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Ground Water Quality Index of Saharanpur city, India and its Spatial Representation using Geographical Information Systems

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ABSTRACT: Groundwater present between the pore space of sediments such as sands or gravels or in the cracks of fractured rock such as crystalline rock and limestone is one of major source of drinking water and also represents 30% of worlds fresh water. Most groundwater contamination is the result of anthropological activities, where contaminants can seep into groundwater from leaking underground tanks, cesspools, septic tanks, and landfills. Pesticides and fertilizers used on farmlands and lawns can find their way into groundwater, as can substances have discharged from factories. Saharanpur city of Uttar Pradesh state, India has been taken as study area and the impact of industrialization and urbanization of ground water quality and quantity has been assessed. The main source of water in the city being mainly from handpumps and tube wells, it was necessary to study and understand the ground water quality status of Saharanpur and effect of waste water disposal. Total 15 samples collected from site, performed water quality analysis and outcomes are represented in terms of water quality index (WQI). Results showed 6 samples' WQI was below the permissible water quality limit and 9 samples resulted within drinkable limit. This study also showed that borewells having depth less than 30 m deep were polluted thus shallow aquifer of city may be considered to be affected. To represent the pollution level in groundwater, GIS based groundwater spatial map of the study area has been also developed. It shows the severity of the ground water quality in every location of the study area.

Keywords: ground water, industrialization, pollution, water quality parameter, water quality index.

Abbreviations: hierarchical Claster Analysis (HCA); Principal Component Analysis (PCA); Water Quality Index (WQI); Geographical Information systems (GIS); Bureau of Indian standards (BIS); American public health association (APHA); Total Dissolved Solids (TDS); Electrical Conductivity (E.C), Total Hardness (TH).

I. INTRODUCTION

Increase in urban and industrial development, along with huge demand for water has led to water management problems. Water pollution is a serious problem in India as nearly 70 percent of its surface water resources are contaminated with biological, toxic, organic and inorganic pollutants and a growing percentage of its groundwater reserves. Ninety-six percent of water pollution problems in India are due to the indiscriminate discharge of municipal. Industrial effluents are liable for contamination to a lesser degree however the impact created by them might have a progressively huge impact as nature is frequently incapable to acclimatize them. The runoff generated from agriculture sector such as from animal husbandry which consist of various fertilizers and chemical pesticides is also polluting the water bodies degrading its quality [1].

Various researcher assessed drinking water based on its quality and quantity in the country, Water quality index of Jajrooed, Damavand river and Mamloo dam water were assessed, using sodium adsorption ratio. Water quality of Jajrood River and Mamloo dam was resulted good with water quality index of 71.7 and 77.3 and lowest WQI of Damavand river of 64 [2]. Also, Kali river, due to industrial waste disposal was studied to assess the metals contamination level using hierarchical claster analysis (HCA) and principal component analysis (PCA). The analysis shows high content of heavy metals concentration (Fe, Cd, Zn, Cr and Pb) which pose high threat to flora and fauna [3]. Geographical information system (GIS) and water quality index (WQI) are most suitable ground water quality assessment approached [4]. Water quality assessment based on fuzzy pollution index method used to assess pollution level in Qi river. Spatial variation indicates water quality of Nabashque section is pessimal and proposed method was observed most reliable [5]. Using weighted arithmetic water quality index assessment method, water quality index for river Sabarmati, Gujarat had worst water quality, giving the cause of deterioration due to high social and economic development, illicit discharge of sewage, industrial effluent, absence of proper sanitation, susceptible river sites and urban runoff [6]. Various studies based on water quality has been performed but proper evaluation of various pollutants from surface and groundwater of Saharanpur city being an industrialized area have not been done and very few works is found on groundwater quality in Saharanpur. Also, in most literature there lacks a proper data of point and nonpoint sources of river pollution along with Impact of human activities and industrialization on the quality of the water and sustainability for their use. The study aims to find out point sources of pollution for the selected study area in Saharanpur and to assess the impact of industrialization on water quality of groundwater and river/drain. Also, the severity of water quality is presented with help Arc-GIS which will be more beneficial to read the criticality of underground water condition with exact location of the city and take proper mitigation.

II. MATERIALS AND METHODOLOGY

Site description: Saharanpur district is one of the populous districts in the state and is situated in the North Western part of upper Ganga-Yamuna interfluves in the upper Hindon river Basin. In Saharanpur, a significant imbalance in the sustainable development of the water resources in terms of quality and quantity is being noticed due to Urban Development and industrialization. The Saharanpur town has a relatively fast development of industrial activity as a result of the presence of a number of medium and major industries. These industrial units include a notable paper mill along with related subsidiary cardboard factories, a cigarette manufacturing unit, a slaughterhouse and several other industries related to Chemicals. Most of these industrial unit's discharge waste effluents into the nearby drains with or without treatment [7].

Experimentation: Considerable effort has been put into the development of standard analytical procedures for the estimation of various constituents in natural waters (APHA, 1998) [8]. In the current study, the procedures described by Standard Methods (APHA, 1998) for the examination of water and waste-water has been referred for determination of the various constituents. The BIS standards (10,500) and (2490) [9] have been referred for comparing the quality of groundwater for drinking and surface water for direct disposal into runoff waters.

