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CONTENTS

Spatial distribution of water quality for Indo-Gangetic alluvial plain using Q-GIS

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ABSTRACT: Haridwar district lies in the western part of the Uttarakhand which is spread over in an area of 2360km^2. The river Ganga is the major resource for agricultural sector in the district as far as minerals and water supply are concerned. In the study area, majority of population depends on animal husbandry and agriculture for their livelihoods. The district receives a good amount of annual rainfall up to 950 mm but due to lack of rainwater harvesting interventions, the rainfall drains out in the form of runoff which leads to dry condition in the district. The major problem of the district was fertility of the soil. Thus, to have an idea upon the fertility of soil a complete mapping using Q-GIS was done to determine the quality of water for drinking and irrigation purpose using inverse distance weighted method. The main objective for using GIS is that it can be used widely for analyzing and storing of data, which can be further visualized on a map. It provides an automated cartographic transformation, helps for generating graphics and thematic maps. The result showed that the groundwater for Roorkee and Bhagwanpur block should be used for irrigation with higher restriction, whereas in rest blocks with moderate restriction. Bhagwanpur, Laksar and Chudiala areas needs to reroute the industrial waste for sewage treatment before meeting the streams.

Key words: Inverse distance weighted, Q-GIS, WHS, Water Quality Index

Water is found to be the elixir of life and a key factor for sustaining life on Earth. Water is found to be continuously moving in our atmosphere in the form of rivers, ice sheets, and underground water (VidvanVishvam, 2003). In simple term, 71% of Earth surface is covered with water and remaining 29% constitutes the islands and the continents. Groundwater plays a crucial element for our life support system. It is being utilized for irrigation, drinking, and also for industrial purpose (Singh, 2010). The deterioration in the quality of water is a matter of concern. The reason for deterioration is geogenic as well as anthropogenic activities.

In India, the availability of water in quality as well as in quantity varies from region to region. In general, groundwater is considered to be the water flowing all the way through the shallow aquifer, but, in technical sense, it also contains moisture *viz*., soil moisture. It behaves as a lubricant for the movement of undesired substance. The contamination of water is found to be more prominent in surface water than groundwater, which makes it convenient for use. Now-a-days a number of factors are responsible for the deterioration of water resource like change in demography, urbanization, globalization etc. (Mufid al-hadithi, 2012; Reddy and Patode, 2013).

Water Quality Index (WQI), given by Horton, is as valuable as water; it gives a unique rating to portray the status of its quality which helps to provide the appropriate techniques for water quality management and for meeting its issues (Tyagi *et al.,* 2013). The concept of WQI was widely applied and accepted by many countries. The indices vary biological as well as physico-chemical parameters. It is being determined with an objective to evaluate the aptness of groundwater for its consumption (Farooquee *et al.,* 2008). It allows handling of data related to water quality into information's related to environment (Ckakraborthy *et al*., 2007; Bhaskar and Nagendrappa 2008; Ramakrishnalah *et al.,* 2009; Sathish and Elango, 2011). Geographic Information Systems (GIS) have a vast use in hydrology. It is capable of capturing the data, storing the data, querying as well as analyzing the data and displaying the results in different format (Adimalla, 2019). The main objective for using GIS is that it can be used widely for analyzing and storing of data, which can

be further manipulating and visualizing the information on a map. It provides an automated cartographic transformation, helps for generating graphics and thematic maps (Jaffrey and John ,1990). The ability of GIS for performing spatial analysis forces researcher to prefer GIS for creating maps. Though the concept of GIS was introduced in the year 1960s, but its application came into existence in the year 1990s. Much software such as QGIS, ArcGIS, ILWIS etc. (Srivastava *et al*., 2013). are being used in day today life. The objective of the study is to generate thematic maps of spatial distribution of water quality parameters and indices using Geographical Information System.

