Evaluation of Water Quality of Different Colleges of Karachi City

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Summary: The quality of drinking water is equally important for every human being and when the concerned consumer of water is a young citizen, the importance of evaluation of drinking water quality becomes more evident. In the present study twenty three (23) samples of drinking water, collected from different colleges of Karachi city were evaluated for different physical and chemical parameters. The concentration of major chemical constituents like calcium, magnesium, sodium, potassium, chloride, sulfate and fluoride were analyzed in the range of (33-48) mg/ L,(9-80) mg/ L, (30-470) mg/ L, (4.9-7.1) mg/ L, (42- 688) mg/ L (32-214) mg/ L and (0.75-1.13) mg/ L respectively. The quality of this water was compared with USEPA and WHO drinking water standards and was found to be within the permissible limits in all of the samples excluding one, collected from Zamzama College, Clifton, whereas with reference to the concentration of nitrate 48 % samples were found to be with elevated levels of nitrate as nitrogen, according to both the WHO and USEPA guidelines, making the water unfit for human consumption. Further more data was statistically evaluated by normal distribution analysis.

Introduction

Human and animal consumption is perhaps the most evident essential use of water. Each person on the earth requires about two litres of clean drinking water each day which amounts to 10 million mc^3/ day for the world population [1]. Water is an essential part of the life of all human beings, and it supports the life process and without water it would not have been possible to sustain life on this planet. The total quantity of water on earth is estimated to be 1.4 trillion cubic meter [2] however for human beings, all water is not potable as such due to the presence of certain minerals, sediments and biological contamination which render different types of water fit and unfit for human consumption. Dissolved inorganic and mineral substances exert adverse effects on human beings dependent upon their concentration. The importance of studying the adverse effects of water borne chemicals upon human health has gained momentum and it has been established that many inorganic and organic constituents enter into natural waters from natural or man-made sources. The significance of these constituents to the quality of water, depends on many inter-dependent parameters [3]. Evaluation of physical, chemical, biological, bacteriological and radiological characteristics of water assists in determining its quality. Water used for drinking must be free from turbidity, color, odor and objectionable taste as well as from disease causing organisms and inorganic and organic substances, which may produce adverse physiological effects [4].

According to Agenda 21, the United Programme of Action for Rio Conference in 1992, an estimated 80 % of all diseases and over one third of the deaths in developing countries, such as Pakistan, are caused by the consumption of contaminated water and an average as much as one tenth of each person productivity time is sacrificed to water related diseases [1]. In Pakistan the access to safe water is available to only 60 % population (85 % urban, 47 % rural) [5]. Karachi is the biggest city of Pakistan having a population of 15 millions. This city has been confronting the menace of serious aquatic pollution since long time, mainly due to rapid industrial development, poor sanitation and unhygienic practices of civil authorities and the general public. When the water is being used by the nation builders, the importance of evaluation of water quality becomes a necessity. As hundred of students drink this contaminated water daily for an average time of 4-5 hours; it may definitely cause illness to them. In this scenario, drinking water samples, collected from different colleges of Karachi city were analyzed for various physicochemical parameters.

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Table-1A: Analysis of physical parameters in Water samples collected from different colleges of Karachi

S. No.	pH	Conductance (μS/cm)	Color (CU)	Turbidity (NTU)
*WHO	6.5	-	15	5
**USEPA	6.5	-	15	0.3-1
1.	7.61	401	<20	1
2.	7.60	464	10	0.8
3.	7.80	438	10	0.6
4.	7.42	490	10	1.1
5.	7.38	626	<20	0.9
6.	7.67	564	<20	1.4
7.	7.70	571	<20	1.7
8.	7.81	485	<20	0.6
9.	7.56	576	<20	0.3
10.	7.56	503	<20	2.3
11.	7.67	470	<20	3.0
12.	7.69	493	10	1.8
13.	7.63	487	10	0.9
14.	7.29	2970	<10	1.8
15.	7.38	449	10	2.1
16.	7.87	462	10	1.7
17.	7.39	527	10	1.9
18.	7.01	508	<20	2.2
19.	7.28	743	<20	0.9
20.	7.46	503	<20	2.4
21.	7.89	490	10	2.4
22.	7.65	413	<20	3.1
23	7.73	426	<10	2.7

