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ESTIMATION OF QUALITY CONTROL PARAMETERS AND TRACE METAL LEVELS IN VARIOUS PUBLIC UTILITY WATERS: PART II. – PUNJAB

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Using standard analytical methods, together with atomic absorption technique, various water quality control parameters and trace metal levels for public utility waters in a selected area of Punjab are estimated and reported. The study entails measurements of alkalinity, hardness, phosphate, nitrate/nitrite, dissolved oxygen and chemical oxygen demand contents in natural, non-treated waters drawn from springs, wells, and tank supplies. The trace metal levels in these waters are estimated for duplicate runs at a precision of ± 1.5% for sodium, potassium, copper, iron, zinc, strontium, nickel, cobalt, lead, cadmium, chromium, barium and mercury. The data are reported at ± 2S confidence level, and discussed in terms of acceptance/rejection of the waters as per maximum allowed tolerable levels for the estimated burden of various parameters.

Key words: Water Quality; Trace Metal Levels in Water; Water Quality Parameters.

INTRODUCTION

The importance of studying the adverse effects of water-borne chemicals upon human health as gained momentum during the past two decades. It has been established that many inorganic and organic constituents enter natural waters from natural or man-made sources. The significance of these constituents to the quality of waters in public use depends on many interdependent parameters.

Studies on sources and aqueous ionic species of toxic metals have shown that man is constantly exposed to potentially harmful chemicals present in waters [1]. Maximum acceptable exposure levels for the inorganic constituents and those for trace metals are well documented [2, 3]. There is today a dire need to establish enforceable standards for drinking waters in order to limit the concentration of chemicals/trace metals below levels that produce harmful effects. Sound data pertaining to quality control parameters and trace metal levels for public utility waters have been produced by various governmental bodies in advanced countries [4, 6].

Several liquid-liquid extraction procedures have been evolved in conjunction with the estimation of trace metals by atomic absorption method [7-9].

In line with the previous study on the public utility waters of NWFP, the present work entails a follow-up of the earlier work based on the objective cited above. Water samples were collected from selected areas of the Punjab falling within a radius of 80 km from Islamabad. This area has recently started undergoing fast urbanization and has no longer secured from impacts caused by industrialization. The choice of sampling sites was thus tentative. Springs, wells and tank supplies were selected for examination as they serve a large population in respective areas. Coupled with field estimations, laboratory analyses were conducted both in terms of estimations of quality control parameters and trace metal levels following the procedure laid down in Part 1.

Details on sampling and analytic methods involved have been described elsewhere [10].

RESULTS AND DISCUSSION

The sampling site distribution for the present study is shown in Fig. 1. The measured physico-chemical parameters appear in Table 1. Maximum temperature is encountered in the case of sample S-5 having origin in a deep well. The pH range of these waterfalls within the prescribed range of 6.5-9.5; thus all waters are basic in nature, with alkalinity values spreading between 179 and 472 mg/l as $CaCO_3$, a range within the stipulated limit of 500 mg/l set for domestic waters. Samples S-1, S-18, S-19, S-20, S-21, S-23 and S-24 have moderate hardness, whereas the rest of the waters are hard. Maximum hardness is found in case of sample S-25 that has a hardness of 168 mg/l $CaCO_3$ in excess of the maximum tolerable level set at 300 mg/l $CaCO_3$ for hard water. The same sample has maximum amount of total dissolved solids (TDS). Thus, this water as such is not acceptable for human ingestion.

Both nitrate and nitrite seem to pose no physiological problem in that their cumulative amount does not exceed

Table 1. Estimated physico-chemical parameters for various water samples.

