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Ground water quality status in different blocks of sonbhadra district, Uttar Pradesh in India

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Abstract
The water and environment has become an emotive issue for the people and policy makers. The chief causes for the pollution of water and environment are anthropogenic activities of human beings. Studies of Physico-chemical parameters of groundwater quality based on Physico-chemical paratmeres have been taken from eight blocks of Sonbhadra district, Uttar Pradesh was conducted in pre monsoon season of the year 2016 to evaluate its suitability for domestics' purpose. The quality analysis has been made through the pH, EC, TDS, Cations like Sodium, Pottassium, Calcium, Magnesium, Anions like Carbonate, Bicarbonate, RSC, SAR and iron. A systematic calculation of the correlation coffecient has also been used between different analyzed parameters. Comparative studies of samples in different blocks were conducted and it was found that the value of Electrical Conductivity and Total Dissolved Solids (TDS) for standard deviation mean is $\pm$ 0.31 and $\pm$ 208.32 respectively. The majority of groundwater samples on the basis of salinity (EC) were found to be medium to high salinity class, but on the basis of sodicity (SAR) and alkalinity (RSC) more than 90 % samples were found to be normal. On the basis of cationic and anionic composition of groundwater it can be concluded that the groundwater of Sonbhadra district is Na-Mg-Ca type.

Keywords: pH, EC, TDS, Sodium, Potassium, Calcium, Magnesium, Carbonate Bicarbonate, RSC and SAR etc.

Introduction
Water is the one of the essential source of life on the earth planet. It also performs unique and indispensable activities in earth ecosystem, biosphere and biogeochemical cycles. Thus, high quality water is always a need for living organisms. Water is the most important component among the natural resources, and is crucial for the existing of all living organisms. Water is a resource that can be uses in different form including recreation, transportation, and hydroelectric power, domestic, industrial, and commercial uses. Water covers 70.9% of the Earth's surface ("CIA-The world fact book" Central Intelligence Agency) and is vital for all known forms of life ("United Nations". Un.Org.2005-03-22). It could mean that there is more than enough water on the earth. But we rarely consider that about 97.5% of total water is saline. Only about 2.5% is "Fresh Water" i.e. not saline can be directly consumed by us and most of the land organism. Approximately 70% of fresh water is consumed by agriculture (Baroni *et al.*, 2007) [4]. Fresh water is a finite resource, essential for agriculture, industry and even human existence, without fresh water of adequate quantity and quality, sustainable development will not be possible. Water is one of the fundamental requirements of life and any undesired addition of chemical substances leads to its contamination and makes it unfit for human utility (Mayank *et al*., 2011) [12]. In many developing countries, access to clean and safe water is a major problem. Many industrial and power plants use rivers, streams and lakes to dispose of waste heat and also can have a disastrous effect on life in an aquatic ecosystem (Maitera *et al*., 2011) [11]. Fluoride, nitrate, arsenate are some of the compound that is widely present in groundwater worldwide. Exposure to these in drinking water has a number of adverse effects on human health including neuro, gastrointestinal, skin and skeletal disorders that is a significant cause of morbidity in a number of regions of the world. The frequency of life threatening infections caused by consumption of untreated water has increased worldwide and is becoming an important cause of mortality in developing countries (Al-Bari *et al*., 2006) [2]. According to the UN, 1.1 billion people still do not have access to an adequate supply of drinking water and these people are among the worlds poorest. Due to limited clean and safe water source, surface water either from rivers or rain fed ponds has become one of the main sources of water supply. This water is vulnerable to various forms of pollution generated from different sources mainly households, agriculture and industries (Abaliwano *et al*., 2008) [1].

Hence the continuous treatment of waste water is more suitable and ideal (Deviram *et al*., 2011) [5]. Ground water is polluted due to industrial effluents and municipal waste in water bodies.

Materials and Methods

Collection of water sample: Ground water samples were collected from different villages of different blocks of Sonbhadra district of Uttar Pradesh from tube well and open wells. Water was collected approximately 250 ml per sample from different areas of different blocks.

