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BACTERIOLOGICAL QUALITY AND CHLORINATION STATUS OF DRINKING WATER IN KARACHI REGION

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ABSTRACT

This cross sectional study investigates the status of drinking water of various sources including municipal water supply, water supply from vendors and mineral water. The city was divided district wise and the samples were collected from each district at the consumer end. Drinking water quality was examined by Most Probable Number (MPN) technique as per method described in APHA (1998) and the results were compared with WHO guidelines. It was found that municipal water from almost all the city is contaminated with the organisms of public health importance in amounts several magnitudes higher than any permitted standards.

Key-words: Bacterial quality, chlorination, drinking water, Karachi

INTRODUCTION

In developing countries like Pakistan despite the high mortality rate especially in the infants, no attention is being given to the drinking water. However, in some places some remedial measures such as filtration and chlorination have been taken but these are confined only to urban areas. It is strongly felt that proper efforts have not been made to create awareness among the masses about the importance of safe drinking water. This situation may be due to the poor economic conditions, low education rate, political instability, socio-cultural problems and low priority to enhance the safe water supply coverage. Most of Pakistan's urban water supply and sewerage works were installed or last upgraded more than 25 years ago are operating above design capacity or have reached the end of the serviceable system life. This situation has left the country facing a critical shortage of potable water supply.

River Indus is the major river and source of fresh water in the country including Karachi, flows across the entire country from north to south and ultimately into the Arabian Sea. Karachi, located some 160 kilometers away from the Indus River, is the last major city harnessing water from the Indus River. Besides the Indus source (also known as the Greater Karachi Bulk water supply system –GKBWS), which supplies over 70% of city's water, other surface (e.g Hub River through Hub Dam supplying around 25%) and subsurface (e.g. Dumlotee wells supplying around 2%) sources also provide the water for the city. (MacDonald and Partners, 1985: United Nations 1988; Karachi Water and Sewerage Board, 1994).

Since Karachi is at the tail-end of the surface water supplies, it receives water which has been used for municipal, agricultural, and industrial purposes, often several times. None of the cities (or other major users) along the Indus River treat the water before discharging it into the river (Bakhtiar, 1992). The contamination ranges from highly saline irrigation return water laced with agricultural chemicals including pesticides to industrial pollutants and human and livestock excreta. During the monsoon flood season (July to September), higher flow dilutes the pollutants; however during the low flow (nine out of twelve months) when the flow is reduced to one-tenth of its monsoon flow, the suspended and dissolved load of the river increases sharply (Gazdar, 1993; Bakhtiar,1992; Rahman *et al*., 1997).

The KWSB operates water treatment plants around the city and claims to supply water that is free of bacterial contaminants (Bakhtiar, 1992). In essence only part of the city's water supply receives complete treatment. Water from the Indus source is sent to the treatment plants, some directly and some through storage/settling lakes.

The treatment plants operate on "flocculation – sand filtration – chlorination" principle. Of these, only the sand filtration seems to be the major treatment process as there are serious inadequacies with coagulation and chlorination, perhaps due to economic factors (Rahman *et al.*, 1997). While the water quality reported by the authorities meets the WHO standards whereas, the water quality tested by others including NGO's, media and other agencies like the Institute of Environmental Studies, and Department of Microbiology, University of Karachi do not meet the WHO standards. The discrepancy may be for several reasons. It could be due to the fact that collection of water samples from the authorities is from source i.e. the treatment plants, other results are from samples originating from consumers taps. The sampling techniques and method of analyses also differ.

