Assessment of seasonal variation of drinking water quality in Mysore, India

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SUMMARY

The seasonal variation of drinking water quality at Mysore, Karnataka, India was carried out during 2007-2008. The physico-chemical and bacteriological assessment was carried out for drinking water samples from selected areas of Mysore. The study revealed that water contained high concentration of fluoride contents in some areas and with excess of iron, copper, magnesium and nitrate contents which exceeded the permissible limit (ISI). Parameters like Total Dissolved Solids (TDS), Alkalinity, were also high in all seasons. Among 15 samples, 8 samples show the positive results during biochemical confirmatory test. The bacteriological studies showed that the water samples were unsafe in all the seasons. The result also showed that there was vide variation in the quality of drinking water supply in different areas of Mysore city. Based on the results obtained by the analysis, the quality of the drinking water supply varied from moderate contamination to larger extent of contamination.

Key words : Drinking water, Water quality, Seasonal variation, Physico-chemical and biological parameters, Alkalinity.

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Eight thousand children around the world die from diarrhea everyday. That is about three million people die every year from preventable disease. According to World Health Organization (WHO, 1984) more than 80 per cent diseases in the world are attributed to unsafe drinking water or inadequate sanitation practices (Diamant, 1982). In India, every year number of death of children under the age of five is attributed to poor quality of drinking water. It is estimated that poor quality and inadequate quantity of water accounts for about 10 per cent of the total burden of diseases in the Karnataka State, India (World Bank Report, ISEC, Bangalore, 2002). Almost 70 per cent of Indian surface water resources and a growing number of its groundwater reserves have been contaminated by biological, organic and inorganic pollutants (Rajanna *et al.*, 2001).

Mortality from disease like gastroenteritis occurs mainly due to contamination of water. Infections of diarrhea make the largest single contribution to the burden of disease associated with unsafe water and hygiene. It is no wonder that the incidents of hepatitis has been increasing dramatically in most Indian cities. In the last 5 years, the spreading of hepatitis is more when compared to that of previous 15 years (Thyagarajan *et al.*, 2002). The fundamental duty of public health system of any government is supplying clean drinking water to reduce the incidents of water borne diseases. But evidences show that supplying clean drinking water is not enough. There are lot of reports (Nagaraju ,1999 and Report in The Hindu, 2007) on epidemic diseases such as amoebic dysentery, vomiting, gastroenteritis, jaundice and typhoid fever along with intestinal diseases in some areas of Mysore, which are caused by consumption of polluted water, supplied by Mysore Municipal Water supply.

Improper management, old and obsolete machinery, lack of management, water politics and many other factors have proved to be a hurdle for effective supply of clean and pure water. Supply of treated water to the residents of Mysore city began in the year 1896 by the Maharaja of Mysore. The water treatment plant located at Belagola (about 10km from Mysore) was supplying 2.27 mg/d of water to the city. In 1998 the water supply system was improved and the city got 140 mg/d of water. The piped water supply to the city also started in 1896 and 227 million liter per day of raw water was being pumped from Belagola pumping station and treated at VVWW (Vani Vilas Water Works) Yadavagiri, Mysore city.

Until recently, Mysore has never faced shortage of water. Even during in acute summer, the water level at Krishna Raja Sagara Dam (KRS) stands at 80 feet. Water can be pumped from the reservoir even when the water level at the reservoir is 64 ft. As per the CPHEEO (Central Public Health and Environmental Engineering Organization, New Delhi) guidelines, each resident has to be supplied 135 litre of water per day. The total quantity of water required for a population of 10 lakh is 192 million

litre per day. A total of 160 million litre per day of water is being pumped, but despite such huge quantity of water, many areas of the city do not get adequate water, because of the usage for industrial purposes and other losses. The main hurdle for the effective water supply is the defective water distribution system. Though water is pumped to the maximum extent from the reservoir, its quantity will be reduced to half when it reaches the pumping station, while some more quantity of water get wasted during the purification process at pumping station and during supplying system. Hence, the residents receive only 20% of water. Cauvery river water is supplied to different areas of Mysore city through four different pumping stations, which are Belagola Station, Hongalli Station second stage, Hongalli Station third stage and Melapura station.

