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QUALITY OF ICE MANUFACTURED IN KARACHI CITY

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The production of ice being sold in the local market of Karachi is neither regulated nor its quality and safety for human consumption is evaluated. This investigation examined the physico-chemical and bacteriological characteristics of 50 ice samples collected from different areas of Karachi city. The water being used for ice manufacturing is of poor quality, almost all the samples were found unsafe as per WHO guidelines for safe drinking water; total bacterial count exceeded the upper limit 100 CFU/mL, forty one samples out of fifty had high coliform and faecal coliform counts. The ice produced in the city by commercial manufacturers is of very poor microbiological quality and its consumption pose an immediate threat to public health. The potential for disease exists in the ice industry of Pakistan which demands special need for the implementation of appropriate remedial measures to ensure that ice produced and sold in the market is safe for human consumption.

Key words: Ice, Microbiological quality, Chemical analysis, Particulate analysis, WHO guidelines.

Introduction

Large quantity of ice is presently being used in Karachi, the most populated city of Pakistan, having a population above twelve million, by high as well as low-income groups and also by snack bars, restaurants and other commercial outlets in the local tropical climate which prevails almost throughout the year. Bulk quantity of ice is also used to preserve meat, fish and other perishable edible and non-edible items during the summer season. Although ice is considered as a food and its manufacturing is covered by the regulations for food, it has been observed that ice making is not properly regulated and that there is no proper control of the relevant authorities on the quality of water being used for the production of ice in Karachi. In the absence of any precautionary measure, water is at present being indiscriminately used from all available sources in ice making factories spanning through the whole Karachi city.

The population of the mega city of Karachi has multiplied several fold during the last two decades. Owing to the unprecedented increase in the population density and poor planning on the part of administrators and town planners, great pressure has been built up on the inherent infrastructure and above all on provision of essential amenities to the local population. As a result, the whole system laid down for supply of water and disposal of sewerage has been over burdened and badly crumbled (Mahmood *et al* 1998). Water, if contaminated by pathogenic organism, may pose serious health risks and is the root cause of several water borne diseases (Moe *et al* 1991; Falco *et al* 1993). The ground water is usually considered clean and safe, having constant chemical composition but unlike surface water, it is neither renewable nor self cleansing (Anonymus 1990). The quality of ground water in the Karachi region has been badly affected, both chemically as well as microbiologically, due to the mixing of sewage wastewater from leaking sewage lines (Zubair and Rippey 2000). The microbiological quality of piped/supply water in Karachi is also poor, because the water supply system provides intermittent service and usually laying of the pipelines is faulty. The treated supply water is often contaminated due to admixture with seepage from sub soil water and sewers (Beg *et al* 1985).

Surveillance and monitoring of ice quality to ensure microbiological and chemical safety, are vital public health functions especially in developing countries like Pakistan because human illness is also attributed to ingestion of drinking water, beverages and juices served with contaminated ice.

As no evidence could be found that the quality of ice being manufactured and sold in local market of Karachi has been examined, this study was carried out to determine the quality and source of water being used for ice making and to assess

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the quality and safety of ice being sold in the market of Karachi city. The generation of baseline data in this particular respect would eventually help and guide the relevant civic authorities to adopt appropriate preventive and corrective measures, as regards quality of water used in making ice, microbial contamination of ice produced and proper sanitary and hygienic conditions in the ice factories.

Materials and Methods

A total of fifty ice samples, were collected particularly from those localities where ice factories and large ice-depots were located in the vicinity. Since approximately 3 to 4 kg of ice was needed to produce the required total melted volume of the sample, 5kg of ice sample was purchased in sterilized polythene ice bags. The collected ice samples were placed in insulated coolers and immediately transported to laboratory where they were stored in a freezer. It was ensured that the time period between collection and processing should not be more than 72 h. To prepare samples for analytical procedures, the ice samples were transferred to previously sterilized wide mouth glass bottles having screw caps, and left at room temperature over-night for melting. The resulting water was mixed to ensure homogeneity and then poured into especially prepared sample containers for microbiological and chemical analysis.

Particulate analysis was performed by gross and microscopic examination of filter membranes. One kg of melted ice (well mixed) was passed through a standard glass fiber filter (Whatman 4.7cm); pH and total dissolved solids were determined by standard methods [APHA 1989].

