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Bacteriological Analysis of Groundwater of Karachi

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Abstract. The level of microbial contamination in open wells in selected areas of the Karachi city was studied in consideration of the health of the inhabitants of the areas. A total of 115 well water samples were collected and examined for total bacterial count and counts of coliform, faecal coliform and *Pseudomonas aeruginosa*. The microbiological analysis yielded presence of coliform and faecal coliform in 66.63% and 60.89% of the samples examined, respectively, while, *Pseudomonas aeruginosa* was detected in 30% of the ground water samples. 84.34% of the water samples were found unsatisfactory as per WHO standards.

Keywords: ground water, bacterial contamination, WHO guidelines, Karachi city, drinking water quality

Introduction

Water has great influence on all aspects of human life particularly that of human health (Ahmad, 2000; ASTM, 1981; Hawkins, 1976; AWWA, 1971). However, globally, large number of people do not have access to drinking water or to sufficient amount of water for maintaining basic hygiene. In developing countries, use of polluted water and improper hygienic practices result in thousand of deaths everyday, mostly that of children of less than five years (WHO/UNICEF, 2004). It is estimated that 15% of all child deaths under the age of five years in developing countries results from diarrhoeal diseases (Thompson and Khan, 2003; WHO, 2000).

Globally 1.1 billion people rely on unsafe drinking water sources such as lakes, rivers and open wells; majority of such people (20%) reside in Asia; moreover worldwide 2.4 billion people lack adequate sanitation (WHO/UNICEF, 2004). The population of the mega city of Karachi has multiplied several folds during the last two decades, adversely affecting the water supply system due to poor planning, lack of proper monitoring and management (Mahmood *et al.*, 1998).

Increase in the demand of water has obliged the people to focus on other sources of water such as wells, tube wells and hand pumps for their needs. Borehole/well, a low-cost technology option for domestic water supply in developing countries, is generally considered 'safe' source of drinking water but the quality of groundwater in Karachi region has been badly affected both chemically as well as microbially, by the leakage of sewerage from faulty pipe lines. This contamination has direct effect on the increase of the level of inorganic nutrients and bacteria in the ground water of Karachi. (Zubair and Rippey, 2000). Numerous cases of ground water contamination with sewerage have been documented worldwide (Rao *et al.*, 1986; Jackson, 1980; Fried, 1975).

The present study was carried out to determine the microbial quality of well water being used for drinking purpose. The generation of baseline data in this respect would help and guide the relevant civic authorities to adopt appropriate preventive and corrective measures. Properly constructed and maintained water supply lines provide consistent supply of safe water with low microbial load and little need for water treatment. It is the fault in collection, transportation, storage and decanting of water that leads to subsequent contamination (Howard *et al.*, 2003).

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Materials and Methods

After carrying out geological survey of the study area, 115 ground water samples were collected from randomly selected areas of Karachi city, during October to December 2006.

For microbial analyses, samples were immediately filled into sterile plastic bottles (250 ml) and sealed. All samples were labelled and stored in ice cooler and carried to the laboratory for analyses.

The pH and the temperature of the collected samples were also measured at the time of collection, using standard methods (AOAC, 2000; APHA, 1998) with portable digital pH meter and conductivity meter JENWAY /E.U/430 pH/cad./portable/02162, whereas, the colour, taste and odour were recorded in the laboratory. The depth of the wells was also recorded.

Determination of microbial contamination. Media used for microbiological tests were Plate Count agar (Merck), BGLB

(Merck), MacConkey's broth (Merck), EC medium (Oxoid) and Cetrimide agar (Merck). Media were prepared according to the manufacturers' instructions and autoclaved at 121 °C for 15 min. All glassware were sterilized using autoclave or high temperature oven.

The presence of aerobic bacteria, presumptive coliform, faecal coliform and *Pseudomonas aeruginosa*, in the water samples collected from the wells, was determined using standard procedures (APHA,1998; AOAC, 1984). For total aerobic bacterial count, each bottle of water sample was vigourously shaken and 0.1 ml water was withdrawn aseptically, spread on agar plates and incubated at 35 °C for 48 h. For total coliform detection, Multiple Fermentation Tubes containing MacConkey's broth were inoculated with 10 ml (for double strength broth), 1.0 and 0.1 ml (for single strength broth) of samples and incubated at 37 °C for 48 h. BGLB Media was used for confirmation of total coliform. EC (Merck) medium was used for the detection of faecal coliforms; the inoculated EC medium tubes were incubated at 44 °C for 48 h. *P. aeruginosa* was detected on Cetrimide agar using standard method (Merck Microb. Manual, 2000). *P. aeruginosa* colonies produced a yellow green pigment on the plates; colonies were further confirmed by performing oxidase test.

