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Assessment of Groundwater Quality and its Suitability for Drinking and Agriculture Purpose Used in District Banda, Uttar Pradesh, India

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Abstract:

Study was conducted to evaluate the ground water quality for drinking and agriculture use in the area. Five sampling stations were selected in Banda district. The ground water samples were analyzed to measure physico-chemical and biological parameters for agriculture and domestic use. The different in geochemical process affecting the ground water quality and analyzed results shows higher concentration ofhardness, conductivity, alkalinity, TDS, calcium and magnesiumwhich indicates signs of risk as per WHO, BIS and ICMR standards. On the other hand the entire ground water samples were from suitable for irrigation purposes based on irrigation quality parameters.

Keywords: Ground water; Water quality; Physico-chemical;Biological parameter; Na%; SAR.

1.0 Introduction:

The water is essential for life on the earth and any other planet. Groundwater is the primary source of water for domestic, agricultural and industrial uses in many countries, and its contamination has been recognized as one of the most serious problems in Banda. The chemical alteration of meteoric water depends on several factors such as soil-water interaction, dissolution of mineral species, duration of solid-water interaction and anthropogenic sources (Deswal and Chandana, 2007; Drever, 1982). In some places the bore wells and hand pumps were digged in the premises of houses. Today in most of the cities and villages, municipal or village corporations are supplying water for drinking purpose. Most of the people rely on the ground water for their day-to-day life. The Banda is a region of intensive agriculture. Over the few decades, competition for economic development, associated with rapid growth in population and urbanization, has brought in significant changes in land use, resulting in more demand of water for agriculture and domestic activities (Moxonir and Thomas, 1993; Garg, 2003). Due to inadequate availability of surface water, to meet the requirement of human activities, groundwater remains the only option to supplement the ever-increasing demand of water. Importance of hydrochemistry of groundwater has led to a number of detailed studies on geochemical evolution of groundwaters (Malik and Banerji, 1981; Mehta *et. al,* 1990). Hence, the present work had the objective of understanding the spatial and temporal distribution of hydro-chemical constituents of groundwater related to its suitability for agriculture and domestic use. The trace elements and nitrogenous ions elements in this water are determined to check the quality of the water (Malik and Banerji, 1981; Stallard and Edmond, 1983; Rao, 2002).

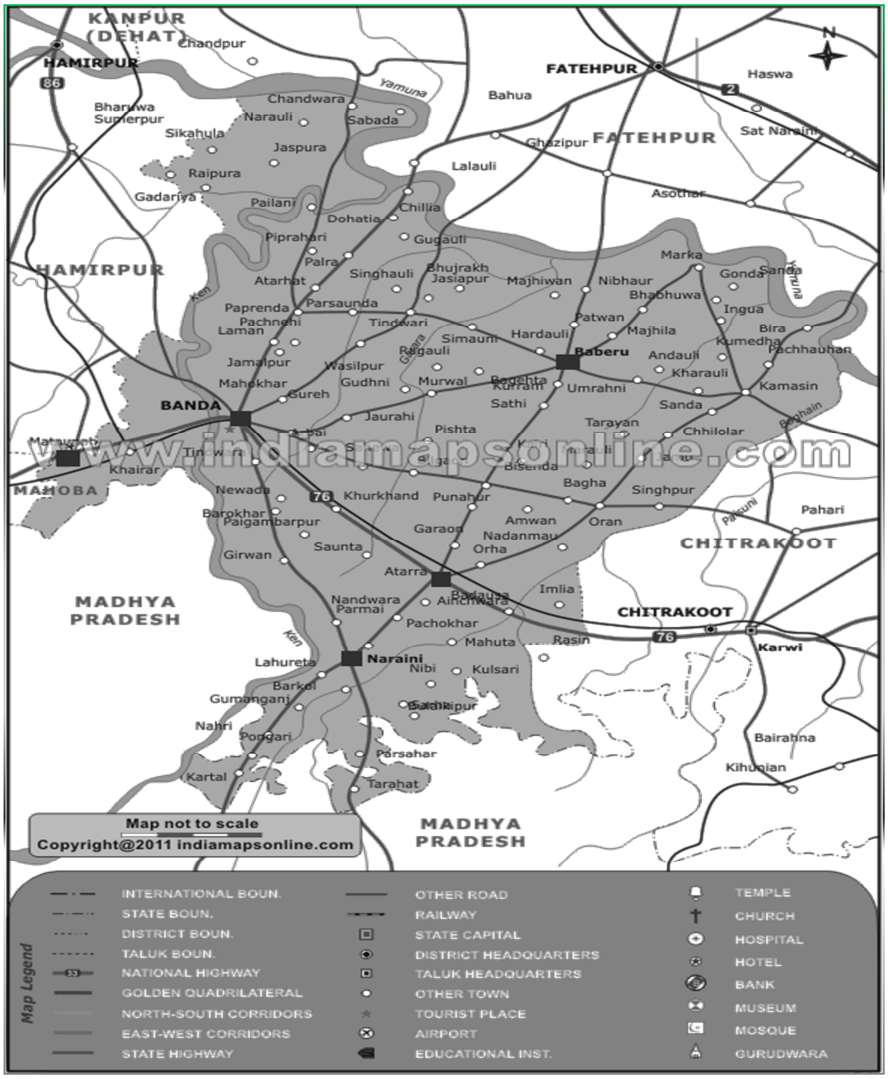
1.1 Description of study area:

