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METAL CONTENTS IN RAWAL LAKE WATER AND FISH

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Concentration of metals (Al, Fe, Mn, As, Sr, Zn, Cd, Cr, Cu, Pb, Ni, and Co) were measured in Rawal lake water and fish. The objective of the study was to determine metal load in Rawal lake water and fish. Physiochemical characteristics of the lake water were also determined. Rawal lake was monitored at 12 sites in three profiles. At each station, water samples were collected from surface, middle and bottom column. Results of the study revealed that water quality of Rawal Lake, in terms of physiochemical characteristics (pH, electrical conductivity, total dissolved solids and alkalinity), is satisfactory and the values of these parameters are within permissible water quality limits. Metal concentrations at different stations varied widely because these are carried into the lake from different sources. However, in lake water, average As is found in high concentration while average contents of Al, Fe, Mn, Sr and Zn were within WHO permissible limits. Ni, Cd, Cr, Cu, Co and Pb were below detection limit (< 0.001 μg/ml). In general, metal ions concentration increased with water column depth which indicates that metal ions originated from weathering. Metal ions in two species of fish (Labeo rohita and Tor species) were higher than the levels found in water. The study concludes that increasing population in catchments Zone of Rawal Lake must be regularized and there should be some management policy to check further increase in the number of poultry and agro farms in the catchments zones.

Keywords: Rawal lake, Metals, pH, EC, Temperature, TDS, Hardness, Rawalpindi, Korang, Water depth, Stream

1. Introduction

The city of Rawalpindi is located besides Islamabad, the capital of Pakistan. The shallow hydrogeological system of the Leh Basin underlying Rawalpindi city does not meet water supply demand of an estimated population of about 0.55 million. The rapid growth of population is further aggravating the problem of clean drinking water supply. The alternate major source of water supply for the city is the Rawal Lake. This lake is fed mainly by the Kurang River and partly, by streams emanating from the jurisdiction of the federal capital, Islamabad. The Kurang River and the streams receive local spring discharges, diverted untreated sewage water and occasionally polluted run-off water during rainy season. The run off water contain contaminants from poultry farms, sewage drains and landfill sites located in adjacent villages and residential areas [1].

Field observations in the catchment area of the Rawal Lake indicate that the Islamabad -Barakaho zone serves as the main area of concern w.r.t. pollution risk to the Lake. This "area of concern" is the most densely populated part of the catchment zone for this lake and is currently experiencing extensive development practices. Furthermore, the sewage and poultry waste from this area apparently reaches the lake very quickly because of the short distance involved and the presence of the stream network. This in turn, is posing a serious threat to community health in the Rawalpindi city [2, 3].

Since the construction of Rawal dam in 1962, the chemical and bacteriological quality of raw water in Rawal Lake is determined routinely by the Water Quality Laboratory of Rawal Dam Filtration Plant in association with the National Health Laboratory, Islamabad. In addition, some agencies have also monitored the chemical and biological quality of the dam water from time to time. In the late 1980's and early 1990's, evidence of pollution in the lake promoted a more intensive water quality monitoring exercise in 1991 and 1992 by the Environmental Protection Agency, Government of The Punjab (GoPu). In order to ensure and manage the clean water supply in Rawalpindi city, assessment of Rawal Lake water and its feeding

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streams and rivers is imperative.

Metals enter the water bodies of our environment by a variety of routes, of both natural and anthropogenic origin: atmospheric deposition, weathering of rocks, erosion, runoff, untreated sewage, agricultural activities and industries. The elements such as Al, Fe, Mn, As, Sr, Zn, Cd, Cr, Ni, Cu, Pb and Co, have well known toxicity effect on human beings and aquatic life. These elements may originate from geological weathering of sediments and/or as domestic and industrial waste effluents. They have received considerable public attention all over the world, partly because of concern that they will cause long-term damage to the environment. Such long-term damage can be caused by highly concentrated pollution, produced over a short time and remaining in one place, or due to low concentration, insidious pollution, requiring a considerable time to produce an effect. These insidious effects are difficult to measure and establish with certainty [4].

Chemical techniques can be used to address this issue in order to identify the sources of pollutants and to assess changes in surface water and groundwater pollution dynamics. This paper addresses the water quality issues of Rawal Lake in terms of metals contents.

