Assessment and minimisation of pollution level of ground water for drinking purpose

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Abstract: Revolutionary advancement in human life style through civilization, industrialization, modernization and globalization created environmental imbalance resulting increased pollution of natural resources and challenging the earth's existence. A valuable component of hydrological cycle is water used for drinking and to solve other domestic purpose. It is necessary that everyone would be known about the water quality. Keeping in view, the presented study is aimed to access water quality of district Saharanpur, Uttar Pradesh, India by calculating Water Quality Index (WQI) using data obtained after analysing ground water (60 samples) for physicochemical properties as pH, total dissolved solids (TDS), total hardness (TH), major anions like bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{-2}), nitrate (NO_3^-) fluoride (F^-) and some cations such as calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^+) and potassium (K^+) for drinking purpose suggested by Bureau of Indian standard. Water quality ascertained on the basis of WQI values that varied from 48.83 to 118.76 indicating presence of mostly good water in the studied area. Water was discovered to be alkaline and contaminated with bicarbonate, nitrate and magnesium ions with high level of TDS, EC and TH. The suitability of drinking water of Saharanpur district was also described by computing percent compliance. The simple correlation coefficient value was computed using regression method to predict correlation among the studied variables of physicochemical parameters. Drinking water quality must be excellent for healthy environment but most of area has good water and some part was traced with poor water while none has excellent. It was observed that after treating with chitosan beads as an adsorbent, the physical properties as pH, TDS, EC, TH were found to be reduced by 20-40 % that is an indicative of improvement of water quality for drinking.

Keywords: Physicochemical, parameter, compliance, correlation, WQI.

1. INTRODUCTION

Revolutionary advancement in human life style through civilization, industrialization, modernization and globalization created environmental imbalance resulting increased pollution of natural resources and challenging the earth's existence. A valuable component of hydrological cycle is water. It is a dynamic, replenishable natural gift and is essential for survival of living beings. Due to scarcity of surface water, the living organisms are widely dependent on groundwater for drinking purposes. There are some factors like climate change, pollution, composition of recharge water, the chemical reactions of water with rock and soil as water stay in contact with them in a particular zone, their residual time etc. which determine the quality of water in that area.

Presently, degradation of water quality is expected due to geogenic and anthropogenic activities. As poor quality of water reduces the economy and environmental health of society, water quality of groundwater must be assessed and monitored regularly to decide the appropriateness and also to take innovative and progressive steps towards protection of present and coming generations. Keeping this aim in view, we have chosen to determine water quality of Saharanpur district.

Scientists (Chaurasia et al., 2018; Kumar et al., 2003) used geo statistical methods to determine the water quality parameter but the most effective approach is calculating water quality Index (WQI) which provide to decide more precisely the water quality of chosen area. The WQI is a mathematical relationship using by analysts to convert a large number of complex data of water's physicochemical properties into a single numbered value (Batabyal et al., 2015; Charmaine et al., 2010: Khan et al., 2017; Reza et al., 2010).

The area under investigation is Saharanpur district of Uttar Pradesh in India in which the people living in rural and urban regions are completely dependent on ground water to drink and to fulfil their other domestic requirements. The objective of study is to analyse ground water for physicochemical parameters referred as Bureau of Indian standard (BIS, 2012) for drinking water and computed WQI values to assess suitability of ground water for drinking purpose.

II. STUDIED AREA OF SAHARANPUR

Saharanpur lies between latitude $29^{o}25'$-$30^{o}24'$ and longitude $77^{o}07'$-$78^{o}13'$. Total geographical area of Saharanpur district is 3860 Sq. Km. It falls in extreme uppermost corner of Ganga-Yamuna doab of fertile alluvium of Indo Gangetic basin. It is rectangular in shape and bordered by Uttarakhand in north, Haryana lies in its west, Haridwar in the east, Shamli and Muzaffarnagar to its south. River Ganga flows to east and river Yamuna to its west as shown in figure 1.

