

Determination of Major, Minor and Trace Metals in Drinking Water Samples of Lahore and Kasur

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(Received 15th October, 1996, revised 17th December, 1996)

Summary: Drinking water samples of Lahore and Kasur regions were collected from 15 different sampling areas. Physico chemical parameters such as pH, conductivity, hardness and alkalinity were measured immediately. The major and minor metal constituents were determined using Atomic Absorption Spectrophotometer. Sodium concentration was found relatively high in Lahore and more so in Kasur water samples. The results have been discussed with reference to the local soil conditions and industrial waste pollutants finding their way to the underground water streams.

Introduction

Environmental pollution especially in industrial cities is generally expected to deteriorate the quality of drinking water. One of the important parameters of the quality of water is represented by the concentration of major, minor and trace elements. Lahore and Kasur regions, due to lot of industrial activity around, may be expected to present a considerably elevated level of some of these elements as a result of excessive industrial discharges which might find their way to the drinking water streams. Contrary to such theory one may opine that the drinking water stream may still be out of the reach of the expected pollutants and a systematic study to determine concentration of different elements in Lahore and Kasur water samples may be a timely requirement. Many metals present in drinking water at major, minor and trace levels are reported to be essential for human health [1]. However, their ingestion in excessive amounts may cause severe health problems [1-5].

In this study major elements like Ca, Mg Na and K, minor elements Fe and Zn and trace elements Pb, Cr and Cd were determined in different drinking water samples by atomic absorption spectrophotometry. Further, physico-chemical parameters such as, pH, alkalinity, hardness and conductivity were also recorded. The results are presented and discussed with reference to a remote possibility of industrial discharge related pollutants finding their way to the underground water streams.

Results and Discussion

Physico-chemical parameters

Results on physico-chemical parameters of water samples of Lahore and Kasur are described in Table-1. Acceptable alkalinity for public utility water is generally between 30 to 500 mg CaCO₃ equivalent lit⁻¹ [6]. Apart from Kasur water

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Table-1: Physio-chemical parameters of water samples.

Sample Area	Average pH	Average Alkalinity (mg ^l ⁻¹ CaCO ₃)*	Average Hardness (mg ^l ⁻¹ CaCO ₃)	Average Conductivity (mScm ⁻¹)
Misri Shah (L)	8.0 ± 0.1	360 ± 13	400 ± 20	1.097 ± 0.002
Rang Mahal(L)	7.5 ± 0.1	368 ± 7	284 ± 9	0.861 ± 0.003
Delhi gate(L)	8.0 ± 0.3	364 ± 11	332 ± 7	0.653 ± 0.005
Gawal Mandi(L)	8.0 ± 0.1	279 ± 5	152 ± 4	0.671 ± 0.003
Badami Bagh(L)	8.0 ± 0.3	372 ± 8	248 ± 7	0.645 ± 0.004
Muslim Town(L)	8.5 ± 0.2	396 ± 7	216 ± 9	0.748 ± 0.003
Bagban pura(L)	8.5 ± 0.3	328 ± 9	108 ± 10	0.656 ± 0.001
Ravi river(L)	7.0 ± 0.1	185 ± 6	100 ± 6	0.263 ± 0.003
Industrial area(L)	8.0 ± 0.2	584 ± 8	244 ± 11	1.116 ± 0.009
Saddar(L)	8.5 ± 0.1	600 ± 8	232 ± 13	1.145 ± 0.005
Lahore road(K)	8.5 ± 0.3	689 ± 9	344 ± 12	1.730 ± 0.011
Niaznagar(K)	8.5 ± 0.2	700 ± 14	316 ± 11	1.425 ± 0.006
Din Garh(K)	8.5 ± 0.1	716 ± 12	300 ± 6	1.539 ± 0.005
Railway Qrts(K)	8.5 ± 0.2	696 ± 16	332 ± 8	1.633 ± 0.004
Nizampura Rd(K)	8.5 ± 0.3	662 ± 18	324 ± 14	1.721 ± 0.009

*CaCO₃ equivalent (L) Lahore (K) Kasur

samples, the observed alkalinity for Lahore water samples under investigation fell within this safe range. Since observed pH of the samples followed a range of 7.0-8.5 pH units, the estimated alkalinity may be of the bicarbonate type, with less possibility of it being of carbonate or hydroxide alkalinity. Old city areas of Lahore, namely Misri Shah, Rang Mahal, Dehli Gate, Gawal Mandi and Badami Bagh presented alkalinity values in the range of 250-400 mg CaCO₃ lit⁻¹ (Table-1). The lowest value for alkalinity was observed for Ravi samples being less than 200 mg CaCO₃ lit⁻¹. Industrial area and Saddar region of Lahore city recorded higher alkalinity values, over 500 mg CaCO₃ lit⁻¹, in comparison to old city areas. This may be due to a difference of soil structure of the area, as the possibility of industrial discharge containing the inorganic salts entering ground water stream looked unlikely. One other interesting aspect of these results could be seen in high alkalinity of Kasur water samples in comparison with those of Lahore. Kasur soil is known to be saline and porous and this factor may solely be responsible for the observed alkalinity values. Industrial chemical discharges may be partially held responsible for the high alkalinity and elevated level of total dissolved solids (TDS) with only some reservations.