Banda district lies between latitude $25^0$00’00” and $25^0$59’00” north andlongitude $80^0$06’00” and $81^0$00’00” east. Total geographical area of the district is4460 sq. km. District headquarter is at Banda having 04 tehsils and 8 blocks. As perthe 2011 census the district has total population of 1548220. Literacy rate of the district is 57.5%. Geologically the area comprises Precambrian Bundelkhand granitesunconformable overlain by Vindhyan are quaternary alluvium. The main and majordrainage of the district are Yamuna, Ken and Baghain which are part of Yamuna river system. Physio-graphically the area can be divided into three physiographic units–

Alluvial Plain, Marginal Alluvial,and High Land (Hard rock) area.

Agriculture is the main source of economy of the district. Both surface and ground water are used for irrigation. The net irrigated area is 153804 Ha. and the net area sown is 336000 Ha. which shows that 45.77% area is irrigated by ground water and the surface water while the rest depends on rainfall. Length of canal network in the district is 1193 Km. and the number of government tube wells is 460. Banda district is drained by Yamuna, Ken and Baghain rivers. River Yanuna bifurcate the district Banda from Fatehpur in north and flows from west to east in the entire district. River Ken meets Yamuna at Chilla. River Baghain also bifurcate Banda from Chitrakoot in southeast. On the basis of hydrogeological information ground water occurs in unconfined conditions in shallow depths and confined conditions in deeper depth in alluvium. The thickness of alluvium varies from 45.00-200.00 mbgl in the district. Granites (Bundelkhand) have also good potential and yield at economical discharge. Ground water occurs in fractures and joints in the hard rock. The potential fractures are encountered from around 28.00-96.00 meters in some places.

Ground Water Quality: The electrical conductance was in the range of 570 to 2600 µm/cm at 25^{o} C. Total hardness is from 110 to 400 mg/lit. Fluoride ranges from 0.16 to 0.89 mg/lit and Nitrate is upto 306 mg/l which is high. Phosphate was absent (Pant, www.cgwb.gov.in)



Map of Banda district showing selected stations

2.0 Material and Methods:

Physico-chemical and biological monitoring of ground water (GW) of Banda were carried out, during February to April 2012. Five ground water sources currently in use were selected based on the preliminary field survey carried out to understand the overalldistribution of the various types of sources in the studied area. Five sampling stations were selected for the study namely Banda, Baberu, Naraini, Mataundh and Atarra as these are the major town of Banda district. The selected sources are used for domestic and agricultural purposes and were found uniformly distributed over the area of concern. About two liter water samples were collected from both selected ground water stations. Water samples were collected in precleaned polypropylene bottles with necessary precautions. For the drinking water quality temperature, pH, Ca^{++}, Mg^{++}, total hardness, DO, BOD, COD, total coliform,sulphate, alkalinity and for irrigation water quality conductivity, chloride, TDS, sodium, percent sodium, SAR, and boron were analyzed. All analysis was carried out using standard methods for examination of water and wastewater (APHA-AWWA-WPCF, 1995).SPSS-17 software was used for stastical analysis.