The climate of Saharanpur is warm and temperate. The average annual temperature of the district is 23.9^{o}C. In the selected area, the rainfall per year is approximately 757.71 to 901.6 mm. Saharanpur district comprises of twelve blocks covered by a thick population of 34,466,382 (density = 900/Km) according to census 2011 with a growth rate of 19.59 % over the decade and have mini cluster of industrial areas with paper mills, wood craft, dying,

Figure 1- Location map of Saharanpur district.

pharmaceutical and agro based industries. All these industries generating toxic effluents might contaminate the groundwater of Saharanpur district. The major river of the area is Yamuna and its tributary Hindon. Dhamola river is a tributary of Hindon river which is flowing through Saharanpur. Twelve blocks namely Baliakheri, Nagal, Nakur, Nanauta, Rampur, Punwarka, Sadauli Kadim, Deoband, Gangoh, Sarsawa, Mujaffarabad and Sahranpur city are showing in figure 1.

III. GEOLOGY OF SAHARANPUR

Geologically, quaternary alluvium and lower piedmont plain is characteristic of Saharanpur. Lithologically, the studied area is comprising of Khadar, Bangar and Alluvial plain except for some variations in the northern part where Bhabar of Himalayas categorise into the plains. Alluvium is composed primarily of fluviatile and subariel clay, sand and gravels deposits. In General, Saharanpur district can be characterised by three parts i.e. Siwalik Hill Tract, Bhabar Land and Tarai or the plains. The part of Shiwalik hill tract in the district has middle and upper Siwalik composed of sand stones, conglomerates sands, clay, silts etc. Geomorphologically, the area shows rough and uniform lithology which provide steepness and sharpness to slopes of hills resulting highly alleviated and deep incised drainage. The Bhabar land, just lying below the foothills of Siwalik, characterized by boulders, Pebble, Cobbles etc. with relatively dry terrains belt and lying at higher elevation as compared to the plains having steeper gradient which covers mostly the Muzaffarabad and Sadualikadim block. Tarai or the plains part of district lies just below the Bhabar zone. It is almost a plain surface sloping towards south with a gradient around 1.2 m/Km. This area is characterized by coarse sand, gravel etc.

IV. METHODOLOGY

The area of district Saharanpur in U.P., India has been selected for investigation of ground water quality and its twelve blocks were chosen to collect ground water during February and March, 2019. Five samples of ground water from each block (totally 60) were collected after ten minutes of pumping. It was stored in properly washed plastic bags at 4ºC until the analysis were finished. Different physicochemical parameters suggested by BIS, 2012 such as pH, total hardness (TH), total dissolved solids (TDS), electrical conductivity (EC), major anions like bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{-2}), nitrate (NO_3^-) fluoride (F^-) and some cations such as calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^+) and potassium (K^+) were analysed in each of the collected sample. Heavy metals like arsenic (As), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb) and cadmium (Cd) were also analysed to study the pollution level of water. To test all the parameters, the standard methods were followed and it was recommended by American Public Health Association (2005).

The analytical data obtained for each of the block for each of five collected samples and computed average value for each of the studied physicochemical parameters which is used to compute WQI values as represented in table 1. WQI is a mean by which water quality describing parameters are summarised into a rating number for reporting to the public in a consistent manner and capable of comparing quality of water area wise. The determination of WQI was obtained using Indian Standard specified for drinking water (BIS, 2012).

Further, correlation was made among the studied 13 physicochemical parameters. The suitability of ground water for drinking purpose for each of the studied blocks of Saharanpur district was made sure by computing percent compliance in comparison to standard values projected by BIS (2012). To calculate WQI values we have followed following steps –

Initially the relative weightage (W_i) for each 13 physicochemical parameters (pH, EC, TDS, TH, Ca^{+2}, Mg^{+2}, Na^+, K^+, HCO_3^-, Cl^-, SO_4^{-2}, NO_3^- and F^-) was calculated by assigning a weight (w_i) to each parameter accordingly to their relative importance for drinking water e.g. NO_3^- concentration involving highest participation to assess water quality, hence assigned highest weight (w_i) of 5. Minimum weight 1 was assigned to magnesium because of its less significant role in drinking water. All the other parameters were given weight (w_i) between 1 and 5 as they have moderate participation. Following formula was used to calculate relative weightage (W_i) for studied physicochemical parameters (Tiwari et al., 1985).

$$W_i = w_i \Big/ \sum_{i=i}^{w_i} w_i$$

w_i= weight assigned to parameter

n = Total number of parameters (n=13) for drinking purpose

The Computed values for relative weight (W_i) obtained are listed in table 2. In next step, a quality rating scale (q_i) was calculated using formula as under (BIS, 2012)

$q_i = 100 \times C_i/S_i$

Where C_i, measured concentration or value of each parameter and S_i is Standard desirable value for parameter according to BIS, 2012 guidelines.