Physico-chemical analysis of the water sample

Physicochemical parameters of the water sample were determined by using specific methods, which are given in Table 1. A mathematical relationship between EC and TDS has been devised, making it easy to correlate one type of measurement with the other. For most water, TDS, in milligrams per litre, is expressed as: TDS (in mg/L) = EC (in dS/m) × 640. The residual sodium carbonate may be calculated simply by subtracting the quantity of Ca +Mg from the sum total of carbonates and bicarbonates determined separately in a given sample and expressed in me L^{-1}. Thus, RSC = $(CO_3^{--} + HCO_3^{-}) – (Ca^{++} + Mg^{++})$. Sodium Adsorption ratio is calculated using the formula;

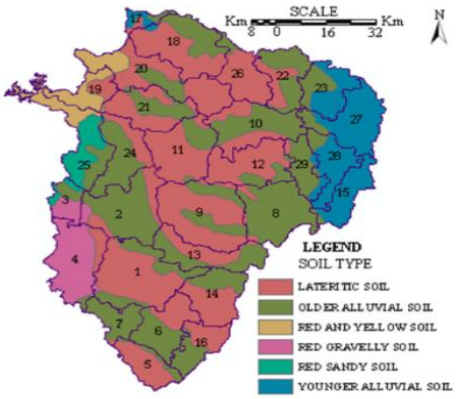
$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Statistical analysis

Data obtained from all the observation were statistically analyzed. The statistical analysis has been performed using standard methods. The least square difference values were calculated to test the significance of treatment difference and values were evaluated at 1% level of significance. Methods used for Physico-chemical Analysis-

Table 1: Methods for determining physicochemical parameters of the water sample

S. No	Parameter	Method
	Physical	Parameters
1.	pH	pH Meter
2.	EC	Conductivity Meter
3.	TDS	
	Chemical	Parameters
4.	Calcium	Titration
5.	Magnesium	Titration
6.	Carbonate	Titration
7.	Bicarbonate	Titration
8.	Iron	DTPA Titration
9.	Sodium	Flame Photometer
10.	Potassium	Flame Photometer



Results and Discussion

The water samples were analyzed for TDS, pH, EC, ionic composition including important cations, anions, SAR and RSC. The TDS content of groundwater samples are given in table 2 which varies from 198 to 877 ppm with an average value of 465 ppm. The lowest value of TDS (198 ppm) was observed in Myorepur block whereas; the highest value (877 ppm) was recorded in Gorawal block. A perusal of data presented in table 3 revealed that pH of groundwater of Sonbhadra district varied from 7.80 to 8.68 with an average value of 8.31 and the Maximum value (8.68) was recorded in the groundwater of Chatra and the minimum value (7.80) was observed in Robertsganj block and incase electrical conductivity of sonebhadra district varied from 0.299 to 1.351 with an average value of 0.915 and the maximum value (1.315) was recorded in the groundwater of Gorawal and the minimum value (0.299) was observed in Myorepur block. Further in reference to data presented in table 3.It is clears that the ground water of Robertsganj block is comparatively good and the mean value are near neutral whereas, Dudhi block is worst affected by high pH of groundwater followed by Chatra and Myorepur block. The results of the present investigation are in line of the findings of Prasad and Minhas (2007) [13] who have reported a variation of pH of groundwater in Mahoob Nagar district of Andhra Pradesh. Similar results were also reported by Yadav (1999) [23], Kumar *et al.* (2007) and Ramkumar *et al.* (2010) [14]. A critical observation of the data in table 4 and 5 revealed that the cations of groundwater of Sonbhadra district varied from place to place. The calcium content in groundwater of Sonbhadra district varied from 10.00 to 74.00 mg L^{-1} with the mean value of 36.62 mg L^{-1}. The standard deviation was ± 21.20 of Sonbhadra. Maximum value of calcium (74.00 mg L^{-1}) was found in groundwater of Bhabhani block whereas the minimum value of calcium (10.00 mg L^{-1}) was recorded in Duddi block. These results are in agreement with those of Gurugnanam *et al.* (2009) [7] who have reported the calcium content of groundwater. Similar were the results of Anbazhagan and Nair (2004), Farooq *et al.* (2011) [11] and Singh (2012) [17].The magnesium content in groundwater of Sonbhadra district was varied from 4.00 to 52.00 mg L^{-1} with the mean value was 26.33 mg L^{-1} and standard deviation was ±13.08. Maximum value of magnesium (52.00 mg L^{-1}) was found in groundwater of Ghorawal block whereas the minimum value of magnesium (4.00 mg L^{-1}) was recorded in Myorepur block. The result of the present investigation are supported by the research findings of Swarna and Nageswara (2010) [18] and Farooq *et al.* (2011) [11] who have reported the magnesium content in groundwater. Singh (2012) [17] also reported the similar variation in magnesium content in groundwater in Rajsamand district.The sodium content in groundwater of Sonbhadra district varied from 35 to 165 mg L^{-1} with the mean value of 26.33 mg L^{-1}. And standard deviation was ± 39.08 of sodium. Maximum value of sodium (165 mg L^{-1}) was found in groundwater of Ghorawal block whereas the minimum value of sodium (35 mg L^{-1}) was