2. Materials and Methods

2.1 Water sampling and preservation

Surface water and depth water samples were collected from Rawal Lake as well as major/ minor streams and rivers feeding the lake in September 2008. Rawal Lake was sampled in the following three profiles:

Profile-1: Boat area to Lakhwal, Profile-II: Middle of Lake (opposite naval area towards Banni Galla), Profile-III: From entrance of Bari Imam Nala towards Kurang River

In each profile, water samples were collected from four stations. Table 1 describes details of these stations and total water depth at each station. Figure 1 shows location of various sampling points in and around Rawal Lake. A submersible pump was used to collected samples from Rawal Lake. The streams were approached through road. Sampling locations were monitored with GARMIN Global Positioning System (GPS)

Table 1. Details of sampling stations.

S. No.	Sampling Site	Water Depth (m)	Location	Latitude	Longitude
Profile-I					
1	Station-1	1	Boat Basin	33-41-61	73-07-22
2	Station-2	13	Opposite Spillway	33-41-70	73-07-31
3	Station-3	13	Between CDA Guest house and Spillway	33-41-77	73-07-68
4	Station-4	14	Extreme of Lake Lakhwal	33-41-80	73-07-85
Profile-II					
5	Station-5	12	Opposite Naval Boat Area	33-41-89	73-07-27
6	Station-6	14	Opposite Spillway	33-41-86	73-07-49
7	Station-7	14	Opposite CDA Guesthouse	33-41-88	73-07-74
8	Station-8	12	End of lake toward Banni Galla	33-41-89	73-07-84
Profile-III					
9	Station-9	14	Entrance of stream from Imam Bari	33-42-06	73-07-24
10	Station-10	11	Opposite Spillway	33-42-16	73-07-31
11	Station-11	7	Parking Picnic point	33-42-80	73-08-38
12	Station-12	4	Extreme of Lake near Korang Nala	33-42-80	73-08-53

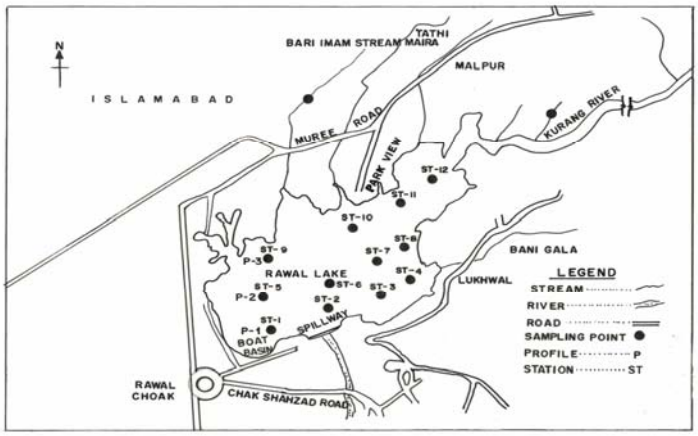

Figure 1. Sampling locations in Rawal Lake.

Model GPSMAP 60Sx. From each location, samples were collected from surface, middle and bottom zone. The water samples were acidified with analytical grade concentrated HNO_3 (~1.5 ml/L) to pH 2.0. High quality non breaking and frost proof plastic bottles were used for water sample collection. Lake water samples were filtered through nitrocellulose filter paper (0.45 µm) and preserved for metal analysis in accordance with standard procedure [5, 6, 7]. Fish sample was collected from Rawal Lake in polyethylene bags. Polyethylene gloves were worn during sample collection and handling to avoid any contamination with bare hands.

2.2. Field in-situ analysis

Temperature, electrical conductivity, TDS and pH were measured in-situ. Electrical conductivity and temperature were measured with portable conductivity meter (Model HI 8633, M/S HANNA Instruments). pH was determined using a portable pH meter (Model: PS-19 M/S Corning, Canada). Each instrument was duly calibrated before use.

2.3 Metal analysis

Metal analysis in water and fish samples were performed on fully computerized inductively coupled plasma optical emission spectrometer (ICP-OES) Model 6500 [8]. Fish samples were digested in accordance with standard procedure [9].

3. Results and Discussion

The physiochemical parameter and metal analysis data of Rawal Lake and its input water sources (feeding streams and Kurang River) are shown in Table 2. The following section presents discussion on their analysis.

3.1 Physiochemical water quality parameters

Physiochemical parameters of feeding streams and Rawal lake water is presented in Table 2. The pH of the Rawal Lake surface water (depth: ~ zero meter) was quite consistent in the range of 8.1 to 8.2. Generally the pH of Lake water decreases from the top to the bottom of water column. The pH of water in Rawal Lake is within the permissible limits [10].