The main purpose of this study is an assessment of seasonal variation of the drinking quality supplied by municipal water supply of the Mysore, Karnataka, India. The physico-chemical analysis and bacteriological test of the drinking water from different residential areas of Mysore city were carried out, in order to find out possible source of water contamination.

MATERIALS AND METHODS

The study area, Mysore is a unique city having around 12 lakh population and was the capital of former princely state of Karnataka. It lies between 12^0 9' and 11^0 6' latitude and $77^0$7' longitudes and general elevation is little more than 1800 feet above sea level. It has been described as an undulating tableland with granite rocks protruding at odd intervals. The principle rock types of Mysore are igneous granites and metamorphic gneissic and schist's of Precambrian age. The yield of wells in the crystalline rocks depends on the presence of weathered pockets, joints and fractures. (Radhakrishna and Vaidyanadhan, 1997). The climate of the city is moderate throughout the year with temperature during summer ranging from 30^0 to 34^0 C. The rainy season is from May to October with maximum rainfall in the month of May, September and October. The average annual precipitation is around 76 cm. The predominant wind directions during summer season are from south-west and north-west with maximum wind speed 7 km/h. Similarly in winter season, the predominant wind direction is south-west with maximum wind speed of 9 to 12 km /h. The source of water is mainly depending on the both Cauvery river and ground water for the domestic purposes.

The assessment of drinking water quality of Mysore city in selected areas (Fig. 1) was carried out in the study period from October 2007 to March 2008 (Post-monsoon and Pre-monsoon). The sample collections from 15 different locations were spread all over the Mysore city. The samples from all the locations were collected in sterile sampling bottles and were processed in duplicate.

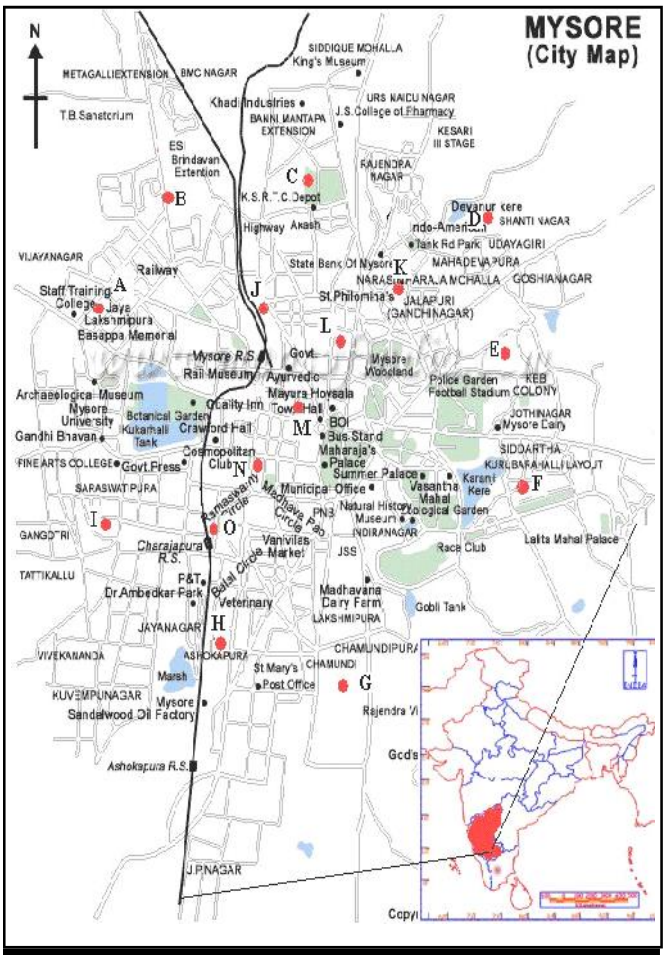

Fig. : 1 Mysore city map showing sample sites in different areas

The water quality parameters like physico-chemical and biological analysis were carried out. Physical parameters like turbidity, temperature, pH and chemical parameters like total solids, dissolved oxygen with some of the metals were analyzed using APHA (1992) standards and the bacteriological parameters of the water samples were examined by multiple tube fermentation techniques. In this method MacConkey broth was used, and also the samples which gave positive result in presumptive test, were subjected to confirmatory test by using BGLB (Brilliant Green Lactose Bile) (APHA, 1981 and BIS, 1983).