recorded in Navgoan block. These results are in close conformity with the findings of Kumar *et al.* (2007) and Gurugnanam *et al.* (2009) [7] who have reported that the sodium content of groundwater varied from place to place. Similar were the results of Swarna and Nageswara (2010) [18], Farooq *et al.* (2011) [11] and Singh (2012) [17].The potassium content in groundwater of Sonbhadra district varied from 0.15 to 4.50 mg L^{-1} with the mean value of 2.04 mg L^{-1}. And standard deviation was ± 1.05 of potassium. Maximum value of potassium (4.50 mg L^{-1}) was found in groundwater of Robertsganj block whereas the minimum value of potassium (0.15 mg L^{-1}) was recorded in Navgoan block. On the basis of average values of cationic concentration in groundwater of Sonbhadra district it was found that the sodium is dominating cation with the average concentration of 26.33 mg L^{-1} followed by magnesium (average concentration 26.33 mg L^{-1}) and calcium (average concentration 36.62 mg L^{-1}). A critical observation of the data given in table.6 revealed that carbonate content in groundwater of Sonbhadra district varied from 0.00 to 27.00 mg L^{-1} with the mean value of12.19 mgL^{-1}. And standard deviation was ± 11.25. The maximum value of carbonate (27.00 mg L^{-1}) was found in Dudhi block whereas the minimum value (0.00) was recorded in Bhabhani, Ghorawal and Robertsganj blocks. These results are strongly supported by the findings of Sadashivaiah *et al.* (2008) [16] and Gurugnanam *et al.* (2009) [7] who have reported that the carbonate content of groundwater vary from place to place. Similar results about carbonate content of groundwater were also reported by Singh (2012) [17]**.** The perusal of data presented in table.6 revealed that the bicarbonate content in groundwater of Sonbhadra district varied from 89.00 to 165.00 mg L^{-1} with the mean value of 117.91 mg L^{-1}. And standard deviation was ± 22.42.The maximum value (165.00 mg L^{-1}) was found in Dudhi block whereas the minimum value (89.00 mg L^{-1}) was recorded in Bhabhani block. These results are in agreement with the findings of Farooq *et al.* (2011) [11] and Singh (2012) [17]. The RSC indicates the excess of carbonate and bicarbonate over calcium and magnesium in groundwater. The data presented in table.7 revealed that RSC values of groundwater of Sonbhadra district varied from -5.45 to 1.45 me L^{-1} with an average value of -1.66 me L^{-1}.And standard deviation was ± 2.36. The high average RSC in groundwater was observed in Myorepur followed by Chatra block. A critical examination of data presented in table. 8 clearly indicated that sodium absorption ratio varied from 7.73 to 23.79 with a mean value of 14.10 and standard deviation was ± 5.46. The minimum SAR (7.73) was reported in Navgoan and the maximum (23.79) was found in Ghorawal block. These results are in agreement with the Verma *et al.* (2003) [22], Prasad *et al.* (2007) [13] and Singh (2012) [17] who reported the SAR variation in their studies. Data pertaining to available iron in water have been presented in table:9. The content of available iron in water of the study area ranged from 0.80 to 4.70 mg L^{-1} with an average value of 1.91 mg L^{-1} and standard deviation was ± 0.65. The minimum (0.80 mg L^{-1}) and maximum (4.70 mg L^{-1}) available iron were recorded in Bhabhani and Chatra block respectively.