The pH of the collected samples of ice was measured after melting and all other estimations were completed within the holding times specified by the analytical method. Chemical analyses were performed for each sample in triplicate and the average values were recorded. Analytical grade (A.R.) chemicals were used in the preparation of reagents and standards. Standard spectrophotometric, flame photometric and titrimetric procedures were used for the determination of different parameters (Fresenius *et al* 1988; APHA 1989).

Media used for microbiological tests were Lactose TTC agar with Tergitol 7 (Merck), Plate count agar (Merck), Cetrimide agar (Merk), Tryptone Water (Merck). All media were prepared according to manufactures' instructions and autoclaved at 121°C for 15 min. All glassware and filtration setup were sterilized either by using autoclave or oven.

The melted ice samples (water samples) were analyzed for coliform count, and faecal coliform count *(E.coli)* by membrane filtration method (ISO 2000). 1:10 Dilutions (100 mL) were used for filtration through sterile membrane filters, composed of cellulose acetate having pore size of 0.45 µm. After filtration one filter membrane was placed on Lactose TTC agar and incubated at 36 ± 2°C for 21 ± 3 h. Second membrane was placed on Lactose TTC agar and incubated at 44 ± 0.5°C for 21 ± 3 h. Sterile water after passing through membrane was also incubated as control. These membranes were examined after incubation and Lactose positive bacteria were counted which showed yellow colour development in the medium.

For the confirmation of coliforms the colonies were subcultured on plate count agar and tryptone broth. Oxidase and Indole tests were performed. Colonies, which were giving negative results for both, were counted as coliforms and those which were giving negative Oxidase and positive Indole, were confirmed as *E.coli*.

Total aerobic count was also performed by Standard Plate Method (Bact. Anal Manual 1984) using pour plate technique.

Pseudomonas aeruginosa was detected by using Cetrimide agar employing standard method (Microb. Manual 2000). *Pseudomonas aeruginosa* colonies produced a yellow green pigment on the plates, the colonies were further confirmed by performing Oxidase test.

Results and Discussion

The physico-chemical analysis of the ice samples was carried out to determine the quality and source of water being used for ice making, to evaluate the quality of ice and its safety and to detect potential contamination during ice making.

Fibers, paper and plastic chips, hair, algae, mold spores and insect parts were common in the ice samples Table 1. Ant, dust-mite and flies were most common insect parts found on the membranes through which melted ice samples were passed. The presence and nature of the particulate material (Table 1) in the ice reflect the sanitary conditions under which the ice is being manufactured, stored and sold in the city.

Analytical data (Table 2) reveals that pH values of all the samples were within the maximum contamination levels (MCL) of pH for drinking water, as recommended by World Health Organization (WHO), US Environmental Protection Agency (USEPA) and Pakistan Standards (PS). The pH, ranged from 6.8 to 8.2; nine samples had less than 7.0 pH, thirty nine samples showed 7.0 or more than 7.0 pH, whereas, only two samples contained more than 8.0 pH.

A critical review of Table 2 shows that all the analyzed water (ice) samples had low concentration of cations and anions except four samples i.e. sample Nos. 44, 45, 46 and 47. The variations in range values expressed in mgl^{-1} were: Cl^- 5-25, SO_4^{--} 1.0 - 118, HCO_3^- 18 - 186, NO_3 - N 0.45 - 6.46, Ca^{++} 2 - 46, Mg^{++} 1- 29, Na^+ 2 - 128 and K^+ 1 - 6; whereas total dissolved solids (TDS) was 42-638 mgl^{-1}. The concentrations of anions and cations in forty six samples were well below the maximum contamination levels (MCL) as per WHO, USEPA and Pakistan Standards. Four samples (Nos. 44,45,46 and 47) had relatively high levels of anions and cations. The ranges were: Cl^- 312 - 1684, SO_4^{--} 83 - 134, HCO_3^- 61 - 158, NO_3- N 4.69 - 8.69, Ca^{++} 19 - 50, Mg^{++} 17 - 25, Na^+ 19 - 1075 and K^+ 6 - 10; total dissolved salts ranged from 815 to 3018 mgl^{-1}.

The chemical quality of water depends upon the total dissolved solids which consist mainly of cations and ions viz. Ca^{++}, Mg^{++}, Na^+, K^+ and Cl^-, SO_4^{--}, HCO_3^-, NO_3^-. The WHO and USEP guideline values for total dissolved salts (TDS) in drinking water are 1000 and 500 mgl^{-1} respectively which are based on taste considerations.