3.0 Result and Discussion:

Details of the sampling stations ascode of sampling stations, sampling locationsweremention ed. The result ofphysico-chemical and biological monitoring of ground water samples ofselected points of Banda District.Monthly physico-chemical characteristics observed in February to April, 2012 are given in Table-1 to 3.The results of monitoredparameters were also compared with theirrecommended standards prescribedby BIS (1990) WHO (1994) and ICMR (1975).The temperature is most importantparameters of and GW which shows theeffect on physico-chemical parameters of waterbecause it is responsible for decreasing orincreasing ability of physico-chemicalparameters.

3.1 Temperature: In ground water samples, atwarmer temperature, solubility of calciumcarbonate is decreased, at colder. The temperature ranged from 24.5-26.5^{0}C in ground water.The temperaturealways increases with the depth of the sourcesof samples. The average value of temperature was observed 25.53 ^{0}Cat all selected stations.

3.2 pH: pH is one of the important factor of ground water. In the study area pH value was recorded from 7.2-8.0 in GW Table-4 indicated that water was slightly alkaline at all sampling stations of GW. Alkaline pH was recorded due to the high extent of granite. The average value of pHwas observed 7.53 at all selected stations.

3.3 Total hardness (TH): Total Hardness is considered as a major character of drinking water. Hardness is defined as the concentrations of calcium and magnesium ions. Calcium and magnesium are dissolved from most soils and rocks. A total hardness value varies from 464-584 mg/l Table-4 which may be due to presence of Calcium (Ca) and magnesium (Mg) in lime stone and soil. The average value of TH was observed 516.4 mg/l at all selected stations shown in Fig-b.

3.4 Electrical Conductivity (EC): Conductivity is the measure of capacity of a substance to conduct the electric current. Most of the salts in water are present in their ionic forms and capable of conducting current and conductivity is a good indicator to assess groundwater quality. Electrical conductivity is an indication of the concentration of total dissolved solids and major ions in a given water body. Electrical Conductivity in groundwater was observed in the range from 870-948µmohs/cm Table-4. All values of EC of ground water were higher from their permissible limit. The average value of conductivity was observed 917.6 mg/l at all selected stations shown in Fig-f.

3.5 Total dissolved solids (TDS): The total dissolved solids (TDS) are the concentrations of all dissolved minerals in water indicate the general nature of salinity of water. The total dissolved solids in all the study area varies from 538-632 mg/l Table-4. The higher value of total dissolved solids is attributed to application of agricultural fertilizer contributing the higher concentration of ions in to the groundwater. The average value of TDS was observed 588.27 mg/l at all selected stations shown in Fig-f.

3.6 Calcium (Ca^{++}): Calcium is naturally present in water. Calcium is a determinant of water hardness, because it can be found in water as cations. Calcium content in the groundwater varies from 118-156 mg/l Table-4. All samples were within maximum permissible limit. The average value of calcium was

observed 135.47 mg/l at all selected stations shown in Fig-c.

3.7 Magnesium (Mg^{++}): A large number of minerals contain magnesium; Magnesium is washed from rocks and subsequently ends up in water. It also ends up in the environment from fertilizer application and from cattle feed. The values of magnesium range from 32-52.2 mg/l Table-4. The average value of magnesium was observed 41.96 mg/l at all selected stations shown in Fig-c.

3.8 Chloride (Cl): Chloride originates from sodium chloride which gets dissolved in water from rocks and soil. It is good indicator of groundwater quality and its concentration in groundwater will increase if it mixed with sewage or sea water. The chloride content in study area has shown variation from 24-48 mg/l Table-4. All values were within permissible limit. The higher values of Chloride suggest leaching of effluents from Agricultural fertilizer in to the ground water. The average value of chloride was observed 36.4 mg/l at all selected stations shown in Fig-c.

3.9 Sodium (Na): Sodium is the sixth most abundant element in The Earth's crust and sodium stems from rocks and soils. Not only seas, but also rivers and lakes contain significant amounts of sodium. Concentrations however are much lower, depending on geological conditions and waste water contamination sodium compounds serve many different industrial purposes, and may also end up in water from industries. The Sodium content in study area has shown variation from 64-96 mg/l Table-4. The average value of chloride was observed 79.33 mg/l at all selected stations shown in Fig-e.

3.10 Alkalinity: Alkalinity is mainly found in form of carbonate, bicarbonate and hydroxide. It was found in concentration range of 278-332 mg/l in GW Table-4. High concentration of alkalinity was recorded in the form of HCO_3^- in water which is justified on account of much occurrence of carbonate rocks therein. The average value of alkalinity was observed 305.47 mg/l at all selected stations.