Now Sub index (SI) is estimated for parameters by multiplying q_i value to relative weight (W_i)

$SI= W_i \cdot q_i$

Finally WQI is computed by using expression as given below

$WQI = \Sigma\ SI_{i-n}$

The quality of ground water, on the basis of the WQI values, are classified into five categories for drinking purposes as excellent water ($WQI \leq 50$), Good (WQI = 50-100), Poor water (WQI = 100-200), Very Poor water (WQI = 200-300) and water unsuitable for drinking ($WQI \geq 300$).

Suitability of drinking water of an area on the basis of each studied physicochemical parameter is described by percent compliance as calculated by given formula-

% Compliance = 100 x No. of Samples below standard value / Total no. of samples

The calculated percent compliance values including median, standard deviation, minimum and maximum values measured for each parameter are represented in table 3.

V. WATER TREATMENT METHOD

Chitosan beads were prepared as described by Vaishali et. al (2018) and 100 g of water kept with 1g of beads to equilibrate for 24 hand then tested for four physicochemical properties i.e. pH, TDS, EC and TH.

VI. RESULTS AND DISCUSSION

The physical properties of ground water was described by pH, electrical conductivity, total dissolved solids and total hardness. The pH of water ranges from 7.0–8.9 which assigned the alkaline nature of water. None of the samples was found to have below standard pH. Few number of samples were recorded to have higher than permissible values of pH as referred by BIS standard (6.5 - 8.5). pH of water is a measure of acidity or alkalinity of water and of the cations /anions balance in water alkalinity in the most natural waters is usually but not always due to bicarbonate ion (Dallas and Day 2004). Other sources of alkalinity include the carbonate ion (CO_3^{-2}), the hydroxide ion (OH^-) and a few other minor ions. Higher value of pH shows that OH^- ion concentrations is higher than H^+ concentration in Saharanpur district water.The total dissolved solids (TDS) content of fresh water is the sum of the concentrations of the dissolved major ions (Allan et al., 2007). Total dissolved solid depends on various factors such as geological nature of watershed, rainfall and amount of surface runoffs and gives an indication of the degree of dissolved chemicals (Fatoki et al., 2001). The observed TDS values were ranging from 308-1050 mg/l as measured for samples of the studied blocks, reflected that TDS are within the permissible limit of BIS (500-2000 mg/l and WHO 1000-2000 mg/l). Only 61.67 percent water samples of Saharanpur district had fresh water, healthy for drinking purpose while Nakur, Rampur, Sadaulikadim, Sarsawa and Saharanpur City showed higher average values of TDS content as guided by BIS Standard. Higher values of TDS are the indicative of higher mineralised water in some part of the district area.

The hardness of natural water depends mainly on the presence of dissolved calcium and magnesium salts. Hardness may vary over a wide range and depends over water flow and flood conditions (USEPA, 2006). The variation in total hardness during studied period at all the sites was recorded as 154 – 458 mg/l as compared to BIS standard 300-600 mg/l, revealed that only 16.67 percent of water samples in Saharanpur district area had soft water while Nakur and Rampur blocks showed the presence of hard water. Higher values of TH shows the presence of higher concentration of Ca^{+2} and Mg^{+2} ions.

The electrical conductivity (EC) is a measure of the electric current carrying ability of water and is related to the concentration of dissolved ions present. In the studied area the Electrical conductivity determination of water samples indicated a range from 350-1400 µs/cm with nil compliance. Higher obtained values compared to BIS 2012 for all samples in district region is an indication of highly mineralised water of district.

The chemicals dissolved in groundwater were analysed quantitatively for major cations and anions. It has been concluded that among all studied cations Ca^{+2} ion showed the highest average value and K^+ ion the least concentration. The order of average concentration was observed as $Ca^{+2} > Na^+ > Mg^{+2} > K^+$ in studied area except in Nakur, Nanauta and Punwarka blocks where the average concentrations were measured in order of $Ca^{+2} > Mg^{+2} > Na^+ > K^+$. Ca^{+2} was most abundant in groundwater of studied area, but it was estimated within a range of 38-80 mg/l with 95 % compliance. It means that 5% samples of studied area had exceeded concentration than the Standard value (75mg/l) recommended by BIS and World Health Organization (WHO) in 2011. Higher level of Ca^{+2} is not desirable in washing, bathing and laundry, while small concentrations are beneficial in reducing the corrosion in pipelines (Dallas and Day 2004). Na^+ and K^+ ions were also pointed out as 11-150 mg/l and 0 - 12 mg/l respectively showing 75% and 96.67% compliance respectively. On the other hand, Mg^{+2} Concentration was measured as 6 - 80 mg/l with 88.33 % compliance. This concluded that only 11.67 % of water samples in Saharanpur district was noticed with large quantity of dissolved Mg^{+2} with respect to Standard value (30 mg/l) but none of sample exceeded with respect to permissible value (l00mg/l) finalised by BIS and WHO.

