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Original Research Article

Assessment of ground water quality using for drinking purpose in Shivamogga Town, Karnataka, India

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A B S T R A C T

Keywords

Drinking water, Physico-chemical & biological parameters, Water quality, Drinking water standard

The present study attempts to bring an acute awareness among the people about the quality of ground water by taking water samples from 10 various locations in study area during pre and post monsoon seasons. Various physico-chemical and biological parameters such as pH, Temperature, Electrical conductivity, TDS, TH, Ca^{2+}, Mg^{2+}, Cl^{-}, total alkalinity, DO, fluoride, nitrate, iron, sulphate and *E. coli* test was experimentally analyzed. The results were compared with BIS standards. The results reveal that few samples show slightly alkaline along with high concentration of hardness, calcium & magnesium in both the seasons. Statistical regression analysis applied to study the correlation between various physico-chemical parameters.

Introduction

Ground water is one of the earth's widely distributed, renewable and most important resources. It's located beneath the earth's surface in soil pore spaces and in the fractures of rock formations. Ground water is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches the water table. Ground water makes up about 20% of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice. Global ground water storage is roughly equal to the total amount of fresh water stored in snow & ice pack. This makes it an important resource which can act as a natural storage that can buffer against shortages of surface water, as in drought (Tanvir, 2008).

According to the United States geological survey states that there is about 4.2 million cubic kilometers of water within 0.8 kilometer of the earth's surface.

The importance of groundwater for the existence of human society cannot be overemphasized. Ground water is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector. India is the largest user of groundwater for irrigation in the world. The drawn amount of groundwater is estimated to be 210 billion cubic meters per year compared to 105 billion cubic meters in China and 100 billion cubic meters in US (Shankar *et al.*, 2011). Indian agriculture is sustained by groundwater. According to the 2005–06 agricultural Census of the country, 60.4 percent of the net irrigated area is irrigated using groundwater. In addition around 80% of the rural population relies on groundwater for meeting their drinking water needs. Water utilization projections for 2000 put the groundwater usage at about 50% (Sophocleous, 2002).

Generally, both groundwater and surface water can provide safe drinking water, as long as the sources are not polluted and the water is sufficiently treated. Groundwater is preferable over surface water for a number of reasons. First of all, groundwater is reliable during droughts, while surface water can quickly deplete. Groundwater is, in general, easier and cheaper to treat than surface water, because it tends to be less polluted. Groundwater can become contaminated, by many of the same pollutants that contaminate surface water. Pollution of groundwater occurs when contaminants are discharged to, deposited on, or leached from the land surface above the groundwater. Even if there are no industrial and domestic pollution sources in the area, it is important to realize that the water may not be free from contaminants, and should be tested before human consumption.

Groundwater quality has become an important water resources issue due to rapid increase of population, urbanization, lowland, & too much use of fertilizers, pesticides in agriculture (Joarder *et al.*, 2008). Over burden of the population pressure, unplanned urbanization, unrestricted exploration and dumping of the polluted water at inappropriate place enhance the infiltration of harmful compounds to the ground water (Pandey and Tiwari, 2009a). Pollution can come from two types of sources, point and non-point. Point sources are identifiable and localized sources of pollution. Point sources that can contaminate groundwater include landfills, buried gasoline or oil storage tanks, septic systems, industrial sources and accidental spills. Non-point sources tend to be in the form of pesticides and nutrients that enter the soil as result of intense agricultural operations or the widespread use of road salts and chemicals. Most of the industries discharge their effluent without proper treatment into nearby open pits or pass them through unlined channels, resulting in the contamination of ground water (Jinwal and Dixit, 2008). The incidence of ground water pollution is highest in urban areas where large volumes of waste are concentrated and discharge into relatively small areas. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It therefore becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it.

The objective of the present work is to assess the quality of groundwater used for drinking in Shivamogga town

Material and Methods

Study area

Shivamogga city is located at $13^0\ 55^1\ 18^{11}$ N, $75^0\ 34\ ^1\ 12^{11}$ E. The city has a total area of about $50km^2$ (19.31 square miles) (Fig.1). The climate of Shivamogga is tropical wet and dry. Summer average temperature 20–35 degree centigrade. Shivamogga is a part of a region vernacularly known as Malnadu in Karnataka. Shivamogga city is divided into 35 Municipal wards/ Divisions. From the 35 wards in the city, 10 sites are selected for the study.

Sample collection

Groundwater samples were collected from ten (10) various locations within study area during pre & post monsoon season. Samples were collected in polythene bottles to avoid unpredictable changes in characteristic as per standard procedure (APHA, 1998) (Table 1).