3.11 Sulphate (SO_4):was found in the range of 14-26 mg/l in GWTable-4. Values of all GW samples were founded within their permissible limit. The average value of sulphate was observed 18.93 mg/l at all selected stations shown in Fig-e.

3.12 Dissolved oxygen (DO): It is obvious from Table-4 that dissolved oxygen (DO) ranges from 1.0-1.5 mg/l in GW. Other words, values of dissolved oxygen (DO) in GW samples were founded low due to the high depth and developed under ground situation result in no or little possibility of free aeration or anaerobic condition in the GW samples. The average value of DO was observed 01.67 mg/l at all selected stations shown in Fig-a.

3.13 Chemical Oxygen Demand (COD): Table 5 showed that chemical oxygen demand (COD) was quite low within its permissible limit in GW samples. Low limit of COD in GW showed that no inorganic and organic pollutants reach from any sources. Value of COD was recorded from 3.4-4.8 mg/l in GW Table-4. The average value of COD was observed 4.25 mg/l at all selected stations shown in Fig-a.

3.14 Biochemical oxygen demand (BOD):BOD value was recorded in the range of1.8-3.2 mg/l in GW Table-4. Extent of BOD was exceeded in under limit in GW samples. The average value of BOD was observed 2.37 mg/l at all selected stations shown in Fig-a.

3.15 Total coli form (TC):TC was almost low extent was recorded in GW samples. Low extent was noticed only due to the absence of point pollution load in GW. TC value was recorded from the range of 08-15 MPN/100ml in GW Table-4. The average value of TC was observed 11.87 mg/l at all selected stations shown in Fig-e.

3.16 Soluble Sodium Percent (SSP): The Soluble Sodium Percent (SSP) for groundwater was calculated by the formula,

$$SSP = Na \times 100/Ca^{2+} + Mg^{2+} + Na^{+}$$

The concentrations of Ca^{2+}, Mg^{2+} and Na^{+} are expressed in milliequivalents per liter (epm). The Soluble Sodium Percent (SSP) values less than 50 or equal to 50 indicates good quality water and if it is more than 50 indicates the unsuitable water quality for irrigation. The values of Soluble Sodium Percent (SSP) range from 19.84-30.36 with an average value 25.3 Table-4. 60% Soluble Sodium Percent (SSP) values for the groundwater of study area are less than 50 and indicate good quality water for irrigation purpose while remaining 40% is more than 50 indicate the unsuitable water quality for irrigation Table-5.

3.17 Sodium Absorption Ratio (SAR): The sodium adsorption ration (SAR) indicates the effect of relative cation concentration on sodium accumulation in the soil; thus, sodium adsorption ration (SAR) is a more reliable method for determining this effect than sodium percentage. Sodium adsorption ration (SAR) is calculated using the following formula:

$$SAR = [Na^{+}] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$$

Ions are expressed as milliequivalents per liter (meq/L). The potential for a sodium hazard increases in waters with higher sodium adsorption ration (SAR) values. The sodium adsorption ration (SAR) content in study area has shown variation from 1.66-2.56 with an average value 2.16 Table-4. 40% Sodium adsorption ratios for groundwater samples of the study area are less than 10 indicate excellent quality for irrigation and samples fall in excellent category while 60% Sodium adsorption ratios for groundwater samples of the study area are within range 10-18 indicate good quality for irrigation and samples fall in good category Table-5.The average figure given is in shown in Fig-d.

3.18 Boron: Boron values were founded in the range of 1.0-5.0 mg/l in GW sample. The average value of boron was observed 3.42 mg/l at all selected stations shown in Fig-d.

Table-1: Results of Physico-Chemical and Biological Analysis of Ground Water, February 2012