Table 2: Data of TDS in water sample

Block	TDS of groundwater		
	Minimum	Maximum	Mean
Babhani	467	534	501
Chatra	224	253	239
Chopan	493	507	500
Dudhi	467	488	477
Gorawal	838	876	849
Myorepur	198	269	242
Navgoan	276	324	298
Robertsganj	619	624	624
District Mean			465.22
Standard Deviation			± 208.32

Table 3: Data of pH and EC in water sample

Block	pH of groundwater			EC of ground water		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Babhani	7.90	8.55	8.19	0.697	0.801	0.75
Chatra	8.30	8.68	8.39	0.339	0.380	0.35
Chopan	8.22	8.50	8.35	0.732	0.760	0.74
Dudhi	8.40	8.58	8.50	0.687	0.732	0.71
Gorawal	7.90	8.30	8.15	1.257	1.315	1.2
Myorepur	8.05	8.60	8.37	0.297	0.403	0.36
Navgoan	8.15	8.50	8.35	0.415	0.486	0.69
Robertsganj	7.80	8.30	8.08	0.929	0.936	0.697
District Mean			8.31			0.691
Standard Deviation			± 0.15			±0.31

Table 4: Data of Calcium and magnesium water sample

Block	Calcium			Magnesium		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Babhani	54	74	65	18	36	27
Chatra	21	28	25	8	12	10
Chopan	19	29	24	20	32	27
Dudhi	10	21	16	28	36	32
Gorawal	46	56	52	40	52	46
Myorepur	18	31	24	4	9	6
Navgoan	19	23	20	19	27	23
Robertsganj	64	72	68	37	41	39
District Mean			36.65			26.36
Standard deviation			± 21.20			± 13.08

Table 5: Data of sodium and potassium water sample

Block	Sodium			Potassium		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Babhani	59	72	65	1.90	2.80	2.40
Chatra	38	51	44	1.50	2.50	2.06
Chopan	92	105	97	1.50	2.35	1.97
Dudhi	92	102	98	1.60	2.50	2.06
Gorawal	149	165	156	1.32	1.50	1.41
Myorepur	39	52	46	1.70	2.50	2.12
Navgoan	35	45	40	0.15	0.56	0.26
Robertsganj	75	83	76	3.5	4.5	4.01
District Mean			77.93			2.05
Standard deviation			± 39.08			± 1.05

Table 6: Data of Carbonate and bicarbonate water sample

Block	Carbonate			Bicarbonate		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Babhani	00	00	00	89	107	98
Chatra	23	26	24.30	112	121	117
Chopan	10	15	12.40	90	104	98.40
Dudhi	22	27	25	152	165	159
Gorawal	00	00	00	129	139	134
Myorepur	9	15	12	128	142	134
Navgoan	22	26	24	89	123	104
Robertsganj	00	00	00	98	101	99
District Mean			12.17			117.91
Standard deviation			± 11.25			± 22.42