Results and Discussion

Physical and microbiological analyses of the water samples was carried out to evaluate the quality of water and its suitability for human consumption.

Physical analysis. The resut of analyses of 115 groundwater samples is presented in Table 1. The samples of well water had pH ranging from 6.3 to 8.7. Out of the total 115 samples, 11 samples had pH less than 7.0, whereas, 101 samples had pH between 7.0-8.0; only 3 samples had pH more than 8.0. The value of pH recommended by WHO in drinking water is 6.5-8.5. The pH value of one sample collected from New Karachi, was found to be 8.7 which is above the limit.

Colour of water is one of the most important and conveniently observed indicators of its quality. Water of the best quality should be colourless. In the present study, 93.91% of the water samples were colourless. According to WHO standards, the taste and the odour of water should be non-objectionable or acceptable; 61.75% samples had acceptable taste while 87.82% samples were odourless. The temperature of the well water samples ranged from 26.5-41.3 °C.

Microbiological analysis. Total bacterial count of 84.34% of the examined 115 water samples exceeded the recom-

Table 1. Physical parameters observed in 115 samples of ground water collected from different towns of Karachi city

Area/Town	Atmospheric temp. (°C)			Water temp. (°C)			pH		
	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range
Gulshan	33.5	32.8	32.8-34.9	30.9	30.7	30.6-31.4	7.0	7.0	6.9-7.1
Shah Faisal	34.1	34.0	34.0-34.2	32.0	31.1	30.5-34.6	7.1	7.0	6.9-7.4
Malir	34.2	34.0	33.0-36.0	31.1	30.5	30.0-32.1	7.0	7.0	6.6-7.5
Bin Qasim	34.0	34.0	33.5-34.0	31.5	31.1	30.5-33.3	7.0	7.0	7.0-7.2
Landhi	34.3	33.5	33.5-34.5	30.8	30.8	30.5-32.3	7.1	7.1	6.9-7.5
Saddar	35.1	35.0	35.0-36.0	33.1	33.0	30.4-33.8	7.2	7.1	7.0-7.3
Jamshed Road	33.8	33.5	27.0-36.5	30.9	31.3	26.5-32.5	7.2	7.3	6.3-7.9
Korangi	31.1	37.0	36.0-37.5	32.0	30.9	30.0-36.7	7.2	7.2	7.1-7.5
Gidap	31.0	31.0	31.0-31.0	29.8	30.5	28.5-30.5	7.6	7.6	7.4-8.0
New Karachi	35.9	36.5	33.0-37.5	32.4	31.3	29.0-41.3	7.6	7.5	6.9-8.7
North Nazimabad	32.4	31.5	30.0-36.5	29.9	30.0	29.0-31.4	7.5	7.5	7.3-7.8
Liaquatabad	31.8	32.0	30.5-33.0	31.1	31.2	29.4-32.5	7.2	7.2	7.1-7.3
Kemari	36.1	36.5	35.5-36.0	33.0	33.0	32.0-34.0	7.1	7.2	6.8-7.9
Lyari	36.1	36.0	36.0-37.0	30.7	30.8	30.0-31.3	7.4	7.4	7.1-8.0
Gulberg	29.3	29.0	28.0-31.0	28.1	28.0	27.4-29.0	7.0	7.0	6.5-7.5
Orangi	35.7	36.0	32.0-37.0	31.7	31.7	30.0-33.0	7.3	7.3	7.0-7.5
Baldia	37.7	38.0	36.2-38.0	32.3	32.9	30.1-33.0	7.3	7.7	6.9-7.8
Clifton	34.8	35.0	34.0-35.0	33.8	31.5	30.0-31.5	7.2	7.1	6.7-7.9
SITE area	33.3	33.5	33.0-33.5	32.0	32.0	32.0-32.0	7.5	7.5	7.5-7.5

mended range i.e. more than100 colonies per ml. The monitoring results showed that 66.63% and 60.90% of the samples were found badly contaminated by coliform and faecal coliform, respectively. Test for *Pseudomonas aeruginosa* was positive in 30.43% samples (Fig. 1).According to PSQCA (2002), in addition to the absence of pathogenic bacteria, water samples should not contain *P. aeruginosa* as well; besides, it should be free of abnormal taste, odour and turbidity.