Parameters	Unit	GW-1	GW-2	GW-3	GW-4	GW-5
Temperature	^{0}c	25.00	25.50	25.50	24.50	25.00
pH	-	7.20	7.50	7.40	7.40	7.60
EC	µmhocm^{-1}	914.00	934.00	870.00	910.00	890.00
TDS	mg/l	588.00	610.00	538.00	592.00	572.00
TH as $CaCO_3$	mg/l	538.00	494.00	502.00	512.00	508.00
Ca Hard. as $CaCO_3$	mg/l	352.00	324.00	346.00	398.00	322.00
Mg Hard. as$CaCO_3$	mg/l	210.00	192.00	188.00	170.00	212.00
Ca^{++}	mg/l	124.00	142.00	138.00	130.00	128.00
Mg^{++}	mg/l	40.20	44.00	38.80	38.60	40.80
Na^{+}	mg/l	68.00	74.00	86.00	72.00	92.00
Alkalinity	mg/l	280.00	290.00	318.00	312.00	308.00
Chloride	mg/l	38.00	40.00	24.00	32.00	28.00
SO_4^{--}	mg/l	20.00	16.00	14.00	18.00	16.00
DO	mg/l	1.20	1.20	1.50	1.00	1.00
BOD	mg/l	2.00	3.20	3.20	1.80	2.00
COD	mg/l	4.20	4.60	4.80	4.00	3.80
Total Coli form	MPN/100ml	10.00	14.00	10.00	15.00	09.00
Na %	-	23.74	23.06	27.06	24.46	29.10
SAR	-	1.92	1.97	2.36	2.01	2.56
Boron	mg/l	4.50	3.80	3.90	5.00	3.80

Table 2: Results of Physico-Chemical and Biological Analysis of Ground Water, March2012

Parameters	Unit	GW-1	GW-2	GW-3	GW-4	GW-5
Temperature	^{0}c	25.50	25.50	26.00	26.00	25.00
pH	-	7.80	7.60	7.20	7.60	7.50
EC	µmhocm^{-1}	948.00	922.00	908.00	928.00	932.00
TDS	mg/l	592.00	588.00	568.00	578.00	592.00
TH as $CaCO_3$	mg/l	488.00	464.00	532.00	584.00	554.00
Ca Hard. as $CaCO_3$	mg/l	384.00	388.00	356.00	406.00	364.00
Mg Hard. as$CaCO_3$	mg/l	210.00	214.00	176.00	198.00	182.00
Ca^{++}	mg/l	152.00	126.00	152.00	136.00	118.00
Mg^{++}	mg/l	48.60	52.20	48.40	33.80	42.80
Na^{+}	mg/l	86.00	84.00	78.00	96.00	78.00
Alkalinity	mg/l	282.00	278.00	332.00	316.00	318.00
Chloride	mg/l	42.00	46.00	34.00	42.00	48.00
SO_4^{--}	mg/l	22.00	26.00	18.00	24.00	18.00
DO	mg/l	1.40	1.00	1.20	1.20	1.00
BOD	mg/l	2.60	3.20	2.20	2.00	2.00
COD	mg/l	4.40	4.60	4.80	4.20	3.80
Total coli form	MPN/100ml	14.00	14.00	08.00	12.00	12.00
Na %	-	24.40	25.66	22.67	30.36	26.49
SAR	-	2.19	2.25	1.99	2.69	2.21
Boron	mg/l	4.50	3.00	4.00	4.50	4.00

Table 3: Results of Physico-Chemical and Biological Analysis of Ground Water, April 2012

Parameters	Unit	GW-1	GW-2	GW-3	GW-4	GW-5
Temperature	^{0}c	26.00	26.50	25.50	26.50	25.00
Ph	-	7.40	7.80	7.20	7.80	8.00
EC	µmhocm^{-1}	942.00	916.00	910.00	930.00	910.00
TDS	mg/l	632.00	622.00	588.00	568.00	596.00
TH as $CaCO_3$	mg/l	526.00	506.00	508.00	508.00	522.00
Ca Hard. as $CaCO_3$	mg/l	334.00	322.00	306.00	362.00	352.00
Mg Hard. as$CaCO_3$	mg/l	205.00	190.00	176.00	192.00	210.00
Ca^{++}	mg/l	156.00	138.00	132.00	142.00	118.00
Mg^{++}	mg/l	42.00	46.80	42.20	32.00	38.80
Na^{+}	mg/l	64.00	68.00	76.00	84.00	84.00
Alkalinity	mg/l	318.00	306.00	298.00	324.00	302.00
Chloride	mg/l	42.00	38.00	28.00	32.00	32.00
SO_4^{--}	mg/l	18.00	18.00	20.00	22.00	14.00
DO	mg/l	1.20	1.20	1.40	1.00	1.00
BOD	mg/l	2.00	2.20	3.00	2.00	2.00
COD	mg/l	4.20	4.40	4.60	4.00	3.40
Total Coli form	MPN/100ml	10.00	150.00	14.00	100	11.00
Na %	-	19.84	22.24	24.43	27.31	28.68
SAR	-	1.66	1.80	2.08	2.34	2.42
Boron	mg/l	3.90	3.80	4.00	5.00	4.00

