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Research Article

Studies on Seasonal Variations of Ground Water Quality in Major Cities of Southern Part of India (Chennai, Bangalore and Hyderabad)

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Abstract

Three major cities in India such as Chennai, Bangalore and Hyderabad were selected for this study. The study mainly focused on assessment of physico-chemical as well as biological properties of ground water on four different seasons like spring, summer, autumn and winter in the year 2012. The physico-chemical parameters like pH, turbidity, TDS, TH, Ca^{2+}, Mg^{2+}, TA, Cl^{-}, SO_4^{2-}, NO_3^{-}, F^{-}, Fe and biological parameters like total coliforms were analyzed using standard procedures and all the parameters were expressed in milligram/L except turbidity which expressed in NTU and total coliforms which expressed in MPN/100 mL. Based on the results obtained from this study, clear evidence on seasonal wise variations on ground water quality was observed in Southern part of India. Further the suitable reverse osmosis technology is recommended for accessing the safe drinking water from ground water.

Keywords: Total coliforms, pH, turbidity, TDS and TH

INTRODUCTION

Ground water quality is the most important one, because the poor quality of water may adversely affect the plant growth and human health (Wilcox, 1948; Thorne and Peterson, 1954; US Salinity Laboratory Staff, 1954; Holden, 1971; Todd, 1980; ISI, 1983; WHO, 1984; Hem, 1991; Karanth, 1997). Due to increased population in major cities like Chennai, Bangalore and Hyderabad assessing the surface water is tedious one for drinking and the result is shifting into a ground water. Further the exploitation of ground water has greatly increased, particularly for drinking and agricultural purpose, because large part of the country have little or no rainfall due to frequent failures of monsoon and variable reach of surface water sources like rivers, lakes and artificial basins.

A number of studies focused on quality of ground water in various parts of the country but mainly for irrigation purpose in rural area. In this study the heart of southern part of Indian cities like Chennai, Bangalore and Hyderabad were selected and the samples from bore wells frequently used by the public were collected and analyzed for the physico-chemical as well as biological characteristics of water for the assessment of safe drinking water and also assessed the studies on seasonal wise variations in water quality parameters with respect to the locations and suggested the suitable treatment methods.

MATERIALS AND METHODS

Sampling and ground water analysis

50 Samples each in a month were collected from different places of Chennai, Bangalore and Hyderabad cities in a sterile container at four different seasons like spring, summer, autumn and winter in the year of 2012. Aseptically collected samples were carefully shifted to our water quality research centre, Eureka Forbes institute of environment, and were analyzed for bacteriological test such as total coliforms, physico-chemical parameters like pH, turbidity, total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), total

alkalinity (TA), total chlorides ($C1^-$), sulphate (SO_4^{2-}), nitrate (NO_3^-), fluoride (F^-), iron (Fe) as per IS 10500:1991, drinking water specifications.

Biological analysis

Total coliforms

The presence of total coliforms in the sample was analyzed using most probable number (MPN) analysis method.

Physico-chemical analysis

The pH and turbidity were analyzed using digital pH meter and Nephlometric turbidity meter, respectively. The total dissolved solids (TDS) were analyzed using gravimetric method. Total hardness as $CaCO_3$ and calcium (Ca^{2+}) were analyzed using EDTA titrimetric method. Magnesium (Mg^{2+}) was calculated by taking the differential value between total hardness and Ca^{2+} concentrations. Total alkalinity as $CaCO_3$, was estimated by titrating with HCL. Chloride (Cl^-) was determined titrimetrically by standard $AgNO_3$ titration. Sulphate (SO_4^{2-}), nitrate (NO_3^-), fluoride (F^-) and iron (Fe) were analyzed using spectrophotometer. All parameters were expressed in milligram per litre except turbidity level expressed in Nephlometric turbidity units (NTU).

