INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES

Volume-3, Issue-3, July-Sept-2013
ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 02nd May-2013 *Revised: 12th May -2013* *Accepted: 13th May-2013*

Research article

ASSESSMENT AND EVALUATION OF THE QUALITY OF DRINKING WATER AT THE CONSUMER END –A STUDY OF HYDERABAD, ANDHRA PRADESH

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ABSTRACT: Concern over the presence of feacal coliform in public drinking water supplies has been expressed in recent years in Hyderabad since it has been regarded as pathogenic organism of prime importance in gastroenteritis. The present study was undertaken to examine the drinking water quality in and around Hyderabad at consumer end by collecting samples from twenty different locations. Residual chlorine was found in the range of 0.05 to 0.12 mg/l where as the coliform count ranged from nil to 04 cfu/100ml and E.Coli absent in the tap water at consumer end. The finished water quality at the consumer end meets the level of standards described as per APHA for potability in terms of its phyisco-chemical characteristics. Overall aim of this study is to create awareness about contamination of drinking water at consumer end and to make recommendations to provincial agencies such as Hyderabad Metro Water Supply & Sewerage Board (HMWSSB) and Andhra Pradesh Pollution Control Board (APPCB) that regular monitoring should be carried out to ensure that the chlorine residual is available at consumer end.
Key Words: water quality; consumer end; chlorine; public water supply; coliform

INTRODUCTION

For mankind water remains a basic need. It influences and alters the social, cultural, political and religious heritages of different communities. The need for plentiful supply of water is universally perceived and demanded. However, much importance is not given for the quality of water. Contamination of drinking water is a significant concern for public health throughout the world. The latest report of the WHO/UNICEF 2010 Joint Monitoring Programme on Water Supply and Sanitation entitled Progress on sanitation and drinking water update provides the most recent data for drinking water and sanitation, along with the implications and trends these new data reveal for reaching the basic sanitation and safe drinking-water MDG target [1]. With the MDG target date of 2015 only five years away, it is time to intensify efforts towards achieving the MDG target and addressing the glaring disparities worldwide. The provision of clean drinking water has been given priority in the Constitution of India, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State. In urban areas, the municipal authorities believe that their prime responsibility is merely to provide water connections, irrespective of the quality for human consumption, quantity and frequency of the supplied water. Water distribution systems play a pivotal role in preserving and providing quality water to the public. Little is known about the movement of contaminants, particulates, and disinfectants within the distributions system. Chlorine has been widely used as disinfectant due to its low cost and effectiveness in many countries. It is added to drinking water to reduce or eliminate microorganisms which are responsible for causing water borne diseases. Chlorine effectively inactivates the majority of organisms that cause diseases in humans like at 0.2 mg/l chlorine concentration for 3 minutes cause 99.99% reduction of Escherichia coli and at 0.5 mg/l chlorine for 6 minutes reduces 99% Salmonella typhi [2]. Addition of chlorine indifferent water treatment plant is a common practice, but it is not sufficient to ensure the safety of water. Regular testing is essential to ensure that adequate free residual chlorine is still present in the treated water. The maintenance of chlorine residue is needed at all points in distribution system supplied with chlorine as a disinfectant. Chlorine residuals of drinking water have long been recognized as an excellent indicator for studying water quality in the distribution network [3]. In the absence of a disinfectant residual, microorganisms in the distribution network will be recovered at high levels.

The presence of any disinfectant residual reduces the microorganism level and frequency of occurrence at the consumer's tap. Keeping residual chlorine at a certain level in tap water is effective not only in improving sanitary conditions but also in suppressing the re-growth of microorganisms and preventing the formation of bio-films on the internal surface of distribution pipelines.

The present study was based on order to assess the drinking water quality at consumer end in areas of Hyderabad, Andhra Pradesh and suggest remedial measures to improve upon the present system. The water samples were collected from twenty locations in and around Hyderabad at consumer end and analyzed for physico-chemical parameters. The physico-chemical quality of drinking water was analyzed using the standard methods given in APHA (American Public Health Association). The present study was funded by Andhra Pradesh State Council of Science and Technology (APCOST) 2011-12, Hyderabad, Andhra Pradesh, India.