Hardness

The results on water hardness of various areas of Lahore and Kasur are also mentioned in Table-1. These results presented a relatively

unusual high hardness for Misri Shah area water samples being in the range of 400 mg CaCO₃ equivalent lit⁻¹. One possible explanation for this could be linked with soil conditions and underground water hydrology rather than linking it with the presence of cottage industries in this area. During the last fifty years or so, tanneries remained concentrated in this area and some effect of this industrial activity might be linked to this observation, though, such possibility looked remote. Ravi river water samples showed least hardness as compared with other samples being around 100 mg CaCO₃ lit⁻¹, which may be due to precipitation and settlement of the constituents to the river bed. Kasur water samples showed hardness in the range of 300-350 mg CaCO₃ lit⁻¹ indicating higher concentration of Ca and Mg salts. The rejection limit for water in consideration to hardness figure could be equivalent to 500 mg CaCO₃ lit⁻¹. Fortunately all the water samples tested fell in the safe range.

Conductivity

Results on conductivity of water samples (Table-1) showed the Saddar region of Lahore city has the highest value of 1.145 mS cm⁻¹ in comparison to other samples. This area is mostly residential and thus may represent only a small quantum of industrial activity. These results may suggest further investigation to determine whether it could be linked to some industrial activity or other parameters. Amongst the old city areas.

Misri Shah water showed conductivity around 1 mS cm^{-1} and these values are in-line with hardness values which apart from other factors may also show some sort of residual effects of past anthropogenic activity. Other areas of old city of Lahore showed the conductivity values in the moderate range, i.e. between 0.6 to 0.8 mS cm^{-1} . Industrial area water showed conductivity over 1 mS cm^{-1} which may be expected because of industrial nature of the area with some reservations. Kasur water samples recorded conductivity values of over 1.73 mS cm^{-1} which are considered high but are in agreement with high alkalinity and hardness values.

pH value

The normal acceptable pH limit for municipal water supply lies between 6.5 to 9.5 pH units. Some water sources may have an extended range between pH 5.0 to 10.0 units. This has a significance of being direct indicator of solubility of various alkali and alkaline earth species in water. Hence, the overall quality of water is greatly influenced by the pH value, as is well established [7], that water with high pH tends to be scale forming, and that of low pH normally corrosive to certain metals, asbestos, cement and lined pipes. The estimated pH values of water samples collected for investigation ranged from a lowest value of 7.0 (Ravi river) to the highest value of 8.5 (Kasur water). Thus all the water samples were basic in nature and the general neutral-alkaline trend of natural ground water of the Lahore and Kasur regions may have a marked neutralizing influence on the trace heavy metal solubilities.

Concentration of metallic elements

Although sodium and potassium are not strictly considered as trace metals present in drinking water, yet they do constitute an important indicator of water quality. It is well known that certain metals such as Na are concentrated in body fluids, and are circulated throughout the human body. These elements are known to participate in life sustaining processes operating throughout the complicated nervous system controlled by the brain. Results presented in Table-2 show relatively high concentration of sodium in Misri Shah, Baghban-pura, Saddar and industrial areas of

(Lahore) and Kasur. Misri Shah has low elevation compared to other areas of Lahore, therefore this factor may be affecting ground water flow to the Misri Shah direction. Sodium salts are extensively used in large quantities in tanneries and according to one opinion existence of such units around could influence concentration of sodium in Lahore and Kasur water samples. Higher sodium concentration may create problem of hypertension and affect the public health. As the reported values are close to the allowed limits there may not exist any serious threat of underground water pollution especially in Lahore area.

Fig. 1 shows variation of Ca, Mg, Na and K in drinking water samples of different localities of Lahore and Kasur areas in Lahore region, it is evident that metal content of Misri Shah water samples, in general, was on the higher side as compared with other areas of Lahore. It may be due to the low elevation of Misri Shah in comparison to other areas of Lahore. This low elevation may be causing ground water flow to the Misri Shah direction resulting in higher concentration of salts. In addition presence of the waste water pumping station in the area may have some sort of effect on the drinking water quality.

Another interesting feature, evident from the results presented in Figure 1 showed high metal content of all the Kasur water samples which may partially be due to the saline and porous nature of the soil with high permeability. These factors may partially explain the higher metal content of the Kasur water samples.