RESULTS AND DISCUSSION

The Post-monsoon samples were collected during October to December 2007 and the results of physico-chemical analysis have been shown in the Table 1. The

Table 1 : Physico-chemical characters (Post-monsoon season, 2007)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Jayalakshmipuram	19	--	--	900	6.5	627.1	0.9	106	1.5	100	24	33	30	NF	NF	120	NF	NF	100
Kumbarakoppalu	19	--	--	850	6.5	654.26	0.6	78	0.16	130	27.7	41	50	NF	NF	120	NF	NF	150
Shivarathreeshwaranagar	19	--	--	840	7.5	628.1	0.8	99	0.2	150	30	45	30.5	NF	0.1	120	NF	NF	200
Shanthinagar	19	--	--	1200	6.5	577.3	0.5	106	0.8	180	30.1	48	20	NF	0.2	100	NF	NF	150
Jyothinagar	19	--	--	920	7	462.4	0.9	72	0.5	110	28	32	30	NF	NF	120	NF	NF	150
Siddarthalayout	18	--	--	908	6.5	598.2	0.9	78	2.4	80	35	44	30	NF	NF	100	NF	NF	100
Vishweshwaranagar	19	--	--	950	6.4	528.9	0.6	90	1.7	120	41	40	45.9	NF	0.2	120	NF	NF	150
Ashokpurum	19	--	--	938	7	524.4	0.9	106	1.5	100	26.6	27	53	NF	NF	80	NF	NF	150
Kuvempunagar	19	--	--	956	7.5	493.2	0.1	90	1.9	120	17	44	35	NF	NF	80	NF	NF	120
Tilaknagar	21	--	--	1200	7	570.3	0.1	78	0.2	75	15	41	50.2	NF	NF	100	NF	NF	120
N.R Mohalla	20	--	--	1466	7.5	513.7	0.5	78	0.2	120	17	40	50	NF	0.1	115	NF	NF	150
Veeranagere	20	--	--	790	7	495	1.2	90	1.8	120	30	55	40	NF	NF	90	NF	NF	100
Kumbarageri	19	--	--	850	6.5	587.5	0.9	108	0.6	90	37	45	20	NF	NF	90	NF	NF	120
Sunnadhakeri	19	--	--	1300	6	563.1	1.6	150	2.5	150	40	48	20	NF	0.3	120	NF	NF	100
Vidhyaranyapurum	20	--	--	1100	6.5	112.4	1	110	1.4	80	27	44	48	NF	NF	110	NF	NF	100

1. Temparature, 2. Colour, 3. Odour, 4. Conductivity, 5. pH, 6. TDS, 7. Iron, 8. Chloride, 9. Fluoride, 10. Hardness,
11. Magnesium, 12. Calcium, 13. Nitrate, 14. Manganese, 15. Copper, 16. Sulphate, 17. Zinc, 18. Chromium, 19. Alkalinity.

Pre-monsoon samples were collected during January to March 2008 and the results of physico-chemical analysis have shown in the Table 2. All the water samples observed are found to be colourless, except samples which were chlorinated and the temperature of samples ranged between 18^0 C to 24^0 C, and there was no marked variation in temperature.