The electrical conductivity (E.C.) values of surface water in the area are in the range of 319 to 375 µS/cm (micro Siemen). These values are within the range as prescribed by the various environmental agencies for drinking water quality [10]. However, the minor stream showed an E.C. value of 531 and Kurang River 444 µS/cm. The Kurang River water has relatively low E.C. value as compared to the other stream. Generally, electrical conductivity at each sampling station was higher in the middle of water column followed by bottom part of Lake and lowest at surface with a few exceptions. Low E.C in surface water of Rawal Lake is attributed to addition of low E.C run off water. It may be mentioned that EC of surface water compared to depth water profile of water bodies is season dependent. The EC of surface water in hot and dry seasons is higher due to high evaporation rate from surface water thus increasing salt contents, whereas in humid seasons the E.C of surface water is low due to very little evaporation.

Table 2. Physio-chemical characteristics of Rawal Lake and feeding streams.

S.No	Location	Depth	Lat./ Long.	E.C. (µS/cm)	pH	TDS (mg/l)	Temp. ^{o}C)	Hardness (mg/l)
Feeding streams								
1.	Bari Imam	Surface	33-43-11 73-07-36	531	8.20	350	28.5	7.4
2.	Kurang River	Surface	33-44-40 73-11-59	444	7.80	294	30.7	5.1
Lake water								
3	Station -1	Surface	33-41-61 73-07-22	318	8.24	209	31.0	1.8
4	Station -2	Surface	33-41-70 73-07-31	319	8.30	211	30.0	3.3
5		Middle (7m)		450	7.50	299	30.1	2.2
6		Bottom (13 m)		381	7.20	251	30.6	19.4
7	Station -3	Surface	33-41-77 73-07-68	325	8.20	216	29.9	13.9
8		Middle (7 m)		395	7.50	260	30.2	17.2
9		Bottom (13m)		388	7.40	255	30.4	13.5
10	Station -4	Surface	33-41-80 73-07-85	328	8.30	270	29.8	11.5
11		Middle (7 m)		345	7.76	228	30.1	11.0
12		Bottom (14 m)		361	7.60	239	30.2	12.1
13	Station -5	Surface	33-41-89 73-07-27	327	8.32	215	29.8	7.5
14		Middle (6 m)		391	7.60	258	30.3	8.1
15		Bottom (12 m)		381	7.40	252	30.4	8.3
16	Station -6	Surface	33-41-86 73-07-49	323	8.30	215	29.8	7.7
17		Middle (6 m)		397	7.55	262	30.1	10
18		Bottom (14 m)		384	7.35	253	30.6	9.5
19	Station -7	Surface	33-41-88 73-07-74	323	8.25	213	30.2	9.5
20		Middle (7 m)		394	7.50	259	30.6	8.6
21		Bottom (14 m)		383	7.32	252	30.8	9.1
22	Station -8	Surface	33-41-89 73-07-84	324	8.30	214	31.0	10.0
23		Middle (6m)		383	7.46	252	29.9	10.3
24		Bottom (12 m)		391	7.40	258	29.8	10.2
25	Station -9	Surface	33-42-06 73-07-24	323	8.25	214	30.9	7.2
26		Middle (7 m)		390	7.50	257	31.9	9.1
27		Bottom (14m)		384	7.35	253	31.6	7.3
28	Station -10	Surface	33-42-16 73-07-31	325	8.32	214	29.7	6.4
29		Middle (5.5 m)		393	7.60	258	29.8	7.8
30		Bottom (11 m)		391	7.60	258	29.9	7.3
31	Station -11	Surface	33-42-80 73-08-38	350	8.30	230	30.9	5.6
32		Middle (3.5 m)		348	7.50	229	31.9	5.4
33		Bottom (7 m)		350	7.50	230	31.6	5.7
34	Station -12	Surface	33-42-80 73-08-53	375	8.20	246	31.0	6.9
35		Middle (2 m)		362	7.00	238	29.0	6.2
36		Bottom (4 m)		353	7.10	231	29.9	6.1
WHO/EU Permissible Limit				--	6.5 -8.5	<500	-	<150

Table 3. Metal contents in Kurang River and stream entering Rawal Lake.