STUDY AREA

The Haridwar district is located in Uttarakhand spread over a geographical area of about 2630 km^2. The river Ganga, originating from *Gangotri* glacier and after travelling a distance of about 300 km, enters the plains at Haridwar. In India, the river Ganga is known for its holy secrets. It is regarded as the descended from the heaven. The study area is surrounded by three agro-climatic zone namely Upper region, Gangetic region and Plain region and the land zone characteristics are divided into *Tarai*, normal land and *Bhabhar* (CGWB, 2016). The upper region of the district lies in the water logged condition, the gangetic region is found to have a low water table whereas the plain region is the area that comes under the irrigated zone. The climatic condition of Haridwar district comes under hot sub-humid (dry) with distinct seasons *viz*. summer (March to June) followed by rainy (July to September) and winter (October to February) seasons. The temperature during summer and winter seasons generally range from 24.7–42.0 ^{0}C and 2.0-17.7^{0}C, respectively (GMU, 2016). The major river of the area is river Ganga. Kotwali *Rao*, Rasawan *Nadi* and Pili *Nadi* emerge from Siwalik hills in the eastern part of the district). The district comprises of four *Tehsils* namely, *Bhagwanpur, Roorkee, Haridwar* and *Laksar* and six development blocks *viz*. *Roorkee, Bhagwanpur, Laksar, Bahadrabad, Khanpur* and *Narsan.* All the 6 blocks lie in the hot sub humid agro-ecological zone and the district experiences maximum rainfall in the foothill and towards the south's it starts decreasing gradually. The natural drainage network of the district is shown in Fig. 1.

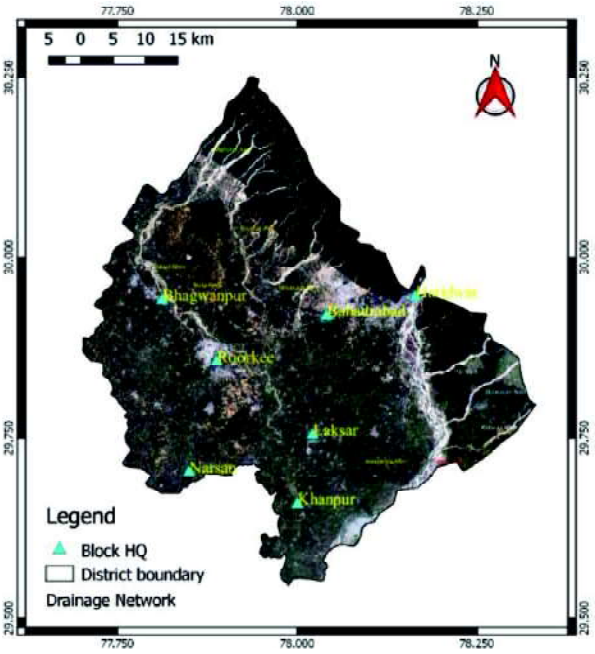


Fig. 1: Imagery showing natural drainage of Haridwar district

MATERIALS AND METHODS

The ground water samples were collected from the whole district from tube wells and the bottles were sealed and were taken to laboratory. In the laboratory all sampling sealed bottle kept inside refrigerator to avoid contamination. In laboratory, all the necessary physio-chemical parameters required for drinking and irrigation purposes were determined under standard protocol given by APHA i.e. American Public Health Association (APHA, 2012).

Physico-chemical Analysis

The parameters such as pH, Electrical Conductivity, Total dissolved solid, Total hardness, Calcium and Magnesium content, Alkalinity, Turbidity, Nitrate, Chloride & Sodium and Potassium were determined (Method 150.1: EPA-1983). The suitability of water was decided taking several standards given by different agencies such as BIS, ICMR and WHO and the range of standard values are given in Table 1. As per WHO standards, the water used for drinking

purpose should be colourless and odourless (WHO, 1996). The determined values of all the physic-chemical parameters are then noted and transferred to the excel sheet for further analysis of data in the GIS software named Q-GIS. The data are saved in form of .csv, and the data were then analyzed using different ranges of values given by different agencies as discussed above.