The pH of all samples ranged between 6 to 7.8 and it indicated that the pH ranges from acidic to alkaline. The electric conductivity of all the samples of water supply ranged between 750m mho to 1466mho. The electric conductivity of water samples reveals that the level of dissolved ionic substance was high during the period of Post-monsoon season. Some other areas have high

Table 2 : Physico-chemical characters (Pre-monsoon season, 2008)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Jayalakshmipuram	21	--	--	750	6	538.6	1	106	0.6	120	30.1	36	35	NF	0.1	120	NF	NF	150
Kumbarakoppalu	21	--	--	750	6.5	525.9	0.5	90	2.3	120	35	44	32	NF	0.1	80	NF	NF	120
Shivarathreeshwaranagar	21	--	--	855	6.5	530.4	0.3	95	1.1	150	30.1	33	30	NF	0.1	80	NF	NF	110
Shanthinagar	22	--	--	920	7	502.5	0.9	78	0.6	130	26	52	26	NF	NF	100	NF	NF	100
Jyothinagar	22	--	--	1201	6.5	561.6	0.8	78	0.8	90	40	38	35	NF	0.1	120	NF	NF	100
Siddarthalayout	22	--	--	760	7	529.3	1.2	108	1.1	90	25	55	42	NF	NF	150	NF	NF	120
Vishweshwaranagar	22	--	--	890	6.5	593.7	1.1	150	1.6	100	27	40	42	NF	NF	90	NF	NF	120
Ashokpurum	21	--	--	1151	7.8	589.7	0.7	90	1	130	32	32	37	NF	NF	90	NF	NF	120
Kuvempunagar	22	--	--	1015	6.5	613.3	1.2	106	1.1	150	33	28	27	NF	NF	80	NF	NF	180
Tilaknagar	24	--	--	900	6.5	546.55	0.3	106	0.25	180	19	32	25	NF	NF	99	NF	NF	150
N.R Mohalla	24	--	--	830	7	535.7	0.9	110	0.8	80	30	35	30	NF	0.1	115	NF	NF	150
Veeranagere	22	--	--	1200	7.8	444.4	0.8	98	0.6	120	27	32	35	NF	0.1	120	NF	NF	90
Kumbarageri	22	--	--	1300	7.5	486.5	0.8	99	0.7	75	34	29	42	NF	0.1	65	NF	NF	100
Sunnadhakeri	22	--	--	780	6.5	444.8	0.8	98	1	80	28	36	42	NF	0.1	80	NF	NF	120
Vidhyaranyapurum	24	--	--	950	7	102.2	1	100	1.2	90	25	30	40	NF	0.1	70	NF	NF	90

1. Temparature, 2. Colour, 3. Odour, 4. Conductivity, 5. pH, 6. TDS, 7. Iron, 8. Chloride, 9. Fluoride, 10. Hardness,
11. Magnesium, 12. Calcium, 13. Nitrate, 14. Manganese, 15. Copper, 16. Sulphate, 17. Zinc, 18. Chromium, 19. Alkalinity

amount of ionic substances in water samples during Pre-monsoon season.

In the present investigation, the TDS values ranged between 65 mg/l to 200mg/l in both the seasons, and are found within permissible limit which do not cause any harm to the consumers. But when compared the concentration of TDS was more in Post-monsoon season (Table 1) this may be due to more suspended and dissolved solids are present in the Cauvery river bed. However, there are reports by Jain *et al.* (2003) that TDS limit extends upto 500mg/l, concentrations can cause gastrointestinal irritation.

The calcium contents were comparatively higher than magnesium. The calcium contents ranged from 28 mg/l to 55.0 mg/l during both the seasons of the study which are found to be well under permissible limits (75 mg/l). The most common effect of calcium in water is its tendency to react with soap to form a precipitate called 'Soap Curd (Dilip *et al*., 2001).

Magnesium is exceeding the permissible limits in some areas. In drinking water magnesium acts as a nutrient within permissible limit (30 mg/l). Calcium concentration in natural waters should generally be less than 75mg/l. Calcium and magnesium can combine with carbonate and interfere in maintenance of water quality. Pure water at 23ºC can dissolve about 13 ppm of calcium carbonate or about 5ppm of calcium. The major anion in water is sulphate and when bicarbonate concentration is low, the solubility of calcium sulphate will control the final concentration of calcium in water.

