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EVALUATION OF GANGES WATER QUALITY AND ITS SUITABILITY FOR AGRICULTURE USE FROM RISHIKESH TO PRAYAGRAJ, INDIA

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Abstract: Authors attempted to study the quality of Ganges water from Rishikesh to Prayagraj during July 2019 to December 2019 based on quality parameter tools. The Ganges water was examined for various physico-chemical parameters such as pH, TDS, DO, EC and elements such as Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg). Sodium Adsorption Ratio (SAR), Kelly's ratio (KR) and Soluble Sodium Percent (SSP) were evaluated to find out the suitability of Ganges water for agriculture purposes. SAR was found to be ranged from 0.24 to 4.01 with a mean value of 0.87(meq/L). The result indicates that Ganges water is suitable for agriculture purposes in the area studied.

Keywords: Ganges water, Irrigation, KR, Pollution, SAR, SSP, Water quality.

INTRODUCTION

River Ganges is the largest rivers in India spread over almost 2,525 km long from Gangotri to Bay of Bengal and its basin covers about 8,61,404 sq km, providing water for life to more than twenty five cities and thousands of villages. Ganges River represents vast diversity of billions of microbial and aquatic habitats living in it and therefore, monitoring of the water quality of the river is of central importance especially because of known worldwide concern for declining the water quality (Bauder *et al.*, 2011; Singh and Verma, 2016).

In irrigation, the quality of water is evaluated on the basis of chemical and physical characteristics. The toxicity or suitability of water is determined by varying amounts and different ions. Irrigation water quality is generally judged by few determining factors such as sodium adsorption ratio (SAR), soluble sodium percentage (SSP), Kelly's ratio (KR) and electrical conductance (EC) (Deshpande *et al.*, 2012). Ganges water quality assessment for irrigation has become a necessary and important task for present and future Ganges water quality management and sustainability of Ganges water (Peiyue *et al.*, 2011). Unplanned growth, rapid industrialization and urbanization leads to increase in anthropocentric sources of almost all the rivers including Ganges water and soil (Prakash *et al.*, 2020). These factors widely vary from location to location due to discharges from the human activities; hence the hydro geochemical study is important. The major sources of ions in rivers are terrestrial and anthropogenic weathering processes. Thus, evaluation of irrigation water quality of the Ganges River becomes significant as it provides water and ions to huge areas of agricultural fields. Keeping this view for the larger interest of farmers, authors attempted to study the quality of Ganges water from Rishikesh to Prayagraj during July 2019 to December 2019.

MATERIALS AND METHODS

Locations

The locations for the sampling and analysis were selected along the river Ganges, *namely* Prayagraj, Kanpur, Narora, Haridwar and Rishikesh (Fig. 1). The samples were collected for investigations during post rainy season from each station. The details of the sampling sites are given in table 1. The study areas are highly cultivatable due to availability of sufficient amount of groundwater and Ganges water resources.

Sampling procedure

The physicochemical properties were measured *in situ* on the flowing water using the water analysis kit (GPS Aqua Meter- AP-1000, Aqua Read Ltd, U.K). 100 ml of water samples were collected in plastic bottle washed with double distilled water which was previously rinsed with 15% (v/v) HNO_3 for 24 hours. Before analysis, the samples were filtered with Whatman-542 filter paper (G.E. Healthcare U.K. Limited). Alkalinity of water was measured by Titration method. Major cations (Na^+, K^+, Mg^{++}, Ca^{++}) and anions (F^-, Cl^-, SO_4^{--}, NO_3^{--} , PO_4^{--}) were measured by using ion exchange chromatography system (Dionex Corporation, Sunnyvale, CA, USA). To evaluate the suitability of the groundwater for agriculture purposes, sodium adsorption ratio (SAR), soluble sodium percentage (SSP) and Kelley's ratio (KR) were examined.