Methodology

For Physico chemical and biological analysis the following standard methods & instruments used

Parameters	**Intruments & Methods Used Followed**
pH	pH pen-pH ep®
TDS & Conductivity	Water analyzer kit 371(Systronics)
Alkalinity, Hardness, D.O, Chloride, Cal**c**ium	Titrimetric method
Nitrate, Iron & Sulphate	UV-VIS spectrophotometer 119 (Systronics)
E. coli	*E. coli* test kit (Himedia)

Results and Discussion

Table 2 and 3 shows physico chemical values of the sampling points. The pH value of drinking water is an important index of acidity, alkalinity and resulting value of the acidic-basic interaction of a number of its mineral and organic components. pH below 6.5 starts corrosion in pipes (Pandya *et al.*, 2013). In the study pH value ranges between 6.7 and 8.2 in pre monsoon season & 6.9 to 8.2 in post monsoon season. It is within the prescribed limit of BIS. TDS is sum of the cations and anions concentration. A high contents of dissolve solids elevates the density of water, influences solubility of gases (like oxygen) reduces utility of water for drinking irrigation and industrial purpose (Pandya *et al.*, 2013). In the present study Total Dissolved Solid ranges from 107 to 304 mg/L, in pre monsoon season and136 to 384mg/L in post monsoon season, TDS is due to high dissolved salts of Ca, Mg and Fe. It requires specific cation and anion analysis (Sandeep *et al.*, 2009). All the values of Total Dissolved Solids are in the prescribed limit of BIS. Electrical conductivity depends on the function of dissolved mineral matter content. If the TDS is high then EC will be high (Ananthakrishnan *et al.*, 2012). In the present study conductivity ranges from 294 to 744 µs/cm in pre monsoon season and 306 to 745 µs/cm in post monsoon season. Alkalinity ranges from 106 to 298 mg/L; in pre monsoon season and 100 to 306 mg/L, in post monsoon season; it is not in the prescribed limit of BIS. Alkalinity is the cause of carbonate and bicarbonate ion and its salts (Pandey *et al.*, 2009b). The hydroxide, carbonates and bicarbonates probably released from limestone sedimentary rocks, carbonate rich soils, cleaning agents contributes to the alkalinity. Chlorides are common constituents of all natural water. Higher value of it impacts a salty taste of water, making it unacceptable for human consumption (Ananthakrishnan et al, 2012). The chlorides contents in the samples between 28.36 to 162.0 mg/L, in pre monsoon season, and 51.04 to 198.52 in post monsoon season; Cl content is within the limit of BIS.

Table.1 Details of sampling sites

S.No	NAME OF THE SITES	Depth of boaring	SOURCE	APPARENT WATER QUALITY	USES OF WATER
1	Sahyadri Nager	Approx.180feet	Under ground water	Colourless, odourless	Drinking & domestic purposes
2	Kuvempunagar	300feet		Colourless, odourless	
3	Navale	350feet		Colourless, odourless	
4	Chatnalli	300feet		Colorless, odorless	
5	Gandhinagar	45feet		Colourless, odourless	
6	Vinobanagar(well water)	25feet		Colourless, odourless	
7	Koteroad(well water)	33feet		Colourless, odourless	
8	Urgadur	266feet		Colourless, odourless	
9	Venkatesh nagar	200feet		Colourless, odourless	
10	Hosmane	400feet		Colourless, odourless	

Table.2 Physico-chemical & biological parameters at different sampling sites recorded during pre monsoon season (March to May 2012)

S. No	Parameters	Site I	Site II	Site III	Site IV	Site V	Site VI	Site VII	Site VIII	Site IX	Site X	BIS Standard
1	pH	8.2	7.4	7.2	7.3	7.3	6.7	6.7	7.3	7.4	7.2	6.5-8.5
2	Temperature °C	27	27	26	26	27	27	27	27	26	26	-
3	Conductivity (µs/cm)	672	306	415	306	513	421	356	294	744	567	-
4	TDS (ppm)	304	107	212	112	246	210	188	107.5	238	235	500
5	Alkalinity (ppm)	256	156	170	112	298	156	144	106	208	166	200
6	Chloride (ppm)	70.9	72.3	75.15	28.36	62.3	62.3	51.0	36.0	162.0	51.0	250
7	Total hardness(ppm)	286	188	156	190	314	186	196	118	320	143	300
8	Calcium(Ca)	66.4	44.0	36.05	30.4	51.3	32	33.6	27.3	67.3	30.4	75
9	Magnesium (Mg)	26.88	17.6	31.4	26.8	43.8	24.8	26.3	11.3	35.0	15.4	30
10	Sulphate (ppm)	25.26	13.1	23.8	13.28	28.4	25.8	12.08	18.4	32.1	12.3	200
11	Iron(ppm)	0.02	0.01	0.05	0.01	0.04	0.008	0.08	0.06	0.007	0.005	0.3
12	Nitrate(ppm)	0.03	0.03	0.01	0.04	0.05	0.04	0.02	0.01	0.03	0.02	45
13	Dissolved O_2(ppm)	4.9	4.5	4.0	5.3	3.6	4.9	4.5	4.9	5.6	5.6	4-6
14	Fluoride	0.006	0.02	0.01	0.006	0.009	0.006	0.005	0.008	0.007	0.006	1-1.5
15	E.coli	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table.3 Physic-chemical & biological parameters at different sampling sites recorded during post monsoon season (November to December, 2011)

