

WATER QUALITY MONITORING REPORT OF RAWAL LAKE

***Submitted to
Supreme Court of Pakistan***



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Pak-EPA, PCRWR, PCSIR, Punjab-EPA, WASA and ICT Administration

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WATER QUALITY MONITORING OF RAWAL LAKE

1. INTRODUCTION

Rawal Lake is the most important source of drinking water supply for Rawalpindi city and cantonment. Rawal dam was constructed on Kurang River and has a catchment area of 106 sq miles. There are four major streams and 43 small streams contributing to its storage. Korrang River, which originates in the Murree Hills area, is the major feeding channel of Rawal Lake. Water, during its passage through this river, streams, and surface carries various dissolved and suspended impurities into the Rawal Lake. Apart from these factors, increasing population, industrial growth and agricultural practices are the other major causes that result in the deterioration of the water quality of this lake.

2. PURPOSE

In pursuance of Rawal Lake fish kill incident which took place in July, 2017 and on the recommendation of National Assembly Standing Committee on Climate Change, the Director General Pak-EPA called upon a meeting on 9th January, 2018, of all concerned stakeholders and notified “Rawal Lake Monitoring Committee” which is comprised of members from ICT Administration, Punjab-EPA, Pak-EPA, PCSIR, PCRWR, Small Dam Organization Punjab and WASA Rawalpindi.

The purpose of the committee formulation was to conduct the water quality monitoring and analysis of the Lake and preparation of joint report. For this purpose the member collected water samples simultaneously and analyzed independently in their respective labs.

3. METHODOLOGY

A total of 10 water samples were collected by Rawal Lake Monitoring Committee members with the support of their laboratory teams on 24th December, 2017. Water samples were being collected from eight (08) different locations which were mutually selected by the committee. Four peripheral locations were selected to assess the potential contamination entry points, two locations were in the middle of the Lake, where four samples have been taken at two different depths. One sample was taken near the spillway and one sample after treatment.

Table-1: Sampling Details**Sampling Date: 24-01-2018**

Sr. No.	Sampling Time	Temp.	Sample Code	Sample Location	GPS Readings	
					Latitude	Longitude
1.	12:30 pm	13.5	RL-1	Inlet coming from Banigala side	33° 42.544' N	073°08.440'E
2.	12:45 pm	14.3	RL-2	Inlet from 3 rd Avenue	33° 42.752' N	73° 07.733' E
3.	2:00 pm	13.8	RL-3	Inlet from Diplomatic Enclave	33° 42.665 'N	073°07.356'E
4.	3:10 pm	13.9	RL-4	Inlet from Twin Towers	33° 42.842'N	073°06.996'E
5.	2:10 pm	14.1	RL-5A	Middle of the Lake (from Surface)	33° 42.291' N	073°07.213'E
6.	2:15 pm	12.8	RL-5B	Middle of Lake (6ft below from Surface)	33° 42.291' N	073°07.213'E
7.	2:30 pm	12.5	RL-6A	Middle of Lake (from Surface)	33° 42.077' N	073°07.259'E
8.	2:45 pm	11.7	RL-6B	Middle of Lake (6ft below from Surface)	33° 42.077' N	073°07.259'E
9.	3:30 pm	13.3	RL-7	Near Spill Way	33°41.077' N	073°07.408'E
10.	4:17 pm		RL-8	After Treatment from WASA Filtration Plant		