Water in the distribution pipelines gets contaminated during flow. The close proximity of sewerage and waterlines in Karachi has been lay crisscrossed both leak profusely in most areas. Estimates for unaccounted water from the treatment plant to the consumers vary from 40 to 70 percent, with a substantial portion making up the leakage (Rahman *et al.*, 1997). As a result, leakage from the sewerage lines would be greater than in water lines. Thus when the water supply is interrupted, the water from the sewerage lines or from the surrounding subsurface material gets enters into the water supply lines. As most of the residents withdraw water from the water lines using suction pumps, this further increases the entry of sewage water into water lines. The underground water tanks also receive contaminants through seepage from the surrounding areas. Moreover, underground and overhead water tanks owned by the residents are not cleaned regularly. Bakhtiar (1992) reported a study by KDA (Karachi Development Authority, a government organization) where 70 % of the underground water tanks in the old city areas of Karachi were found to be contaminated by faecal organisms. (Rahman *et al.*, 1997; Bakhtiar, 1992).

The system to provide water to the people of Karachi was actually devised in 1948 with prioritized phases of time and for fourth phase it was planned to provide 280 million gallons water to Karachi through Kinger Gujjo canal. Silting and wastage has decreased the capacity of KG canal and other water reservoirs to supply the desired amount of water to the city. Despite of providing 280 million gallons per day to the city, increased population has changed the demand figures of water to the city. Demand of water keeps on increasing but supply remained limited, which resulted in the present shortfall.

According to the United Nations (1988), "only 40% of Karachi household receive piped water, usually for only a few hours daily" (pp: 24). Nearly three million people in squatter settlements must either use public stand pipes or buy water from vendors at inflated prices (Gazdar 1993 ; Rahman 1997). Rahman *et al.,* (1997) reported that none of the households receive piped water around the clock. Most are supplied water for only a few hours a day and even that supply is very erratic, having very low flow rates. Almost all such houses (and other buildings) have underground and roof-top water storage tanks. Due to the low flow rate (and hence pressure), water from the municipal water supply is first collected in the underground storage tanks and then pumped up to the overhead tanks. As the demand for water keeps increasing, the flow rates have been dwindling with time and suction pumps are generally installed in the underground water tanks. In the presence of leaky pipelines, this practice has led to the incidence of wastewater entering into water pipes as well. Most of the underground storage tanks have poor linings and surrounding subsurface water and accompanying contaminants leak into underground tanks (Rahman *et al.*, 1997; Bakhtiar, 1992).

In many areas in addition to expensive residential districts, the piped municipal water does not reach the houses and the residents have to buy water from private vendors selling water in truck mounted "tankers" whose source and quality of this tanker water is almost completely unknown to the users.

The katcchi abadis (squatter colonies) have either public stand-pipes or the people have to buy water from vendors, if not through truck mounted tankers, then smaller containers (generally 50 to 200 liter capacity) on animal driven or push carts. The cost of this water relative to the income of the users is relatively high (Rahman *et al.*, 1997).

Many homes in Karachi have access to the high water table, and have placed wells on their property. These wells draw water directly from the ground, and may be used exclusively, or mixed with municipal supply (Sami and Rehman, 1985). Urban runoff, sewage leaks, and metals however quite often contaminate this source. However, users have no method to judge its quality except for taste. Thus, most of the residents drink polluted water unknowingly, and do not question its quality. In addition to these sources a number of commercially available bottled water are available in the market. However, the quality of such water is often questionable from public health point of view. Only if not most of them are below standard when compared to WHO guidelines (WHO, 1996). Due to high cost the use of this water is very limited. The study will be helpful for the concerned authorities i.e planners, managers, researchers and implementers to take the measure for the improvement of drinking water quality of the city.

MATERIALS AND METHODS

For the present study the whole city is divided district wise (East, West, North, South and Central) and from each district 10-15 samples were collected. District central represents the most thickly populated area therefore greater number of samples were collected from this district. The laboratory equipment used in the present study was calibrated first and the results were compared with positive control (lactose broth inoculated with *E.coli*) and negative control (uninoculated lactose broth). For bacteriological analysis the water samples were collected in presterilized bottles in a way to avoid possible contamination from the outside environment.