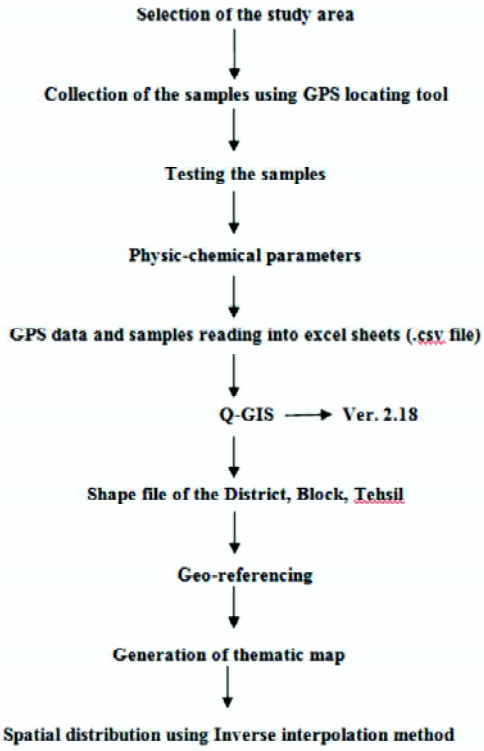
Table 1: Drinking water standards and recommending agencies.

Sl. No.	Parameters	Standard * values	Recommending agency
1	pH	6.50-8.50	ICMR/BIS
2	Electrical conductivity	300.00	ICMR
3	Total dissolved solid	500.00	ICMR/BIS
4	Total hardness	300.00	ICMR/BIS
5	Total suspended solid	500.00	WHO
6	Calcium	75.00	ICMR/BIS
7	Magnesium	30.00	ICMR/BIS
8	Chloride	250.00	ICMR
9	Nitrate	45.00	ICMR/BIS
10	Sulphate	150.00	ICMR/BIS
11	Dissolved oxygen	5.00	ICMR/BIS
12	BOD	5.00	ICMR

**All values are in mg/l, except pH and electrical conductivity*

Flow chart analysis of the study

The spatial analysis of groundwater quality mapping is an important task as it helps to carry out a systematic work for determining its suitability for drinking and irrigation purpose. For the present work, Quantum GIS (QGIS) ver. 2.18 was used for obtaining the spatial distribution map of the water quality parameter for the Haridwar district. The vector data was stored in the form of line, point or in polygon features. The satellite image of Haridwar district, Uttarakhand was downloaded from Google earth and was used in the QGIS software. The satellite map and the street maps were clipped using the satellite map and street map of the region and the district shape file in QGIS. The shape file of the Haridwar district, available from the Indian Remote sensing site, was used whereas the blocks were delineated using the district administrative map after geo-referencing it in QGIS. The shape files of the block boundaries were saved as vector files. The satellite map and the street maps were clipped using the satellite map and street map of the region and the district shape file in QGIS. All the sampled



locations, blocks, tehsils and the parameters were located in the clipped map by using the data layer in .csv file. For locating the sampling point, the latitude and longitude of the different sampling stations were recorded using GPS and the stations were interpolated in the map using GIS software. The locations of sampling points and the concentrations of different physico-chemical parameters were traced using the delimited text layer tool in QGIS. The thematic maps of different physico-chemical parameters were generated using the inverse distance weighted interpolation (IDW) method in QGIS. The concentration contours were spatially plotted in the map using the contour tool in QGIS.

RESULTS AND DISCUSSION

As per the standards given by different agencies, ideal range of pH for drinking water lies between 6.8 -8.6. In this study, the pH for most of the samples lies between 7.1 to 7.7. The Fig. 2 showed that the pH of Bhagwanpur and Narsan block was more than 7.5, from which it can be concluded that water in these blocks is within the permissible limit as far as