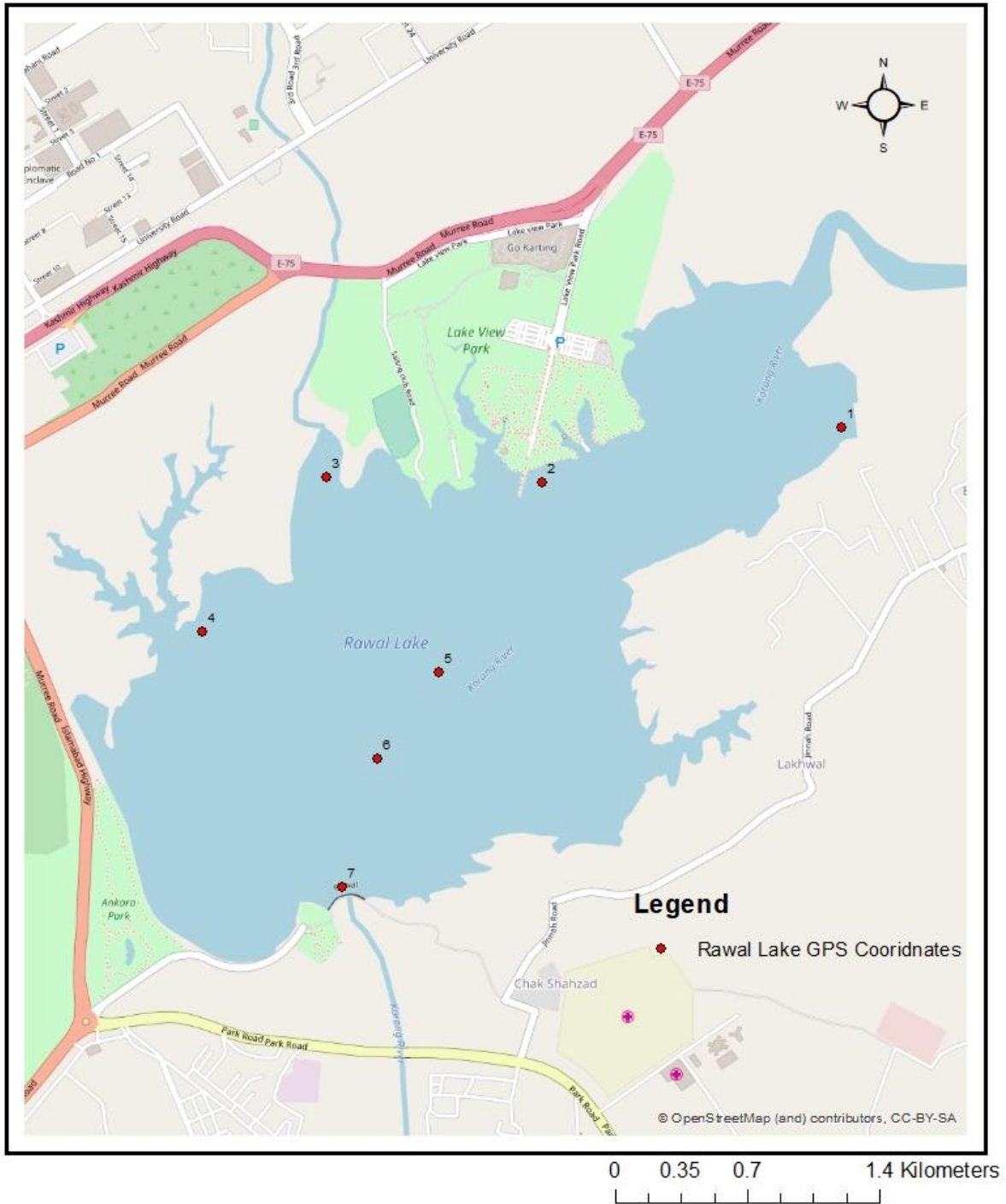
Five sets of water samples were collected and given the same sample identification codes. Samples were taken at the same locations and same time by each laboratory technical team and were analyzed according to American Public Health Association, (APHA) Standard Methods for the Examination of Water and Waste Water, 22nd Edition, 2012.