Sample Code	Location/ Nature	Temperature C^{o} ± 0.1	pH ± 0.1	Conductance mho/cm x 10^{-4} ± 0.2	Alkalinity mg/1 ± 5.0	Hardness mg/1 ± 6.0	Phosphate mg/1 ± 0.08	Nitrite mg/1 ± 0.008	Nitrate mg/1 ± 0.1	TDS mg/1 ± 5.0	DO mg/1 ± 0.2	COD mg/1 ± 0.25
S- 1	Chakwal*/NT (TW)	18.2	7.6	4.5	205	182	1.47	0.02	14.1	250	2.8	18.0
S- 2	Jatli/NT (W)	16.1	7.7	4.9	356	282	4.00	0.06	9.8	262	1.4	18.0
S- 3	Mandra/NT (SW)	15.2	7.2	4.3	332	262	2.17	0.05	18.3	196	2.0	15.6
S- 4	Garda/NT (S)	14.3	7.9	6.9	472	385	1.29	0.60	10.5	230	2.0	16.2
S- 5	Baigwal/NT (DW)	19.2	7.6	6.3	385	292	3.33	0.06	6.9	448	1.3	26.5
S- 6	Moghal/NT (TW)	17.1	7.7	5.8	375	295	0.83	0.01	9.1	324	3.5	19.6
S- 7	Chattar/NT (TW)	15.1	7.5	6.7	436	345	2.35	0.20	10.5	285	3.1	20.1
S- 8	Lawrencepur/NT (TW)	14.2	7.9	5.4	380	313	1.00	0.01	8.4	305	2.4	14.5
S- 9	Kamra/T (TS)	18.2	7.3	4.4	190	210	0.92	0.08	4.9	245	4.2	12.8
S-10	Boota/NT (ST)	14.2	7.9	5.6	320	321	0.97	0.07	5.7	450	2.8	18.9
S-11	Jabbi Kasran/NT (W)	11.4	7.9	4.3	311	261	2.50	0.10	2.9	426	3.2	14.2
S-12	Bhagwan/NT (SW)	14.1	7.7	6.2	280	300	3.70	0.42	3.1	475	4.1	22.7
S-13	Fateh Jang/NT (TS)	15.0	7.7	7.5	179	281	3.00	0.01	7.2	335	2.7	16.2
S-14	Quatball/NT (W)	13.0	7.7	6.2	210	205	1.90	0.06	9.2	337	2.3	28.2
S-15	Choohar Harpall/T (TS)	10.0	8.0	4.6	272	271	2.30	0.03	17.5	185	3.4	12.9
S-16	Sadar(RWP/T (TS)	14.0	8.3	2.6	232	269	4.39	0.01	19.3	295	3.6	13.0
S-17	Rawat/NT (W)	12.0	7.8	7.7	377	315	2.12	0.03	7.3	276	5.1	13.6
S-18	Poly.T.C/T (TS)	16.0	8.3	3.4	237	136	1.92	0.03	13.1	320	2.8	16.4
S-19	Hasan Abdaal/NT (S)	17.0	7.7	3.3	225	135	4.27	0.01	11.3	340	4.0	7.2
S-20	Gujar Khan/NT (TW)	17.0	8.0	7.0	258	168	0.91	0.02	5.1	157	3.5	7.1
S-21	Deena/NT (HP)	17.0	7.5	4.8	257	136	0.35	0.02	1.9	125	4.2	12.1
S-22	Galli Jageer/NT (DW)	18.0	8.4	8.2	310	180	0.72	0.03	1.7	214	7.3	10.3
S-23	Dhulyan Moor/NT (SW)	17.0	7.8	6.6	326	108	0.89	0.01	4.2	168	4.3	8.7
S-24	Kot Feteh Khan/NT (DW)	16.0	8.2	5.5	203	124	1.94	0.03	1.3	218	6.0	8.1
S-25	Ghor Ghashi/NT (SW)	17.0	7.8	9.6	191	468	1.39	0.04	4.3	723	2.9	4.3

*NT = Non-treated; T = Treated; W = Well water; SW = Shallow well; DW = Deep well; TS = Tanks supply; ST = Stream water; HP = Hand pump; S = Spring water; RWP = Rawalpindi; Poly. T.C. = Polytechnical College.

