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Metallic contamination in sewerage, canal and drinking waters of Taxila- a gateway to Ghandara civilization

[1]Hussain, S.T., [1]Mahmood, T.*, [2]Malik, S.A. and [3]Amir, S.,

[1]Nano Sciences and Catalysis Division, National Centre for Physics, Quaid-i-Azam University campus, Shahdrah valley Islamabad, Pakistan
[2]Department of Biochemistry, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan
[3]Inorganic/Analytical Section, Department of Chemistry, Quaid-i-Azam University, Islamabad, Pakistan

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Abstract

Taxila is the tehsil of district Rawalpindi, of Pakistan. Now a day due to rapid industrialization and increase in population, various sources of water are contaminated. Analysis of cadmium (Cd), lead (Pb) and copper (Cu) in sewerage, canal and drinking waters potentiometeric analysis (PSA) was conducted. Samples were collected from different locations in the thasil Taxila of Rawalpindi. The data indicated wide variation in the concentration of these heavy metals among various water samples. The ranges of Cd, Pb and Cu in drinking water lie between 0.23-2.75, 0.025-1.88 and 0.67 mg/l respectively. Similarly the results of sewerage water showed the concentration of Cd and Pb in the range of 0.036-1.25 and 0.004 and 11.50 mg/l while copper concentration was below detection limit in all samples. The highest level of Cd and Pb in the canal water were 0.38 and 2.08 mg/l respectively. The results thus obtained were compared with the guidelines recommended for drinking water.

Key words: Taxila: Ghandara; wastewater; metals; canal water; metallic pollution.

INTRODUCTION

Taxila is an important archaeological site in Pakistan containing the ruins of the Gandharan city of **Takshashila** (also Takkasila or **Taxila**). It remained as center of one of the oldest civilization of world i.e. Gandhara. Taxila is situated at the western region of the Islamabad Capital Territory- Rawalpindi and on the border of the Punjab and North West Frontier Province

(NWFP) about 30 kilometers west-north-west of Islamabad, just off the Grand Trunk Road. Taxila is situated at *(Latitude: 33° 46′ 45″ N 33.779167° Longitude: 72° 53′ 15″ E 72.8875°)*
Environmental pollution is the matter of great concern worldwide. Rapidly increasing industrialization and motorization have greatly polluted the environments and consequently raised the native heavy metal levels in water and food materials. Water is indispensable to life and hence plays vital role in the environment. Water is an essential component of the human the environment into which toxic metals may easily be increased from various sources of pollution. Water is the one of the most abundantly available and widely distributed substances in nature. The discharge of heavy metals into aquatic ecosystems has become a matter of concern over the last few decades [1].

Heavy metals occur in immobilized form in sediments and as ores in nature. However due to various human activities like ore mining and industrial processes the natural biogeochemical cycles are disrupted causing increased depositions of heavy metals in terrestrial and aquatic environment. Release of these pollutants without proper treatment poses a significant threat to both environment and public health, as they are non biodegradable and persistent [2].

Water bodies are being overwhelmed with bacteria and waste matter. Among toxic substances reaching hazardous levels are heavy metals [3]. Heavy metals of concern include lead, chromium, mercury, uranium, selenium, zinc, arsenic, cadmium, silver, gold, and nickel [4]. Heavy metal pollution in the aquatic system has become a serious threat today and of great environmental concern as they are non-biodegradable and thus persistent. Metals are mobilized and carried into food web as a result of leaching from waste dumps, polluted soils and water. The metals increase in concentration at every level of food chain and are passed onto the next higher level–a phenomenon called bio-magnification [5].

The determination of heavy metals in various types of water samples has become an important part of most studies concerned with environmental pollution and occupational health hazards. Contaminated drinking water has direct effect on human beings while sewerage; canal water and industrial effluents have indirect effect on crops, vegetables and fruits irrigated with polluted waters, which become harmful to humans and animals. Heavy metals include both essential and toxic mineral elements. It is well known that an essential metal become toxic at sufficiently high intakes [6]. Lead (Pb) and cadmium (Cd) are dangerous environmental pollutants [7]. Excess amount of copper in drinking and irrigation water has a distinctly harmful effect on many crops and other living organisms [8]. Heavy metals can be determined by several techniques however, Potentiometeric Stripping Analysis (PSA) is an electrochemical approach for the assay of trace metals and is particularly well suited in liquid samples since normally no pre-treatment is required [9,10,11,12]. Finding of another study also shows similar results for drinking and irrigation waters [13]. Aziz [14] determined pollution parameters of some water resources of sewage water and observed significant variation in the values of pH, EC and other metals.