STATE PROFILE

Hyderabad is the capital and largest city of the Indian state of Andhra Pradesh. It occupies 650 square kilometres (250 sq mi) on the banks of the Musi River on the Deccan Plateau in southern India. The population of the city is 6.8 million and that of its metropolitan area is 7.75 million, making it India's fourth most populous city and sixth most populous urban agglomeration. The Hyderabad Municipal Corporation was expanded in 2007 to form the Greater Hyderabad Municipal Corporation. As a growing metropolitan city in a developing country, Hyderabad experiences substantial pollution and other logistical and socio-economic problems. Its predominant topography is sloping rocky terrain of grey and pink granites. Several small hillocks are scattered throughout the area. Hyderabad has an average altitude of 1,778 feet (542 m) above mean sea level. Its highest point is Banjara Hills at 2,206 feet (672 m). In 1996 the city had 140 lakes and counted 834 water tanks smaller than 10 hectares (25 acres). The city's lakes are often called *sagar* (sea). Hussain Sagar, built in 1562, is near the city centre. Osman Sagar and Himayat Sagar are artificial lakes created by dams on the Musi.

STUDY AREA

The study was undertaken in the following locations of Hyderabad in consultation with the Hyderabad Metro Water Supply and Sewerage Board (HMWSSB), Hyderabad. Table-1.

Table-1: Sampling locations

S.No	Sampling location
L1	L.B Nagar
L2	Boinpally
L3	Uppal
L4	Malkajgiri
L5	Kukatpally
L6	Tolichowki
L7	Red Hills
L8	Masab Tank
L9	Erragadda
L 10	Shaikpet
L11	Begumpet
L12	Vidyanagar
L13	Musheerabad
L14	Abids
L15	Malakpet
L16	Mogalpura
L17	Bahadurpura
L18	Kanchanbagh
L19	Yakatpura
L20	Shalibanda

SAMPLING

Water samples were collected in sterile glass bottles containing three to four drops of 3% sodium thio-sulfate in order to neutralize any residual chlorine. Water samples were collected and stored on ice and transported to the laboratory for microbiological and physicochemical analysis within 20 hours.

CHEMICAL ANALYSIS

Chlorine residual, was determined by DPD ferrous titrimetric method as per methods described in the standard methods [4]. Turbidity was measured by the nephelometric method using a Hach model 2100A turbidimeter. Similarly, temperature and pH was measured using a Hach pH meter (sension 1) whereas TDS and electrical conductivity were also determined by Hach meter (sension 5). Remaining parameters where analyzed as per the APHA standards.

MICROBIOLOGICAL ANALYSIS

The total coliform and fecal coliform counts were determined by multiple tube dilution procedure given in the Standard Methods for the Examination of Water and Wastewater using lauryl tryptose broth (LTB) for the presumptive test and brilliant green lactose broth for confirmation. Standard plate counts (SPC) were also determined as per standard methods. Standard methods were followed in collecting, handling, preserving, and analyzing samples for the abovementioned parameters (APHA 2005).

RESULTS AND DISCUSSIONS

The observation of the physico-chemical characteristics of drinking water samples collected from the different consumer end is given in Table 2. The analysis results indicated that all the drinking water samples collected at the consumer end are within the permissible levels and potable.

WATER QUALITY CHARACTERISTICS

The physico-chemical parameters were analyzed to assess water quality of the collected water samples at the consumer end. The analysis details are as follows

pH: The pH values measured for the water samples at consumers end in Hyderabad varies between 7.14 to 7.94. All the values are well within the WHO permissible limit of 6.50-8.5. These results are also in accordance with the earlier study conducted by [5] in which the pH values varied from 7.02 to 7.30.