Sampling Site	Metals Concentration (mg/l)								
	Al	Fe	Mn	As	Sr	Zn	Cd	Cr	Cu
Bari Imam	0.08	0.18	0.01	0.027	1.61	0.16	BDL	BDL	0.03
Kurang River	0.35	0.17	0.03	0.011	1.11	BDL	BDL	BDL	BDL

BDL= 0.001 mg/l, RSD < 2 %

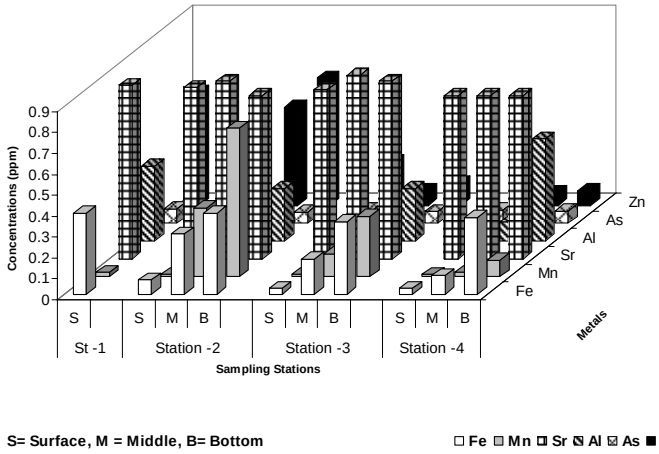

Figure 2. Depth wise metal contents in Profile-1.

The temperature of the Kurang River is higher by about 2^{o}C as compared to the other stream. Temperatures of top surface water in the Rawal Lake remain consistent around 30^{o}C which is attributed to well mixing of Lake water. Further, the temperatures of top water column are almost identical to middle and bottom zones at each sampling stations.

TDS of Kurang River is lower than other small stream from Barri Imam. However, TDS of Kurang River and streams are well within the permissible limits of WHO [10]. TDS of surface water of Rawal Lake varied from 209 to 270 mg/l which is well below WHO guidelines of drinking water. Generally TDS values of water decreased with the depth with a few exceptions.

Hardness of Kurang River is lower than Stream entering into the dam, whereas hardness of surface water in lake ranged from 1.8 to 13.9 mg/l which is below WHO permissible limits [10].

3.2 Metal analysis

Table 3 shows the metal contents of feeding streams of Rawal Lake just before entrance into lake. Concentration of Al in Kurang River was 0.35 mg/l and was significantly higher than stream coming from Bari Imam. Concentration of Fe, Mn, and Sr was quite comparable in Kurang River and stream. Concentration of Cr, Cd, Ni, Cu, Co and Pb in both streams were below detection limit (< 0.001mg/l). Table 4 represents the concentration of metals in Rawal Lake water. Cd, Cr, Pb, Ni, Cu and Co was not detected in water samples. Their concentration was found to be below detection limit (< 0.001 mg/l).

3.2.1 Profile - I boat area to Lakhwal

Profile – I starts from boat basin towards south of the lake (Lakwal). Depth wise metal contents in Station-1 to station -4 are shown in Figure 2. At station # I (boat area) only surface water was collected due to low water depth. Significant difference in Al concentration was observed in surface water and ranged between 0.05 to 0.36 mg/l. Al concentration increased with depth at all location. Maximum Al concentration (0.49 mg/l) was recorded in bottom water sample at station # 4 near Lakhwal followed by surface water at station # 1.