Table 4: Average and Statistical Summary of Physico-Chemical and Biological Parameters of Ground WaterFebruary-April, 2012

Parameters	Unit	Minimum	Maximum	Average	±S.D.
Temperature	^{0}c	24.50	26.50	25.53	0.58
pH	-	7.20	8.00	7.53	0.24
EC	µmhocm^{-1}	870.00	948.00	917.60	19.97
TDS	mg/l	538.00	632.00	588.27	22.90
TH as $CaCO_3$	mg/l	464.00	584.00	516.40	28.56
Ca Hard. as $CaCO_3$	mg/l	306.00	406.00	353.87	29.58
Mg Hard. as$CaCO_3$	mg/l	170.00	214.00	195.00	14.74
Ca^{++}	mg/l	118.00	156.00	135.47	11.94
Mg^{++}	mg/l	32.00	52.20	41.96	5.48
Na^{+}	mg/l	64.00	96.00	79.33	9.19
Alkalinity	mg/l	278.00	332.00	305.47	16.78
Chloride	mg/l	24.00	48.00	36.40	7.06
SO_4^{--}	mg/l	14.00	26.00	18.93	3.45
DO	mg/l	1.00	1.50	1.67	0.17
BOD	mg/l	1.80	3.20	2.37	0.52
COD	mg/l	3.40	4.80	4.25	0.40
Total Coli form	MPN/100ml	08.00	15.00	11.87	2.32
Na %	-	19.84	30.36	25.30	2.88
SAR	-	1.66	2.56	2.16	0.28
Boron	mg/l	1.00	5.00	3.42	0.51

Table-5: Drinking Water Quality Standards

Parameters	Maximum permissible limit		
	World Health Organization (WHO,1994)	**Bureau of Indian Standard (BIS,1990)**	**Indian Council of Medical Research (ICMR, 1975)**
pH	7.0-8.5	6.5-8.5	7.0-8.5
Turbidity	10	5	10
EC	500	-	500
TDS	500	500	-
TH as $CaCO_3$	300	300	300
Ca^{++}	75	75	75
Mg^{++}	30	30	30
Alkalinity	200	-	200
Chloride	200	-	200
SO_4^{--}	250	-	-
DO	4-6	-	5.0
BOD	6.0	-	5
COD	10	-	-
Total Coli form	50/100ml	-	50/100ml

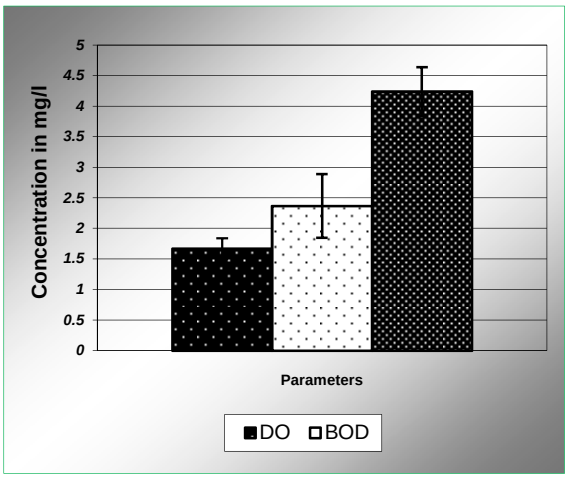


Fig-a: Average Concentration of DO, BOD and COD.