- i. The fisheries department of ICT Administration collected the fish samples and dispatched these to the Punjab forensic laboratories for the analysis of per-methrine and other toxic chemicals.
- ii. The PCSIR Laboratory analyzed the pesticides including per-methrine in addition to other routine analysis, waste water, heavy metals and microbiological parameters
- iii. The PCRWR National Water Quality Laboratory analyzed the Total Nitrogen and Total Phosphorous in addition to other waste water, heavy metals and microbiological parameters.

- iv. EPA-Rawalpindi conducted metal analysis on ICP in addition to other routine analysis and waste water parameters.
- v. WASA Rawalpindi laboratory conducted routine analysis available in laboratory.
- vi. The Punjab Small Dam Organization officials provided necessary logistic arrangements for sample collection on 24th January, 2018.



RAWAL LAKE MONITORING POINTS



4. RESULTS OF WATER SAMPLES ANALYZED BY DIFFERENT LABORATORIES

The nominated departments collected water samples simultaneously and analyzed independently in their respective laboratories and submitted the results for combine report. Following are the analytical results.

Table-2: Results prepared by PCRWR

Sr #	Parameters	Unit	NSDWQ/NEQS /USEPA	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
PHYSICO-CHEMICAL ANALYSIS													
1	pH value		6.5-8.5	7.31	7.40	7.56	7.44	7.93	7.87	7.80	7.94	7.69	7.69
2	Electric conductivity	µS/cm	NGVS	826.00	660.00	637.00	667.00	477.00	478.00	480.00	481.00	480.00	479.00
3	Turbidity	NTU	50 (surface water)	37.50	22.45	38.90	55.23	12.00	20.23	25.53	30.49	35.50	BDL
4	Total Dissolved Solids	mg/L	1000	454.00	363.00	350.00	367.00	262.00	263.00	263.00	263.00	263.00	454.00
5	Chloride as Cl ⁻	mg/L	250	38.70	20.00	20.00	36.00	20.00	20.00	20.00	20.00	20.00	20.00
6	Sulphate as SO ₄	mg/L	250	52.00	30.00	36.00	16.00	34.00	40.00	41.00	40.00	39.00	36.00
7	Calcium as Ca ²⁺	mg/L	NGVS	60.00	80.00	80.00	75.00	48.00	48.00	48.00	48.00	48.00	48.00
8	Magnesium as Mg ²⁺	mg/L	NGVS	44.00	19.00	15.00	15.00	19.00	19.00	22.00	22.00	19.00	19.00
9	Nitrite as N	mg/L	3	2.30	2.40	5.10	BDL	2.20	2.10	BDL	BDL	2.10	2.30
10	Bicarbonates	mg/L	NGVS	320.00	260.00	260.00	260.00	180.00	180.00	180.00	180.00	180.00	180.00
11	Total Hardness as CaCO ₃	mg/L	500	336.00	280.00	260.00	256.00	200.00	200.00	210.00	210.00	200.00	200.00
12	Potassium as K ⁺	mg/L	NGVS	7.40	2.10	4.20	8.00	4.90	4.60	4.40	4.60	4.70	4.70
13	Sodium as Na ⁺	mg/L	NGVS	42.00	19.00	23.00	25.00	21.00	20.00	19.00	20.00	19.00	21.00
14	Phosphate		NGVS	1.00	BDL	0.07	3.70	BDL	BDL	BDL	BDL	BDL	BDL
15	Fluoride as F ⁻	mg/L	1.5	0.29	0.21	0.18	0.21	0.12	0.30	0.20	0.29	0.24	0.28
16	Total Nitrogen		NGVS	0.84	0.56	1.12	16.80	0.84	0.56	0.84	0.56	1.12	1.68
17	Total Phosphorous		NGVS	0.33	BDL	0.02	1.21	BDL	BDL	BDL	BDL	BDL	BDL