RESULTS AND DISCUSSION

A detailed results and summary of the Chennai, Bangalore and Hyderabad cities on seasonal wise variations of biological as well as chemical analysis in ground water for the year 2012 is presented in Tables 1–3 followed by the comparison of chemical variations were expressed in Figures 1–3, respectively.

Table 1: Summary of the average results on seasonal wise changes of chemical compositions in Chennai city ground water quality for the year 2012

Seasons	Chemical parameters tested (mg/L)											
	pH	Turbidity (NTU)	TDS	TH	Ca2+	Mg2+	TA	Cl^-	SO_4^{2-}	NO_3^-	F^-	Fe
Spring	7.2	1.0	1400	877	380	67	43	174	47	0.4	0.3	0.25
Summer	7.3	1.2	1635	563	292	70	52	129	49	6	0.35	0.2
Autumn	7.25	1.25	1255	707	376	63	41	145	49	6	0.25	0.2
Winter	7.1	0.9	755	300.5	121	47	38	111	26	6	0.2	0.2

Table 2: Summary of the average results on seasonal wise changes of chemical compositions in Bangalore city ground water quality for the year 2012

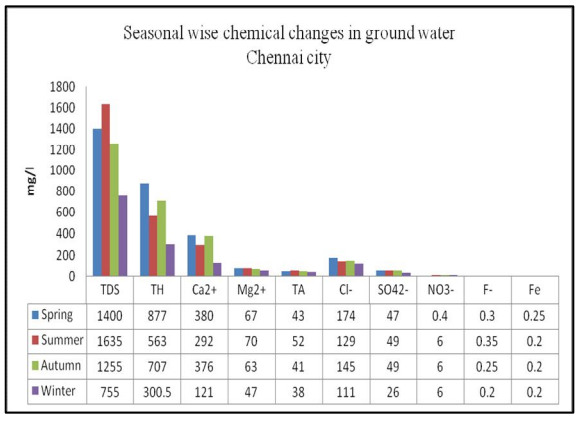
Seasons	Chemical parameters Tested (mg/L)											
	pH	Turbidity (NTU)	TDS	TH	Ca2+	Mg2+	TA	Cl^-	SO_4^{2-}	NO_3^-	F^-	Fe
Spring	7.4	0.7	511	283	92	38	590	172	58	23	0.2	0.1
Summer	7.6	0.9	486	265	80	30	323	144	47	34	0.3	0.1
Autumn	7.3	0.9	412	225	65	32	301	126	39	28	0.2	0.1
Winter	7.6	0.7	447	243	72	35	316	137	42	28	0.2	0.1

Table 3: Summary of the average results on seasonal wise changes of chemical compositions in Hyderabad city ground water quality for the year 2012

Seasons	Chemical parameters Tested (mg/L)											
	pH	Turbidity (NTU)	TDS	TH	Ca2+	Mg2+	TA	Cl^-	SO_4^{2-}	NO_3^-	F^-	Fe
Spring	7.5	2.9	620	480	172	32	156	127	32	27	0.82	0.2
Summer	7.3	2.5	540	376	104	28	124	112	28	23	0.74	0.08
Autumn	7.5	3.7	700	512	240	37	197	153	37	34	0.91	0.4
Winter	7.8	1.8	450	244	96	22	93	86	22	19	0.56	0.07

Chennai city

The total coliforms in the samples were ranges from 11 to 460 MPN/100 mL. The high level of coliformic bacteria observed mainly in autumn and winter season. The pH of the ground water varies from 7.1 to 7.3 with the TA ranges from 38 to 53 mg/L. The turbidity level varies from 0.9 to 1.25 NTU. Concentration of salinity (TDS) ranges from 755 to 1635 mg/L. The higher concentration of salinity was observed in summer season followed by autumn and spring. In winter the concentration of salinity was reduced half off the summer season concentration indicating the ground water table recharge using rain water in monsoon period. As per the TDS classification (Fetter 1990), the ground water collected from 90 to 98% of total samples are belonging to brackish type (>1000 mg/L). The rest of the samples are fresh water in the respective seasons. The TH was highest in spring and autumn (877, 707 mg/L, respectively) followed by summer and winter (563, 300 mg/L, respectively) indicating the presence of calcium and magnesium level high in spring and autumn season. According to the TH classification (Sawyer and McCarty 1967) the ground waters are hard (150 mg/L - 300 mg/L) and very hard (>300 mg/L). In all the seasons TH was more than the TA which indicates that the ground waters are characterized by non carbonate hardness (Chow 1964).