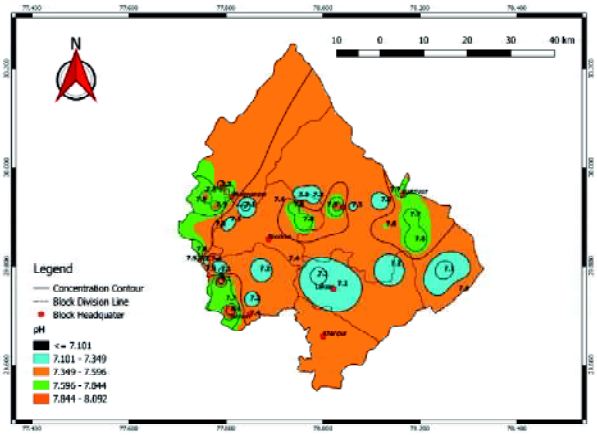


Fig. 2: Spatial distribution of pH in groundwater of Haridwar district

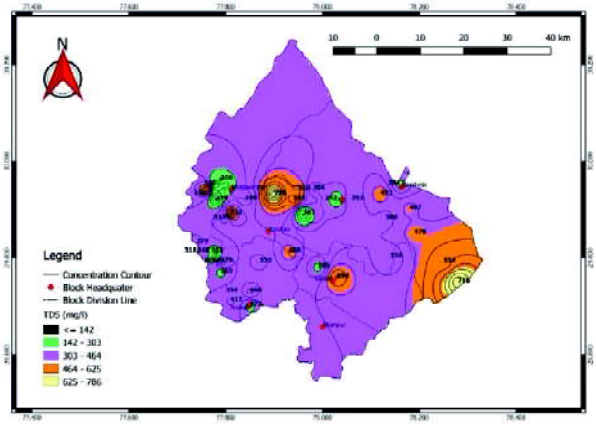


Fig. 3: Spatial Distribution of TDS in groundwater of Haridwar district

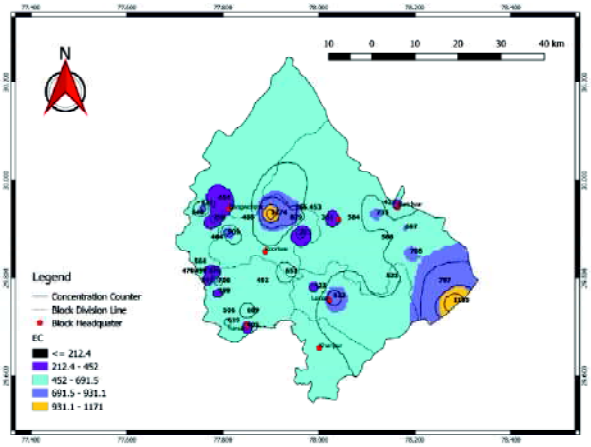


Fig. 4: Spatial distribution of Electrical Conductivity in groundwater of Haridwar district

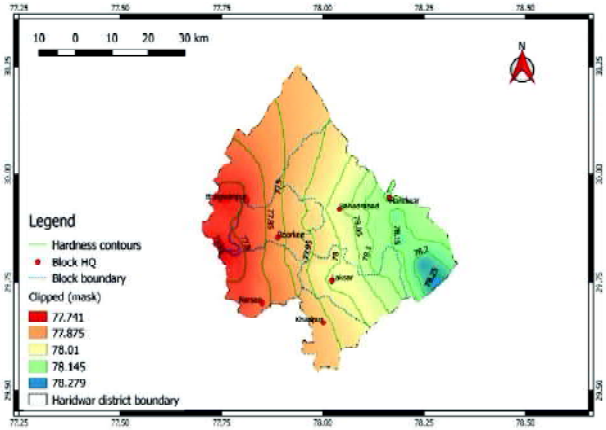


Fig. 5: Spatial distribution of Total Hardness in groundwater of Haridwar district

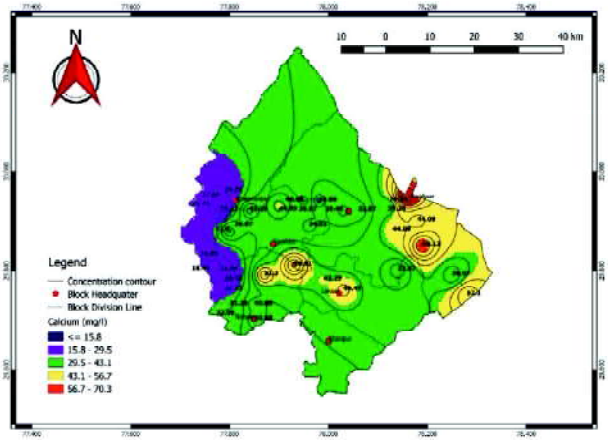


Fig. 6: Spatial distribution of Calcium content in groundwater of Haridwar district