It would be observed from Table 2 that on the basis of TDS concentrations the analyzed water/ice samples may be placed in five categories i.e. i) TDS less than 100 mgl^{-1}, ii) TDS more than 100 but less 200 mgl^{-1}, iii) TDS more than 200 but less than 400 mgl^{-1}, iv) TDS more than 400 but less than 1000 mgl^{-1} and v) TDS more than 1000 mgl^{-1}. This classification clearly indicates the source and quality of the water used for ice manufacturing.

A critical review of the chemical constituents (Table 2) reveals that the analyzed samples are from different water sources. It is worth mentioning that there are three main water supply sources for Karachi city viz. Indus (Kinjhar Lake), Hub Dam and Dumlotti Wells (Zahid 1992). A comparison of the analytical data of the samples (Table 2) with that of the characteristics of supply water available in Karachi (Table 4) clearly shows that in addition to available water supply sources, other waters have also been utilized for ice making.

Very low levels of anions, cations and TDS of the analyzed nineteen samples i.e. Nos. 1, 2, 3, 4, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 and 27 clearly indicate that these neither supply waters nor ground/well water. Their chemical compositions suggest that they are condensed steam samples contaminated with certain quantities of supply or well water. Similarly high concentrations of anion, cations and TDS of sample Nos. 44,45,46 and 47 suggest that well/ground water has also been used for ice making.

Table 1
Particulates in the ice samples

No. of samples	Fibers
41	1- 7
5	10-15
4	Nil
No. of samples	*Papers*
27	1-3
1	7
22	Nil
No. of samples	*Plastic*
12	1-3
38	Nil
No. of samples	*Hair*
14	1-3
36	Nil
No. of samples	*Algae*
5	1-5
45	Nil
No. of samples	*Mold spore*
19	1-3
1	4
1	5
29	Nil
No. of samples	*Insect parts*
22	1-3
28	Nil

* Particulates per kg of ice.

The microbiological quality of the ice samples (Table 3) was evaluated by performing total aerobic count and tests for coliform and faecal coliform bacteria and *Pseudomonas aeruginosa*. Forty one samples out of the analyzed fifty samples, contained high coliform and faecal coliform counts. Nine samples were negative for faecal coliform bacteria but contained high coliform count and total bacterial count. Test for the presence of *Pseudomonas aeruginosa* was positive in twenty samples.

Ice produced in the Karachi city demonstrates high bacterial count and all the analyzed samples, except for two samples, (Nos. 23 and 24) exceeded the upper limit of 500 Colony Forming Unit (CFU)/ml recommended by the Packaged Ice Association USA (Assoc. 1989). Total bacterial count of these water samples (ice) also exceeded the upper limit 100 CFU/ml established by USA Public Health Service for drinking water quality.

As per WHO guidelines (WHO 1984), water for human consumption should not contain pathogenic bacteria. A zero faecal coliform count and zero coliform per 100 ml are appropriate standards for drinking water, however not a single sample of