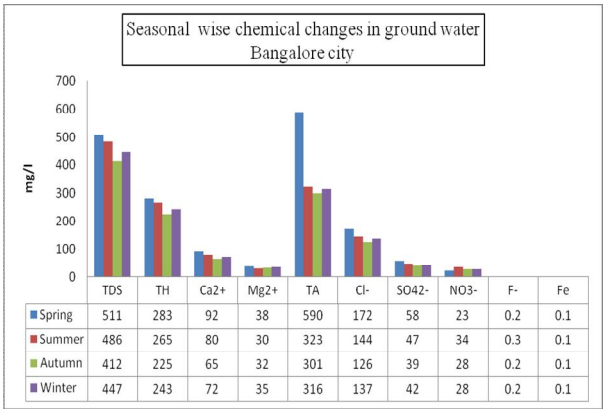
	TDS	TH	Ca2+	Mg2+	TA	Cl-	SO42-	NO3-	F-	Fe
Spring	1400	877	380	67	43	174	47	0.4	0.3	0.25
Summer	1635	563	292	70	52	129	49	6	0.35	0.2
Autumn	1255	707	376	63	41	145	49	6	0.25	0.2
Winter	755	300.5	121	47	38	111	26	6	0.2	0.2

Figure 1: Seasonal wise comparison of chemical changes in ground water – Chennai city

Among the cations (Ca^{2+} and Mg^{2+}) varies in different seasons ranges from 380 to 121 mg/L and 47 to 70 mg/L. Dissolved anions responses in spring to winter seasons like Cl^-, SO_4^{2-}, NO_3^-, F^- ranges from 174 – 111 mg/L, 47 – 26 mg/L, 0.4 – 6 mg/L, 0.3 – 0.2 mg/L, respectively . The Ca^{2+} shows decreasing concentration in spring to winter and Mg^{2+} shows increasing and decreasing concentration in summer followed by autumn and winter. Similarly, Cl^-, SO_4^{2-}, NO_3^-, F^- ions showed decreasing concentration from spring to winter.

Bangalore city

The total coliforms in the samples were ranges from 11 to 460 MPN/100 mL. The high level of coliformic bacteria observed mainly in autumn and winter season. The pH of the ground water varies from 7.3 to 7.6 with the TA ranges from 316 to 590 mg/L in various seasons. The turbidity level varies from 0.7 to 0.9 NTU. Concentration of salinity (TDS) ranges from 412 to 511 mg/L. The higher concentration of salinity was observed in spring season followed by summer and winter. As per the TDS classification (Fetter 1990), all the ground water collected from Bangalore city are less than the brackish level (>1000 mg/L) indicating the fresh water in all the seasons. The TH was highest in spring and summer (283, 265 mg/L, respectively) followed by winter and autumn (243, 225 mg/L, respectively) indicating the presence of calcium and magnesium level high in spring and summer season.