Table 2- Details of Physico-Chemical Analysis of Drinking Water at Consumer End

#	Parameters	Desirable Limitsas per IS:10500	Sampling Locations at Consumer End																			
			L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20
1.	pH	6.50 – 8.50	7.49	7.51	7.62	7.78	7.84	7.54	7.29	7.28	7.56	7.26	7.36	7.58	7.14	7.38	7.94	7.62	7.26	7.42	7.42	7.46
2.	Electrical Conductivity (µS/cm)	--	398	418	414	456	336	286	290	276	288	336	296	452	434	408	426	356	358	362	338	358
3.	Total Dissolved Solids (mg/L)	500 max	256	268	266	292	218	182	182	172	182	214	188	288	278	264	272	222	228	234	216	228
4.	Turbidity (NTU)	5 max	1.80	2.80	2.20	2.6	2.50	1.60	1.30	1.80	1.60	2.60	3.1	1.60	1.70	2.20	2.10	2.0	2.60	2.20	2.00	2.10
5.	Color	Colorless (CL)	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
6.	Total Hardness as $CaCo_3$ (mg/L)	300 max	128	136	128	120	96	104	112	104	112	112	96	120	120	120	128	120	112	120	112	104
7.	Chloride as Cl (mg/L)	250 max	49.7	53.3	53.2	42.6	35.5	31.9	31.9	28.4	28.4	35.5	28.4	63.9	63.9	56.8	49.7	35.5	39.0	35.5	35.5	49.7
8.	Nitrate as No_3 (mg/L)	45 max	4.3	3.8	3.8	3.8	3.2	2.8	2.5	2.4	2.5	2.5	2.5	3.8	3.7	3.2	3.7	3.3	3.1	3.3	3.6	3.3
9.	Residual Chlorine (mg/L)	0.2 max	0.08	0.12	0.16	0.08	0.09	0.06	0.05	0.08	0.09	0.12	0.07	0.09	0.06	0.07	0.09	0.08	0.08	0.08	0.06	0.07
10.	Fluoride as F (mg/L)	1.0 max	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
11.	Coliform Bacteria (cfu/100mL)	10 max	06	02	Nil	02	04	Nil	01	04	02	Nil	01	02	02	Nil		Nil	Nil	Nil	Nil	01
12.	E.Coli (cfu/100mL)	Absence (A)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Total Dissolved Solids (TDS): The TDS values of water samples at consumers end ranged from 172 to 292 mg/l respectively. The United States Environmental Protection Agency [6] recommends treatment when TDS concentrations exceed 500 mg/L or 500 parts per million (ppm). The TDS concentration is considered a secondary drinking water standard, which means that it is not a health hazard. However, water with a high TDS concentration may indicate elevated levels of ions that do pose a health concern, such as aluminum, arsenic, copper, lead, nitrate, and others. These results are also in agreement as reported by [5].

Electrical Conductivity (EC): A Conductivity value varies from 286 to 456 µS/cm. There is a direct relationship between TDS and conductivity as it is evident from the results. As the concentration of dissolved salts (usually salts of sodium, calcium and magnesium, bicarbonate, chloride, and sulfate) increases in water, electrical conductivity increases [7]. The electrical conductivity is higher for water that has more dissolved ionic species.

Residual Chlorine: In drinking water samples at consumer end in Hyderabad, the value of total chlorine observed varied from the lowest value of 0.05 to the highest value of 0.16 mg/l free chlorine is the most effective residual disinfectant and may serve as a marker or flag in the distribution network [7].

These results are in line with the findings of [9] who found no residual chlorine detected at any of the sampling points while assessing the potable water quality at the end-user level in 14 major urban centers in India. Similar findings have also been reported by [8] who found free and combined chlorine in the range of 0.2 to 1.0 mg/L in drinking water distribution system. Presence of a disinfectant residual is especially important in developing countries because of poor sanitary conditions and the high risk of recontamination during distribution. In a study conducted by [10] in Islamabad, Pakistan where hepatitis E outbreak occurred when consumers drank untreated water during major reparation of a treatment plant. Turbidity: The turbidity values were within the highest desirable level values of WHO [11] i.e., 5 NTU, and ranged from 1.3 to 3.1 NTU. Similar results were also reported earlier in a study conducted by the National Water Quality Program, PCRWR [12] which revealed the range of turbidity from 1.10 to 6.40 NTU. Deterioration in drinking water quality in distribution networks is probably due to an increase in microbial numbers, an elevated concentration of iron or increased turbidity, all of which affect taste, odor, and color in the drinking water. Turbidity can provide shelter for opportunistic microorganisms and pathogens [13].