Sr #	Parameters	Unit	NSDWQ/NEQS /USEPA	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
TRACE ELEMENTS													
18	Copper as Cu ²⁺	mg/L	2	0.01	0.05	0.04	0.06	0.02	0.04	0.03	0.03	0.05	0.03
19	Zinc as Zn ²⁺	mg/L	5	0.03	0.02	0.02	0.03	BDL	0.08	0.04	0.07	0.03	BDL
20	Arsenic	µg/L	50	1.48	1.07	0.84	2.15	0.87	0.85	0.69	0.86	0.74	1.80
21	Manganese as Mn ²⁺	mg/L	0.5	0.35	0.16	0.04	0.24	0.02	0.03	0.05	0.05	0.05	0.04
MICROBIOLOGICAL EXAMINATION													
22	Total Coliforms	CFU/100ml	NGVS	52.00	68.00	72.00	96.00	32.00	46.00	22.00	34.00	16.00	.-ve
23	Fecal Coliforms	CFU/100ml	31/100 ml (surface water)	14.00	12.00	16.00	48.00	2.00	0.00	2.00	6.00	.-ve	.-ve
24	E.Coli	CFU//100ml	31/100 ml (Surface water)	-ve	-ve	14.00	38.00	-ve	-ve	-ve	2.00	-ve	-ve
WASTE WATER PARAMETERS													
25	Chemical Oxygen Demand (COD)	mg/L	150 (effluent)	28.00	14	12	355.00	BDL	8.00	BDL	16.00	BDL	BDL
26	Biochemical Oxygen Demand (BOD ₅)	mg/L	80 (effluent)	10.00	BDL	BDL	87.00	BDL	5.00	BDL	10.00	BDL	BDL
27	Total Suspended Solids	mg/L	200 (effluent)	85.00	42.00	82.00	232.00	20.00	40.00	30.00	50.00	55.00	BDL
28	Dissolved Oxygen	mg/L	5 (surface water)	4.70	7.60	6.50	1.00	9.24	6.85	8.51	6.72	8.12	

Where NGVS= No Guideline Value Set;

BDL = Below Detection Limit

CFU; Colony Forming Unit

Highlighted: Unsafe parameters

Table-3: Results prepared by PCSIR

Sr #	Parameters	Unit	WHO Guidelines	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
PHYSICO-CHEMICAL ANALYSIS													
1	pH value		6.5-8.5	7.24	7.08	7.38	6.74	7.47	7.27	7.26	7.17	7.28	7.27
2	Electric conductivity	μS/cm	NGVS	665	548	422	689	388	385	390	384	392	388
3	Salinity	ppt	NGVS	416000	343000	264000	431000	243000	241000	244000	240000	245000	243000
4	Turbidity	NTU	5	1.21	6.6	2.23	33.31	0.84	4.37	ND	4.2	ND	1.46
5	Total Dissolved Solids	mg/L	1000	416	343	264	431	243	241	244	240	245	243
6	Chloride as Cl ⁻	mg/L	250	49.91	23.39	23.39	29.63	21.83	20.27	15.59	23.39	20.27	28.07
7	Sulphate as SO ₄	mg/L	250	5.03	19.1	22.1	26.7	19.9	22.8	23	36.2	21.1	36
8	Calcium as Ca ²⁺	mg/L	NGVS	50	60	40	40	40	40	40	40	40	40
9	Magnesium as Mg ²⁺	mg/L	NGVS	69.6	83.28	70.8	49.68	48	32.64	45.84	39.84	32.4	44.64
10	Nitrite as NO ⁻	mg/L	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Iron as Fe ²⁺	mg/L	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12	Alkalinity as CaCO ₃	meq/L	NGV	7.1	7.3	4.3	7.3	4.4	4.4	4.4	3.9	3.8	5
13	Carbonates	mg/L	NGV	355	365	215	365	220	220	220	195	190	250
14	Bicarbonates	mg/L	NGV	433.1	445.3	262.3	445.3	268.4	268.4	268.4	237.9	231.8	305
15	Temperature	°C	---	24	24	24	24	24	24	24	24	24	24
16	Total Hardness as CaCO ₃	mg/L	500	415	497	395	307	300	236	291	266	235	286
17	Ca Hardness as CaCO ₃	mg/L	NGVS	125	150	100	100	100	100	100	100	100	100
18	Mg Hardness as CaCO ₃	mg/L	NGVS	290	347	295	207	200	136	191	166	135	186
19	Potassium as K ⁺	mg/L	NGVS	8	2	5	14	5	5	5	5	5	5
20	Sodium as Na ⁺	mg/L	200	70	40	40	80	40	40	40	40	40	40
21	Nitrate as NO ₃ ⁻	mg/L	50	1.26	1.28	1.26	1.02	1.16	1.14	1.14	1.12	1.14	1.14
22	Fluoride as F ⁻	mg/L	1.5	0.29	0.28	0.27	0.32	0.29	0.29	0.28	0.28	0.28	0.28