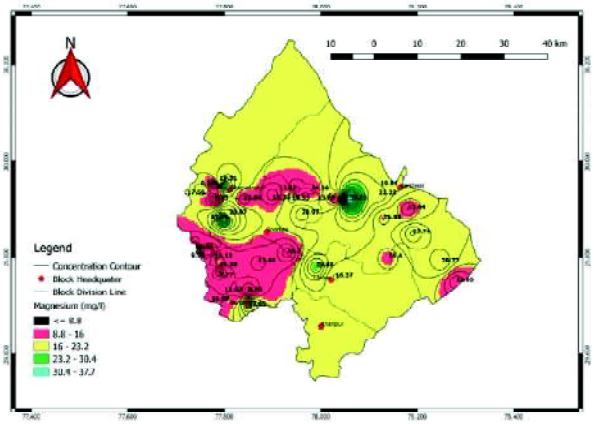


Fig. 7: Spatial distribution of Magnesium content in groundwater of Haridwar district

human consumption is concerned. Total dissolved solid (TDS) refers to the presence of inorganic salt (calcium, magnesium, sodium, etc.) and some dissolved organic matter in water. It is expressed in mg/l or parts per million. Keeping the taste of water in view, the values of TDS for excellent, good,

fair, poor and unacceptable classes were taken as<300, 300-600, 600-900,900-1200 and > 1200 mg/l, respectively. No sample was found under the poor and unacceptable class. The spatial distribution of TDS over the Haridwar district, shown in Fig. 3, showed that the shallow groundwater of Bahadrabad, Bhagwanpur, Narsan and Laksar blocks was slightly affected by TDS.

Electrical conductivity (EC) in water helps in measuring the salinity level, it indicates the presence of solids and dissolved ions. According to the WHO standard, the permissible limit decided for EC is 500 µS/cm. It constitutes cations such as Sodium, Potassium, and Magnesium. The spatial distribution of EC over the Haridwar district, shown in Fig. 4, showed that the groundwater in Bahadrabad, Roorkee and Laksar blocks were affected by the presence of EC beyond 1000 µS/cm. The total hardness in water is generally found because of the presence of calcium, magnesium and their chlorides and sulphates in it. The permissible limit for total hardness in water for drinking purposes is 300 mg/l. The spatial distribution of total hardness over the Haridwar district is presented in Fig. 5.

Calcium is regarded as one of the essential nutrients for human being, plants and soil. The excess consumption of calcium may lead to diarrhea, protein deficiency diseases, problems related to structural and functional activities of body. As per WHO, BIS and ICMR standards, the maximum permissible limit