A study reported by [14] indicated that the removal of turbidity and soft deposits from water distribution pipelines decreased microbial growth in the distribution system during the summer season when there were favorable temperatures for microbial growth. [15] Found out that turbidity and soft deposits are the key site for microbial growth in drinking water distribution networks. The microbial numbers in the soft deposits were significantly higher than numbers in running water mainly consisting of heterotrophic bacteria, coliform bacteria, actinomycetes, and fungi. Waters with high turbidity from organic sources also give rise to a substantial chlorine demand and for disinfection purposes [16]. This could result in reductions in the free chlorine residual in distribution systems as protection against possible recontamination. Increased prechlorination dosage requirements are strongly correlated with increases in turbidity. Microbiological Analysis: The coliform and E.Coli test revealed that the samples were not contaminated. Other parameters: The hardness in the samples varied from 96 to 136 mg/l, Chloride from 28.4 to 49.7 mg/l, nitrate 3.1 to 4.3 mg/l and fluoride from 0.3 to 0.4 mg/l which are under permissible limits.

CONCLUSION

In general it was found that the water quality of 20 samples collected from tap at consumer end is suitable for drinking purpose. Hence, the new water distribution systems are capable of maintaining high water quality from the water treatment facilities to the end-user. If water distribution pipelines are changed according to the suggested time period it will not decay the properties of pipeline materials, hydraulic conditions, biofilm thickness, excessive network leakages, corrosion of parts, and intermittent service. Water distribution systems play a pivotal role in preserving and providing quality water to the public. Regular testing is essential to ensure that adequate free residual chlorine is still present in the treated water. The maintenance of chlorine residue is needed at all points in distribution system supplied with chlorine as a disinfectant. Keeping residual chlorine at a certain level in tap water is effective not only in improving sanitary conditions but also in suppressing the re-growth of microorganisms and preventing the formation of biofilms on the internal surface of distribution pipelines.

SUGGESTIVE MEASURES

Providing safe drinking water to all in urban India is a challenging task. Given the diversity of the country and its people, solutions have to be diverse. One has to look at an approach that seeks the participation of users through interventions engaging the communities with various government schemes and policies. Citizens should be made aware of the demand for clean drinking water as a right. Such an integrated approach would incorporate collaborative efforts of various sectors involving the government, civil society and needless to say the people.

Supporting awareness drives

One of the major challenges is to make people aware on the need to consume safe water. There are examples where despite being provided potable water by the government, people drink water from contaminates surface sources. The government needs to support civil society and organizations involved in increasing awareness. An integrated campaign can result in wide spread information dissemination amongst the masses on the ways and means of preventing contamination of water sources.

Testing and remedial action

There is an urgent need to enhance the monitoring network by establishing monitoring stations across all regions and seasonal assessments of all water sources. In case of contamination being detected, an action plan for dealing with sources should be provided. The challenge lies in establishing well equipped laboratories with well trained staff. This also calls for training of people and infrastructure development. Although there has been wide usage of field testing kits, they often give false or semi-quantitative results.

One can rely on field testing kits for a broader picture, but laboratory tests are necessary for accurate results. The generated data should be made available in the public domain. Generating data, its interpretation and communication is essential for effective management of water and the use of Geographical Information System (GIS) can assist in mapping, modeling and decision-making.

Capacity building of communities

A prerequisite for increasing community participation is training of people from the communities so that they are able to make well-informed decisions. The objectives of decentralization can come about only if there is an attitudinal change among government functionaries as well as the people, with respect to decentralization, transferring authority and responsibility to the people at the community level. The role of the government in implementing capacity building programmes is essential.

ACKNOWLEDGEMENT

The authors thank the Andhra Pradesh State Council of Science and Technology (APCOST) Hyderabad, Andhra Pradesh, India for funding this project in the year 2011-12.

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