An Investigation of Inorganic Contaminants of Potable Water of Karachi

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Summary: Drinking water available at Karachi was collected from 11 stations and was analysed for a number of pollutants. The concentration of most of the impurities lie within the permissible criteria of drinking water quality. The results suggest that most of the inorganic pollutants were introduced through the distribution system since the concentrations were relatively low at Kinjhar lake, a major source of water supply.

Introduction

Clean water for domestic use is a basic need for human health. However water is never clean. Taste of water is imparted by the impurities in it and may be that "pure water" without impurities cannot be agreeable to drink. The impurities associated with water may be of biological or chemical nature. Some chemicals which cause odour or taste include acidities or alkalinities, naturally occurring salts, sulphates, chlorides, detergents, phenolic compounds, grease and oils etc. Some of these contaminants if present above a certain level may constitute a direct health hazard when ingested in with water or as a result of contact during bathing. Thus an international quality criteria has been established to provide basis for the control of human exposure to many of these substances [1-3]. A frequent analysis of drinking water supply is needed to scrutinise the levels of hazardous impurities. Thus we carried out analysis in 1983 and 1986 of inorganic and organic contaminants of water in fifteen different areas of Karachi city. The station selected get their water supply mainly from River Indus through Kinjhar lake; Hub Dam or Dumloti Wells. In addition to the above sources, well water from three stations was also analysed. The concentration of pollutants are correlated with the possible sources and are compared with the permissible criteria for water quality [3]. The

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concentration of pollutants in surface waters may fluctuate depending on run offs caused by rainfall, snow melt and anthropogenic inputs from domestic, industrial and agricultural sources. The sites selected cover the entire city adequately and include residential areas (Defence Housing Authority, Gulberg, Gulshan-e-Iqbal, P.E.C.H.S., North Nazimabad, North Karachi etc.), industrial areas and industrial cum residential areas (Landhi, Liaquatabad). All the areas are thickly populated, the industrial areas have different types of industries where waste disposal facilities are inadequate.

In part I of this paper we will discuss inorganic contaminants and the organic contaminants will be presented in part II.

Results and Discussion

The main sources of drinking water in Karachi originate from river Indus through Kinjhar lake. This water is treated with alum, filtered and chlorinated before it is supplied to the city. There are, however, other alternate auxilary sources of water such as Hub Dam and Dumloti Wells. The Hub Dam is situated at about 30 km from Karachi and drains its water from Hub River which in turn gets its water from seasonal rain in the southern Balochistan and Sindh and has a large catchment area.

The Dumoloti Wells are situated in Malir, Karachi. The wells are near Malir River which owes its limited supply of water to very uncertain and scanty rainfalls. The wells are exhausted if it does not rain for a few years.

The water distribution system of the city is very complicated; various localities get water primarily from anyone of the above sources and in case of shortage of water, alternate sources are used to compensate for the short fall since the distribution systems of all the sources are interconnected.

The inorganic contaminants calcium, copper, iron, magnesium, zinc, silicon and anions were analysed in potable water since pollutants have considerable effects on human health. The results were compared with those of Kinjhar lake waters in order to understand the sources of such contaminants. One such study was made in 1983 and other in 1986 and attempt has been made to compare the results and rationalise the differences if any.

Table I represents the concentrations of inorganic contaminants in drinking water supplies. The permissible values for potable water quality criteria are summarized in Table II [3].

The pH of the samples examined in 1983 was 6.7-7.5 whereas it was between 6.5-8.0 in the samples collected in 1986 and falls within the permissible limits for drinking water. The little variation in the pH may be attributable to the presence of natural buffers such as CO_3^{2-} and

Table I: Concentration of Inorganic Pollutants

	pH		Ca*		Cu*		Fe*		Mg*		Zn*		Si*	
	83	86	83	86	83	86	83	86	83	86	83	86	83	86
Defence Housing Authority	6.8	6.5	0.55	0.58	Nil	Nil	0.40	0.40	0.70	0.40	0.20	0.40	0.85	–
Gulberg	6.9	6.8	0.58	0.70	Nil	Nil	0.60	0.50	0.40	0.30	0.10	0.36	0.80	–
Gulshan-e-Iqbal	6.9	7.1	0.67	0.70	Nil	Nil	0.09	0.40	0.30	0.30	0.25	0.36	0.73	–
Landhi	7.0	6.8	0.63	0.68	Nil	Nil	0.09	0.07	0.40	0.50	0.20	0.45	0.69	–
Liaqatabad	7.0	7.2	0.63	0.55	0.69	–	0.56	0.30	0.50	–	0.23	–	0.84	–
Orangi	7.0	7.0	–	–	–	Nil	0.70	0.84	–	–	–	–	–	–
Nazimabad	6.8	8.0	0.66	0.73	Nil	Nil	0.30	0.55	0.30	0.40	0.30	0.36	0.80	–
North Karachi	7.0	7.0	0.62	0.75	0.69	Nil	0.05	0.30	0.23	0.09	0.22	0.34	0.90	–
North Nazimabad	7.0	6.4	0.59	0.63	0.69	Nil	0.05	0.50	0.21	0.40	0.19	0.50	0.80	–
P.E.C.H.S.	7.0	6.4	0.56	0.62	0.56	Nil	0.04	0.10	0.22	0.30	0.18	0.37	0.78	–
Saddar	7.0	6.7	0.50	0.65	Nil	Nil	–	–	–	–	–	–	0.73	–
Nazimabad (well)	7.3	8.0	0.72	–	0.50	0.55	0.60	0.75	–	–	0.45	0.45	–	–
Nishtar Road (well)	6.9	7.0	0.63	0.73	0.72	0.68	0.60	0.80	0.20	0.40	0.48	0.51	0.90	–
Saddar (well)	6.7	7.0	0.67	0.68	0.87	0.69	0.05	0.20	0.35	0.40	0.34	0.50	0.98	–
Kinjhar lake	7.5	7.9	0.70	0.59	Nil	Nil	1.00	–	0.50	0.30	Nil	Nil	–	–

*in ppm, Ni, Co, Mn, Cd absent.