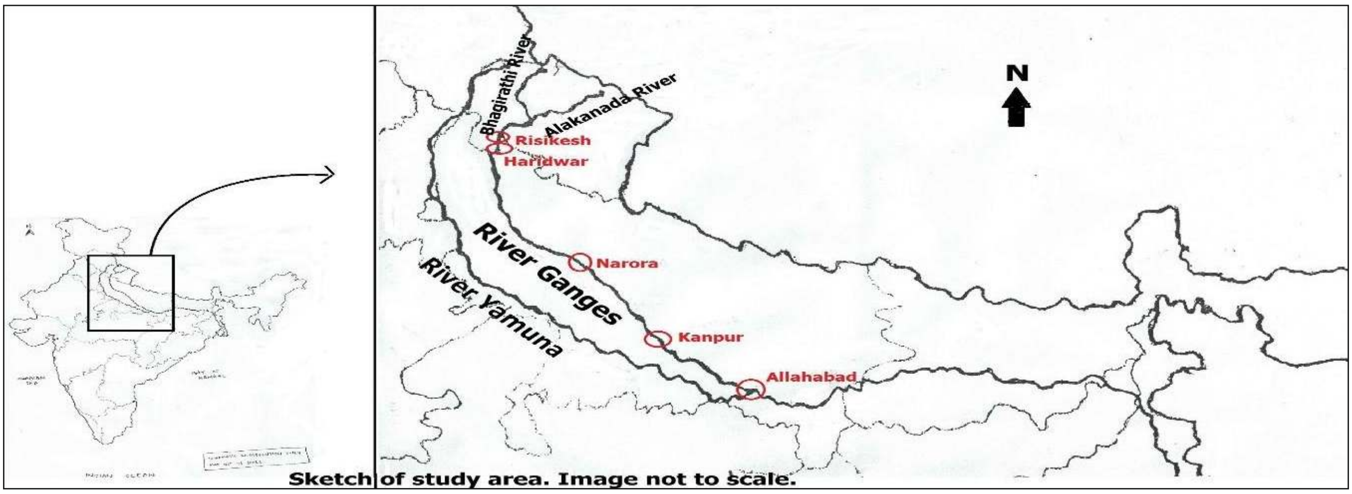

Fig.1: Sampling locations from Ganges River.

Irrigation water quality

Groundwater is the main source of irrigation in entire study area. The estimation of quality of irrigation of water is most critical factor in predicting, managing, and reducing salt-affected soils in water bodies. Besides affecting crop yield and soil physical conditions, irrigation water quality can affect fertility needs, irrigation system, performance and longevity. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. SAR, KR and SSP are the most important quality criteria, which influence the water quality and its suitability for irrigation (Wang and Jiao, 2012; Darwish *et al.*, 2012).

Sodium Adsorption Ratio (SAR): It is commonly used as an index for evaluating the sodium hazard associated with an irrigation water supply. The estimation of SAR hazard index was carried out by equation-1 (Shah and Mistry, 2011).

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}} \quad ....1$$

All cations measurements are expressed in millimoles/ liter (mmol/l).

Alternatively, if the cation measurements are expressed in milli equivalents/ liter (meq/l), then the SAR is expressed in equation-2 (Shah and Mistry, 2011).

$$SAR = \frac{Na}{\sqrt{(Ca^{+2}+Mg^{+2})/2}} \quad ....2$$

Irrigation water having high SAR levels can lead to the buildup of high soil Na levels over the times, which in turn can adversely affect the soil infiltration and percolation rates (due to soil dispersion). Additionally, excessive SAR levels can lead to soil crusting, poor seedling emergence, and poor aeration. High value of SAR indicates that sodium enhances the dispersion of colloids or clays when it comes in contact with the soil and may replace calcium and magnesium ions in the soil.

The KR was calculated by using the equation-3 (Bauder *et al.*, 2011; Deshpande *et al.*, 2012). It is estimated by using sodium measured against Ca and Mg ions.

$Na^{+} / Ca^{2+} + Mg^{2+}$ ....(3)

Where, all the ionic concentrations are expressed in mq/L.

Soluble Sodium Percent (SSP): The SSP for groundwater is calculated by equation-4.

$$SSP = \frac{Na^{+} x100}{Ca^{2+} + Mg^{2+} + Na^{+}} \quad ....4$$

Where, the concentrations of Ca, Mg and Na ions are expressed in milli equivalents per liter (epm).

RESULTS AND DISCUSSION

The results of the physiochemical parameters and irrigation parameters are detailed in table 2 and table 3 respectively. It can be seen from table 2 that pH in Ganges water varied from 7.85 to 8.7 from Rishikesh to Prayagraj. The electrical conductivity in groundwater varies from 132.6 to 520.4 micro Mohs/cm (μS/cm). As per the classification of conductivity values, it might be seen that all Ganges water samples were below the safe limit of 1500 micro Mohs/cm in the study area. The total dissolved solids (TDS) in the study area varied from 86.2 to 338.4 mg/L with an average value of 348.7 mg/L. The TDS values in all of samples were within the permissible limit prescribed by BIS (2012).

The salinity content in groundwater samples of study area was found to be varied from 0.06 to 0.26 g/L while dissolve oxygen content has shown a variation from 10.9 to 12.5 mg/L. It is found that sodium content varied from 12.7 to 75.8 mg/L, potassium content from 2.8 to 8.9 mg/L while calcium content from 29.6 to 68.4 mg/L. All the samples were within maximum permissible limit prescribed by BIS (2012). The magnesium content ranged from 6.3 to 21.5 mg/L. The higher values of conductivity and sodium ions in some samples show the excessive use of fertilizers during agricultural practices in the regions of Kanpur and Prayagraj.