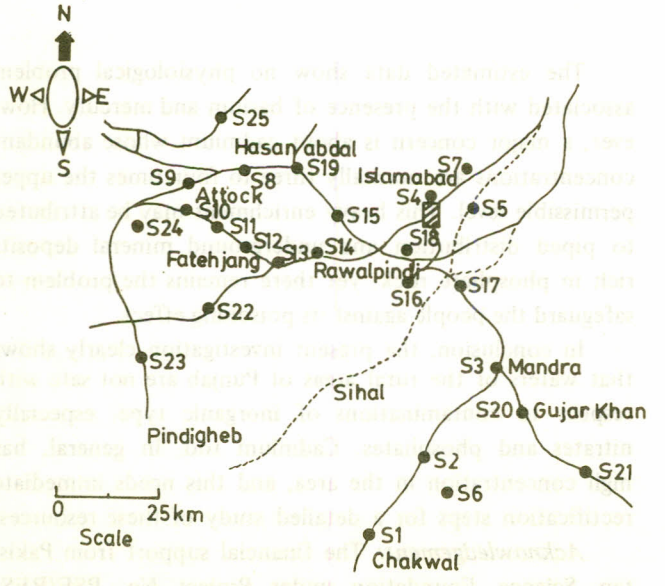

Fig. 1. Sampling site distribution for the area under investigation.

20 mg/1 even in the extreme case of sample S-16. However, in view of Canadian standards for drinking waters, the nitrate/nitrite additive amount should not exceed 10 mg/1. For the latter case, then, samples S-1, S-3, S-4, S-7, S-16, S-17, S-18 and S-19 have nitrate/nitrite concentration that exceeds this standard tolerable level. These high values suggest a probable organic waste decomposition, sewage contamination, and/or surface runoff in the form of nitrogen fertilizers.

The data suggest that with the exception of 8 samples the rest of the samples have strong phosphate enrichment emanating through underground phosphate minerals and/or a probable absorption through surface runoff. It has been well established that rock phosphates and fertilizers often contain high levels of trace elements, especially cadmium [11]. The present finding supports this view. Measured values for both dissolved oxygen and chemical oxygen demand reveal that no significant organic contamination problem is associated with these waters.

Table 2. Estimated concentrations of trace metals.

