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ASSESSMENT OF THE IRRIGATION WATER QUALITY OF RIVER GANGA IN HARIDWAR DISTRICT

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ABSTRACT

This paper is an attempt to analyze the water quality of river Ganga in Haridwar district for irrigation purpose. Water samples were collected from 5 sampling stations. The study area has been divided into three seasons: Winter (November-February), summer (March to June) and rainy (July to October). Water quality variables were measured in the river over a period of two years (Nov.2006 to Oct. 2 008). The samples were analyzed for electrical conductivity (Ec), total dissolved salts (TDS), magnesium content (MC), sodium percent (SP), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and permeability index (PI). Study of all these characteristics indicates that river water in rainy season is not suitable for irrigation purpose because of high values of total dissolved salts, Ec and SP

Keywords: Water analysis; Ganga river water; Irrigation water quality; SAR; RSC

INTRODUCTION

India is rich in water resources being endowed with a network of rivers that can meet a variety of water requirements of the country. However, with the rapid increase in the population of the country and the need to meet the increasing demands of irrigation, human and industrial consumption, the available water resources are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents.It can be said that no water is pure or clean owing to the presence of some quantities of gases, minerals and life. However, for all practical purposes, pure water is considered to be that which has low dissolved or suspended solids and obnoxious gases as well as low in biological life. Such high quality of water may be required only for drinking purposes while for other uses like agriculture and industry, the quality of water can be quite flexible and water polluted up to certain extent in general sense can be regarded as pure[1].

Ganga river is one of the major rivers of India, which is considered sacred. The Ganga has by far the largest river basin in India, 15th in Asia and 29th in the world, draining as much as 861404 sq km within the country, covering more than a quarter (26.2%) of India's geographical area. The basin has large surface water and ground water resources. The annual flow in the basin is 468.7 billion cubic meters, which accounts for 25.2% of India's total water resources. Out of this only 142.6 billion m^3 is consumed in the basin. Irrigation alone accounts for more than 94% of total basin consumption, whereas domestic and industrial sector use only 2.9 and 2.8 percent respectively. Due to the much higher intensity of rainfall in the Himalayan region, the streams which join the Ganga from North contribute more than 60% of the water flowing in the Ganga basin. The peninsular streams contribute the remaining 40% water from the south region.

The main stream of the river Ganga, the Bhagirathi originates from the ice cave of Gaumukh (30º 55' N, 79º 07'E) at the snout of Gangotri glacier in the Garhwal portion of western Himalayas at an elevation of about 4100 meters. The Alaknanda, the sister stream of Bhagirathi rises beyond Mana pass, 8 Km away from badrinath 30º44'29'' N, 79º29'41''E , joins it at Dev Prayag. Below this confluence the united stream is known as Ganga river. After a run of some 267 Km it emerges into Indo-Gangetic plains at Haridwar (Elevation 288m) where it swells in to a might system about 750 meters wide.

The location of Haridwar on the Globe is on Latitude 29˚58'N and longitude 78˚10' E, while the height from sea level is 285.56 meters. Present study was carried out on the stretch of 10 Kms from Bhooma Niketan to Pul Jatwara, which is having a width of 15-40 meters and depth of 2-10 meters. Total surface area and volume of water for this area was recorded 220000 m^2 and 1760000 m^3. The climate for this region is temperate, dry winter and warm to hot summer, with an ambient temperature for winter, summer and monsoon 9.3 to 16.3˚C, 26.8 to 40.4˚C and12.9 to 28.5˚C respectively. Annual precipitation here is over 31 centimeters.

