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Remote Sensing and GIS Techniques for Monitoring Water Quality of River Ganga at Its Origin to Rishikesh

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Abstract
We used physiochemical and biological parameters to assess the water quality of holy river Ganga in Uttarakhand. The monitoring was conducted three times in the year (2015-2016) during the different seasons. Water samples were collected from Gangotri and Rishikesh followed by the course of river site of ongoing Hydroelectric project, industrial and Urban areas. The monitoring techniques (remote sensing technology and GIS) were used to store and retrieve the information about the management of river for long distances around the sites. The assessment of different physiochemical parameters (pH, EC, DO, BOD, COD, cation anion and heavy metal) indicates that the water quality of river Ganga is classified good to moderate. Contrarily the total bacterial count and differential membrane filter methods have been used to assess the estimation of microbial concentration in the industrial and transport areas.

Keywords- Hydro-Electric Project, RS, GIS, Differential Membrane Filter Method.

1. Introduction

The origin of Ganges i.e. Gangotri glacier is at an elevation of approximately 4255 m (13,200 ft) Gangotri glacier is the valley type glacier which is surrounded between latitudinal 30°43'22"–30°55'49" and longitudinal 79°4'41"–79°16'34" with at height of 4120 meter to 7000 meter.

Rishikesh is located in the foothills of Himalayas at the bank of Ganges, in Dehradun district of Uttarakhand. Rishikesh is at 30.103368^{O} N 78.294754^{O} E with an elevation of 1754 ft. Rishikesh is surrounded by Pauri Garhwal, Haridwar and Tehri Garhwal .Rishikesh is the starting point of Char DhamYatra ,which is the major causes of the pollution of river Ganges apart from other factors like natural calamities, Industrial waste Projects, human (Semwal and Akolkar, 2012).

A brief introduction of the research work entitled- **"Remote Sensing & GIS Techniques for monitoring Water Quality of River Ganga at its origin to Rishikesh"** is presented

herewith. Motivation for carrying out the research along with the discussion on the research issues and the statement of problems, scope of study, importance and the objectives of the study along with sampling, data analysis, result and discussions have been briefly presented.
India is a fast developing country and the rivers are the key contributors in most of the development and economic activities. Thus, the assessment and monitoring of the water quality of the rivers in relation with the anthropogenic activities is crucial and water quality directly affects the public health and the aquatic life. The information generated through the assessment of river Ganges provides invaluable information on the existing status of our water resources, water standards, anthropogenic effects. (Sharma et al., 1990; Zhou and Smith, 2002). The 'use' criteria helps to calculate the power of production of water, its utility potential. It also provides an integrated evaluation of all parameters (viz., physical, biological, and chemical) of water bodies concerning human health and environment. (WHO, 2004; Joshi et al., 2009; Devi and Goswami, 2014)

Monitoring of water quality proposes to estimate the availability of water, to manage and reduce water pollution, to make available water of standard quality for its diverse uses. The gathered water quality data is used not only for pollution control, but also for the investigation of continuing pollution trends, their environmental impacts and preservation of biodiversity (Kumar and Sinha, 2010; Ayoade and Aggarwal, 2012).

Remote Sensing has made it possible to collect data from inaccessible areas, while GIS helps in storing retrieving, analyzing and for management of complex databases (Joshi et al., 2015; Arora et al., 2017). Water quality data are frequently used for protection of the biological, chemical and physical features of water. They are also used for other fundamentals of water quality management such as pollution control, use and abstraction of water and land use. It also contributes to planning effective management, remedial and restoration decisions that affect the masses and the environment (Trivedi, 1986). It supports the communities in instituting comprehensive scientific practices to measure the fitness of local water bodies. This empowers the stakeholders in initiating processes to guard, enhance the condition, uses of the water body and its watershed. Water is indispensable substance for all living organism. We know that any chemical, physical or biological change in the quality of water that has harmful effects on any living organism is termed as Pollution (Tyagi et al., 2014). The current study, which is undertaken in order to reveal the suitability of the water of Ganga for all purposes. The rural and urban areas people of Uttarakhand are dependent upon the rivers, while the rivers are being contaminated by different ways, especially in summer season (Pilot report of MoEF, 2004-2009).

Seasonal variations were observed in almost all parameters when studies were carried out on Tehri Dam Reservoir and rivers of Uttarakhand (Kumar et al., 2010; Ayoade and Aggarwal, 2012). To what extent water is suitable for different uses that will be the main outcome of this study. The primary focus of the study was to assess the physio- chemical

parameters of the river Ganga at the chosen two sampling locations. The study also explored the seasonal variations in the concentrations of the different physical and chemical parameters.

The objective of the study was to assess the pollution level of river Ganga at a specific location and its tributaries drain, which ultimately leads to increase the pollution level of Ganga River.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. Designated use of water includes the following: Raw drinking water, public water supply, food processing, fish, other aquatic life, wildlife; agriculture; recreation and aesthetics, industrial water supplies as also presented in the Third Indian Fisheries Form Proceedings (Kumar and Dobriyal, 1993)

Each objective for a location is based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical or biological characteristics affecting that water body. In order to accomplish the research objective of physio- chemical assessment of the water of the Ganga River under the study, different physical and chemical water quality parameters needed to be analyzed. For this, the basic physical, core, general and trace metal parameters have been chosen. For the, samples of water of the Ganga river were collected thrice a year 2015-2016 i.e. in March-June, July- October and November-February, i.e. in summer, monsoon and winter season. Sampling was done at the same time on each sampling day. Sampling was conducted at the previously selected sampling sites along the river. The selected sites are Gangotri and Rishikesh. This was followed by statistical data analysis to determine the relationship between the different water quality parameters. It concluded with the RS and GIS analysis done to determine the statistically significant variations in the water quality of the Ganga River.