The principal aim of this study was to quantify the presence of selected heavy metal and pH in some drinking, canal and sewerage waters and subsequently to comment on the radiological implications if any, of their intake through different routes of entry.

MATERIALS AND METHODS

Sample collection and preparation

Samples of drinking, canal and sewerage waters were collected from different places in the Taxila area. All the water samples were taken to the laboratory in plastic bottles immediately after collection. After measurement of pH, all water samples were acidified by addition of 0.5 ml of HCl to a pH 2.0 for conservation.

Analysis of different water samples

The drinking, canal and sewerage waters were assayed for pH measurement and heavy metals according to the methods given below:

pH measurement

The pH meter was switched on and allowed to warm for 3 minutes. Standardized with buffer solution of 4.00 and 9.12 for acidic and alkaline ranges respectively and the pH of the water samples was measured using fisher automatic titrimeter model 36 pH meter.

Determination of selected heavy metals

Simultaneous determination of Cd, Cu and Pb was carried out by the potentiometeric stripping technique [15] using the Tecator striptec system (Model 1069-001) comprising glassy carbon electrode, saturated calomel electrode (SCE) and platinum wire as counter electrode. Detailed procedure has been given elsewhere [13].

RESULTS AND DISCUSSION

Global demand for fresh water is increasing every year. At present, renewable water resources available per person are roughly half what they were in 1960, a value that is expected to drop by half again by the year 2025. Growing demand is compounded by pollution wherever fresh water is used for agricultural, industrial and domestic purposes. Hence, if water resources are not better managed and protected, shortages and contamination will present major dangers to health and the environment [16].

Keeping in view hazardous impact of Pb, Cd and Cu on human beings, animals and plants, it is necessary to establish occurrence of these toxic heavy metals in the environment. Lead is one of the non-essential trace elements extensively studied because of its various toxic effects in human at low dose [7]. The typical symptoms of lead poisoning are choleric, anemia, headaches, and convulsions, chronic nephritis of the kidneys, brain damage and central nervous system disorders [17]. It is mainly released to the environment from motorization. Its permissible level is 0.05 ppm for drinking water according to WHO. Another heavy metal called cadmium may enter to water as a result of industrial discharges, automobiles tires, motor oils, plastic, coal and galvanized pipes. Cadmium is extremely toxic and accumulates in humans and damages mainly the kidneys and liver. Its permissible level is 0.01 ppm [18, 19].

Electrical conductors and alloys discharge of mine tailing disposal of industrial wastes and municipal wastes are the sources of Cu releases into lake water. Copper treated water be used for irrigation but it has a distinctly harmful effect on many crops [8]. Copper is essential to humans, the adult daily requirement has been estimated at 2.0 mg. the maximum permissible level for Cu in drinking water is 1.0 ppm [18].

Selected heavy metals concentrations in drinking water are presented in Table-1. Twenty samples were taken from different locations. The result showed wide deviation for cadmium and lead. The concentration of cadmium and lead in all the samples were higher compared to the values in guideline for the samples. The ranges of Cd, Pb and Cu lie between 0.023-2.75, 0.025-1.88 and 0-067 mg/l respectively. Maximum level of Cd (2.75) was observed in the sample collected from Jokar while the maximum Pb concentration (1.88) was detected in Margalla drinking water. Copper was detected only in two samples.

Table-1: The pH and heavy metal concentration of drinking water

Sr. No.	Location	pH	Cd	Pb	Cu.
1.	Kharamwal	6.97	0.094	0.043	*
2.	Khuram	8.29	0.042	0.085	0.144
3.	Margalla	6.95	0.060	0.025	0.500
4.	Jokar	7.00	0.028	0.096	*
5.	Thata Khalil	7.30	0.054	0.462	*
6.	Taxila Cantt	7.40	1.00	0.800	*
7.	H.M.C	7.36	0.150	0.116	*
8.	Railway Station	7.80	0.167	0.219	*
9.	Pind Godwal	7.75	0.107	0.250	*
10.	Ban	7.70	0.525	0.235	*
11.	Ghazi Kholi	8.18	0.688	0.180	*
12.	Shah Dhari	7.84	0.750	0.050	*
13.	Engg. University	8.25	0.313	0.068	0.670
14.	Bhularh top	7.45	2.750	0.167	*
15.	Salargah	7.73	0.630	0.056	*
16.	Wah Cantt	7.19	0.023	*	*
17.	Munirabad	7.45	0.600	0.500	*
18.	Gadwall	8.09	1.750	0.160	*
19.	Bhabrah	7.76	0.750	*	*
20.	Wah Railway Station	7.80	0.050	1.880	*
	Range	6.95-8.25	0.023-2.75	0.025-1.88	0-0.67
	Mean	7.60	0.526	0.270	0.066
	S.D	0.429	0.684	0-4.428	0.182
	C.V	5.64	130.04	158.52	275.76

1. values are means of 2-3 independent determination.
2. S.D standard deviation
3. C.V (coefficient of veriability) = $\frac{S.D. \times 100}{Mean}$

* Below detection limit.