Table 4. Metal concentration in Rawal Lake

S.No.	Location	Depth	Metals Concentration (mg/l)					
			Al	Fe	Mn	As	Sr	Zn
Profile-1: Boat area to Lakhwal								
1	Station-1	Surface	0.36	0.39	0.02	0.070	0.83	0.54
2	Station -2	Surface	0.06	0.07	0.01	0.008	0.82	0.01
3		6 m	0.13	0.29	0.33	0.009	0.85	0.47
4		13 m	0.25	0.39	0.71	0.053	0.78	0.61
5	Station -3	Surface	0.05	0.03	0.01	0.06	0.81	0.21
6		7 m	0.12	0.17	0.11	0.07	0.88	0.07
7		13 m	0.25	0.35	0.29	0.057	0.85	0.11
8	Station -4	Surface	0.06	0.03	0.01	0.064	0.78	0.12
9		7 m	0.09	0.09	0.02	0.063	0.78	0.06
10		14 m	0.49	0.37	0.08	0.06	0.85	0.07
Profile-II: Middle of Lake								
11	Station -5	Surface	0.04	0.02	0.01	0.047	0.77	0.01
12		6 m	0.14	0.24	0.44	0.059	0.79	0.03
13		12 m	0.22	0.26	0.51	0.034	0.8	0.1
14	Station -6	Surface	0.05	0.03	0.01	0.049	0.8	0.01
15		6 m	0.13	0.24	0.23	0.042	0.9	0.04
16		14 m	0.09	0.16	0.21	0.056	0.85	0.02
17	Station -7	Surface	0.14	0.12	0.01	0.055	0.84	0.06
18		7 m	0.09	0.12	0.24	0.06	0.85	0.01
19		14 m	0.57	0.74	0.58	0.062	0.77	0.04
20	Station -8	Surface	0.2	0.13	0.01	0.064	0.77	0.12
21		6 m	1.15	BDL	0.65	0.060	0.85	0.14
22		12 m	0.13	0.17	0.43	0.060	0.79	0.01
Profile-III: From entrance of Bari Imam Nala towards Kurang River								
23	Station -9	Surface	0.07	0.09	0.02	0.041	0.78	0.01
24		7 m	0.1	0.16	0.31	0.035	0.83	BDL
25		14 m	0.26	0.37	0.54	0.019	0.78	BDL
26	Station -10	Surface	0.11	0.25	0.01	0.028	0.78	BDL
27		5.5 m	0.09	0.1	0.15	0.033	0.86	0.01
28		11 m	0.11	0.15	0.22	0.026	0.85	0.01
29	Station -11	Surface	0.12	0.12	0.02	0.018	0.84	0.02
30		3.5 m	0.22	0.26	0.03	0.018	0.83	0.05
31		7 m	0.19	0.77	0.03	0.002	1.38	0.39
32	Station -12	Surface	0.58	0.56	0.05	0.007	0.9	BDL
33		2 m	0.26	0.29	0.04	0.007	0.87	0.09
34		4 m	0.23	0.24	0.04	0.010	1.01	0.02

BDL = Below Detection Limit (0.001 mg/l), Relative Standard Deviation (RSD) < 2 %

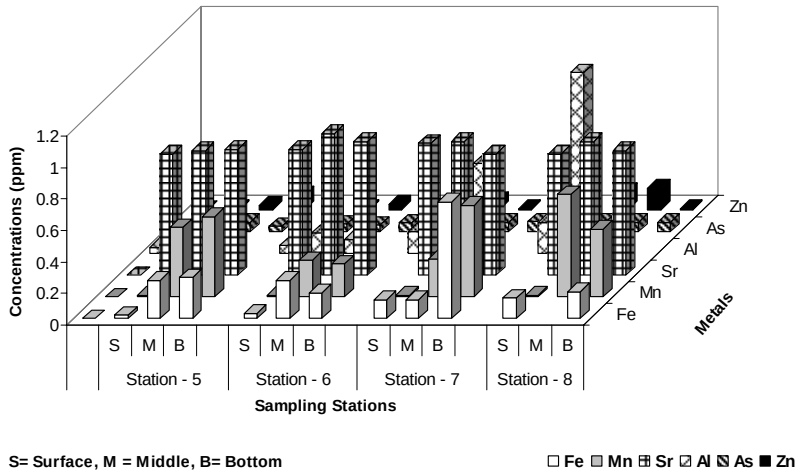

Figure 3. Depth wise metal contents in Profile- 2.

Concentration of Fe ranged from 0.03 to 0.39 mg/l in surface water. Maximum concentration was recorded at station # 2 near spillway. An increasing trend in Fe concentration was observed with depth. Except at St # 1, Fe concentration was low in surface water. Significantly high levels were observed at bottom of water column and it ranged from 0.35 to 0.39 mg/l.

Mn in surface water of profile-I ranged between 0.01 – 0.02 mg/l. Its concentration also showed increasing trend with depth. Maximum contents were observed at bottom of water column at station No. 2 (0.71 mg/l). Arsenic contents in lake surface water varied between 0.008 to 0.07 mg/l and its distribution with depth was quite irregular. Its concentration increased with depth at station # 2 and decreased with depth at station #3 while it was consistent in station # 4. Maximum concentration was recorded at surface water of station # 1 and middle of station # 3 (0.07 mg/l). Sr contents in water were fairly consistent in the range of 0.78 to 0.83 mg/l in surface water. No significant increasing or decreasing pattern was observed with depth. Zn concentration in surface water varied between 0.01 – 0.54 mg/l. No systematic distribution in water column was observed with depth. At station # 2, Zn concentration showed an increasing pattern with depth whereas at station 3 and 4 no regular pattern was observed. Maximum level of Zn was recorded at bottom sample of station # 2 (0.61 mg/l).