Sr #	Parameters	Unit	WHO Guidelines	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
TRACE ELEMENTS													
23	Copper as Cu ²⁺	mg/L	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24	Zinc as Zn ²⁺	mg/L	3	0.33	0.167	0.295	0.724	0.331	0.237	0.533	0.38	0.52	0.317
25	Mercury as Hg ²⁺	mg/L	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26	Lead as Pb ²⁺	mg/L	0.01	0.001	0.001	0.001	0.01	ND	ND	ND	ND	0.002	ND
27	Cadmium as Cd ²⁺	mg/L	0.003	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28	Arsenic	µg/L	10	ND	ND	ND	15	ND	ND	ND	ND	ND	ND
29	Nickel as Ni ²⁺	mg/L	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30	Chromium as Cr ⁶⁺	mg/L	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31	Cobalt as Co ²⁺	mg/L	NGVS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
32	Manganese as Mn ²⁺	mg/L	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
33	Cyanide as CN ⁻	mg/L	0.07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MICROBIOLOGICAL EXAMINATION													
34	Total Coliforms	MPN/100ml	0/100 ml	>1600	>1600	>1600	>1600	>1600	>1600	920	>1600	920	ND
35	Fecal Coliforms	MPN/100ml	0/100 ml	94	240	540	>1600	240	79	130	110	94	ND
36	<i>E.coli</i>	MPN/100ml	0/100 ml	20	79	40	>1600	13	4.5	7.8	13	ND	ND
37	<i>Pseudomonas aeruginosa</i>	MPN/100ml	NGVS	ND	4.5	ND	ND	ND	ND	ND	2	ND	ND
WASTE WATER ANALYSIS													
38	Chemical Oxygen Demand (COD)	mg/L	NGVS	48.53	ND	ND	673.19	ND	ND	ND	ND	ND	ND
39	Biochemical Oxygen Demand (BOD ₅)	mg/L	NGVS	0.45	1.02	1.68	ND	1.11	1.64	1.76	1.15	1.19	ND

Sr #	Parameters	Unit	WHO Guidelines	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
40	Total Suspended Solids	mg/L	NGVS	15.7	14.1	25.5	89.62	18.5	40.61	10.1	20.19	12.17	ND
41	Dissolved Oxygen	mg/L	NGVS	4.57	4.95	5.65	ND	4.82	5.16	5.05	5.36	5.25	4.86
PESTICIDES/ORGANIC ANALYSIS													
42	Permethrin	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
43	Heptachlor	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
44	Aldrin	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
45	Dieldrin	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
46	Bifenthrin	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
47	Phenols	mg/L	≥0.002	0.001	0.001	0.001	4.35	ND	ND	ND	ND	0.001	ND
48	Grease and Oil	mg/	NGVS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
49	Ammonia	mg/L	0.5	ND	ND	ND	2.61	ND	ND	ND	ND	ND	ND