Among the major anions studied, $HCO3^-$ is most abundant in studied area of Saharanpur district showing a range of 175 - 520 mg/l with 33.33 % of compliance. This range of concentration of $HCO3^-$ ions was below the permissible limit (732 mg/l), however 66.67 % of water samples were ascertained with exceeded concentration than the standard value (244 mg/l) accepted by BIS and WHO.

Another anion $NO3^-$ which was found in least concentrations within a range of 0-230 mg/l exceptionally, Rampur block showed presence of higher concentration of 190 mg/l. The percent compliance was found to be 91.67 with respect to BIS standard value of 45-100mg/l. Higher average concentration of $NO3^-$ (190 mg/l) for Rampur block is not desirable. F^-, Cl^- and SO_4^{-2} ions, persisted in groundwater with range of 0 .01 - 0.7mg/l, 15.4-162 mg/l and 6-164 mg/l respectively with 100% compliance with respect to suggested standard values by BIS and WHO. Nakur showed highest concentration of Cl^- (135 mg/l). Heavy metals As, Cu, Hg, Ni, Pb and Cd were found below the standard limit hence, water was found to be safe for drinking standard.

The quality of groundwater of Saharanpur district on the basis of WQI is shown in figure 2. Rampur block, with highest WQI value of 118.76 and Nakur block with second highest WQI = 110.17 were pointed out as the most polluted area in Saharanpur district, contaminated with higher concentrations of Mg^{+2}, HCO_3^- and NO_3^- ions that may be responsible for higher EC, TDS and TH values. Both of the blocks of Saharanpur district were

Table 1- Biochemical parameters of Saharanpur district.

Blocks	pH	EC	TDS	TH	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-2}	NO_3^{-}	F^{-}	WQI
Baliakheri	7.7	445	381	170	44	15	21	4.8	244	7.1	20	0	0.43	56.85
Deoband	7.96	547	450	200	60	12	28	10	232	43	28	5.2	0.64	70.34
Gangoh	8.09	550	469	210	40	27	29	5.3	305	14	16	0.19	0.52	67.36
Mujaffarabad	7.77	490	420	170	56	7.3	28	1.9	256	14	12	1.4	0.19	56.53
Nagal	8.1	401	350	160	48	10	15	3.8	232	7.1	5.3	0.02	0.22	48.83
Nakur	7.45	1302	947	330	56	46	130	8	488	135	55	0.45	0.17	110.17
Nanauta	7.9	558	422	200	40	24	22	5.9	244	14	44	0.02	0.61	56.19
Punwarka	7.49	438	370	180	44	17	15	4.1	232	7.1	26	0	0.45	50.99
Rampur	7.52	1300	976	450	72	66	82	2.4	342	78	113	190	0.32	118.76
Sadauli kadim	7.75	632	512	250	64	22	25	1.5	354	7.1	14	4.2	0.01	66.26
Sarsawa	7.85	705	578	250	68	19	43	5.3	366	35	13	0.33	0.27	72.43
Saharanpur city	7.93	832	734	290	64	51	76	5.1	286	73	38	16.8	0.25	82.83
District(Average)	7.8	683.33	550.75	238.67	54.67	26.36	42.83	4.84	298.42	36.2	32.025	18.22	0.34	71.46

*EC in µS/cm and all other chemical parameters in mg/L.

Table 2- Relative weight of physicochemical parameters.