Trace Metal/ Sample Code	K mg/l ± 0.150	Na mg/l ± 0.100	Zn mg/l x 10^{-1} ± 0.020	Co mg/l x 10^{-1} ± 0.005	Sr mg/l x 10^{-1} ± 0.035	Ni mg/l x 10^{-1} ± 0.005	Cu mg/l x 10^{-1} ± 0.001	Fe mg/l x 10^{-1} ± 0.001	Cd mg/l x 10^{-1} ± 0.002	Cr mg/l x 10^{-2} ± 0.003	Pb mg/l x 10^{-2} ± 0.005	Hg mg/l x 10^{-4} ± 0.00002	Ba µg/l ± 0.50
S- 1	5.50	11.11	2.00	0.94	3.40	1.31	0.18	1.25	0.14	2.85	*	2.04	19.3
S- 2	6.28	11.20	5.10	0.94	1.36	1.31	0.18	2.51	0.14	3.50	2.16	2.24	16.5
S- 3	1.77	10.90	4.16	0.94	1.13	1.31	0.28	1.25	0.11	4.25	1.62	2.24	21.3
S- 4	2.00	9.83	0.89	0.92	4.28	0.36	0.28	1.24	0.15	2.85	2.16	2.96	20.1
S- 5	1.63	10.24	0.89	0.92	1.42	0.35	0.27	2.08	0.10	3.50	1.08	2.70	19.6
S- 6	1.99	8.81	17.17	0.87	1.30	0.45	1.60	1.13	0.14	3.90	7.16	2.24	30.0
S- 7	2.24	7.97	0.89	0.87	1.01	0.45	1.60	2.27	0.14	3.10	1.08	1.43	20.1
S- 8	3.65	8.17	3.31	0.78	0.67	0.42	0.24	0.35	0.48	1.95	10.93	4.10	30.2
S- 9	2.02	9.47	1.36	0.55	1.35	0.50	0.19	0.35	0.39	1.95	*	4.92	30.2
S-10	1.50	8.72	5.28	0.37	1.60	0.51	1.22	0.39	0.39	1.95	3.13	6.56	29.8
S-11	2.10	10.11	0.96	0.43	1.05	0.51	0.17	0.36	0.49	4.69	3.91	*	16.7
S-12	1.50	8.72	1.17	0.04	1.40	0.61	0.29	0.36	0.49	1.90	1.56	8.21	18.6
S-13	1.56	8.72	1.20	0.18	1.41	0.30	0.39	0.39	0.58	5.90	3.13	8.21	38.4
S-14	1.87	8.94	0.78	0.19	0.77	0.31	0.44	0.39	0.49	1.95	7.81	8.21	30.0
S-15	1.56	10.81	36.00	0.46	0.53	0.78	0.83	0.51	0.58	3.90	3.20	4.68	29.7
S-16	1.66	10.62	3.60	0.52	1.06	0.97	1.02	0.58	0.39	4.29	3.20	7.80	18.9
S-17	5.72	9.38	13.00	1.65	22.50	1.95	2.80	1.25	1.48	1.95	1.56	7.21	21.7
S-18	1.57	6.29	9.66	0.94	0.62	1.73	0.50	0.54	0.50	2.10	0.78	3.59	35.9
S-19	2.10	0.20	0.90	1.23	3.11	2.07	0.05	0.20	0.56	1.70	1.56	2.50	23.4
S-20	3.60	10.63	3.27	1.32	0.52	2.77	0.46	0.23	0.34	2.68	3.90	6.55	28.8
S-21	2.72	10.63	17.38	1.32	0.46	2.46	1.85	0.22	0.32	3.92	4.14	6.37	34.5
S-22	2.75	12.06	5.47	1.10	0.71	2.69	0.86	0.21	0.31	2.62	4.38	5.20	30.8
S-23	3.75	12.05	0.60	1.10	0.69	2.38	0.51	0.23	0.30	3.26	5.32	5.20	28.8
S-24	4.44	12.19	2.97	0.97	0.50	2.15	0.43	0.22	0.36	5.20	5.05	5.41	32.5
S-25	1.81	13.13	1.56	1.42	1.75	2.53	0.59	0.39	0.34	5.55	6.28	6.37	32.8

* = Below dectection limit.

Trace metal data appear in Table 2. An examination of the listed values shows that sodium and potassium both have concentration values falling within the safe permissible range. This again is true for zinc for which the higest level determined is 1.7 mg/l. In drinking waters, the nickel and cobalt levels is set at 0.5 mg/l, in view of which all water samples are neat with respect to the two trace metals. Likewise, these waters are safe with respect to their iron content. In the case of strontium, sample S-17 exceeds the upper allowed limit, and hence this Rawat source is a potential health hazard. The same water has the maximum cadmium content, thus indicating some underground mineral resource responsible for this heavy enrichment. This water is thus totally unfit for human use. Sample S-8 has the maximum lead content at 0.1 mg/l and as such may pose a direct health problem if used regularly by the consumers of the area.

The estimated data show no physiological problem associated with the presence of barium and mercury. However, a major concern is about cadmium whose abundant concentrations are normally three to four times the upper permissible level. This heavy enrichment may be attributed to piped distribution and underground mineral deposits rich in phosphate rock, yet there remains the problem to safeguard the people against its poisoning effect.

In conclusion, the present investigation clearly shows that waters of the rural areas of Punjab are not safe with respect to contaminations of inorganic type, especially nitrates and phosphates. Cadmium too, in general, has high concentration in the area, and this needs immediate rectification steps for a detailed study of these resources.

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