For the collection of water samples the faucet was first disinfected with alcohol. The faucet was turned on and set to produce a steady, moderate flow of water. The water was allowed to run long enough to flush any stagnant water. The sample was then collected without the flow being changed. After collection the sample bottle was labeled properly assigning a sample I.D number. Samples were collected in duplicate, one bottle used for bacteriological analysis contained few ml of sterile sodium thiosulphate to neutralize the effect of residual chlorine if any, another sample bottle was retained for determining residual chlorine. After collection of samples the bottles were placed in an ice-box maintaining temperature at 4-8^{o}C and transported to the Institute of Environmental Studies, University of Karachi.

The samples were processed in laminar flow hood using sterilized culture media (the sterility of media was checked prior to use) by most probable number technique (MPN) as per standard methods described in (APHA, 1998).

Residual chlorine was determined by titrimetrically as per method described in Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

Table 1 Bacteriological quality of drinking water in different localities of Karachi (MPN/100ml).

Locality	Sample No.	TCC	TFC	Locality	Sample No.	TCC	TFC
	S-1	9	<3		S-37	9	<3
	S-2	4	<3		S-38	<3	<3
	S-3	9	<3	Karachi University	S-39	<3	<3
	S-4	28	150		S-40	<3	<3
	S-5	>2400	75		S-41	15	<3
	S-14	<3	<3		S-64	9	<3
North Karachi	S-16	<3	<3		S-42	>2400	>2400
	S-17	>2400	93		S-44	>2400	460
	S-18	9	<3		S-45	7	4
	S-19	14	<3		S-47	210	93
	S-20	>2400	120		S-48	39	9
	S-22	>2400	93	Gulistan-e-Jauhar	S-52	23	4
	S-23	1100	150		S- 53	23	4
	S-24	1100	150		S-55	9	9
	S-7	<3	<3		S-63	>2400	1100
	S-8	<3	<3		S-67	23	4
	S-10	>2400	2400		S-68	460	14
	S-4	28	150		S-70	39	<3
	S-15	<3	<3	Gulshan-e-Iqbal	S-49	210	210
Federal B area	S-12	<3	<3		S-50	28	40
	S-25	23	9		S-51	>2400	>2400
	S-27	75	9	Korangi	S-65	<3	<3
	S-35	9	<3		S-66	<3	<3
	S-36	93	<3		S-43	<3	<3
	S-20	>2400	120		S-62	<3	<3
	S-22	>2400	93	Malir	S-56	<3	<3
	S-23	1100	150		S-57	<3	<3
	S-24	1100	150		S-59	<3	<3
	S-9	<3	<3		S-60	<3	<3
	S-26	>2400	2400		S-61	<3	<3
North Naziamabad	S-28	75	15	Landhi			
	S-29	7	<3				
	S-30	21	<3				
	S-31	2400	93				
	S-71	1100	23		S-78	460	15
	S-72	39	9		S-79	460	15
Lyari	S-73	7	4	Lyari	S-80	460	15
	S-74	150	28		S-77	460	15
	S-76	21	4				