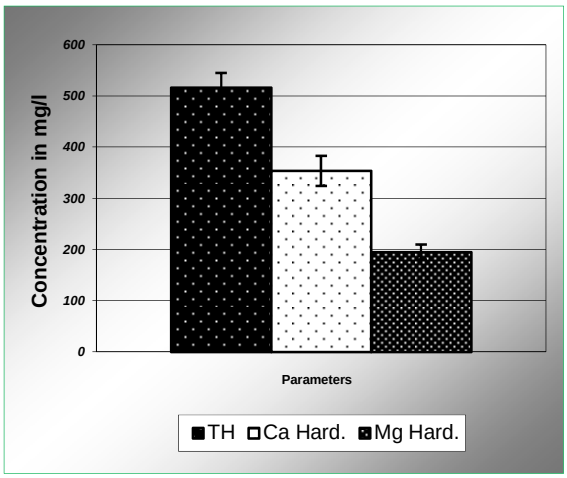


Fig-b: Average concentration of TH, Ca

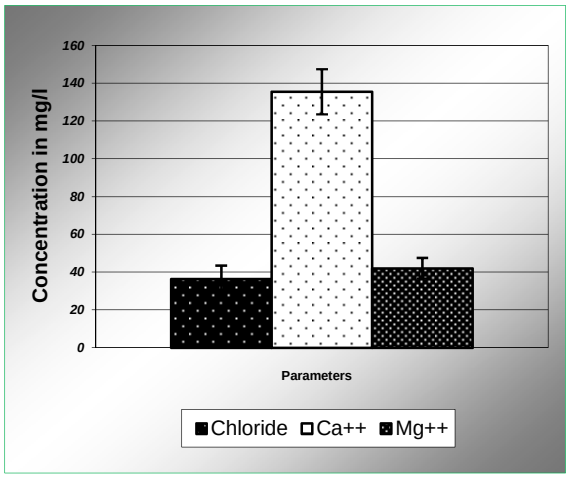


Fig-c Average concentration of Chloride, Ca++ and Mg++

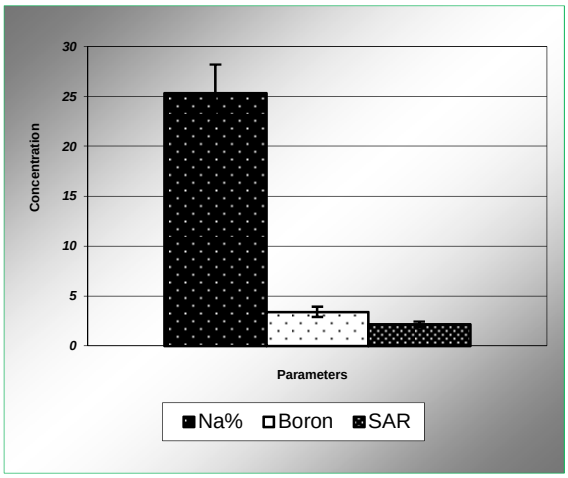


Fig-d Average concentration of Na%, Boron and SAR.

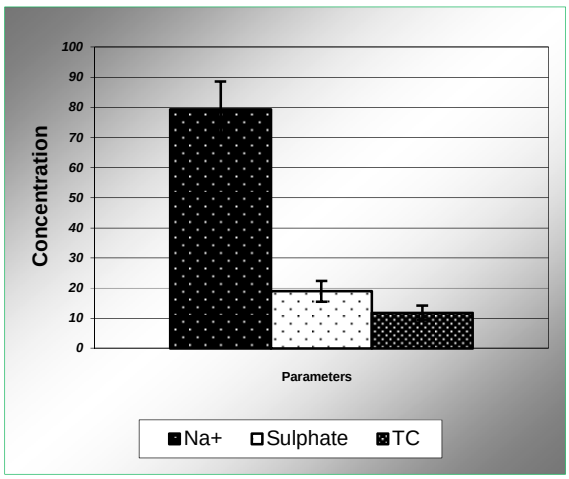


Fig-e Average concentration of Na+, Sulphate and TC

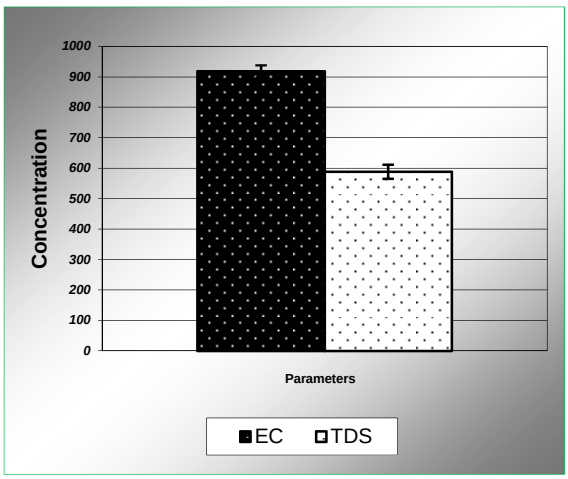


Fig-f Average concentration of EC and TDS

Table 6: Standards Laid by ISI for Waste Water to be Used for Irrigation

Parameters	Class I	Class II	Class III
Percent Sodium	≤ 60	30-70	70-75
Boron, mg/l			
Sensitive plants	≤ 0.5	0.5-2.0	≥ 2.0
Tolerant plants	≤ 1-1.5	Upto 3.3	≥ 3.3
Chlorides, meq/l	≤ 2.0	02-16	≥16
Sulphates, meq/l	≤ 4.0	4.20	≥ 20
EC, micro mho/cm	≤ 1000	500-3000	≥ 3000
Totalsalts	≤ 700	350-2100	≥ 2100