	TDS	TH	Ca2+	Mg2+	TA	Cl-	SO42-	NO3-	F-	Fe
Spring	511	283	92	38	590	172	58	23	0.2	0.1
Summer	486	265	80	30	323	144	47	34	0.3	0.1
Autumn	412	225	65	32	301	126	39	28	0.2	0.1
Winter	447	243	72	35	316	137	42	28	0.2	0.1

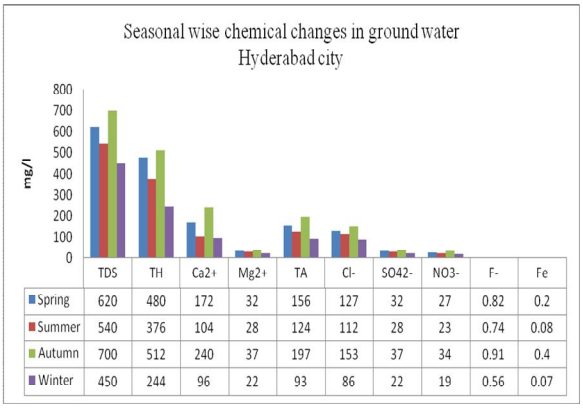
Figure 2: Seasonal wise comparison of chemical changes in ground water – Bangalore city

Among the cations (Ca^{2+} and Mg^{2+}) varies in different seasons ranges from 92 to 65 mg/L and 30 to 38 mg/L, respectively. Dissolved anions responses in spring to winter seasons like Cl^-, SO_4^{2-}, NO_3^-, F^- ranges from 172 – 126 mg/L, 58 – 39 mg/L, 34 - 23 mg/L, 0.3 – 0.2 mg/L, respectively . The Ca^{2+} shows increasing and decreasing concentration fluctuation in spring to winter and Mg^{2+} shows increasing and decreasing concentration

in all the seasons. Similarly, Cl^-, SO_4^{2-}, NO_3^-, F^- ions showed decreasing concentration from spring to winter.

Hyderabad city

The total coliforms in the samples were ranges from 11 to 460 MPN/100 mL. The high level of coliformic bacteria observed mainly in autumn and winter season. The pH of the ground water varies from 7.3 to 7.8 with the TA ranges from 93 to 197 mg/L. The turbidity level varies from 1.8 to 3.7 NTU. Concentration of salinity (TDS) ranges from 450 to 700 mg/L. The higher concentration of salinity was observed in autumn season followed by spring and summer. In winter the concentration of salinity was reduced to lower level indicating the ground water table recharges using rain water in monsoon period. Similarly the TH was also highest in autumn (512 mg/L) followed by spring and summer (480, 376 mg/L, respectively) indicating the presence of calcium and magnesium level high in autumn season. In all the seasons TH was more than TA which indicates that the ground waters are characterized by non carbonate hardness (Chow 1964).



	TDS	TH	Ca2+	Mg2+	TA	Cl-	SO42-	NO3-	F-	Fe
Spring	620	480	172	32	156	127	32	27	0.82	0.2
Summer	540	376	104	28	124	112	28	23	0.74	0.08
Autumn	700	512	240	37	197	153	37	34	0.91	0.4
Winter	450	244	96	22	93	86	22	19	0.56	0.07

Figure 3: Seasonal wise comparison of chemical changes in ground water – Hyderabad city

Among the cations (Ca^{2+} and Mg^{2+}) varies in different seasons ranges from 96 to 240 mg/L and 22 to 37 mg/L. Dissolved anions responses in spring to winter seasons like Cl^-, SO_4^{2-}, NO_3^-, F^- ranges from 86 – 153 mg/L, 22 – 37 mg/L, 19 - 34 mg/L, 0.56 – 0.91 mg/L, respectively . The Ca^{2+} and Mg^{2+} showed increasing concentration in autumn followed by spring and summer. Similarly, Cl^-, SO_4^{2-}, NO_3^-, F^- ions showed increasing concentration from autumn followed by spring and summer.