Table 2: Water Quality Criteria, Domestic Water Supplies

	Permissible criteria*	Desirable criteria*
pH	6.0-8.5	6.0-8.5
Alkalinity	30-500 mg/l	30-500 mg/l
Chloride	0.01	-
Copper	1.0	virtually absent
Iron (filterable)	< 0.3	virtually absent
Nitrate plus Nitrite (as mg/l N)	< 10	virutally absent
Zinc	5	virtually absent

*ppm unless otherwise stated.

HCO_3^- ions which keep the pH between 6.5-8.5. The water from Kinjhar lake shows lower pH than the treated water available at Karachi. Thus water quality has improved after processing. Corrosivity and toxicity of water is strongly dependent on pH. The low pH may be corrosive and may release many metals like Cu, Pb, Zn and Fe into water. On the other hand higher pH may result the corrosion of metals like Al, Sn, Pb etc.

Calcium and magnesium are both major components of earth crust and result in hardness of water [4], calcium and magnesium concentration in 1983 and 1986 samples followed roughly a homogeneous trend.

Iron is essential to human body but its intake through drinking water is an insignificant part of the body requirement. The permissible limit placed on this metal has no health significance but it renders water unsuitable for human hygiene and other human requirements. In the present study variation in the concentration of iron may be attributed to local contamination due to the corrosion in the pipelines or plumbing system, because its concentration is about 1.0 ppm at Kinjhar lake, a main source of water supply. Iron levels at a number of stations was found to be higher than the permissible limit (0.3 ppm). Its concentration was highest at Orangi. The levels at Nazimabad and Nishtar Road wells were also high because of leaching of iron from the surroundings. Surprisingly the concentration of iron wells of Saddar was remarkably low.

Zinc is rarely present in natural waters in considerable concentration but does enter water supplies by the dissolution of metal from zinc galvanizing of pipes and tanks [3]. Zinc is the normal constituent of human body and no significant health hazard is observed up to 40 ppm, though the permissible limit is 5 ppm. However, it imparts an astringent taste to water. Our results showed little variation in the amount of zinc and it is much below the permissible limit. The relatively higher concentration of zinc in the well water is because of leaching from the surrounding earth. Its absence in Kinjhar lake sample indicates its introduction in different samples of city through distribution system.

Copper is not a significant constituent in natural waters, however, it is introduced by dissolution of copper from brass and copper pipes and by the use of copper sulphate as an algicide in reservoirs. Copper is of physiological importance as a supplement to iron for haemoglobin regeneration and is essential constituent of tissue cells. Excess of copper is known to cause gastrointestinal catarrh and hemochromatolysis. In the present analysis it was found to be absent in Kinjhar lake and present in trace amounts at six stations in 1983 samples. Its complete absence in experiments of 1986 suggest that water quality has improved. However it was found to be present in the water of all the samples collected from wells.

Silica was analysed in 1983 and was less than 1 ppm in all the samples. Similarly nitrate and phosphate were found to be present in exceptionally low quantities. High conentration of nitrate may result in infant methaemoglobinaemia. Its sources of introduction are fertilizers and the soil contamination from animal refuse. In agriculture nitrate and phosphate fertilizers are abundantly used throughout the country and their almost absence from the water (nitrate and phosphate less than 0.01 and 0.07 ppm respectively), is surprising.

Acidity and alkalinity are the indicators of limits in natural waters beyond which the life processes are curtailed. They are dependent on the presence of HCO_3^-, CO_3^{2-}, OH^-, $HSiO_3^-$, $H_2BO_3^-$ HPO_4^{2-}, HPO_4^-, HS and NH_3. Acidity of various samples lies within 1.3-2.3 ppm of $CaCO_3$ which is within the permissible limit for the drinking water.

Similarly the alkalinity was also below the permissible criteria of 30-500 mg/litre [3].

Experimental

The samples were collected in precleaned plastic bottles and were preserved according to standard methods [5] for subsequent analysis. The pH was measured on a pH meter. For alkalinity, acidity and hardness measurements titrimetric procedures were adopted [6]. Nitrate was determined spectrophotometrically after complexing with brucine sulphate [6]. All the metals were determined by atomic absorption spectrometry [6]. The glasswares and apparatus used in the analysis were precleaned with special care and the reagents used were of GR/AR grade (E. Merck).

Conclusion

From the preceeding discussion it could be concluded that the sources of most of the inorganic pollutants in potable water of Karachi are not at the origin of the supply system i.e. Kinjhar lake or river Indus. The inorganic contaminants seem to originate from the supply lines, industrial waste of the city or the contaminated environment of the thickly populated areas. There seems to be increase in some pollutants between 83 and 86 but generally the concentration of the contaminants are still below the hazardous limits.

References

1. "Health Hazards of the Human Environment", WHO, Geneva, (1973)
2. "Quality Criteria for Water", U.S. Environmental Protection Agency, Washington, D.C. (1976)
3 J.W. Moore and E.A. Moore, "Environmental Chemistry", Academic Press, New York and references therein. (1976)
4. P.O. Neil, "Environmental Chemistry", George Allen and Unwin, London, (1985).
5. J.R. Moody and R.M. Linderstrom, *Anal. Chem.*, **49**, 2264 (1977).
6. "Methods for Chemical Analysis of Water and Wastes", U.S. Environmental Protection Agency, Environmental Research Centre, Cincinnati, Ohio 45268, (1976).