Parameters	Indian standard value	Wi	Relative weight (W_i)
pH	6.5-8.5	4	0.1
EC	350-1400	4	0.1
TDS	500-2000	4	0.1
TH	300-600	2	0.05
HCO_3^-	244-732	3	0.075
Cl^-	250-1000	3	0.075
SO_4^{-2}	200-400	4	0.1
NO_3^-	45-100	5	0.125
F^-	1-1.5	4	0.1
Ca^{+2}	75-200	2	0.05
Mg^{+2}	30-100	1	0.025
Na^+	50-200	2	0.05
K^+	10-12	2	0.05
n=13		Σwi=40	ΣW_i=1

*EC in µS/cm and all other chemical parameters in mg/L.
**Lower Indian standard value indicates desirable limit and higher indicates permissible limit (BIS,2012)

Table 3- Minimum and maximum value of physicochemical parameters, computed values of median , standard deviation and percent compliance with respect to BIS standards, 2012.

Parameters	Minimum value	Maximum value	Median	Standard deviation	Percent compliance
pH	7.0	8.9	7.7	0.3	-
EC	350	1400	501.5	304.4	0
TDS	308	1050	438	212.4	61.67
TH	154	458	212	81.70	83.33
Ca^{+2}	38	80	48.5	11.41	95
Mg^{+2}	6.0	80	14.5	18.83	88.33
Na^+	11	150	30	34.06	75
K^+	0	12	3.8	2.55	96.67
HCO_3^-	175	520	252.5	84.6	33.33
Cl^-	15.4	162	13.5	39.38	100
SO_4^{-2}	6.0	164	25.5	30.1	100
NO_3^-	0	230	0.8	52.56	91.67
F^-	0	0.7	0.32	0.21	100

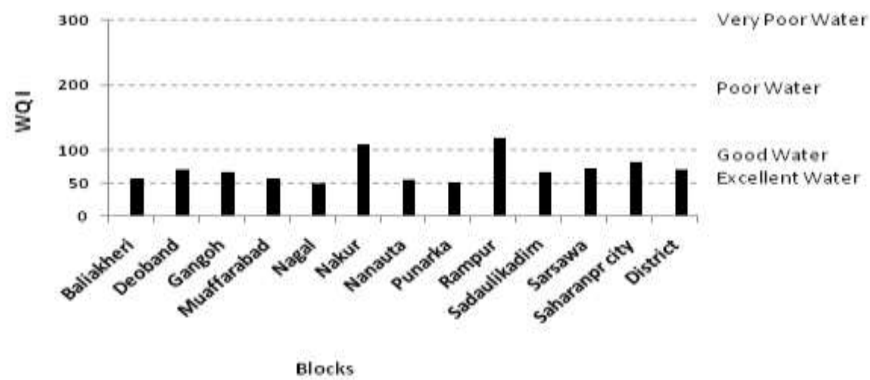

Figure 2- Graph showing comparison of water quality of different blocks of Saharanpur district on the basis of WQI values.

categorised with poor quality of drinking water. Nagal, the only block of studied region was found to be facilitated with least polluted drinking water and was ranked as excellent water with a WQI value of 48.83. Remaining nine blocks were having polluted groundwater with moderate value of WQI and fall in category of good water. Among the blocks in district, Saharanpur City (WQI = 82.83) was noticed for high concentration of HCO_3^-, SadauliKadim and Sarsawa were recognised to have high concentration of HCO_3^- with WQI = 66.26 and 72.43 respectively.

The blocks Baliakheri (WQI = 56.85), Mujaffarabad (WQI = 56.53), Nanauta (WQI = 56.19) and Puwarka (WQI = 50.99) have to be shined with fairly good drinking water.

Hence, Saharanpur district water quality was estimated by taking average of 12 blocks and presented in table 1 which concluded that district had alkaline water with high values for EC, TDS and higher concentrations of Na^+ and HCO_3^- ions. The average WQI value for Saharanpur district is found to be 71.46 indicating presence of good quality of water for drinking.

VII. CORRELATION ANALYSIS

The simple correlation coefficient (r), a value computed using regression method, is widely used correlation criterion between two variables which exhibit suitability of one particular variable to the other which used to measure correlation among a number of variables, when any dependent invariable (x) is influenced by the other independent variable (y) and vice versa (Voudouris et al., 2000). The Correlation Coefficient was calculated using given formula

$$\frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left[n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right]\left[n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2\right]}}$$

Correlation Coefficient values (r) ranges from -1 to +1, where r = +1 reveals strongest positive linear correlation, while r = -1 reflects strongest negative linear correlation. Table 4 indicated strongest (r>0.9) through good (r=0.5 to 0.9) to weak (r<0.5) correlation between various physicochemical parameters. In present research, the correlation matrix of 13 variables along with computed WQI values for Saharanpur district groundwater was calculated and is reflected in table 4 in which Correlation Coefficient r values are given to assess the value of linear association between any two of the parameters. It may be concluded that there are different groups according to correlation coefficient as under.