* World Health Organization

** United State Environmental Protection Agency

Table-1B: Normal distribution statistics for hydro-physical parameters

	pH	Conductance (μS/cm)	Color (CU)	Turbidity (NTU)
Min	7.01	401	-	0.6
Max	7.89	2970	-	3.1
Mean	7.56	611	-	1.68
Median	7.60	490	-	1.7
Mode	7.60	490	-	0.9

Results and Discussion

WHO reports that at every eighth second, a child in low income countries dies of water related diseases [6]. In Pakistan over 40 % of urban deaths are attributed to the diseases caused by drinking of contaminated water [7]. Analytical data as regards water samples collected from different colleges of Karachi city is presented in Tables-1A and 2A. The present study was undertaken to find out, whether the water, being consumed by the students of different colleges of Karachi is safe for human consumption or not.

The quality of water in terms of pH, electrical conductance, color and turbidity does not seem to be deteriorated (Table-1A). pH of all the water samples range between 7.01-7.89, which is within the permissible limits of WHO guideline [8]. Turbidity has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. Turbidity may indicate the presence of disease causing organisms including bacteria, viruses and parasites [9]. In all the samples, turbidity was found to be in the range of 0.6- 3.1 NTU, which is within the allowable limits of WHO that is 5 NTU [8]. The physical appearance in terms of color is very important especially for the people having aesthetic sense. WHO sets the guideline of 15 CU for drinking water [8]. The range of color was 10 - < 20 CU in all of the collected samples. Conductivity of all the drinking water samples vary from 401-2970 μS/cm. These variations are due to the difference in concentration of free ions like Na^+, K^+ Ca^+, Mg^+, Cl^- and SO_4^{-2}

The mean concentration and ranges (given in parentheses) found for major cations and anions in all water samples are: calcium 37.56 (33-48) mg/ L, magnesium 16.56 (09-80) mg/ L, sodium 60.22 (30-470) mg/ L, potassium 6.1 (4.9-7.1) mg/ L, chloride 86.26 (42- 688) mg/ L and sulphate 54.96 (32-214) mg/ L. (Table-2B). The levels of all these ions are within permissible limits of WHO, except the sample No. 14, collected from Zamzama College, Clifton which may be due to sea water intrusion as this area is quite near to the sea. This statement is also supported by the brackish nature of water because its analysis shows that the water is of saline nature type.

Epidemiological studies have indicated a strong association between the occurrence of certain cancers and cardiovascular disease with the presence of metals and hardness in terms of Ca and Mg of the local drinking water supplies [10]. The hardness of samples of water ranges between 124-449 mg/ L as $CaCO_3$. Water is characterized as very soft, if its hardness is < 15 mg/ L as $CaCO_3$, soft when it ranges between 15-50 mg/ L, medium hard when 50-100 mg/ L, hard when 100-200 mg/ L and very hard when it is > 200 mg/ L as $CaCO_3$ [11]. On the basis of results obtained from the analysis, the water at present, being consumed in colleges may be characterized as hard water. There is an evidence that death rates from Cardio Vascular Diseases are inversely correlated with the hardness of water but there is insufficient proof that either the calcium or the magnesium in water is directly involved [8].

Table-2A: Analysis of chemical parameters in Water samples collected from different colleges of Karachi