Table 7: Data of Residual sodium carbonate (RSC) water sample

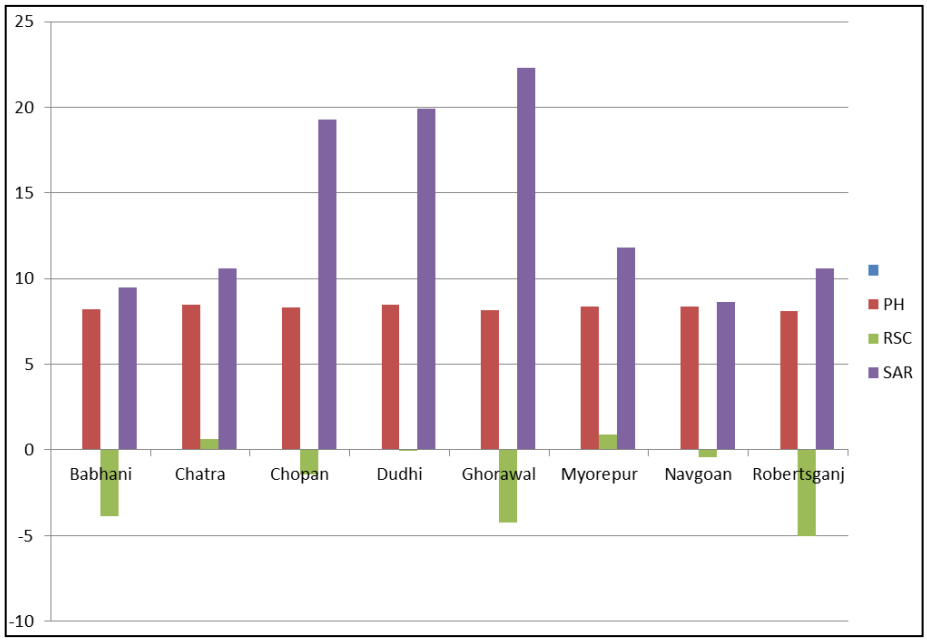
Block	Residual sodium carbonate (RSC)		
	Minimum	Maximum	Mean
Babhani	-4.95	-2.74	-3.88
Chatra	0.53	0.84	0.65
Chopan	-1.91	-0.83	-1.42
Dudhi	-0.51	0.16	-0.05
Gorawal	-4.92	-3.57	-4.25
Myorepur	0.53	1.17	0.89
Navgoan	-0.65	-0.16	-0.42
Robertsganj	-5.32	-4.71	-5.04
District Mean			-1.69
Standard deviation			± 2.36

Table 8: Data of Sodium adsorption ratio (SAR) water sample

Block	Sodium adsorption ratio (SAR)		
	Minimum	Maximum	Mean
Babhani	8.89	11.33	9.64
Chatra	9.56	12.19	10.63
Chopan	17.39	21.69	19.29
Dudhi	18.98	21.79	19.84
Gorawal	21.29	23.79	22.34
Myorepur	11.57	12.65	11.84
Navgoan	7.73	9.59	8.65
Robertsganj	10.01	11.14	10.57
District Mean			14.08
Standard deviation			± 5.46

Table 9: Available iron and (mg L^{-1}) of soil Sonbhadra district

Block	Iron		
	Min.	Max.	*Mean*
Babhani	0.80	1.75	*1.23*
Chopan	1.50	2.00	*1.70*
Chatra	2.50	4.70	*3.32*
Dudhi	1.50	2.00	*1.70*
Gorawal	1.10	1.80	*1.28*
Myorepur	1.50	2.20	*1.86*
Navgoan	1.50	2.50	*2.01*
Robertsganj	1.50	3.00	*2.16*
District Mean			*1.92*
Standard deviation			*± 0.65*



Conclusion

The majority of groundwater samples on the basis of salinity (EC) were found to be medium to high salinity class, but on the basis of sodicity (SAR) and alkalinity (RSC) more than 90 % samples were found to be normal. Further it was found that the quality of groundwater in Chatra block was worst affected by iron followed by Nagwa and Robertsganj blocks. On the basis of cationic and anionic composition of groundwater it can be concluded that the groundwater of Sonbhadra district is Na-Mg-Ca type. Groundwater quality maps were prepared which may be useful for policy maker or planners for easy illustration and decision making. Soils of the study area were found low to medium in organic carbon and available nitrogen and medium in available phosphorus while medium to high in available potassium. In case of micronutrients 8.18, 31.82, 21.82 and 16.36 % samples were found deficient in DTPA zinc, copper, iron and manganese respectively. On the basis of correlation studies it can be concluded that the soil pH, electrical conductivity (salinity) and availability of cationic micronutrients adversely affected with the deteriorated quality of the groundwater used for irrigation.

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