TCC= Total Coliform, TFC= Total faecal Coliform

RESULTS AND DISCUSSION

The results of public health quality of water from district central are reported in Table 1. It can be seen that out of 36 samples only 8 samples were fit for human consumption which would mean that about 97.20% samples are unfit for human consumption. No residual chlorine was detected in any sample. From Table 1 it can be seen that most of the samples are contaminated with the faecal material therefore potentially dangerous for human health. However, it is interesting to note that the few samples of Federal B and C areas and buffer zone are fit for human consumption. Although, the area of buffer zone lies in the close proximity of North Karachi where most of the samples are unfit for human consumption. The quality of water in district east is relatively better. As out of 34 samples 47.05 % samples were fit for human consumption where as remaining 56.80% were unfit for human consumption. The residual chlorine was absent in all samples. It can be seen from Table 1 that the samples from Malir, Landhi and Korangi areas were fit for human consumption. This may be due to the fact that these are the areas, which are close to Gharo treatment plant. Therefore, the effect of chlorine persists during the flow of water in these areas. Although these areas considered to be low from socioeconomic point of view. In district south the samples were collected from Lyari area. It was found that out of ten samples none of the sample was fit for human consumption. This could be predicted by the common gastrointestinal tract problems prevalent in the area. The poor hygienic and sanitation conditions in the area is alrming which further aggravates the problem. The summary of the test results is presented in Table 2. From the Table 2 it can be seen that out of 71 samples only 32% samples were fit for human consumption whereas 67.60 %were unfit. It would mean that these water samples are unsafe for drinking purposes and continuous threat to human health. A worrying issue is that in most of the areas water supply pipelines and sewerage lines are passing criss crossed. Since either of the two networks is defective and old therefore there is continuous mixing of sewerage water with fresh water. Also intermittent water supply creates a vacuum during which impurities as well as sewage can seep in and mix with the water supply. It was quiet alarming that none of the sample contain residual chlorine.

In order to make the study more meaningful mineral water samples were also collected from the market. The results of bottled water analysis are reported in Table 3. it was found that out of 20 samples 45% samples were fit for human consumption whereas, 55% were unfit. The situation is quite alarming as most of the manufacturers claims that they are producing high quality of water.

Table 2. Summary of public health water quality in Karachi region.

District	No. of sample	FHC	UFHC
Central	36	8 (22.22 %)	28 (77.77%)
East	34	15 (41.17)	19 (58.82)
South	10	0 (0%)	10 (100%)
Bottled water	20	13 (65%)	7 (35%)
Total	100	35%	65%

FHC= Fit for human consumption, UFHC= Unfit for human consumption.

CONCLUSION

The study reveals that the water quality in Karachi region does not meet the WHO guide lines. In the interest of public health, supplies should be examined regularly to confirm that they are free from the organisms of public health importance. Moreover, much emphasis should be given on monitoring the chlorine in water supplies upto the consumer level. It is believed that the filtration plant and reservoirs are chlorinating water adequately, and while chlorine levels were, in most cases, adequate throughout the distribution network, they fell during storage in the underground and overhead tanks of the consumers. This may be simply due to excessive storage time or an excess of organic material in the tanks, which are seldom if at all cleaned by the consumers. It was also observed during the study that often the level of chlorine exceeded the maximum permissible limit which changes the organoleptic properties of water.

Table 3. Public health quality of bottled water available in Karachi.

Sample No.	Locations	Parameters MPN/100 ml		Remarks	Residual chlorine mg l^{-1}
		TCC	TFC		
S-81	Brand 1	<3	<3	FHC	Nil
S-82	Brand 2	<3	<3	FHC	Nil
S-83	Brand 3	<3	<3	FHC	Nil
S-84	Brand 4	150	20	UFHC	Nil
S-85	Brand 5	1100	150	UFHC	Nil
S-86	Brand 6	>2400	460	UFHC	Nil
S-87	Brand 7	<3	<3	FHC	Nil
S-88	Brand 8	43	<3	UFHC	Nil
S-89	Brand 9	<3	<3	FHC	Nil
S-90	Brand 10	<3	<3	FHC	Nil
S-91	Brand 11	<3	<3	FHC	Nil
S-92	Brand 12	9	<3	FHC	Nil
S-93	Brand 2	<3	<3	FHC	Nil
S-94	Brand 6	150	20	UFHC	Nil
S-95	Brand 3	<3	<3	FHC	Nil
S-96	Brand 2	<3	<3	FHC	Nil
S-97	Brand 1	<3	<3	FHC	Nil
S-98	Brand 7	<3	<3	FHC	Nil
S-99	Brand 8	1100	<3	UFHC	Nil
S-100	Brand 12	9	<3	FHC	Nil

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