The results of sewerage water are given in Table-2. it was observed that highest amount of Cd (1.250) was in the drainage of Shah Dhari and the least (0.036) in the sample obtained from Gadwal. Similarly the maximum amount of Lead (1.50) was detected in the sample collected from effluents of Bhularh Top while the least (0.004) was observed in the sample of Budhoo. It interesting that copper concentration was below detection limit in all samples.

Table-2: The pH and heavy metal concentrations of sewerage water.

S. No	Location	pH	Cd	Pb	Cu
1.	Budhoo	7.40	0.223	0.004	*
2.	Munirabad	8.69	0.144	*	*
3.	Mohra Chowk	8.09	0.670	0.196	*
4.	Gadwal	3.99	0.036	0.298	*
5.	Shah Dhari	8.22	1.250	0.438	*
6.	Bhularh Top	7.22	0.091	1.500	*
7.	Railway Crossing	7.68	0.318	0.030	*
	Range	3.99-8.69	0.036-1.25	0.0040-1.50	*
	Mean	7.33	0.390	0.350	*
	S.D	1.555	0.433	0.532	*
	C.V	21.22	111.02	152.00	*

1. Values are means of 2-3 independent determination.
2. S.D standard deviation
3. C.V. (coefficient of variability) = $\frac{\text{S.D. x 100}}{\text{Mean}}$

*Below detection limit

The results of canal water, mainly used for irrigation are presented in Table-3. the levels of Cd, Pb and Cu were in the range of 0.008-0.38, 0.031-2.50 and 0.0025-0.50 mg/l respectively. The highest level of Cd (0.38) was noticed at Railway station while Pb (2.08) was observed in the sample collected at Engineering University Taxila.

Determination of means and CV of all the waters indicated wide variation in the heavy metal contents in each case. However, mean concentration of Cd, was highest in drinking water while mean level of Pb was highest in canal water. Maximum mean value of Cu was observed in sewerage water. Monitoring of heavy metals level of different waters in Taxila has not been widely conducted. Elemental concentration of industrial effluents from few industries has been reported in few studies [20].

The hydrogen ion concentration of water is expressed by its pH value. This term is universally used to express the intensity of acidic or alkaline conditions of solution. The experimental data (Tables-1 to 3) indicate that majority of samples were in the permissible pH range given for drinking water samples collected from Khurram was of slightly higher value (8.69). Another sewerage water sample obtained from joker was found on acidic side (3.99).

Table 3: The pH and heavy metal concentration of canal water

S.No	Location	pH	Cd	Pb	Cu
1.	H.M.C	8.05	0.070	0.065	*
2.	Wah Railway Station	7.49	0.0080	0.031	0.500
3.	Engg University Taxila	7.58	0.100	2.080	0.400
4.	Thathoo	7.87	0.054	0.330	*
5.	Wah Cantt	7.51	0.380	*	0.250
6.	Christian Hospital	7.22	0.013	0.043	*
7.	Railway Station	6.80	0.048	2.50	0.263
	Range	5.95-8.05	0.008-0.38	0.031-2.50	0.0025
	Mean	7.32	0.096	0.721	0.202
	S.D	0.721	0.129	1.084	0.207
	C.V	9.85	134.38	134.44	102.48

1. Values are means of 2-3 independent determination.
2. S.D standard deviation
3. C.V. (coefficient of variability) = $\frac{\text{S.D. x 100}}{\text{Mean}}$

*Below detection limit

Figure. 1. Study area Taxila is pointed in Pakistan map

CONCLUSION

It is essential that the supply of water for human consumption and irrigation should be free from unpleasant or harmful impurity and for this reason is subjected to various methods of treatment to render it safe for use. The present study indicates that background values for heavy metals should be monitored regularly in order to evaluate the toxic logical significance of commonly used water samples. The levels of toxic metals in majority of samples were higher as compared to recommended limits. Hence it is suggested that some pre-treatments be given prior to drinking or other uses.

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