This study was performed at five stations starting from sampling station A (Bhooma Niketan- situated on the north of Haridwar on the right bank of Ganga) sampling station B (Jai Ram Ashram- the stream of Ganga is separated from Malviya Point and flows through Kharkhari via Jai Ram Ashram and confluenced with second stream of Ganga river on the left side of Pantdweep) Sampling station C (Har-ki-Pauri- sacred place, people come here to take holy bath and also immerse ashes in the river) Sampling station D (Prem Nagar Ashram- situated between Kankhal and Jwalapur connecting bridge. The water at this point is polluted by a newly constructed colony on the northeast bank of the canal) and Sampling station E (Pul Jatwara- located near the small town of Jwalapur. Entire fecal matter, decaying leaves, and flowers, wooden parts, waste clothes, food materials and ashes, charcoal etc. can be observed in the Ganga at this point. The sewer of B.H.E.L. Nullah also mixes in the water, which may affect the aquatic ecology of the river. The bottom of river at this point is stony and sandy). Figure 1 shows all the sampling stations.

Irrigated agriculture is dependent on an adequate water supply of usable quality. In irrigation water evaluation, emphasis is placed on the chemical and physical characteristics of the water and only rarely are any other factors considered important. Here attempt has been made to assess the irrigation water quality of river Ganga in Haridwar. The quality characteristics studied in the present investigations were as follows: Total dissolved salts (TDS), Electrical conductivity (Ec) Magnesium content (MC), sodium percentage (SP), Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC) and Permeability index (PI).

EXPERIMENTAL

Water samples were collected for two years (November 2006 to October 2008), for three seasons i.e. summer, rainy and winter. 90 samples were collected from five sampling stations located within a radius of 10 kms. Water samples were collected in plastic jerry canes. Grab sampling was generally applied during the sampling. Water samples were analyzed by standard methods[2-9]. MC, SP, SAR, RSC and PI were calculated as follows:

Magnesium content[10]

Magnesium content of water is considered as one of the most important qualitative criteria in determining quality of water for irrigation. Magnesium content is calculated by the following formula.

$$\text{Mg content} = [\, Mg^{2+} / (Mg^{2+} + Ca^{2+})] \; 100$$

(Concentrations are in meq/l)

Sodium percentage (SP)[11]

Doneen [11] method is used to calculate the sodium percentage.

$$Na\% = [\, (Na^{+} + K^{+}) / (Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})] \; 100$$

(Concentrations are in meq/l)

Sodium absorption ration (SAR)[12]

Sodium absorption ratio is an important parameter to determine the suitability of irrigation water and is calculated by the following formula.

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

(Concentrations are in mq/l)

Residual sodium carbonate (RSC) [13]

The concept of residual sodium carbonate (RSC) is employed for evaluating high carbonate waters and is calculated by the formula given below.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

(Concentrations are in mq/l)

Permeability index (PI) [13]

Permeability index is calculated by the method suggested by Domenico and Schwartz[13].

$PI = [(Na^+ + HCO_3^-) / (Ca^{2+} + Mg^{2+} + Na^+)]\ 100$

PI is used to evaluate the sodium hazards of irrigation water.

RESULTS AND DISCUSSION

The results obtained from analysis of water samples of river Ganga are shown in tables 1 - 6.

Total dissolved salts (TDS):

Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. Salts are present in irrigation water in relatively small but significant amounts. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These salts are carried with the water to wherever it is used. In the case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop. A salinity problem exists if salt accumulates in the crop root zone to a concentration that causes a loss in yield. Yield reductions occur when the salts accumulate in the root zone to such an extent that the crop is no longer able to extract sufficient water from the salty soil solution, resulting in a water stress for a significant period of time. If water uptake is appreciably reduced, the plant slows its rate of growth. Water with TDS less than 450mg/l is considered good and that with greater than 2000 mg/l is unsuitable for irrigation purpose.

In the present study the minimum value of total dissolved solids was found in winter season with a range of 42.58 mg/lit to 70.12mg/lit. The maximum value was found in rainy season with a range of 545.68 mg/lit to 950.15mg/lit.

