinc at drainage cannot be considered as the background concentration. The industrial activity and anthropogenic activity may be a source of contamination other than background concentration. The alkalinity and chloride of water at reservoir was within the permissible limit, however, it was above the limit at drainage. The water of drainage was hard than the reservoir. The domestic and industrial sewage might be a reason for the absence of dissolved oxygen at the drainage. The quality of water of drainage was found to be more deteriorated than that of reservoir.

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