2. Result and Discussion

Physico-Chemical parameters observed during the analysis of collected samples are as following in the Tables below.

Results in the above Tables show that Temperature Ranges 7^0 to11^0 (point 2 in Table 1 and 2) has good and pleasing taste but higher temperature when the dissolved gases are less taste is not pleasing. The observed values of temperature also show that temperature is rising on moving down the river, which is because of the fact the width of the river is also increasing. It is also noted that with increasing temperature the metabolic activities of the organisms are also increasing although there are no signs of change in uses of the water.

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Table 1. Physico- Chemical parameters observed during the analysis of samples collected at Gangotri

S.No.	Physico-Chemical parameters	March- June	July- October	November- February
1.	Colour	Colourless	Colourless	Colourless
2.	Temperature(^{0}C)	19	12.99	7.69
3.	pH	6.89	7	6.99
4.	Conductivity(µS/cm)	0.25	0.27	0.23
5.	Turbidity(NTU)	4.99	10.11	5.11
6.	Alkalinity(ppm)	159	180.19	121.30
7.	Total Solids(ppm)	89.92	119.31	67.3
8.	Total Dissolved Solids(ppm)	74.97	95.29	50.19
9.	Total Suspended Solids(ppm)	16	27	15.91
10.	Dissolved Oxygen(ppm)	7.82	7.74	9.86
11.	BOD(ppm)	1.14	1.41	0.94
12.	COD(ppm)	5.20	6.15	4.62
13.	Total Hardness(ppm)	52.90	74.98	48.98
14.	Calcium	11.55	12.97	11
15.	Magnesium	6.21	10.29	7.23
16.	Chloride	4.30	8.29	3.99
17.	Sulphate	10.10	14.86	10.99
18.	Sodium	8.25	12.01	7.6
19.	Potassium	2.55	4.29	2.07
20.	Iron	0.017	0.025	0.014

Table 2. Physico- Chemical parameters observed during the analysis of samples collected at Rishikesh

S. No.	Physico-Chemical parameters	March- June	July- October	November- February
1.	Colour	Colourless	Colourless	Colourless
2.	Temperature(^{0}C)	20.77	19.93	11
3.	pH	7.65	7.89	7.26
4.	Conductivity(µS/cm)	0.35	0.40	0.24
5.	Turbidity(NTU)	6.71	12.81	5.82
6.	Alkalinity(ppm)	198.19	207.09	171.09
7.	Total Solids(ppm)	126.87	198.98	98.36
8.	Total Dissolved Solids(ppm)	99.21	151.03	74.02
9.	Total Suspended Solids(ppm)	26.99	46.09	24.22
10.	Dissolved Oxygen(ppm)	3.52	5.66	7.90
11.	BOD(ppm)	0.99	1.59	0.79
12.	COD(ppm)	2.88	4.17	2.74
13.	Total Hardness(ppm)	82.30	102.21	92.97
14.	Calcium	13.49	26.00	12.70
15.	Magnesium	11.01	13.88	9.68
16.	Chloride	7.43	16.99	6.29
17.	Sulphate	16.42	18.88	14.82
18.	Sodium	11.52	18.19	10.11
19.	Potassium	4.45	5.81	3.76
20.	Iron	0.022	0.032	0.012

According to the results, alkaline nature of water is observed. There is increase in pH value from origin of the river (Gangotri) to the plains (Rishikesh) with increase in carbonates in water. The fluctuations in the pH values are due environmental, weather and biological activities around the river. The pH values from summer to monsoon are varying at two stations in the given period of time (2015 to 2016) as observed in table (point 3 in Table 1 and 2). This is due to pollutants, surface washing, photosynthetic activities.

Conductivity and Turbidity of the river at two sampling stations is also effected as observed (point 4 and 5 in Table 1 and 2). Conductivity is increasing from origin point to plains in

summer to monsoon and decreases in winter. This shows that the dissolved salts are effecting the taste of water and making it less potable.

Turbidity value 12.81 NTU (point 5 in Table 2) makes the water unfit for domestic purpose, food and beverage industries.

The observations are showing that water quality is good and amount of dissolved oxygen is maximum in all the seasons. Value of calcium is high at Rishikesh from summer to monsoon in the given period of time 2015 to 2016 i.e. 26 ppm (point 14 in Table 2) due increase in human activities and industries. Content of chloride is more in Rishikesh as compared to Gangotri. Values of sodium and sulphate are also more at Rishikesh due to weathering of rocks during rainy season.

Heavy metals like Zn, Cu, Cd, Hg, Cr, Pb, Mn, Ni, As, etc. are not detected due to negligible values.

3. Conclusion

The assessment of different physiochemical parameters (pH, EC, DO, BOD, COD, cation anion and heavy metal) indicates that the water quality of river Ganga is classified good to moderate. (Trivedi, 1994; WHO 1999; WHO 2004).

Water of river Ganga is free from heavy metals and not a threat to human health. Proper management of wastes and effluents has made the water potable and has no threat to aquatic flora and fauna. GIS and RS technology has proved to be useful in understanding the various aspects for retaining the hydrological cycle, mainly the vegetal cover over surface water, lithotypes and land forms.

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