Table 2
Chemical analysis of ice samples

Sample No.	Location	pH	Cl	SO_4	HCO_3	NO_3-N	Ca	Mg	Na	K	TDS
1	Karimabad Chowrangi	6.8	5	1	18	0.452	2	1	3	1	42
2	Gareebabad Chowrangi	6.8	8	6	18	0.452	3	2	4	1	46
3	Madina Masjid F.B. Area	6.9	9	7	20	0.790	4	2	5	1	54
4	Hasan Square	6.8	10	8	24	0.677	8	1	7	2	68
5	Gulshan-e-Iqbal Mumtaz Manzil	7.4	28	23	73	1.581	18	5	22	4	180
6	AbulHasan Asfahani Road.	7.3	22	28	96	2.032	22	4	12	4	218
7	Al-Asif Square Sohrab Goth	7.3	44	32	90	1.591	24	8	28	4	228
8	Sohrab Goth Chowrangi	7.4	46	36	98	1.942	27	10	30	4	236
9	Karachi Ice Factory Sohrab Goth	7.3	48	36	98	2.710	22	10	32	5	276
10	Water Pump Chowrangi (Block 13, F.B.Area)	7.4	66	64	120	6.010	32	18	44	6	380
11	Chapal City Gulzar-e-Hijri	7.6	78	72	134	3.500	33	15	62	5	412
12	Near Masjid-e-Ghufran F.B.Area Karachi	7.6	70	78	134	11.060	28	12	58	5	436
13	Sohrab Goth	6.9	7	6	19	0.677	1	2	4	1	52
14	Scout Colony	6.8	9	7	24	0.564	5	1	2	1	65
15	Al-Noor Society	6.9	11	7	24	0.722	3	2	7	2	67
16	Power House	7.0	7	8	29	0.677	7	1	5	1	69
17	Natha Khan Goth	7.0	14	21	37	0.948	10	5	7	1	110
18	Korangi “K” Area	7.4	13	17	37	0.858	10	3	5	1	110
19	K. I. A “D” Singer Chowrangi	7.1	11	15	53	1.016	15	3	5	1	124
20	K. I. A Sector-16	6.9	14	25	45	0.677	13	6	8	1	125
21	Landhi NO.6 D Area	6.9	28	25	37	1.422	8	5	16	1	148
22	Safura Goth (Cold drink shop)	7.1	14	12	35	0.452	11	2	8	2	108
23	Gulistan-e-Juhar	7.4	7	17	49	0.632	12	3	6	3	118
24	Shorab Goth	7.1	14	18	35	0.971	9	4	6	4	120
25	Mohammad Khan Goth	7.2	21	32	37	0.677	4	9	14	2	132
26	Clifton	7.0	18	17	49	0.655	14	3	10	4	139
27	Ancholi	7.0	21	19	62	1.084	14	6	14	3	156
28.	Al. Asif Square Sohrab Goth	7.3	42	31	73	6.458	19	8	27	5	238
29	Water Pump Chowrangi (Block 14, F.B.Area)	7.5	64	68	110	1.874	34	18	41	5	378
30	Gulberg Chowrangi	7.0	78	32	73	3.026	22	6	50	5	315
31	Yousuf Plaza	7.4	42	54	110	3.432	29	15	27	5	315
32	Kornagi 2 ½ Sector -25	7.4	57	49	89	2.597	24	11	31	4	320
33	Shah Faisal Colony Near Falcon House	7.3	57	43	78	-2.077	18	8	40	2	280
34	Shah Faisal Colony No-05	7.8	85	66	110	4.155	23	15	68	5	410
35	Water Pump Main Chowrangi (Block 16,F.B.Area)	7.9	77	81	134	3.681	32	13	72	5	448
36	Saddar	7.2	71	36	73	2.845	18	6	41	5	279
37	Gizri	7.3	49	38	74	2.122	17	8	29	5	248
38	Mosumyat	7.2	21	41	98	1.964	22	7	21	5	247
39	Cantt station	7.3	58	41	71	1.874	15	8	33	5	243
40	Defence	7.2	28	43	78	1.535	22	10	19	4	238
41	Sofura Goth (Ice Depot)	7.2	35	27	65	1.626	18	6	24	5	231
42	Korangi 1 ½	7.3	21	32	73	1.332	18	5	12	1	220
43	Ancholi	7.3	21	33	91	0.948	26	5	14	4	215
44	R.I.G.School F.B. Industrial Area	7.7	1684	98	61	8.694	19	17	1075	10	3018
45	Sohrab Goth Industrial Area	7.4	333	83	120	6.706	33	17	214	6	869
46	Scout Colony	7.6	312	89	120	5.284	36	24	190	6	815
47	Power House Industrial Area	8.1	517	134	158	4.697	50	25	335	8	1351
48	Landhi 36-B. Factory	8.2	129	118	186	4.222	46	29	87	5	638
49	Shafiq Mill	7.8	215	68	129	3.455	29	14	128	6	619
50	Shah Faisal Colony No.3.	7.9	187	105	130	4.606	32	18	107	6	570

All values are in mgl^{-1} except pH.