S. No.	Parameters	Site I	Site II	Site III	Site IV	Site V	Site VI	Site VII	Site VIII	Site IX	Site X	BIS Standard
1	pH	8.2	7.5	7.4	7.3	7.1	7.4	7.9	6.9	6.9	7.6	6.5-8.5
2	Temperature ° C	22.0	22.0	22.0	23	22	22	23.0	22.0	22.0	22.0	-
3	Conductivity(µs/cm)	726	337	465	306	566	497	353	336	745	656	-
4	TDS (ppm)	384	147	227	136	288	216	186	171.4	339	326	500
5	Alkalinity (ppm)	294	152	290	150	306	188	156	100	196	186	200
6	Chloride (ppm)	76.57	55.5	58.14	51.04	73.74	80.83	51.04	52.54	198.52	85.1	250
7	Total Hardness(ppm)	290	186	244	200	304	198	206	186	314	186	300
8	Calcium(Ca)	67.33	44.08	68.93	30.46	51.3	32..06	38.47	32.06	69.73	32.86	75
9	Magnesium (Mg)	27.72	17.2	15.5	29.32	41.4	27.8	25.66	24.8	32.3	24.37	30
10	Sulphate(ppm)	28.66	14.2	26.99	15.26	36.23	25.47	15.66	14.4	39.75	16.3	200
11	Iron(ppm)	0.01	0.01	0.05	0.04	0.006	0.006	0.09	0.06	0.009	0.006	0.3
12	Nitrate(ppm)	0.03	0.01	0.03	0.01	0.03	0.02	0.05	0.01	0.03	0.01	45
13	Dissolved O_2(ppm)	5.3	5.6	3.6	5.6	4.9	5.3	4.0	4.0	4.9	5.6	4-6
14	Fluoride	0.005	0.02	0.01	0.005	0.008	0.006	0.006	0.005	0.008	0.005	1-1.5
15	*E. coli*	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-

Table.4 Karl Pearson's correlation coefficient r is used taking conductivity as dependent variable for all the twelve data points of drinking water

Parameter	Correlation coefficient (r)
PH	0.17
Temp	0.26
TDS	0.95
Alkalinity	0.65
Cl	0.73
TH	0.71
Ca	0.73
Mg	0.44
So_4	0.71
Fe	-0.52
No_3	0.30
D O	0.30
F	0.45