Overall the total coliforms in the samples were in the ranges from 11 to 460 MPN/100 mL. The high level of coliformic bacteria observed mainly in autumn and winter season. pH of ground water in the year 2012 from Chennai, Bangalore and Hyderabad cities in different seasons varies from 7.1 to 7.8 was within the acceptable limits (6.5 – 8.5) prescribed for drinking water by ISI (1983) and WHO (1984). The turbidity level ranges from 0.7 NTU to 3.7 NTU was beyond the acceptable limits (1 NTU) but within the maximum permissible limits (5 NTU) prescribed for drinking water by ISI (2012). The concentration of TDS (450 mg/L to 1635 mg/L) was more than the acceptable limits (500 mg/L) but within the maximum permissible limits (2000 mg/L) (ISI 1983; WHO 1984) in all the ground water samples from different seasons causing gastrointestinal irritation to the consumer.

Concentration of Ca^{2+} and Mg^{2+} ions increases resulted in TH. Ground waters collected from Chennai, Bangalore and Hyderabad cities (in all samples) have TH beyond the acceptable limits of 200 mg/L suggested for drinking water by ISI (2012). Hard water leads to incidence of urolithiosis (WHO 1984), anencephaly, parental mortality, some types of cancer (Agrawal and Jagetia 1997) and cardio-vascular disorders (Durvey *et al.*, 1991). Such waters can also develop scales in pipelines, water heaters, well pumps, boilers, cooking utensils and required more soap for washing clothes (Todd 1980; Hem, 1991; Karanth, 1997). The relationship of TH and TA indicates that the ground water containing non-carbonate hardness. Such water cannot be removed easily from the waters, as in the case of carbonate hardness (TH<TA) by boiling (Chow, 1964).

Interestingly, the Cl^- concentration in Chennai, Bangalore and Hyderabad cities were within the acceptable limits prescribed for ground water by ISI (250 mg/L). In case if excess amount of Cl^- concentration >200 mg/L present in the water will leads to salty taste and cause laxative effect. Similarly, the SO_4^{2-} content tested in Chennai, Bangalore and Hyderabad cities of ground water were within the safe drinking water limits prescribed by ISI (1983) (200 mg/L) and higher concentration resulted in respiratory problems (Maiti, 1982; Subba Rao, 1993). The NO_3^- level tested in all three major cities in different seasons, results revealed within in the acceptable limit prescribed by ISI 1983 (45 mg/L) and incase of excess NO_3^- concentration will leads to number of health disorders

like methemoglobinemia, gastric cancer, goitre, birth malformation and hypertension (Majumdar and Gupta, 2000).

Fluoride is an essential element for maintaining normal development of healthy teeth and bones. Deficiency of F^- in drinking water below 0.6 mg/L contributes to tooth caries. An excess of over 1.2 mg/L causes fluorosis (ISI 1983). Ground water tested from all three major cities was within the acceptable limits. The Fe contents tested in all three major cities were within the acceptable limit prescribed for drinking water by ISI (1983). Hence this study clearly indicates that there is an evidence of seasonal effects on ground water quality.

The result of the above study clearly reveals that there is evidence on seasonal wise variations on ground water quality in Southern part of India. The pH of the water in different season was not much altered and within the safe limit. The TDS levels in Chennai city was high in summer and in Bangalore high in spring followed by Hyderabad city it was in autumn seasons. In Chennai 90 to 98% of total samples were belonging to brackish type (>1000 mg/L) and the rest of the samples were fresh water in the respective seasons but in Bangalore and Hyderabad the 100% of samples are belongs to fresh water (<1000 mg/L). The TH in the samples were crossed the tolerable limits (600 mg/L) but in winter it was in within the tolerable limit but crossed the acceptable limit (200 mg/L). Similarly, Bangalore and Hyderabad sample tested were crossed the acceptable limit of TH (200 mg/L) but within the tolerable limit (<600 mg/L). The Cl^-, SO_4^{2-}, NO_3^- and F^- contents were tested in Chennai, Bangalore and Hyderabad was within the acceptable limit in all the seasons in the year 2012. Hence based on the above evaluation study the suitable reverse osmosis technology may be used for accessing the safe drinking water from ground water.

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