7.1 Strong correlation

EC showed strongest correlation with TDS (r = 0.991) and Na^+ (r = 0.923). TDS is strongly correlated with Mg^{+2} (r = 0.907) and Na^+ (r = 0.911). It is well known fact that the Electrical Conductivity increases with increasing Total

Table 4- Correlation coefficient matrix of physicochemical parameters of ground water for Saharanpur district.

	pH	EC	TDS	TH	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-2}	NO_3^{-}	F^{-}	WQI
pH	1	-0.55	-0.501	0.482	0.8	0.347	0.286	0.509	0.71	0.209	0.249	0.060	0.478	0.641
EC		1	**0.991**	0.870	0.722	0.896	0.923	0.339	0.846	0.876	0.818	0.586	0.017	**0.972**
TDS			1	0.616	0.776	**0.907**	**0.911**	0.346	0.855	0.858	0.788	0.569	0.032	**0.982**
TH				1	0.795	0.803	0.757	0.166	0.751	0.701	0.676	0.645	-0.094	0.899
Ca^{+2}					1	0.563	0.530	0.333	0.781	0.475	0.465	0.381	0.113	0.819
Mg^{+2}						1	0.82	0.170	0	0.767	0.866	0.694	0.039	0.860
Na^{+}							1	0	0.757	**0.977**	0.668	0.383	-0.128	0.851
K^{+}								1	0.421	0.464	0.154	-0.218	0.671	0.430
HCO_3^{-}									1	0.665	0.444	0.186	0.026	0.869
Cl^{-}										1	0.66	0.365	-0.070	0.803
SO_4^{-2}											1	0.859	0.204	0.780
NO_3^{-}												1	0.002	0.705
F^{-}													1	0.162
WQI														1

dissolved solid which is further increased ionic concentration or EC. Na^{+} is also showed strong correlation with Cl^{-} (r = 0.997). This may be due to domestic sewage and industrial waste that tend to increase chloride concentration strongly correlated with Sodium ion.

7.2 Good Correlation

pH with Ca^{+2} (r = 0.8), K^{+} (r = 0.509), HCO_3^{-} (r = 0.71), EC with TH (r = 0.87), Ca^{+2} (r = 0.722), Mg^{+2} (r = 0.896), HCO_3^{-} (r = 0.846), Cl^{-} (r = 0.876), SO_4^{-2} (r =0.818), NO_3^{-} (r = 0.586), TDS with TH (r = 0.616), Ca^{+2} (r =.776), HCO_3^{-} (r = 0.855), Cl^{-} (r = 0.858), SO_4^{-2} (r = 0.788), NO_3^{-} (r = 0.569). TH with Ca^{+2} (r = 0.795), Mg^{+2} (r = 0.803), Na^{+} (r = 0.757), HCO_3^{-} (r = 0.751), Cl^{-} (r = 0.701), SO_4^{-2} (r = 0.676), NO_3^{-} (r = 0.645), Ca^{+2} with Mg^{+2} (r = 0.563), Na^{+} (r = 0.530), HCO_3^{-} (r = 0.781), Mg^{+2} with Na^{+} (r = 0.82), Cl^{-} (r = 0.767), SO_4^{-2} (r = 0.866), NO_3^{-} (r= 0.694), Na^{+} with HCO_3^{-} (r =0.757), SO_4^{-} (r =0.668), K^{+} with F^{-} (r = 0.671), HCO_3^{-2} with Cl^{-} (r = 0.665), Cl^{-} with SO_4^{-2} (r = 0.66) and SO_4^{-2} with NO_3^{-} (r = 0.859) showed good correlation.