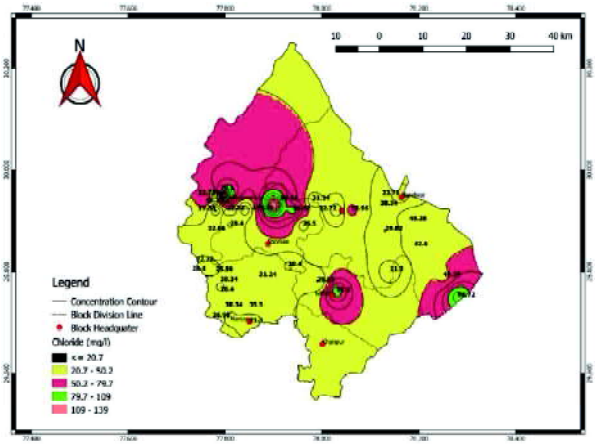


Fig. 8: Spatial distribution of Chloride in groundwater of Haridwar district

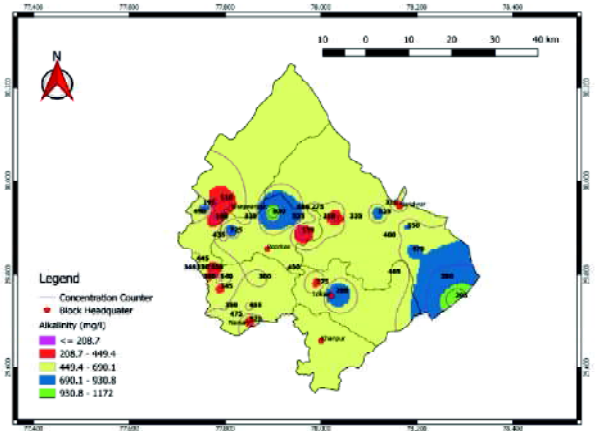


Fig. 9: Spatial distribution of Alkalinity in groundwater of Haridwar district

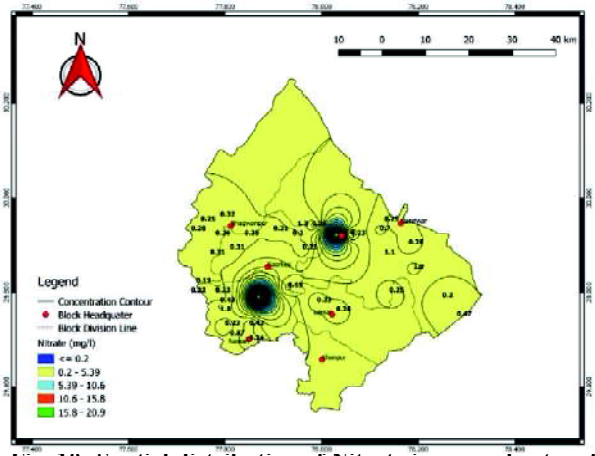


Fig. 10: Spatial distribution of Nitrate in groundwater of Haridwar District

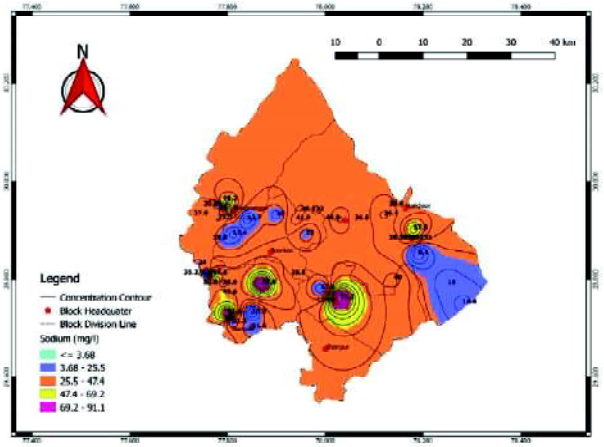


Fig. 11: Spatial distribution of Sodium in groundwater of Haridwar district

for calcium in drinking water is 200 mg/l and the desirable limit is 75 mg/l. The tolerance limit for intake of calcium is 2500 mg/l. The Fig. 6 showed that a majority portion of Laksar, Bhagwanpur and Narsan are affected by higher content of calcium, though under permissible limits, because of the growing industries, sugar mills and practicing of agricultural activities. Magnesium plays as an important role in contributing to hardness in water and is one of the essential qualitative criteria's for determining the water quality for irrigation purpose. According to BIS, ICMR and WHO the maximum permissible limit for magnesium is 100mg/l and the desirable limit is 30mg/l. Magnesium play as an important role in contributing to hardness in water and is one of the essential qualitative criteria's for determining the water quality for irrigation purpose. According to BIS, ICMR and WHO the maximum permissible limit for magnesium is 100mg/l and the desirable limit is 30mg/l. The effect of magnesium on the physical properties of soil is same as that of calcium (Keren, 1984; Levy, 2012). The spatial distribution of magnesium concentration of groundwater over the Haridwar district is shown in Fig. 7.