Data was also evaluated statistically for total coliforms, total faecal coliforms, heterotrophic plate count and for *P. aeruginosa* (Table 2a, 2b, 2c). High incidence rates of coliforms were observed in almost all areas of the city specially Shah Faisal, Gidap, North Nazimabad and Gulberg while in different areas of Gulshan-e-Iqbal, Kemari and Korangi town, incidence rates were relatively low (Fig. 2a, 2b, 2c).

Standard plate count, greater than 500/ml, adversely affects the detection of coliform organisms (Karla *et al.*, 1980). In our study of 27 samples, it was observed that as the total bacterial count rises above 500/ml, the MPN index of coliform organisms drops. Thus, high standard plate counts may be useful for indicating the general drinking water quality and the presence of other pathogens or opportunistic pathogens when coliforms are not even detected (Ahmad *et al.*, 1964).

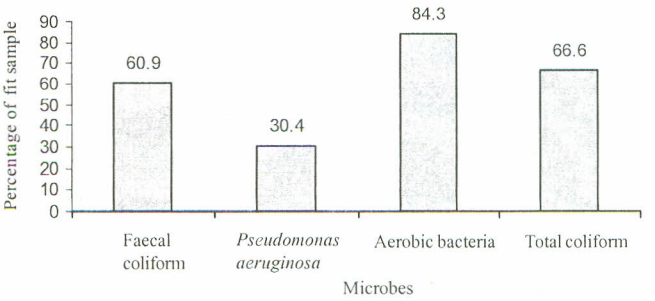

Fig. 1. Percentage of water samples microbiologically fit for human consumption.

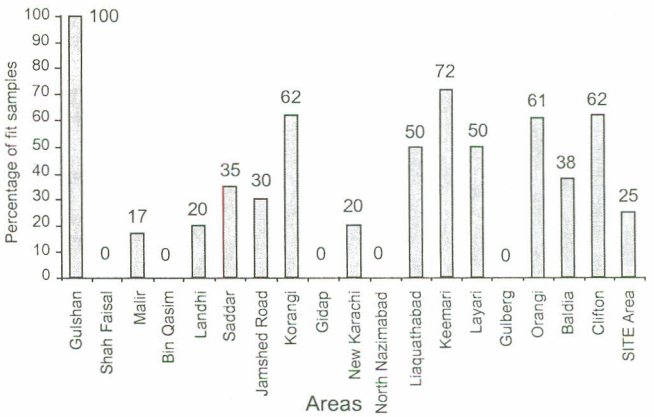

Fig. 2a. Area/town wise percentage of water samples fit for human consumption (total coliform countwise).

Table 2a. Total coliform count/dl in ground water samples collected from different towns of Karachi city

Area/Towns	No. of wells	Total coliform count/dl		
		Mean	Median	Recorded range
Gulshan	3	0	0	0-0
Shah Faisal	3	167. 66	39	4-460
Malir	6	130.83	55.5	0-460
Bin Qasim	4	310	68	4-1100
Landhi	5	274.4	23	0-1100
Saddar	3	400.66	102	0-1100
Jamshed Road	11	18.81	9	0-75
Korangi	8	196.12	0	0-1100
Gidap	3	767	1100	101-1100
New Karachi	16	167.5	33	0-1100
North Nazimabad	6	68.5	96.5	4-110
Liaquatabad	4	167.5	105	0-460
Kemari	3	3	0	0-9
Lyari	6	2.5	2	0-7
Gulberg	3	412	93	43-1100
Orangi	8	53.62	0	0-210
Baldia	8	156.5	6	0-1100
Clifton	11	102.54	0	0-1100
SITE area	4	278.25	6.5	0-1100

Table 2b. Faecal coliform count/dl in ground water samples collected from different towns of Karachi city

Area/Towns	No. of wells	Faecal coliform count/dl		
		Mean	Median	Recorded range
Gulshan	3	0	0	0-0
Shah Faisal	3	49	23	4-120
Malir	6	115.833	55.5	0-460
Bin Qasim	4	299.25	48.5	0-1100
Landhi	5	93.6	9	0-240
Saddar	3	400.66	102	0-1100
Jamshed Road	11	15.63	9	0-75
Korangi	8	195.5	0	0-1100
Gidap	3	1100	1100	1100-1100
New Karachi	16	164.87	33	0-1100
North Nazimabad	6	69.16	48.54	4-210
Liaquatabad	4	97.5	75	0-240
Kemari	3	1.33	0	0-4
Lyari	6	2.5	2	0-7
Gulberg	3	170	43	7-460
Orangi	8	28	0	0-210
Baldia	8	280.37	2	0-1100
Clifton	11	102.09	0	0-1100
SITE area	4	277	4	0-1100