Where NGVS = No Guideline Value Set

ND = Not Detected

Highlighted: Unsafe parameters

Table-4: Results prepared by WASA

Sr #	Parameters	Unit	WHO Guidelines	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
PHYSICO-CHEMICAL ANALYSIS													
1	pH value		6.5-8.5	7.94	7.79	8.28	7.79	8.32	8.28	8.27	8.3	8.17	7.14
2	Electric conductivity	µS/cm	NGVS	410	382	392	622	400	428	390	392	480	428
3	Turbidity	NTU	5	4.1	3.14	3.42	40	3.8	3.92	3.2	3.85	3.97	2.33
4	Total Dissolved Solids	mg/L	1000	205	191	196	311	200	214	195	196	240	214
9	Nitrite as NO ₂	mg/L	1	4	8	6	2	8	6	2	4	8	1.2
16	Iron as Fe	mg/L	0.3	0.48	0.38	0.12	0.49	0.36	0.4	0.44	0.38	0.32	0.22
17	Chlorine	mg/L	0.5-1.5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	1.2
TRACE ELEMENTS													
20	Arsenic	µg/L	10	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
MICROBIOLOGICAL EXAMINATION													
22	Total Coliforms	CFU/100ml	0/100 ml	-	-	-	-	-	-	-	-	-	-
23	Fecal Coliforms	CFU/100ml	0/100 ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	Nil
WASTE WATER ANALYSIS													
28	Dissolved Oxygen	mg/L	NGVS	4.82	11.3	10.15	1.29	9.12	7.85	8.98	6.7	8.87	3.2

TNTC: Too Numerous to Count

Highlighted: Unsafe parameters

Table-5: Results prepared by Punjab-EPA

Sr #	Parameters	Unit	Guidelines	Location Points									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
PHYSICO-CHEMICAL ANALYSIS													
1	pH	-	6-9	7.94	7.79	8.28	7.79	8.32	8.28	8.27	8.3	8.17	8.07
2	Total Dissolved Solids	mg/L	1000	350	340	310	330	280	280	260	280	270	260
3	Chloride as Cl ⁻	mg/L	1000	38	15	17	30	15	16	17	18	18	19
4	Temperature	°C	---	13.5	14.3	13.8	13.9	14.1	12.8	12	--	13.3	--
TRACE ELEMENTS													
5	Arsenic (A ^T)	mg/L	0.1	0.018	0.018	0.014	0.02	0.018	0.017	0.019	0.016	0.019	0.02
6	Boron (B ^T)	mg/L	1	0.204	0.033	0.04	0.027	0.038	0.122	0.074	0.051	0.054	0.033
7	Aluminum (Al)	mg/L	5	0.451	0.171	0.155	0.218	0.163	0.187	0.178	0.228	0.17	0.178
8	Beryllium (Be)	mg/L	0.1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
9	Cadmium (Cd ^T)	mg/L	0.01	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
10	Chromium (Cr ^T)	mg/L	0.01	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
11	Cobalt	mg/L	0.05	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
12	Coper (Cu ^T)	mg/L	0.2	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
13	Iron (Fe)	mg/L	5	0.126	0.088	0.029	0.063	0.005	0.03	0.028	<0.003	0.005	0.004
14	Lead (Pb ^T)	mg/L	0.1	<0.006	<0.006	<0.006	<0.006	<0.006	0.014	0.009	<0.006	<0.006	<0.006
15	Lithium (Li)	mg/L	2.5	<0.004	<0.004	<0.004	<0.004	0.004	0.006	0.004	0.005	<0.004	<0.004
16	Manganese (Mn)	mg/L	0.2	0.324	0.117	0.026	0.142	0.012	0.022	0.023	0.016	0.012	0.006
17	Mercury (Hg ^T)	mg/L	0.01	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.002
18	Nickel (Ni ^T)	mg/L	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
19	Selenium (Se ^T)	mg/L	0.02	0.013	0.015	0.014	0.017	0.009	0.009	0.014	0.0126	0.015	0.016
20	Venedium (V)	mg/L	0.1	0.005	<0.003	<0.003	<0.003	<0.003	0.004	0.005	0.004	0.004	0.004
21	Zinc (Zn)	mg/L	2	0.227	0.028	0.017	0.021	0.012	0.145	0.127	0.023	0.017	0.017
WASTE WATER PARAMETERS													
22	Chemical Oxygen Demand (COD)	mg/L	150	52	24	28	140	48	40	44	40	36	4