Table 3
Microbiological quality of ice samples

Sample no.	Total coliforms count/dl	Faecal coliforms count/dl	Total bactrial count CFU/ML	*Pseudomonas aeruginosa*
1	1010	930	1.3×10^3	Present
2	1020	460	2.9×10^3	Absent
3	1090	890	3.3×10^3	Present
4	1080	450	2.2×10^3	Present
5	690	120	3.8×10^3	Present
6	240	150	9.8×10^2	Absent
7	470	90	1.7×10^3	Present
8	150	30	2.4×10^2	Present
9.	920	210	2.7×10^3	Present
10	910	240	3.0×10^3	Present
11	490	240	1.5×10^3	Absent
12	460	150	2.1×10^3	Present
13	28	Zero	7.8×10^2	Absent
14	1002	72	3.5×10^3	Present
15	460	23	5.0×10^2	Absent
16	460	28	1.0×10^3	Absent
17	900	93	8.3×10^3	Absent
18	810	62	1.8×10^3	Present
19	925	70	1.1×10^4	Absent
20	760	61	3.0×10^3	Absent
21	460	Zero	1.4×10^3	Absent
22	210	Zero	1.0×10^2	Absent
23	75	Zero	8.0×10	Absent
24	20	Zero	5.0×10	Absent
25	1060	112	1.1×10^4	Present
26	990	91	1.6×10^3	Absent
27	460	25	1.7×10^3	Absent
28	93	5	1.5×10^2	Absent
29	43	Zero	4.1×10^2	Absent
30	49	02	3.7×10^2	Absent
31	1002	110	8.0×10^3	Present
32	210	11	8.0×10^2	Absent
33	860	06	6.0×10^3	Absent
34	700	05	1.3×10^3	Present
35	660	64	4.5×10^3	Absent
36	460	52	1.8×10^2	Absent
37	556	63	1.7×10^3	Present
38	96	Zero	1.0×10^2	Absent
39	1006	100	1.2×10^3	Present
40	1018	75	7.0×10^3	Present
41	94	10	1.0×10^2	Absent
42	910	204	1.2×10^3	Present
43	240	Zero	5.0×10^2	Absent
44	98	Zero	8.0×10^2	Absent
45	1080	169	3.0×10^3	Present
46	890	82	4.6×10^2	Absent
47	952	94	1.9×10^2	Absent
48	754	120	2.6×10^3	Absent
49	986	73	5.0×10^3	Present
50	1016	96	1.1×10^3	Present

water (ice) analyzed, is fit for human consumption as per WHO standard.

Absence of pathogenic organisms is the most essential requirement for water, juices, beverages and food for human consumption from health point of view. Coliform group of organisms include *Escherichia coli, Enterobacter, Klebsiella, Citrobacter* and several others. Presence of these organisms is considered as an indicator of pollution. Detection of faecal (thermotolerant) coliform organisms, in the analyzed samples provides definite evidence that sewage and other waste waters have contaminated the water which is being used for ice making in the city.

According to PSQCA, in addition to the absence of pathogenic bacteria, water sample should also not contain *Pseudomonas aeruginosa* (PSQCA 2002). The presence of *P. aeruginosa* may cause secondary infections in addition to complaints about taste, odour and turbidity.

It has been established by this investigation that contaminated water is being used for ice making in Karachi city. The poor microbiological quality of water and unsatisfactory sanitary conditions during manufacture of ice have rendered the ice produced in the city unfit for human consumption. There is very high consumption of ice in drinking water, beverages, juices, lassi and milk in developing country like Pakistan. The obvious health risk and possibilities for transmission of diseases through the use of ice being produced, demand special need for the implementation of appropriate remedial measures to ensure that water used for ice making is free from bacterial and chemical contamination and that the ice produced and sold in the market does not pose any threat to public health.

The study clearly indicates that ice making industry in this mega city of Pakistan is not properly regulated and that the industry is producing poor quality ice, which is not fit for human consumption and injurious to public health. It has also been revealed that sanitary conditions during production and distribution of ice are improper and unsatisfactory.

Ice industry in Pakistan and particularly the ice production in major cities of the country should be properly regulated by the competent relevant Ministry/Agency. Appropriate regulations and standards should be implemented to ensure proper facilities, good source of water quality, microbial decontamination, adequate sanitary conditions during production, and good personal hygienic and sanitary practices of employees during ice production. It should be mandatory, that product ice be regularly tested by competent laboratories for assessing its fitness or otherwise for human consumption.

Table 4
Characteristics of water available in Karachi

Parameters	Dumloti wells	Haleji lake	Kinnjher lake	Hub dam
Colour (Hazen scale)	2.0 - 6.0	35.0 - 53.0	5.0 - 75.0	3.0 - 6.0
pH	7.9 - 8.6	7.9 - 9.1	8.0 - 9.0	7.2 - 8.0
Turbidity (NTU)	1.0 - 5.0	8.0 - 46.0	3.5 - 100.0	2.0 - 6.0
Chloride (ppm)	146.0 - 320.0	44.0 - 78.0	26.0 - 60.0	65.0 - 85.0
Alkalinity (ppm)	100.0 - 162.0	413.0 - 148.0	88.0 - 116.0	60.0- 90.0
Total solids (ppm)	270.0 - 560.0	196.0 - 340.0	140.0 - 250.0	325.0 - 365.0
Bacteriological (MNP)	150.0 - 1800.0/100 ml	1800/100 ml	250.0 - 1800.0/100 ml	25.0 - 250.0/100 ml

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