Electrical conductivity (Ec):

The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (Ec)[14]. The primary effect of high Ec water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the Ec, the less water is available to plants, even though the soil may appear wet. Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as Ec increases .Water with Ec less than 250μmhos/cm is considered good and that with greater than 750 μmhos/cm is unsuitable for irrigation. In the year 2007 and 2008, the minimum Ec was recorded in the winter season ranging from 95.89 μmho/cm to 130.68 μmho/cm. The maximum Ec was recorded in rainy season ranging from 336.72 μmho/cm to 415.66 μmho/cm.

Magnesium content:

Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yields as the soils become more alkaline. In the present study, the magnesium content of the water of river Ganga varies from 27.2 mg/l to 37.7mg/l. So, water is suitable for irrigation purpose in terms of magnesium content.

Sodium Percent (SP):

Sodium percent is another important factor to study sodium hazard. It is calculated as the percentage of sodium and potassium against all cationic concentration. It is also used for adjudging the quality of water for the use of agricultural purpose. The use of high percentage sodium water for irrigation purpose stunts the plant growth. Sodium reacts with soil to reduce its permeability[15]. Sodium percent in water is a parameter computed to evaluate the suitability for irrigation[16]. Usually little or only minor problems occur when SP values are less than 15%. When SP > 15%, reduced permeability will occur**.** The finer the soil texture and the greater the organic matter content, the greater the impact of sodium on water infiltration and aeration. The sodium percent values of river Ganga were 23.56 to 52.35. These values are high in rainy seasons. Gypsum can be added to the soil to reduce the effect of high percentage of sodium in irrigation water.