Metal content of Ravi water samples was rather noticed on lower side as compared with other areas (Fig. 1). Although industrial and municipal waste is discharged into the Ravi river at some convenient points, this factor does not seem to have affected the Ravi water significantly at the reported sampling point. Further the river water, in general, contains less dissolved salts as compared to the underground water streams and this seemed to be in line with the observed results.

Kasur water samples recorded higher metal content but yet not exceeding the normal drinking water level for most of the elements studied. Effect

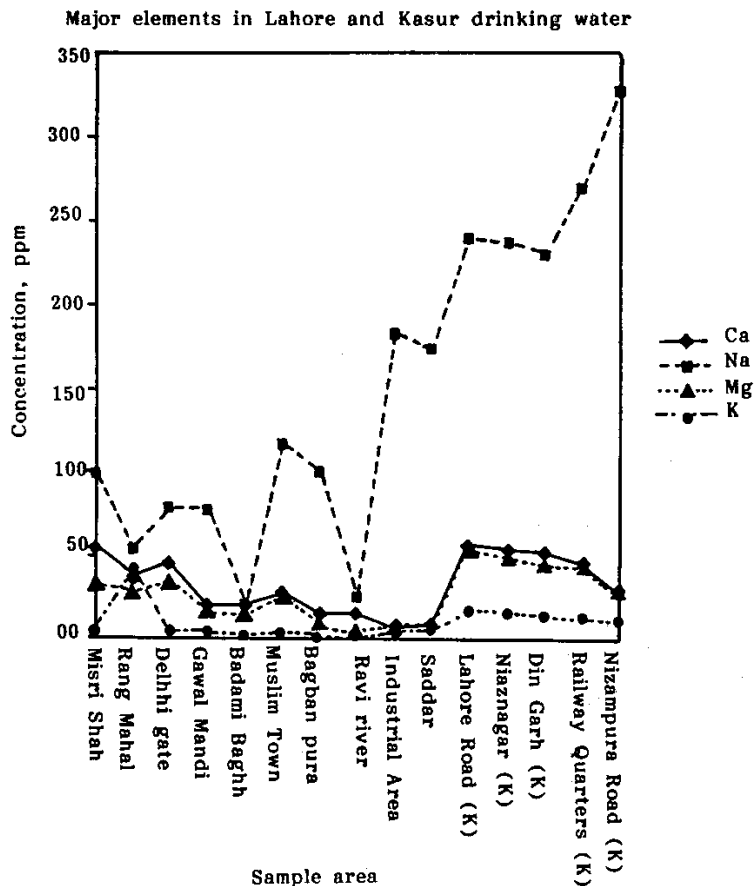


Fig. 1: Metal concentration in drinking water of Lahore and Kasur.

Table-2: Analysis of water samples of Lahore and Kasur.

Sample Area	Ca ^a	Na ^a	Mg ^a	K ^a	Zn ^a	Fe ^a
Misri Shah(L)	56 ± 5	100 ± 9	34 ± 4	05.60 ± 1.10	0.11 ± 0.02	N.D.
Rang Mahal(L)	38 ± 3	054 ± 5	29 ± 3	04.20 ± 0.70	0.10 ± 0.03	N.D.
Dehli gate(L)	46 ± 4	078 ± 8	35 ± 4	05.25 ± 1.24	0.15 ± 0.03	N.D.
Gawal Mandi(L)	20 ± 3	078 ± 7	17 ± 2	05.20 ± 1.10	0.12 ± 0.02	N.D.
Badami Bagh(L)	20 ± 3	021 ± 3	14 ± 2	02.50 ± 0.58	0.13 ± 0.02	N.D.
Muslim Town(L)	28 ± 2	118 ± 11	27 ± 3	04.50 ± 0.80	0.12 ± 0.04	N.D.
Bagban pura(L)	16 ± 2	100 ± 10	8.5 ± 1	01.76 ± 0.25	0.12 ± 0.02	N.D.
Ravi river(L)	16 ± 2	025 ± 3	5 ± 1	01.10 ± 0.16	0.07 ± 0.01	2.4 ± 0.58
Industrial Area(L)	07 ± 1	183 ± 15	8 ± 2	05.00 ± 1.23	0.21 ± 0.06	N.D.
Saddar(L)	08 ± 1	173 ± 13	7 ± 1	05.00 ± 1.18	0.15 ± 0.03	N.D.
Lahore road(K)	56 ± 6	240 ± 21	54 ± 5	18.00 ± 3.54	0.23 ± 0.04	N.D.
Niaznagar(K)	53 ± 5	236 ± 19	49 ± 4	16.00 ± 4.66	0.29 ± 0.03	N.D.
Din Garh(K)	52 ± 5	230 ± 21	44 ± 4	14.00 ± 2.78	0.27 ± 0.03	N.D.
Railway Quarters(K)	45 ± 4	270 ± 26	42 ± 3	13.00 ± 2.10	0.25 ± 0.02	N.D.
Nizampura Road (K)	28 ± 3	328 ± 30	28 ± 3	11.00 ± 1.90	0.28 ± 0.03	N.D.

a: Average concentration ppm. (L) Lahore (K) Kasur

N.D. Not detected.