S. No	Ca	Mg	Na	K	Cl	SO_4	NO_3-N	F	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	TDS
*WHO	-	-	200	12	250	250	12	1.5	-	-	1000
**USEPA	-	-	-	-	250	250	10	04	-	-	500
1.	38	09	30	5.7	44	40	11.21	0.99	132	105	200
2.	37	15	38	6.3	48	56	9.40	1.13	154	113	231
3.	36	12	35	6.2	44	43	9.12	1.06	139	118	219
4.	38	13	42	6.2	53	38	3.85	0.84	148	134	244
5.	44	17	55	7.1	82	52	6.56	0.88	180	141	312
6.	34	17	52	6.7	68	48	12.65	0.88	175	134	281
7.	38	17	50	6.9	69	52	16.78	0.92	165	134	285
8.	38	12	38	6.5	55	36	4.60	0.78	144	133	142
9.	36	17	50	5.8	74	58	15	1.13	160	139	287
10.	38	14	38	4.9	58	44	7.65	0.77	152	138	250
11.	34	16	37	6.3	50	60	8.26	0.84	170	133	235
12.	35	13	42	6.2	64	32	19	0.75	140	123	246
13.	37	13	42	6.3	53	48	2.65	0.81	146	120	243
14.	48	80	470	7.1	688	214	32	1.0	449	338	1480
15.	36	14	32	5.8	46	51	14.52	0.78	147	118	224
16.	35	14	37	5.9	46	54	14.25	0.84	145	102	230
17.	40	13	45	6.1	57	58	6.85	0.78	153	120	262
18.	34	14	45	6.0	70	46	17.10	0.81	142	104	253
19.	48	16	60	6.4	97	68	6.35	0.81	186	125	370
20.	33	12	36	5.7	61	40	14.66	0.88	132	102	250
21.	33	12	46	5.8	69	38	15	0.84	132	100	244
22.	38	10	32	5.4	46	50	8.94	0.81	124	108	206
23.	36	11	33	6.1	42	38	13.11	0.92	135	118	212

Note: All concentrations are in ppm

Table 2-B: Normal distribution statistics for hydrochemical parameters

	Ca	Mg	Na	K	Cl	SO_4	NO_3-N	F	TDS
Min	33	9	30	4.9	42	32	2.65	0.75	200
Max	48	80	470	7.1	688	214	32	1.13	1480
Mean	37.56	16.56	60.22	6.15	86.26	54.96	11.72	0.88	304.61
Median	37	14	42	6.2	57	48	11.21	0.84	244
Mode	38	12	38	6.3	46	38	15	0.84	244

Note: All values are in ppm.

Sodium salts are highly soluble in water and cause softness and if sodium content in the form of chloride and sulfate is very high, it makes the water salty in taste and unfit for human consumption. In 96 % water samples involved in the present study, sodium content were found to be within the safe limits of WHO i.e. 200 ppm [8]. Potassium an important macronutrient like sodium. It also plays an important role in establishing the electrolytic balance of human body [12]. 100 % samples of water have been found to be within the recommended WHO limit of 12 ppm.

The standard value for bicarbonate is 400 ppm in drinking water and has been observed that all the water samples have their values within the safe WHO limits [8]. Most of the sulfate salts are soluble in water and impart hardness to water. Water with about 500 mg/ L sulfate have a bitter taste and thus 1000 mg/ L or more may bring about intestinal disorders [13].

In natural fresh water, high concentration of chloride is regarded as a sign of pollution due to natural mineral deposits, agricultural or irrigation discharges, or from sewage and industrial effluents. The concentration of chloride in the drinking water samples of different colleges varies for 42-688 mg/ L. The reason for the high concentration of chloride in the water sample, collected from the college, located at Clifton may be due to sea water intrusion.

The high concentration of Total Dissolved Solids (TDS) increases the density of water, reduce solubility of gases like oxygen and ultimately makes the water unsuitable for drinking [8]. The highest value of TDS was found to be in sample No. 14. All other samples have dissolved solid in the range of 200 - 370 ppm. These values are under the legal recommendations.

Table-2A shows that nitrate content of samples range between 2.65-32 mg/ L as N. Nitrate is toxic to human beings when present in excessive amounts in drinking water. The most potent health effect of high nitrate levels in water is methaemoglobinaemia (blue baby syndrome) in infants upto 06 months of age [14]. It is also the main cause of exceptionally high 7-8 % mortality rate among the affected infants [15]. Other adverse effects of nitrate on human health are cancer and spontaneous abortion. [16, 17]. Similarly, nitrate which is mostly produced either due to the reduction of nitrate and / or oxidation of ammonia, is not only considered to be the etiologic agent of blue baby syndrome, but also plays its role in the production of carcinogenic nitrosomia. [18].