3.2.2 Profile - II middle of lake (opposite Naval boat area towards Banni Galla)

Profile –II represents middle part of lake. In this profile, Al content in surface water ranged from 0.04 to 0.2 mg/l (Figure 3). No systematic distribution of Al was observed with depth column; however, in general its concentration was higher in bottom of water column. Maximum concentration was recorded in middle column of station # 8 (1.15 mg/l) which is end of lake towards Banni Galla.

Fe concentration in surface water of Profile-II varied from 0.02 to 0.13 mg/l and it increased with the depth with the exception at station # 6. Maximum Fe concentration (0.74 mg/l) was observed in bottom of water column at station # 7. Mn concentration was consistent to 0.01 mg/l in surface water and its levels increased with depth with the exception at station # 8 where maximum concentration (0.65 mg/l) was recorded in middle of the water column. Arsenic was in the range of 0.047 to 0.064 mg/l in surface water samples and was above recommended values as established by WHO [10]. No regular distribution pattern was observed in water column. Sr contents in surface water varied in the range of 0.77 - 0.84 mg/l and close to concentration found in profile-I. No systematic pattern was observed with the depth of water column. Zn contents in surface water samples were in the range of 0.01 to 0.12 mg/l and it did not follow a regular distribution pattern with depth. Maximum Zn concentration was observed at in middle column of station # 8 (0.14 mg/l).

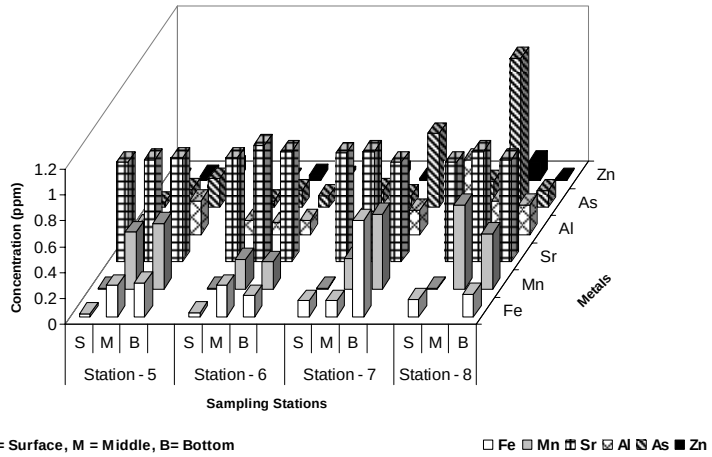

Figure 4. Depth wise metal contents in Profile-3.

3.2.3 Profile - III from entrance of stream from Barri Imam to Kurang River

Four stations were monitored in profile –III starting from entrance of stream from Bari Imam and consisted of station 9-12. Al concentration in surface water was found to be in the range of 0.07 to 0.58 mg/l. Maximum Al concentration (0.58 mg/l) in surface water of profile –III was recorded at station # 12 near entrance of Kurang River into Rawal Lake. At station # 9 Al content increased with depth, while at station # 12 decreasing trend was observed (Figure 4). In general Al contents were above permissible limit of WHO [10]. Fe content in surface water was found to be in range of 0.09 to 0.56 mg/l. Generally, Fe content was high in bottom water samples and high level was recorded at bottom water samples at station # 11 (0.77 mg/l) which is attributed to the boating activity in this region and waste of picnic point. Surface water of station # 12 also bears quite high Fe content (0.56 mg/l). Mn content was found to be in the range of 0.01 to 0.05 mg/l in surface water along profile –III and its concentration increased along depth. Maximum concentration was recorded in bottom column of station # 9. Mn content was considerably below than WHO guideline for drinking water [10].

Arsenic ranged from 0.007 to 0.041 mg/l in surface lake water. No regular distribution pattern was observed with depth. High Arsenic contents were recorded in surface and middle water samples at station # 9 (0.041 mg/l and 0.035 mg/l respectively) and was above permissible limits as set by WHO [10]. Sr content was quite consistent in the range of 0.78-0.9mg/l in surface water. No systematic distribution pattern along depth was observed. Maximum level was observed at bottom column of sampling station # 11 near picnic point (1.38 mg/l). Zn concentration was in the range of 0.01 to 0.02 mg/l in surface water. High Zn contents at bottom samples of station # 11 (0.39 mg/l, picnic point) may be due to recreation and boating activities in the area. No systematic pattern was observed with depth.