Table 7: Classification of Ground Water on the Basis of Na%, SAR, EC and TDS

Parameters	Range	Water class
Na %	20	Excellent
	20-40	Good
	40-60	Permissible
	60-80	Doubtful
	80	Unsuitable
SAR	10	Excellent
	18	Good
	18-26	Doubtful
	26	Unsuitable
EC	250	Excellent
	250-750	Good
	750-2000	Permissible
	2000-3000	Doubtful
	3000	Unsuitable
TDS	≤ 1000	Fresh
	1000-3000	Slightly Saline
	3000-10000	Moderately Saline
	10000-35000	High Saline

4.0 Conclusion:

Finding of the study area indicated that area has high hardness and conductivity, alkalinity and TDS, calcium and magnesium values werehigher than their prescribed standards in all ground water samples. High values of these parameters were noticed due to the naturally or geogenic sources of minerals in study area. All parameters were recorded within their permissible limit prescribed by BIS,WHO and ICMR.Agricultural water quality parameters are also within the permissible limits, according to agriculture irrigation standards. Boron, Na %, SAR are the critical parameter for agriculture and all physico-chemical and biological parameter in ground water were observed within permissible limits and suitable for agriculture use. This type water is called class-I water as per ISI limits. Over all ground water quality is good for drinking as well as for agriculture. Biologically in term of total coliform ground water is in healthy range it shows the ground water of district is very healthy for drinking purpose also.

References:

1) APHA-AWWA-WPCF (1995): Standard methods for the examination of water and waste water (19th Ed.), New York, USA.
2) BIS. Indian Standard (IS: 2490)(1983): Domestic Water Specification. Bureau of Indian Standards, New Delhi.
3) Deswal S. and Chandana P. (2007): Water quality status of SannihitSarovar in Kurukshetra (India),J. of Env. Sc. &Engg, vol. 49, pp. 51-53s.
4) Drever J.J.(1982): The geochemistry of natural waters, Prentice-Hall, Englewood Cliffs, pp. 388.
5) Garg S.S. (2003): Water quality of well and borewell of 10 selected location of Chitrakoot region,Indian J. Environ.Prot. vol. 23, pp. 966-974.
6) Malik S. and Banerji S.(1981): Nitrate pollution of ground water as a result of agriculture development in Indo-Gango Plain, India, In: proc; Int.symp.on Quality of Groundwater the Nether lands.
7) Mehta B.C., Singh, Srivatsava and Das S. (1990): Impact of fertilizer use on groundwater quality in parts of Ganjam District, Orrisa, Bh-Jal News, vol. 5, pp. 44-48.
8) Moxonir D.E. and Thomas J.H.C. (1993): Groundwater nitrate contaminants from the old chalford Nitrate Sensitive Area, West Oxfordshire, J Institution of water and Environment Management, vol.7, pp. 507-512.
9) Pant T. K. Ground Water Brochure of Banda District, U.P. : http://www.cgwb.gov.in/District_ Profile/UP/Banda.pdf
10) Rao G.S. and Rao G.N. (2010): Study of ground water quality in greater Viskhapatnun city, Andhra Pradesh (India),J. of Env. Sc. &Engg. Vol. 52, pp. 137-146.
11) Rao N.S. (2002): Geochemistry of groundwater in parts of Guntur district, Andhra Pradesh, India, Environ. Geol. Vol. 41 pp. 552–562.
12) Stallard R.F. Edmond J.N. (1983): Geochemistry of the Amazon-II. The influence and the geology and weathering environment on the dissolved load, J. Geophys.Res., vol. 88 no. C14, pp. 9671-9688.
13) WHO (1993): Guidelines for drinking water quality, Recommendations (2nd ed.). Geneva: WHO, vol. 1, pp. 130.