Sr #	Parameters	Unit	Guidelines	Location Points									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
23	Biochemical Oxygen Demand (BOD ₅)	mg/L	80	18	9	12	48	18	15	16.5	15	12	1.5
24	Total Suspended Solids	mg/L	Nil	6	4	3	40	3	4	4	3	3	1

PEQS = Punjab Environment Quality Standards.

Remarks: All parameters are within PEQS limits

Table-2: Results prepared by Pak-EPA

Sr #	Parameters	Unit	NSDWQ/NEQS /USEPA	Samples ID									
				1	2	3	4	5	6	7	8	9	10
				RL-1	RL- 2	RL- 3	RL- 4	RL- 5A	RL- 5B	RL- 6A	RL- 6B	RL- 7	RL- 8
PHYSICO-CHEMICAL ANALYSIS													
1	pH value		6.5-8.5	7.94	7.79	8.28	7.79	8.32	8.28	8.27	8.30	8.17	8.07
2	DO	mg/L	NGVS	3.41	3.92	1.29	0.93	6.45	5.80	6.81	6.90	5.91	6.91
3	COD	mg/l	150	96	141	321	386	126	88	86	91	93	22
4	Electric conductivity	µS/cm	NGVS	941	976	1091	1344	896	562	496	521	519	629
5	Turbidity	NTU	50 (surface water)	45.0	65.2	51.80	66.00	18.0	17.22	15.5	22.1	46.80	5.22
6	Total Dissolved Solids	mg/L	1000	522.00	681.00	796.00	1022.00	581.00	491.00	396.00	463.00	461.00	454.00
7	Chloride as Cl ⁻	mg/L	250	41	32.00	36.00	23.00	36.00	19.00	21.00	22.00	23.00	41.00
8	Sulphate as SO ₄	mg/L	250	36.00	43.00	51.00	68.00	31.00	48.00	43.00	49.00	40.00	46.00
9	Calcium as Ca ²⁺	mg/L	NGVS	86.00	61.00	63.00	75.00	38.00	33.00	32.00	58.00	41.00	36.00
10	Magnesium as Mg ²⁺	mg/L	NGVS	38.00	22.00	31.00	36.00	18.00	16.00	26.00	21.00	31.00	22.00
11	Nitrite as N	mg/L	3	4.21	5.80	8.10	6.20	3.20	1.12	BDL	1.02	2.02	3.20
12	Total Hardness as CaCO ₃	mg/L	500	521.00	441.00	356.00	512.00	291.00	286.00	319.00	218.00	258.00	312.00
13	Phosphate		NGVS	1.80	0.98	1.91	4.07	BDL	BDL	BDL	BDL	BDL	BDL
TRACE ELEMENTS													
14	Copper as Cu ²⁺	mg/L	2	0.02	BDL	0.01	0.02	0.03	0.02	0.01	0.01	0.02	0.04
15	Zinc as Zn ²⁺	mg/L	5	0.05	0.12	5.1	6.02	0.12	0.07	0.03	0.08	0.02	BDL
16	Manganese as Mn ²⁺	mg/L	0.5	0.45	0.56	0.59	0.64	0.02	0.01	BDL	0.01	0.02	0.03

5. DISCUSSION:

Results prepared by PCRWR showed that the quality of water coming from the stream near twin tower (RL-4) is worst of all samples. The water is not only turbid but also has higher values of Total Suspended Solid (TSS), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). Even the values of these parameters are higher than those of National Environmental Quality Standards for waste water. Due to high COD and BOD, the value of Dissolved Oxygen (DO) is also very low of 1.00 mg/l, which is dangerous of aquatic life. Other than chemical agent, biological agent viz. Fecal Coliforms and E.Coli were also found in this sample. Concentration of heavy metals also detected within almost all the samples, whereas the values are within safe limits.