Hardness of water mainly depends upon the amount of calcium and magnesium salts or both. In the present study, Hardness ranged between 75 mg/l to 180 mg/l in both the seasons. The total hardness from all samples was within permissible limit 300 mg/l. The presence of calcium and magnesium along with their carbonates, sulphates and chlorides make the water hard.

The presence of nitrate in water sample indicates the biological contamination of water. The permissible limit of nitrate content in drinking water is 10 mg/l to 45 mg/l. In this study, the nitrate concentration was between 20 mg/l to 53 mg/l. The amount of nitrate was above permissible limit in some areas during seasons of Post-monsoon, where as in remaining locations the content was well below the limits. If nitrate in public water supply exceeds 45ppm, remedial measures must be taken.

The result obtained shows that chloride contents ranged between 72 mg/l to 150 mg/l in both the seasons. In all the samples the amount of chloride was found within permissible limit. Shiva Kumar *et al.* (2000) and Hari Haran (2002) reported that concentration upto 250mg/l is an indication of organic pollution.

Fluoride is an important nutrient in drinking water for the development of normal bone and teeth, but it should be within permissible limit. The excess fluoride in the water causes dental flurosis, skeletal flurosis and crippling flurosis. The permissible limit for fluoride in drinking water is 0.6 mg/l to 1.2 mg/l. The fluoride content ranged between 0.2 mg/l to 2.5 mg/l during Post-monsoon-2006 and 0.2 mg/l to 2.3 mg/l during the period of Pre-monsoon-2007. Samples from Siddarthalayout, Vishweshwaranagar, Ashokpurum, Kuvempunagar, Veeranegere, Sunnadakeri and Vidhyaranyapurum consist of high amount of fluoride content during Post-monsoon-2007 which is higher than permissible limit. The amount of Fluoride content was high in Kumbarakoppal, Shivarathreeshwaranagar, Siddarthalayout, Kuvempunagar, Vishweshwaranagar Sunnadakeri and Vidhyaranyapurum during Pre-monsoon-2008.

Sodium sulphate and magnesium sulphate exert a cathartic action in human beings. It is also associated with respiratory illness. The permissible limit in drinking water is 150 mg/l. In present study, sulphate content ranged from 65 mg/l to 150 mg/l and was found to be within permissible limit.

Metal level:

Manganese, zinc and chromium were found to be nil in all the samples collected. The result shows, copper is exceeding the permissible limit in some samples of drinking water supply of Mysore city.

The amount of iron content in water samples ranged from 0.1mg/l to 1.6mg/l, during both the seasons. The result obtained shows less iron content in Kuvempunagar and Tilaknagar. The samples of Sunnadakere, Veeranagere and Vidhyaranyapurum shows high amount of iron contents (upto 1.6 mg/l) during the period of Post-momsoon-2007 and during Pre-monsoon-2008 seasons the iron content ranged between 0.3 mg/l to 1.2 mg/l. The samples of Siddarthalayout and Kuvempunagar showed higher amount of iron content during Pre-mansoon. The concentration of iron exceeds the permissible Indian Standards in most of the locations during both the seasons and is a matter of concern (Table 1 and 2).

Bacteriological quality:

The acceptable limit of MPN/ml for bacteriological quality prescribed for drinking purposes by Indian standard is (ISI, 1982) limit less than 10 total number of coli form per 100 ml and zero for faecal coli forms (ICMR).

The bacteriological quality of drinking water supplied in different areas of Mysore city during Post-monsoon-