3.2.4 Average metal contents in surface water

Table 5 shows average concentration of metals in surface water of Rawal Lake. The highest concentration of metals in surface water of Rawal Lake was in order of Sr followed by Al, Fe, Zn, As and Mn.

Metal concentrations at different stations varied widely. This means that metals are carried into the lake from different sources. Al concentration in surface water of station -1, station -8 and station12 was quite high and above WHO permissible limits. Fe concentration at all stations was found within permissible limits. Mn levels at all stations were within WHO permissible limits. Arsenic contents of surface water were above WHO permissible limits with the exception at station-2 and 12. No guideline is defined for Sr by WHO. Zn concentration was higher than permissible levels at station-1, station-3, station-4 and station-8. However average levels of all metal were within WHO guidelines except for arsenic. Higher concentration of metal ion in Rawal

Table 5. Average metals content in surface water of Rawal Lake (n=12).

Sampling Sites	Metals Concentration (mg/l)					
	Al	Fe	Mn	As	Sr	Zn
Station-1	0.36	0.39	0.02	0.07	0.83	0.54
Station-2	0.06	0.07	0.01	0. 008	0.82	0.01
Station-3	0.05	0.03	0.01	0.063	0.81	0.21
Station-4	0.06	0.03	0.01	0.064	0.78	0.12
Station-5	0.04	0.02	0.01	0.047	0.77	0.001
Station-6	0.05	0.03	0.01	0.049	0.8	0.01
Station-7	0.14	0.12	0.01	0.055	0.84	0.06
Station-8	0.2	0.13	0.01	0.0647	0.77	0.126
Station-9	0.07	0.09	0.02	0.0414	0.78	0.01
Station-10	0.11	0.25	0.01	0.028	0.78	ND
Station-11	0.12	0.12	0.02	0.018	0.84	0.02
Station-12	0.58	0.56	0.05	0.007	0.9	ND
Average	0.15	0.15	0.02	0.04	0.81	0.11
SD	0.162	0.167	0.012	0.023	0.039	0.177
WHO/ EU limits	*0.2*	*1.0*	*0.4*	*0.01*	-	*0.1*

Table 6. Metal concentration in Rawal Lake fish.

Fish Type	Metal Contents (μg/g)					
	Al	Fe	Mn	As	Sr	Zn
Labeo rohita	1.53	0.61	0.04	0.00840	1.44	0.79
Tor Species	1.56	0.65	0.04	0.00814	1.46	0.76

RSD < 2 %

Lake water appears to be due to weathering effects because feeding stream and Kurang River have levels of metals either similar or even less than lake water. Gulzar also observed weathering effect as main cause of metal concentration [11]. Results of present investigation are in line with the findings of earlier research conducted [12, 13].

3.3 Metals in Rawal Lake fish

Table 6 represents concentration of metals in flesh of two fish species harvested from Rawal Lake namely Labeo rohita and Tor species. Concentration of total Al, Fe, Mn, As, Sr and Zn in both types of fish was almost identical. The accumulation orders of metals in flesh of both species was Al> Sr> Zn> Fe> Mn> As. The results of Zn concentration in fish samples of present study is almost same as quoted by some previous researchers [11, 14], whereas concentrations of As, Mn and Fe are lower than these findings. In general, metal ions in the fish is higher than concentration in water which is due to biomagnifications, however, arsenic levels in fish muscle is less than average arsenic content of lake water which indicate that fish muscle do not accumulate arsenic.

The higher concentration of these metals in fish may result in toxic effects in human. It appears that aquatic life in Rawal Lake is surviving under stress.

4 Conclusions

The present investigation indicates that the values of physiochemical parameters of water quality namely: pH, electrical conductivity, temperature and TDS are well within the

Guidelines/Recommended Limits as stated by the WHO. The present study does not indicate any serious concerns with respect to metal pollution in the investigated drinking water supply reservoirs. Only arsenic concentrations are higher than the permissible levels for drinking water. Depth profile of metal in water column indicated that higher contents of metal are present in bottom column which indicate that metal contents in water column mainly originate from weathering of sediments.

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