To a certain extent fluoride ingestion to the level of 0.6 ppm (WHO limits), is useful for bone and teeth development but excessive ingestion causes a disease known as Fluorosis, while the WHO standard and BIS: 10500- 1991 permit only 1.5 mg/ l as a safe limit of F in drinking water for human consumption. [19, 20] Fluorosis may cause skeletal Fluorosis, clinical Fluorosis, Dental Fluorosis, Non skeletal manifestation, or any combination of the above and in final stage it causes premature aging. Incidences of mottled teeth have been observed even with range of 0.7 - 1.5 mg/ L F in drinking water. Keeping in view the limit of 0.6 ppm for fluoride in drinking water, 100 % collected water samples are found to be unsafe. [21], while according to maximum permissible limit of 1.5 mg/ L set by WHO [8], all of the samples come under safe zone with respect to Fluoride.

To look into the trend and distribution pattern of physical and chemical constituents in the collected water samples, data was subjected to statistical analysis. Minimum differences between mean and median values in each case indicate the symmetrical normal distribution pattern (Tables-1B and 2B).

Experimental

Sample collection

During the study, 3-4 samples of drinking water were collected from each college in one liter polyethylene screw capped bottles, pre-cleaned with plenty of tap water followed by deionized water, dried at 100 °C for 1 hr, cooled at room temperature, capped and labeled. Samples were brought to the laboratory with prior care and immediately stored at 4 °C and analyzed as soon as possible. All the necessary precautions were observed while sampling and also during their transportation & storage [22].

Chemical Reagents and Determination

All the chemicals and reagents were of AR grade. Deionized water was used throughout the experiment 3-4 samples of water, from each college were analyzed for their pH, electrical conductance, turbidity, color, total dissolved solids, calcium, magnesium, sodium, potassium, fluoride, nitrate as nitrogen, chloride, sulfate, hardness and alkalinity. The analysis was carried out in triplicate to get a reliable data and mean values were recorded for each parameter. pH, temperature and electrical conductance were measured immediately, after the collection of samples, using portable digital pH Meter and conductivity meter JENWAY /E.U/430 pH/cad./ portable/ 02162. Color and turbidity were measured by Turbiditimeter HACH, 2100A and Aqua quant, Merck respectively.

Calcium and magnesium were determined by complexometric titration, chloride by argentometry and alkalinity by acidimetric titration with HCl to pH 4.5. Level of fluoride was determined through fluoride Ion Selective Electrode (VWR No. 34105-116) by using digital Ion Analyzer, Orion 701A. The calibration curve was prepared against NaF solution containing 0.25, 0.50, 1.0 and 1.50 ppm fluoride. Equal volume of ionic strength adjustment buffer (TISAB III, Orion 940911) was added in standards and also in the samples. The graph was further checked for accuracy by using 1 ppm fluoride /TISAB standard (Orion -040906) and 10 ppm fluoride/ TISAB standard (Orion 040908).

Determination of nitrate as N was performed by nitrate Ion Selective electrode (VWR- Cat # 34105-122) by using Digital Ion Analyzer, Orion 701A. The calibration curve was prepared against KNO_3 solution containing 1, 2.5,5,10,20, 40 ppm NO_3 as N. Coefficient (r) was 0.9979 and 0.9968 for F and NO_3 respectively. Emission spectroscopy was the analytical tool, used for the estimation of Na and K by using FES Corning 400. A series of working standard solution of each cation was prepared from certified stock standard solution (1000 ppm, Merck). Calibration curve drawn between concentration and emission intensity was statistically analyzed using fitting of straight line by least square method [22].

Conclusions

Thousands of students daily consume water in their respective colleges and this study has shown an alarming situation regarding the high contents of NO_3-N in 48 % of the collected samples. The relevant civic authorities should take urgent and effective steps to provide safe and healthy water to the builders of the nation by regulating the quality of drinking water under recommended WHO requirements.

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