Table 3 : Bacterialogical quality of drinking water

	Post monsoon-2007			Pre monsoon-2008		
	Coli-form	f-coliform	Bio-chemi	Coli-form	f-coliform	Bio-chemi
Jayalakshmipuram	39	5.6	+ve	24	2	-ve
Kumbarakoppalu	45	8	+ve	24	2	-ve
Shivarathreeshwaranagar	7.4	0	-ve	9.3	1.8	-ve
Shanthinagar	7.4	0	-ve	9.1	0	-ve
Jyothinagar	25	3.6	-ve	28	3.6	+ve
Siddarthalayout	8	<0	-ve	43	4	+ve
Vishweshwaranagar	31	3.6	-ve	36	3.6	+ve
Ashokpurum	51	8	+ve	11	2	-ve
Kuvempunagar	13	5.5	+ve	23	0	-ve
Tilaknagar	9.3	1.8	-ve	7.3	0	-ve
N.R Mohalla	32	4	+ve	32	2	-ve
Veeranagere	40	6	+ve	32	3.6	-ve
Kumbarageri	20	2	-ve	37	4	+ve
Sunnadhakeri	25	6	+ve	41	5.4	+ve
Vidhyaranyapurum	30	4	+ve	20	1.8	-ve

2007 (Table 3) is unsatisfactory. Water supply samples from only Shivaratreeshwaranagar, Shanthinagar, Siddarthalayout and Tilaknagar have satisfactory value with respect to coli form organisms, presence of faecal-coli form in drinking water serves as a potential indicator of harmful bacteriological pollution. Out of 15 Samples of water supply. Only Shivaratreeshwaranagar, Shanthinagar and Siddarthalayout found free from faecal coli form.

The study of Pre-monsoon-2008 (Table 2) also shows the unsatisfactory result with respect to total coli form except some areas like Shivaratreeshwaranagar, Shanthinagar and Tilaknagar. Out of 15 samples of water supply, only samples of Shanthinagar, Kuvempunagar and Tilaknagar found free from faecal coli form, in drinking water supply. Out of 15, 12 water samples have crossed

Fig. 2 : Contamination of drinking water by sewage water

the permissible limit with respect to the total coli form and feacal coli form bacteria in drinking water during the season of Post-monsoon-2007 and 11 samples crossed the permissible limit of both total coli form and feacal coli form in the water supply during the season of Pre-monsoon-2008. Among them about 5 to 8 samples shows the positive results during biochemical confirmatory test with respect to the seasons of Post-monsoon-2007 and in Pre-monsoon-2008.

Following points were observed during the study regarding the water supply of Mysore city

- The location of water supply pipes are closed to the sewage drains, septic tanks and the leakage of sewage water may enter in to the water supply pipes through breakage, pipe joint connections or may be valves of water supply pipes (Fig. 2).
- Direct exposing of water supply pipes, connection sites, water supply pipes valves, stop wall fits and water storage tanks to the outer surface of earth and atmosphere.
- The pipes which are using for water supply in Mysore city are old and metallic (iron pipes), the pipes are already degraded and corroded and the pipes easily under go leakage, breakage and hole formation during water supply. This is also one of main causes of entry of sewage water, sewage storm water, and surface runoff water into the water supply pipes.
- Direct pumping of bore well water into the over head tanks and direct mixing of bore well water with VVWW supply water, may also cause pollution of drinking water supply of Mysore city. Because almost all the bore well water in Mysore city are chemically and biologically contaminated (Srikantaswamy *et al.*, 2007) and some bore wells are located nearest the sewage drainage (Fig. 2) and also direct entry of sewage water into the bore well is taking place in Mysore city.
- Poor maintenance of tanks, lack of inspection and leakage of water through faults and holes of corroded metal pipes may also lead to pollution or contamination of drinking water in Mysore city.

Conclusions:

The results from the study would greatly facilitate the health and sanitary authorities to monitor and control drinking water pollution in Mysore city. The study indicate that the drinking water supply to the public is nor physico-chemically and biologically satisfactory in both the season. It needs more detailed study on chemical contamination including sewage contamination, bore well contamination and water leakage of drinking water supply in Mysore city. It needs the disinfection of drinking water at the site of each over head tanks and storage tanks in the water supply system. As an alternative option, the boiling of water for 15 to 20 min to kills the bacteria, causing water borne diseases and filtration by micro filter to ensure the prevention of health hazard. Health education awareness and community participation of illiterate labour of the slum areas are very essential to make them aware of utility and importance of portability of drinking water. Periodic water quality monitoring is necessary. The study reveals that there is no considerable difference in quality of drinking water supplied in Mysore city during the Post and Pre-monsoon seasons.

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