Table 2c. Total bacterial count (cfu/ml) in ground water samples, collected from different towns of Karachi city

Area/Towns	No. of wells	Total bacterial count (cfu/ml)		
		Mean	Median	Recorded range
Gulshan	3	113.33	35	25-280
Shah Faisal	3	573.16	495	324.5-900
Malir	6	379.75	171.75	63-1280
Bin Qasim	4	458.37	451.5	250.5-680
Landhi	5	583.2	290	151-1919
Saddar	3	398.33	497	10-688
Jamshed Road	11	277.04	100	0-1345
Korangi	8	572.5	277.5	40-1475
Gidap	3	770	740	195-1375
New Karachi	16	1204.68	772.5	0-5180
North Nazimabad	6	1802.5	1855	55-3550
Liaquatabad	4	292.75	330	85-426
Kemari	3	45	55	25-55
Lyari	6	22.5	20	0-55
Gulberg	3	1709.33	245	10-4873
Orangi	8	1123.75	1345	5-1820
Baldia	8	401.12	217.75	8-1215
Clifton	11	520.09	123.5	3-1500
SITE area	4	326.87	271.25	55-710

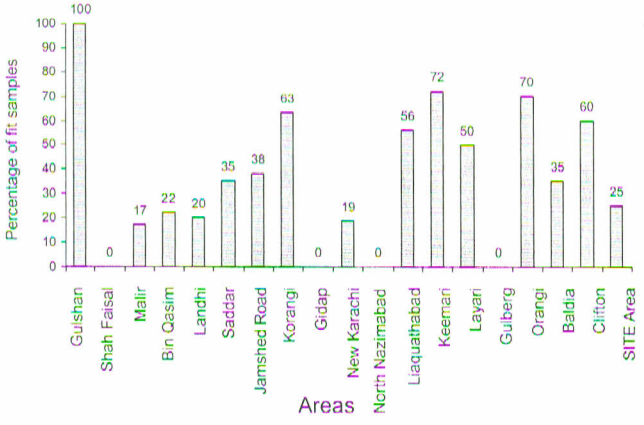

Fig. 2b. Area/town wise percentage of water samples fit for human consumption (faecal coliform countwise).

Evaluation of the well water quality clearly shows that more than 84.34% wells of different areas of the Karachi city are affected by bacterial contamination, while only 15.66% wells were found to be free from bacterial contamination; however during the entire study, after careful survey of the areas under investigation, it was observed that majority of the boreholes and open wells are sited indiscriminately in areas without proper geological survey. Indiscriminate refuse and waste

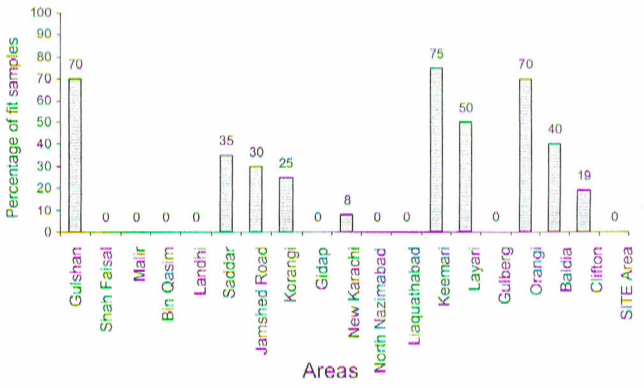

Fig. 2c. Area/town wise percentage of water samples fit for human consumption (total bacterial countwise).

disposal sites and pit latrines were common in the surroundings, which could account for the presence of faecal bacteria in the borehole water.

The study emphasizes the importance of educating the consumer, to increase his awareness about the hazard of consuming contaminated water and the ways to prevent contamination. Improper placement of wells, lack of sanitary seals, proximity of grazing animals to the well, and lack of knowledge about the contaminated water are the factors contributing to poor quality of water supply. More frequent monitoring was helpful in detecting contaminated water supplies which otherwise would have gone unsuspected, particularly during and after the rainfall spells. Consumers need to know that testing of water merely on installation of a well is an inadequate measure of the potability of water supply.

For continued use of a well as a source of drinking water, its detailed hydrogeological study should first be undertaken. Corrective work should not be limited to the modernization of wells, since reduction in the level of bacteriological contamination implies marked improvement in sanitation.

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