Chloride is found in the form of salts i.e., NaCl, KCl, $CaCl_2$ in nature and being highly mobile with water these ions get transported to oceans, closed basin etc. The chloride concentration of water is directly proportional to electrical conductivity thus as the chloride concentration increases the EC will also increases resulting in higher corrosivity. The maximum permissible content of chloride in drinking water is 1000 mg/l and the desirable limit is 250 mg/l as described by WHO, BIS and ICMR. The spatial distribution of chloride concentration over the Haridwar district is presented in Fig. 8. The study revealed that the groundwater from shallow aquifer in Haridwar district can be classed in excellent to good class (class-I) i.e., Safe and suitable for most plants under any condition of soil or climate. Alkalinity is recognized as carbonate hardness and helps in stabilizing the pH content of water. The presence of alkalinity in surface/groundwater is due to calcium carbonate which find it way to water from soil and rocks through which the water passes. Normally, the value for alkalinity ranges from 200-600 mg/l for groundwater. The spatial distribution alkalinity over the Haridwar district is shown in Fig.9.

The identification of source of nitrate in groundwater is a difficult task. This may be due to fertilizers applied during cultivation of crops, septic tanks, runoff from agricultural land, waste water from industries, plant debris, animal excreta, livestock manure and urban drainage (Shrivastava *et al*., 1996). The higher concentration of nitrate in drinking water may leads to health-related issues in infants such as blue baby syndrome (WHO, 2011). According to WHO, ICMR and BIS, the standard limits prescribed for nitrate (as NO_3) in drinking water is 45 mg/l. The spatial distribution of nitrate in groundwater over the Haridwar district is shown in Fig. 4.10 and it is clear that the water in the study area is suitable for drinking and irrigation purpose keeping nitrate concentration in view with proper treatment. Sodium is regarded as the important naturally occurring minerals. The decomposition of Granite terrain increases the sodium concentration (Jameel and Sirajudeen, 2006). The presence of sodium in irrigation water decreases the permeability of the soil and the standard limit of it not prescribed by any of the agency i.e., BIS/ICMR/WHO. The spatial distribution of sodium in groundwater over the Haridwar district is shown in Fig. 4.11. It may be noticed that the water samples from the Laksar, Narsan and Roorkee block have higher amount of sodium that may be due to the effluent from the industries, canal seepage and water logging in these areas.

CONCLUSION

The district receives a heavy rainfall in the northern part which contributes its water to the seasonal *nallah* and the flowing water carries the minerals with it forming *Bhabhar*. The study mainly focused on the spatial distribution of the groundwater sample collected in the Haridwar district by using Q-GIS software. Due to its vast area, it was impossible to cover all the location of each block, thus to avoid the case, inverse interpolation technique was used.

It is observed that the nitrate concentration is higher as compared to any other chemical parameters, which leads the water unfit for consumption. Main contribution of nitrate in the area is nitrogenous fertilizers, sewage waste and decaying of organic matters. From the study, it was also found that the quality of water was in good to excellent category and the water was suitable for different purposes. In the block, Bhagwanpur, Bahadrabad and Narsan need some treatment for TDS, chloride and total hardness, as these have a deep water table thus requires a proper planning for restoring the water resources and the industrial area such as Bhagwanpur, Laksar and Chudiala areas needs to reroute the industrial waste to waterway and requires sewage treatment.

REFERENCES

Adimalla, N. (2019). Groundwater Quality for Drinking and Irrigation Purposes and Potential Health Risks Assessment: A Case Study from Semi-Arid Region of South India. *Exposure and Health*, 11(2):109-123.

American Public Health Association (APHA). (2012). Standard Methods for examination of water and wastewater. 22nd ed. Washington 1360 pp. ISBN 978-087553-013-0.

Bhaskar C. V. and Nagendrappa G. (2008). A comparative study of ground water quality and water quality index of certain selected areas situated around Tumkur city, Karnataka, *Current World Environment*, 3(1): 75- 82.

CGWB. (2016). Report on aquifer mapping and ground water management plan: Haridwar district. Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. 75p.

Chakraborthy S., Paul P. K. and Sikdar, P. K. (2007). Assessing aquifer vulnerability to arsenic pollution using DRASTIC and GIS of North Bengal Plain: A case study of English Bazar Block, Malda District, West Bengal, India, *Journal of Spatial Hydrology*, 7(1):101-121.