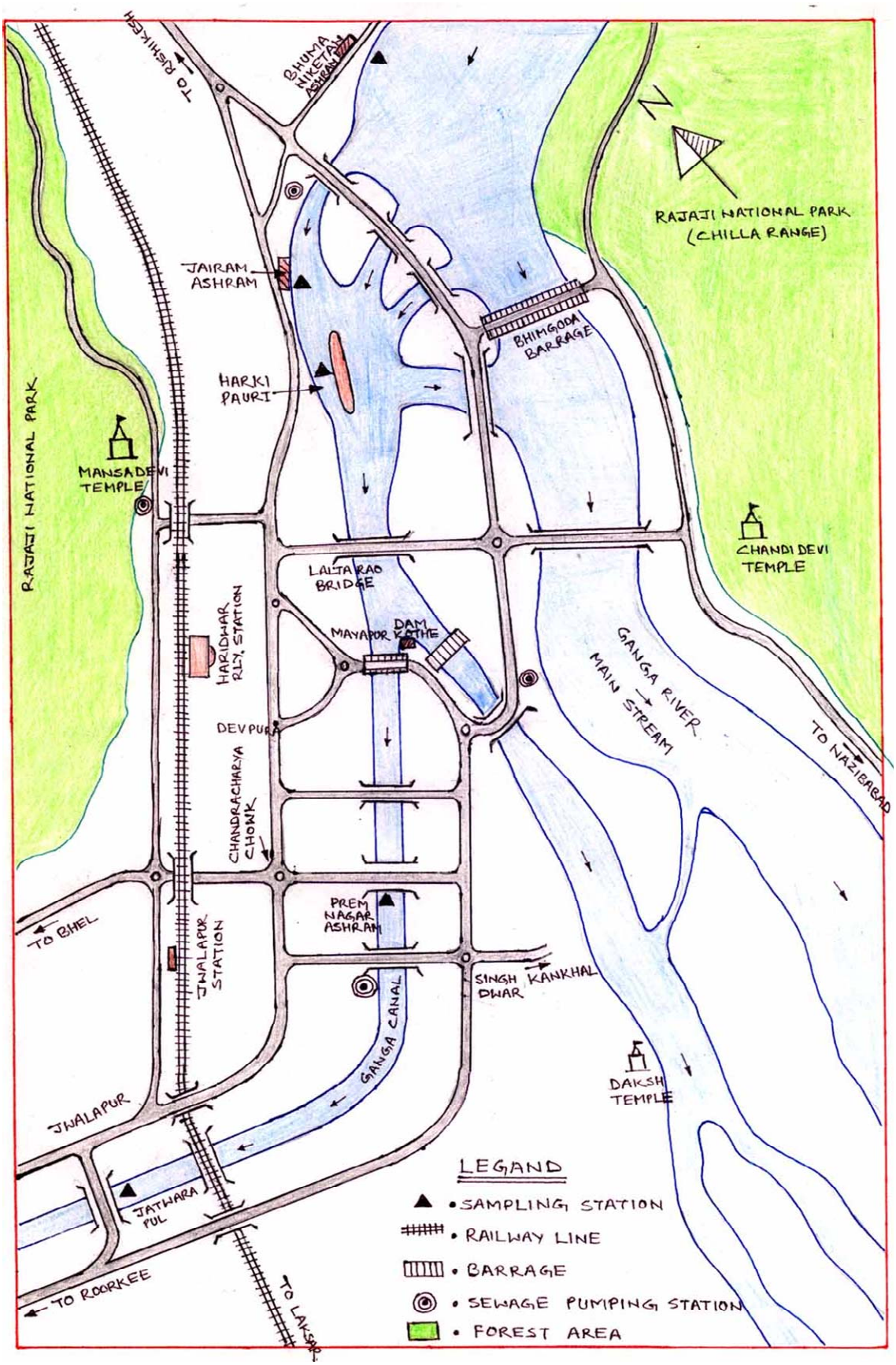

Fig 1 : Map of River Ganga showing sampling sites.

Sodium Adsorption Ratio (SAR):
Excess sodium in waters produces the undesirable effects of changing soil properties and reducing soil permeability[17]. Hence the assessment of sodium concentration is necessary while considering the suitability for irrigation. The degree to which irrigation water tends to enter into cation-exchange reactions in soil can be indicated by the sodium adsorption ratio[18]. Sodium replacing adsorbed calcium and magnesium is a hazard as it causes damage to the soil structure. It becomes compact and impervious. SAR is an important parameter for the determination of suitability of irrigation water because it is responsible for the sodium hazard.The waters were classified in relation to irrigation based in the ranges of SAR values. Water with SAR ranging from 0 to 3 is considered good and with greater than 9 is considered unsuitable for irrigation purpose. In the present study SAR was found to be 0.397 to 1.49. The low value of S.A.R. for Ganga river water can be categorized as water of excellent category. It can be used for irrigation on almost all soil types with little danger of the development of harmful levels of exchangeable sodium.

Residual Sodium Content (R.S.C.):
The concentration of bicarbonate and carbonate also influences the suitability of water for irrigation purpose. One of the empirical approaches is based on the assumption that all Ca^{2+} and Mg^{2+} precipitate as carbonate. Considering this hypothesis, Eaton[19] proposed the concept of residual sodium carbonate (RSC) for the assessment of high carbonate waters. The water with high RSC has high pH and land irrigated with such water becomes infertile owing to deposition of sodium carbonate; as known from black colour of the soil. According to U.S. Salinity Laboratory, an R.S.C. value less than 1.25 meq/lit is safe for irrigation. A value between 1.25 and 2.5 meq/lit is of marginal quality and value more than 2.5meq/lit is unsuitable for irrigation. In the present study R.S.C. values are below 1.25 meq/lit at all sampling stations. So water of Ganga river can be considered safe for irrigation purpose as mentioned according to above considerations.