The SAR, SSP and KR parameters were evaluated by using equations 1, 2, 3 and 4. The estimated values of these parameters are summarized in table 3. The value of SAR was found to be ranged from 0.24 to 4.01 with an average value of 0.87 meq/L) ^ 0.5 which indicates that ground water is in excellent category for irrigation purposes in the study area. The KR value ranged from 0.09 to 1.3 with an average of 0.25. The KR of more than 1 indicates an excess level of sodium in water. 97% of groundwater samples having KR values less than 1 indicate good quality water for irrigation. The SSP value ranged from 8.3 to 56.5 with an average value of 18.9 as tabulated in table 4. It indicates that 97% of groundwater samples having SSP less than 50 indicate good quality water for irrigation purposes while remaining 3% is more than 50 indicates its unsuitability.

Correlation among different hydrogeological components in Ganges water is given in table 5. It shows that dissolved oxygen is positively associated with pH (0.30); calcium is positively associated with Mg (0.82) and Na (0.47); electrical conductivity is positively associated with Na (0.92), K (0.56), Ca (0.68) and Mg (0.78). The SAR is positively strongly associated with Na (0.94) and weakly associated with Mg (0.58) and Ca (0.24). The SSP is positively associated with Na (0.79) and KR is also strongly associated with Na (0.76). The TDS and salinity are positively associated with Na (0.91); Ca is positively strongly associated with Mg (0.82) and moderately associated with Na (0.47). The Na is moderately associated with Mg (0.58) while electric conductivity is positively associated with SAR (0.77).

Table 1: Details of the Sampling stations.

Stations	Site code	Latitude	Longitude	Altitude
Prayagraj	L-1	25_0 25.55' N	81_0 52.97' E	64
Kanpur	L-2	26_0 26.09' N	80_0 24.53' E	100
Narora	L-3	28_0 08.77' N	78_0 25. 77 E	168
Haridwar	L-4	29_0 55.86' N	78_0 08. 34 E	277
Rishikesh	L-5	29_0 57.19' N	78_0 10. 17 E	305

Table 2: Physicochemical properties of Ganges water in different locations.

Parameters/ Code	L-1	L-2	L-3	L-4	L-5
pH	8.7	8.6	8.3	7.53	7.85
DO (mg/L	12.5	11.8	10.1	10.9	10.9
TDS (ppm)	338.4	245.8	142.6	112.5	86.2
EC(μS/cm)	520.4	378.2	219.4	171.1	132.6
Salinity (ppt)	0.26	0.21	0.14	0.08	0.06
Alkalinity (mg/L)	202.2	178.5	89.8	76.2	35.8
Ca^{2+}	68.4	32.9	45.2	38.6	29.6
Mg^{2+}	21.5	18.6	11.5	8.2	6.3
Na_+	75.8	46.5	22.3	14.8	12.7
K^+	8.9	6.5	3.2	2.8	3.6

Table 3: Irrigation parameters observed in different locations in Ganges water.

Location code	SAR (meq/L)^0.5	KR	SSP
L-1	0.24	0.50	56.5
L-2	0.56	1.30	16.9
L-3	0.61	0.17	14.7
L-4	2.88	0.09	32.2
L-5	4.01	0.68	8.3
Min.	0.24	0.09	8.3
Max.	4.01	1.30	56.5
Aver.	0.87	0.25	18.9

Table 4: Classification of Ganges water the basis of SAR, KR and SSP values.

Parameter	Range	Water class	% of sample within specific
SAR	<10	Excellent	100
	10-18	Good	NIL
	18-26	Doubtful	NIL
	>26	Unsuitable	NIL
KR	<1	Good	97
	>1	Unsuitable	3
SSP	<50	Good	97
	>50	Bad	3

Table 5 : Correlation table for hydrogeological components in Ganges water.

S.N.	Parameters (variables)	Pearson's correlation coefficient (r)	Inferences
1.	Ca vs Mg	0.82	Very strong +ve
2.	EC vs Na	0.92	Very strong +ve
3.	TDS vs Na	0.91	Very strong +ve
4.	Salinity vs Na	0.92	Very strong +ve
5.	SAR vs Na	0.94	Very strong +ve
6.	KR vs Na	0.76	Strong +ve
7.	SSP vs Na	0.79	Strong +ve
8.	EC vs SAR	0.77	Strong +ve
9.	EC vs K	0.56	Moderately +ve
10.	EC vs Ca	0.68	Strong +ve
11.	EC vs Mg	0.78	Strong +ve
12.	SAR vs Mg	0.37	Weak +ve

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