PCSIR results also revealed that the sample number RL-4 has higher values as compared to rest of the sample, specially the values of Chemical Oxygen Demand (COD), Fecal Coliforms and E.Coli. Most of the heavy metals have not been detected except Zinc (Zn) which is also within safe range. WASA Rawalpindi gave the results which are within safe limits. Pesticides and organic compound analysis were also conducted, whereas except phenol no other compound has been detected, even per-methrine was not detected in any water sample.

Punjab-EPA Laboratory results showed that although heavy metals detected but are within safe limits. Out of seventeen (17) elements Cobalt and mercury have not been detected. Other parameters are also within safe limits.

Pak-EPA laboratory analyzed and shared the results which revealed that the sample number RL-3 and RL-4 are much contaminated. Their Total Dissolved Solid (TDS), conductivity, turbidity and hardness are much higher than safe guidelines. As far as heavy metals are concerned the concentration of Manganese (Mn) and Zinc (Zn) are higher than safe drinking water guidelines. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of these two samples is higher than National Environmental Quality Standards (NEQ) of wastewater. Due to high BOD and COD, the value of Dissolved Oxygen is much depleted to 1.00 mg/l.

6. CONCLUSION:

The analysis results revealed that most of the Physico Chemical parameters and trace metals are within the safe limit. However the samples collected from the entry points of different streams confirm the considerable amount of contamination entering into the Lake, having high values of Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) and low level of Dissolved Oxygen (DO). The sample # 4 collected near the entry point from **Twin tower/1-constitution** was found highly contaminated with extremely low value of DO of 1.29 mg/l. Such low level of DO is lethal for the sensitive aquatic life. At this point other parameters like COD, BOD and TSS were also found high. The permethrine and other pesticides were also analyzed but not detected in water samples.

The fish are very sensitive to low DO and high temperature because at high temperature the level of Dissolved Oxygen further decreased and can cause fish mortality.

The Dissolved oxygen level should not be below 5 mg/l. The sensitive species of fish like silver code could not survive below this concentration at high temperature. In July the level of dissolved oxygen was below 4 mg/l and temperature was also very high.

It is pertinent to mention that same kind of fish kill incident was happened in July, 2005 (Representative of Small Dam Organization). At that time may be large number of fish seed were added in the Lake by the fishing contractor and due to low DO and high temperature the fish were killed. After that the contract of fishing was abandoned whereas in 2017 again the contract of fishing was awarded and similar incident happened.

7. RECOMMENDATIONS/SUGGESTIONS:

Following are some of the major suggestion / recommendation to reduce the pollution load and improving the quality of water of Rawal Lake;

1. Regular water quality monitoring of Rawal Lake may be ensured.
2. Reservoir area should be clearly demarked and banks may be concreted to avoid any further encroachment.
3. Reservoir should be protected from public access by the construction of wall / fence.
4. Check dams may be constructed in the feeding streams to reduce the soil erosion.
5. Plantation may be introduced on the banks of feeding streams.
6. Dumping of solid and liquid waste into the feeding streams should be discouraged by trialng the culprits in criminal courts.
7. Rawal Lake enforcement force may be established.
8. Sewerage lines may be constructed in the catchment areas of Rawal Lake feeding streams especially in Noorpur Shahan, Banigala and Barakahu.
9. The minimum level of water in Lake should be maintained according to the number of fish in the Lake to fulfill the dissolved oxygen requirement of the aquatic life especially in high temperature season.
10. A proper aeration system should be installed to increase the availability of dissolved oxygen level in water especially in high temperature season.