Permeability Index (P.I.):
The soil permeability is affected by long term use of irrigation water. Sodium, calcium, magnesium and bicarbonate content of the soil influence it. Doneen evolved a criterion for assessing the suitability of water for irrigation based on the permeability index. Accordingly, waters can be classified as class I, Class II and Class III orders. Class I and Class II waters are categorized as good for irrigation with 75% or more maximum permeability. Class III water are unsuitable with 25% of maximum permeability. In the present study the minimum value of P.I. is 62.57. Hence water of River Ganga is of good irrigation quality. In the present study, TDS, MC, SP, RSC, SAR and PI were found to be within permissible range except in rainy season. In rainy season, TDS and PS were a little higher. Hence irrigation water quality of river Ganga was found to be good except in rainy season

CONCLUSION

In the present study MC, SAR, RSC and PI were found in the permissible range for Ganga river water in Haridwar. But Ec, TDS and ESP are higher in rainy season. Hence Ganga river water in Haridwar is suitable for irrigation purpose except in rainy season.

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Table-1 : Irrigation water characteristics in winter season 2007

parameter	BN	JRA	HKP	PNA	PJ
Ec	128.52	110.28	97.86	95.89	100.06
TDS	42.58	49.50	47.50	58.65	50.37
MC	29.412	31.800	35.976	30.246	26.018
PS	31.226	30.358	28.043	38.249	43.773
SAR	0.571	0.629	0.593	0.754	0.871
RSC	0.474	-0.601	-0.804	-0.304	-0.160
PI	115.513	74.361	66.607	91.017	101.644

Table-2 : Irrigation water characteristics in summer season 2007

Parameter	BN	JRA	HKP	PNA	PJ
Ec	125.58	147.67	139.25	142.27	138.25
TDS	217.95	246.20	226.18	234.46	246.15
MC	29.817	33.074	37.703	34.700	32.064
PS	23.566	24.036	23.654	28.409	33.163
SAR	0.396	0.458	0.486	0.534	0.588
RSC	-0.147	-0.168	-0.353	0.027	0.236
PI	89.838	86.130	78.555	98.859	116.566

Table-3 : Irrigation water characteristics in rainy season 2007

Parameter	BN	JRA	HKP	PNA	PJ
Ec	412.32	336.72	345.25	346.47	338.87
TDS	545.68	685.74	865.75	885.42	862.65
MC	29.817	33.074	37.703	34.700	32.064
PS	40.639	40.321	41.911	49.670	52.357
SAR	1.027	1.091	1.202	1.364	1.424
RSC	-0.559	-0.687	-0.801	-0.334	-0.189
PI	77.597	75.490	73.548	89.432	95.697

Table-4 : Irrigation water characteristics in winter season 2008

Parameter	BN	JRA	HKP	PNA	PJ
Ec	130.68	117.58	106.95	110.15	110.68
TDS	51.75	59.25	58.38	70.12	65.28
MC	28.744	32.258	35.032	27.206	27.304
PS	30.741	29.239	26.482	33.924	38.778
SAR	0.593	0.618	0.583	0.706	0.812
RSC	0.386	-0.684	-0.945	-0.491	-0.318
PI	107.001	71.160	62.578	80.067	89.304

Table-5 : Irrigation water characteristics in winter season 2008

Parameter	BN	JRA	HKP	PNA	PJ
Ec	128.60	150.28	141.55	143.80	140.58
TDS	235.12	265.85	258.55	262.15	272.38
MC	28.571	32.258	35.821	30.284	28.331
PS	22.902	22.719	21.580	25.689	29.724
SAR	0.402	0.460	0.463	0.525	0.581
RSC	-0.195	-0.343	-0.526	-0.215	0.021
PI	84.584	77.580	71.183	83.998	97.600

Table-6 : Irrigation water characteristics in rainy season 2008

Parameter	BN	JRA	HKP	PNA	PJ
Ec	415.66	340.28	356.72	360.39	358.15
TDS	562.15	710.65	927.18	948.68	950.15
MC	29.842	32.305	31.040	32.637	31.800
PS	41.281	39.994	39.787	50.125	49.882
SAR	1.070	1.158	1.235	1.499	1.450
RSC	-0.559	-0.915	-1.180	-0.514	-0.454
PI	77.727	70.495	66.115	83.634	85.164

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