Fig.1 Shivamoga District map

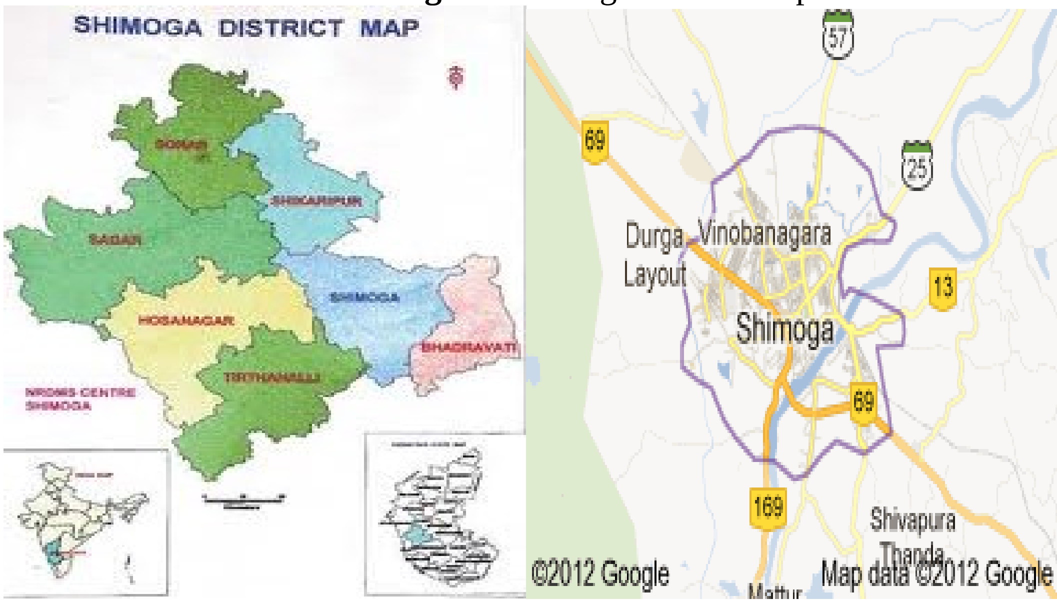
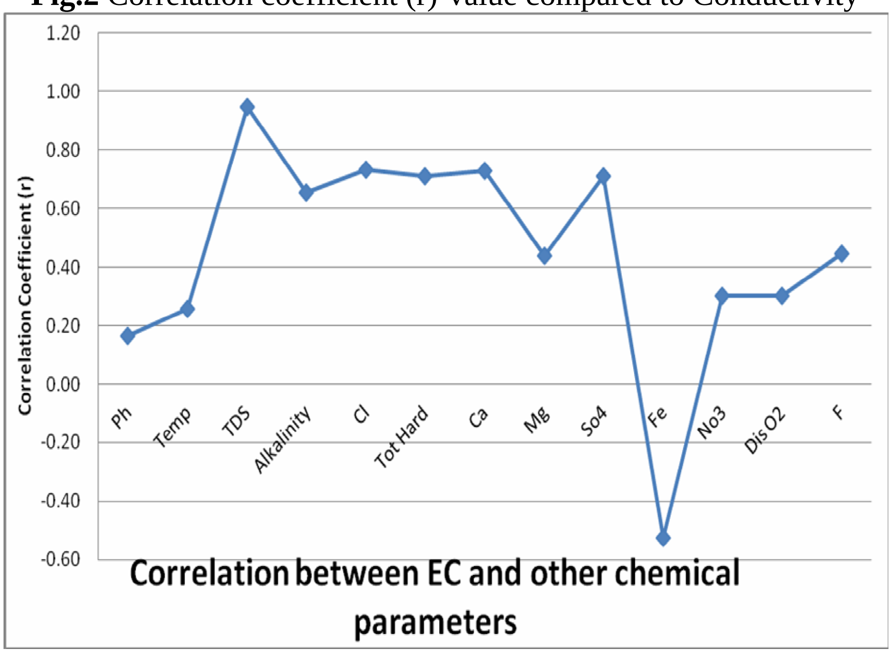


Fig.2 Correlation coefficient (r)-value compared to Conductivity



The total hardness is due to the presence of divalent cations of which Ca and Mg are the most abundant in ground water (Jadhav *et al.*, 2012). In the present study total hardness ranges from 118 to 320 mg/L; in pre monsoon season & 186 to 314 mg/L; in post monsoon season. Magnesium ranges from 11.3 to 43.8 mg/L, in pre monsoon season & 17.2 to 41.4 mg/L in post monsoon season, most of the samples shows above the prescribed limit of BIS for both hardness & magnesium .Calcium ranges from 27.3 to 67.3 mg/L, in pre monsoon season & 30.46 to 69.73 mg/L in post monsoon season which is in the prescribed limit of BIS and Dissolved oxygen ranges from 3.6 to 5.6mg/L in pre monsoon season &3.6 to

5.6 mg/L, in post monsoon season, D.O indicating the nearly pure symptoms of good water quality. Iron ranges from 0.005 to 0.06 mg/L in pre monsoon & 0.006 to 0.09 mg/L in post monsoon season, Fluoride ranges from 0.005 t0 0.02, Nitrate ranges from 0.01 to 0.05 mg/L in both pre and post monsoon season and sulphate ranges from 12.08 to 32.1 mg/L, in pre monsoon season & 14.2 to 39.75 in post monsoon season. Which are all in prescribed limit of BIS & E. Coli is absent in all the samples.

Karl Pearson's correlation coefficient r is used taking conductivity as dependent variable for all the twelve data points of drinking water at Shivamogga city, Karnataka, India (Table 4).

$$r=\frac{\sum xy-\frac{\sum x\sum y}{n}}{(\sqrt{\sum x^2}-\sum(x)^2)(\sum y^2-\sum(y)^2)}$$

Here, n = number of data points
x = values of x-variable
y = values of y – variables;

TDS are highly correlated where alkalinity, total hardness, Ca, Mg, Cl, No3, F, D.O shows moderate degree of correlation (Fig. 2). This suggest as variation in conductivity, there is variation in alkalinity, total hardness, Ca, Mg, Cl, NO_3, F and D.O. therefore alkalinity, total hardness, Ca, Mg, Cl, NO_3, F and D.O. are positively correlated. Iron concentration found to be negatively correlated with respect to conductivity.

The groundwater samples collected from 10 different locations of Shivamogga town is analyzed and studied. On the basis of these analytical findings, the following conclusion can be drawn.

Based on the data recorded Ground water quality in Shivamogga town is acceptable. In few sites where hardness and alkalinity were crossed prescribed limits of drinking water (BIS) the reason behind this may be due to weathering and erosion of bed rocks, due to different soil types, Water chemistry and different human activities. Present study may be treated as one step ahead towards the drinking water quality management.

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