EPA. (1983). Method for Chemical Analysis of Water and Wastes. United States environment protection agency, Washington DC. 491p.

EPA. (2012). Total Dissolved Solids. *In* Water: Monitoring and Assessment. Retrieved from http:/water.epa.gov/type/rsl/monitoring/vms58.cfm

Farooquee, N. A., Budal, T. K., Maikhuri, R. K. (2008). Environmental and socio-cultural impacts of river rafting and camping on Ganga in Uttarakhand Himalaya. *Curr. Sci*., 94:5–10.

GMU. (2016). District Survey Report Haridwar. Geology and Mining Unit, Directorate of Industry, Uttarakhand. 37p.

Horton, R. K. (1965). An index number system for rating water quality. *Journal of Water Pollution Control Federation,* 37(3):300-306.

Jameel, A. A. and Sirajudeen, J. (2006). Risk assessment of physico-chemical contaminants in groundwater of Pettavaithalai area. Tiruchirrapalli, Tamil Nadu- India. *Environmental Monitoring and Assessment* 123: 299-312.

Jeffrey Star and John Estes. (1990). In geographic information system: An introduction. Englewood Cliffs, NJ: Prentice- Hall, p2-3, 1990.

Keren, R. (1984). Potassium, magnesium, and boron in soils under saline and sodic conditions. *In:* Shainberg L, Shal-hevet J. (*eds.*). Soil Salinity under Irrigation: Processes and Management. Berlin, Germany: Springer-Verlag. p. 77–99.

Levy, G. J. (2012). Sodicity. *In:* Huang PM, Li Y, Sumner ME (eds.). Handbook of Soil Sciences (2nd ed.). Resource Management and Environmental Impacts. Boca Ratón, FL: CRC Press.

MoFE. (2009). Status paper on River Ganga, State of Environment and Water Quality. National River Conservation Directorate, Ministry of Environment and Forests, Government of India.

Mufid al-hadithi. (2012). Application of water

quality index to assess suitability of groundwater quality for drinking purposes in Ratmao –Pathri Rao watershed, Haridwar District, India. *Am. J. Sci. Ind. Res*.,3(6): 395-402.

Ramakrishnalah, C. R., Sadashivalah, C. and Ranganna, G. (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka state, India, *E Journal of Chemistry*, 6(2): 523-530.

Reddy, K. R. and Patode, R. S. (2013). Assessment of groundwater quality–A case study of Kondapur mandal, Medak district, Andhra Pradesh. *Current World Environment*, 8(2):267-273.

Sathish S. and Elango, L. (2011). Groundwater Quality and Vulnerability Mapping of an Unconfined Coastal Aquifer, *In. Journal of Spatial Hydrology*, 11(1):18-33.

Shrivastava, R. K., Sinha, A. K., Pande, D. P., Singh, K. P., Chandra, H. (1996). Water quality of River Ganga at Phaphamau(Allahabad): Effect of mass bathing during Mahakumbh. Environ. *Toxico Water Qlty*, 11(1):1–5.

Singh Namrata. (2010). Physicochemical properties of polluted water of river Ganga at Varanasi. *International Journal of Energy and Environment,* 1(5):823–832.

Srivastava, P. K., Singh, S. K., Gupta, M., Thakur, J. K. and Mukherjee, S. (2013). Modeling impact of land use change trajectories on groundwater quality using remote sensing and GIS. *Environmental Engineering & Management Journal* (EEMJ), 12(12): 2343-2355.

Tyagi, S., Sharma, B**.,** Singh, P. and Dobhal, R. (2013). Water Quality Assessment in Terms of Water Quality Index. *American Journal of Water Resources,* 1(3): 34-38.

VidvanVishvam. (2003). Atharvaveda Samhita, Tirumala Triupati Devasthanams, Triupati, 1(4):16-17.

WHO. (1996). Guidelines for drinking water quality: health criteria and other supporting information, World Health Organization, Geneva.

WHO. (2011). Nitrate and nitrite in drinking water: background document for development of WHO Guidelines for Drinking Water, Geneva. 31p.

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