Note: Analyses for 9 elements Pb, Cd, Cr, Fe, Ca, Mg, Na, Zn and K were carried out; Among these elements; Pb, Cd, Cr, Fe, were not detected being below the detection limits for these metals i.e. 0.1-10 nmh.

of the excess metal content may still be harmful in certain cases. Therefore, a water treatment plant must be planned for Kasur drinking water supply.

The highest desirable level of zinc in drinking waters is, on the order of 5 mg lit⁻¹. No sample was found to contain zinc in excess of this limit (Table-2), and hence there did not exist any health problem for the inhabitants of these areas with respect to zinc toxicity.

Trace elements

The absence of toxic trace metals such as lead, chromium, cadmium, mercury and arsenic in the drinking water samples of Lahore and Kasur can be explained by considering many factors affecting the solubility of these elements in water with other important factors such as the depth at which ground water is extracted in Lahore and Kasur, this depth is on the order of 200 feet, which is considered as an efficient filtration barrier due to its ion exchange capability to check entry of the toxic elements into the water streams.

Experimental

Instrumentation

Atomic Absorption Spectrophotometer, Spectra A 300 of Varian AG, Switzerland was used throughout this study.

Operating parameters

The instrument optimum operating parameters such as the analyte wavelength, slit width, lamp current, fuel gas, support gas and the working range were selected for each analyte element following the instrument analytical methods manual and the operating manual. Final choice of the operating parameters was made intuitively after running a few test samples for each analyte element. All parameters were optimized for a maximum and stable output of the instrument.

Calibration and standards

The instrument was calibrated with appropriate set of three calibration standards, in each case, prepared using available 1 mg ml⁻¹ Merck AAS standard solutions. The zero standard or the blank solution was prepared by diluting 5 ml

of concentrated (65%) analytical grade HNO₃ to 400 ml using double-distilled deionized water. All further dilutions required for preparation of working standards were carried out using this blank solution.

The calibration standard solutions were divided into three sets, set(i) for Na, K, Mg and Ca, with 1 ppm, 10 ppm and 50 ppm, set (ii) for Fe and Zn with 1 ppm, 10 ppm and 20 ppm and set (iii) for Pb, Cd and Cr, with 0.05 ppm, 0.1 ppm and 0.5 ppm standard solutions respectively.

Sampling containers

For sampling clean polyethylene containers of volume 400 ml were used and the samples received were immediately processed for analysis.

Sampling container ageing

The empty containers before use were aged for two weeks with 5% HNO₃ solution followed by one week ageing with double distilled deionized water.

Sampling areas

The sampling areas chosen were Misri Shah, Rang Mahal, Dehli Gate, Bagbanpura, Gawal Mandi, Baradari (Ravi River), Muslim Town, Industrial Area (Kot Lakhpat) and Saddar for Lahore and Lahore Road, Niaz Nagar, Dingarh, Railway Quarters and Nazimpura Road for Kasur respectively.

Sample collection

Samples were collected at three points from each selected area of Lahore and Kasur. All the samples collected were from the normal drinking water supply sources, as near as possible, except those collected from Baradari/Ravi River.

Sample treatment

It has been reported that loss of metals due to adsorption on walls of the container can be prevented by adjusting pH value of the collected sample below 1[8]. Therefore, after each sample collection, 5 ml of concentrated nitric acid were immediately added to 400 ml of the sample volume.

Physico-chemical parameters

Immediately after each sample collection a part of the sample, without acid treatment, was used for pH, conductivity, hardness, alkalinity and density measurements using appropriate instrumentation and following standard procedures [9].

Conclusion

1. Sodium concentration in the drinking water samples of Lahore (Misri Shah, Muslim Town) and particularly of Kasur is marginally on the higher side. A further detailed investigation may be carried out to assess the effects of such concentration of sodium on the public health.
2. Toxic trace metals of Lahore and Kasur drinking water samples are well below the maximum permissible limits.
3. Physico-chemical parameters of Lahore and Kasur water samples indicate marginally higher level of conductivity, alkalinity and hardness, through always falling in the permissible range.

Acknowledgement

Thanks are due to Dr. Mansha Ch. and Shaukat Saeed for their help and advice. We would also like to offer our sincere thanks to Dr. Riffat Qureshi for his technical and useful consultation. Special thanks are due to Mr. Rahat Rasool for his assistance in AAS analysis. We are also very thankful to Binyamin, M. Islam and Khalid Mahmood for their hard work during this investigation.

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