7.3 Weak Correlation Coefficient

This coefficents are calculated for pH with TH (r = 0.482), Mg^{+2} (r = 0.347), Na^{+} (r = 0.286), Cl^{-} (r = 0.209), SO_4^{-2} (r = 0.249), NO_3^{-}(r = 0.060), F^{-} (r = 0.478), EC with K^{+} (r = 0.339), F^{-} (r = 0.017), TDS with K^{+} (r = 0.346), F^{-} (r = 0.032), TH with K^{+} (r = 0.166), Ca^{+2} with K^{+} (r = 0.333), Cl^{-} (r = 0.475), SO_4^{-2} (r = 0.465), NO_3^{-} (r = 0.381), F^{-} (r = 0.113), Mg with K^{+} (r = 0.170), F^{-} (r = 0.039), Na^{+} with NO_3^{-} (r = 0.383), K^{+} with HCO_3^{-} (r = 0.421), Cl^{-} (r = 0.464), SO_4^{-2} (r = 0.154), HCO_3^{-} with SO_4^{-2} (r = 0.444), NO_3^{-} (r = 0.187), F^{-} (r = 0.026), Cl^{-} with NO_3^{-} (r = 0.365), SO_4^{-2} with F^{-} (r = 0.204), NO_3^{-} with F^{-} (r =0.002) showed less correlated problems.

7.4 Negative Values for Correlation Coefficient

This coefficient have been computed for pH correlation with EC and TDS (r = -0.55 and -0.501 respectively), TH with F^{-} (r = - 0.094), Na^{+} with F^{-} (r = -0.128), K^{+} with NO_3^{-} (r = -0.218) and Cl^{-} with F^{-} (r = -0.07)

In Correlation matrix, the WQI has also been incorporated to predict the role of various physicochemical parameters on the WQI values. It is clearly concluded that EC and TDS are strongly correlated with WQI (r = 0.972 and 0.982 respectively). pH (r = 0.641), TH (r = 0.899), Ca^{+2} (r = 0.819), Mg^{+2} (r = 0.860), Na^{+} (r = 0.851), HCO_3^{-} (r = 0.869), Cl^{-} (r = 0.803), SO_4^{-2}(r = 0.78), NO_3^{-} (r = 0.705) are showed good correlation with WQI, only two parameters K^{+} (r =0.430) and F^{-} (r = 0.162) showed weak correlation with WQI.

VIII. TREATMENT OF WATER

Water was treated with chitosan beads which removes pollutant cations and anions from polluted drinking water and concentration of studied ions decreased hence, values for pH, EC, TDS and TH were also lowered as presented in table 5. This clearly concluded that adsorption process decreased the pollution level of ground water samples. It is a well known

Table-5 Average value of physicochemical properties (pH, EC, TDS, TH) before and after treating water with chitosan beads.

Block	pH		EC		TDS		TH	
	Before	After	Before	After	Before	After	Before	After
Baliakheri	7.7	6.4	445	324	381	297	170	143
Deoband	7.96	6.5	547	401	450	346	200	158
Gangoh	8.09	6.8	550	406	469	365	210	157
Mujaffarabad	7.77	7.0	490	396	420	318	170	123
Nagal	8.1	7.0	401	294	350	243	160	143
Nakur	7.45	6.9	1302	935	947	678	330	256
Nanauta	7.9	6.55	558	356	422	302	200	149
PUNWARKA	7.49	6.83	438	298	370	285	180	134
Rampur	7.52	6.94	1300	928	976	689	450	324
Sadauli kadim	7.75	6.58	632	430	512	358	250	174
Sarsawa	7.85	6.86	705	513	578	448	250	168
Saharanpur city	7.93	7.1	832	587	734	516	290	184
District(Average)	7.8	6.79	683.33	489	550.75	403.75	238.67	176

fact that adsorption process is very suitable for removing dissolved salts and other soluble pollutants. It can be predicted that adsorption certainly reduced WQI values of ground water with the improvement of its quality for drinking as decided by BIS.

IX. Conclusion

In average, the drinking water of Saharanpur district was discovered to be alkaline in nature but also good in quality, leaving a small region of Nagal (0.87% inhabitants) facilitated with excellent water and a total of 2.8% Population of Nakur and Rampur block displaying poor drinking water quality. However, in some parts of the region, water has been found to be contaminated with bicarbonate, nitrate and magnesium ions caught high levels of TDS, EC, TH. This can be attributed to anthropogenic activity from an improper sanitation system. Higher concentrations of objectionable ions may also be reduced by adopting one or more very common purifying procedures such as demineralization, coagulation, precipitation, reverse osmosis, electro dialysis and adsorption that can minimize the concentration of contaminating ions upto required standard values referred by BIS. Furthermore, studies must needed to determine the change in drinking water quality parameters over time, climate and by using suitable different adsorbents to select the best. There must be a need of survey to carried out to determine the existence of other organic pollutants, which pose health risks in nature, and to spread incurable disease so that we can take measures to achieve target of disease free drinking water quality.

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