Total of 15 nos. of water samples were collected in sample bottles of 500 ml capacity from the selected localities. The sample bottles were cleaned prior to sampling using standard procedures to prevent contamination during handling.

Sampling points: Samples of groundwater and surface water from Saharanpur town were taken in 15 locations, in which 9 samples are from Kamdhanu industrial area Saharanpur indicated by L1S1 to L1S9 and 6 samples are from Industrial area Delhi road Saharanpur indicated by L2S1 to L2S6 as shown in Fig. 1.

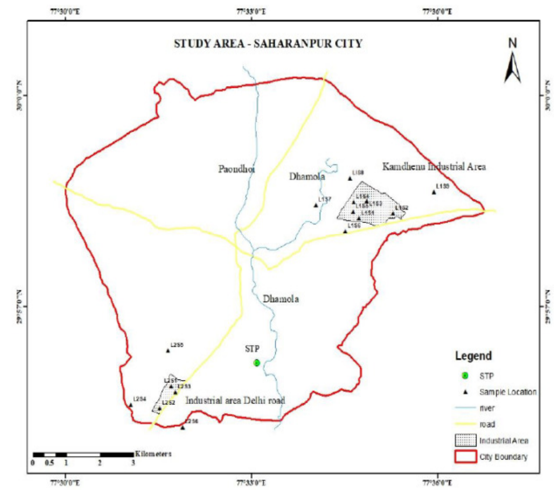

Fig. 1. Sample collection points.

Throughout the area, there were enough locations for sampling which had shallow groundwater in the vicinity of high pollution suspected sources. Sources are basically point source (industrial area), line source (all the open and sewer drains of the city) and nonpoint source which consisted of urban residential and commercial areas. Since no new bores were installed and only existing boring installed with hand pumps were picked up for collecting water samples. Because of which coverage of all possible localities where pollution was suspected was limited. The results of physio-chemical analyses of groundwater are given in Fig. 2 and 3. The quality parameters of samples having higher concentration than permissible BIS limits are considered only if more than 10% of total samples results in excessive concentration. In this study, there were only two or more cases, since the total number of ground water sample collected was only 15. The water quality parameters taken into account to assess the acceptability of Saharanpur city with regards to drink-ability are taken as chloride TDS, Electrical Conductivity, pH, Total Hardness, Turbidity, Alkalinity, and Salinity in decreasing order.

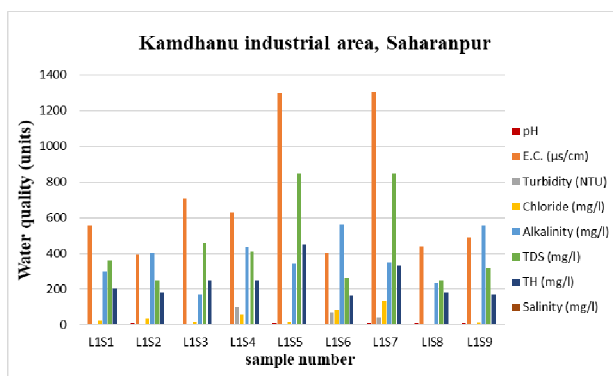

Fig. 2. Water quality, Kamdhanu industrial area.

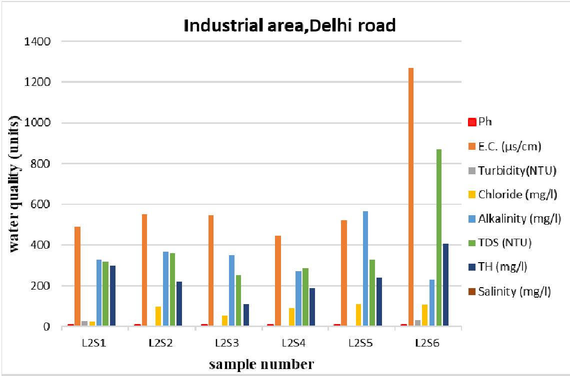

Fig. 3. Water quality, Delhi road, Saharanpur city.

III. RESULTS AND DISCUSSIONS

The permissible limit of TDS is 500 mg/l as per Indian standards. Some of the samples show higher TDS in terms of Bureau of Indian Standards (BIS: 10500) in Kamdhanu Industrial area as well as in Industrial area Delhi road, Saharanpur as the TDS ranges between 248.7-870 mg/l. In Kamdhanu industrial area, high TDS is observed at 2 locations and in Industrial area Delhi Road, Saharanpur, high TDS is observed at 1 location. However, the general range by which the TDS exceeds the BIS limit in both the areas is not indeed very large in terms of national and international guidelines and its effect can be considered cosmetic only as the populace of the town has virtually adjusted to these ranges of TDS in drinking water without experiencing visible harmful effects.

Hardness is a significant factor for acceptance of groundwater for drinking. The hardness is contributed by Ca and Mg which seem to be high at some places in the study area, Kamdhanu Industrial area and Industrial area Delhi road, Saharanpur. The range of $CaCO_3$ hardness found in the groundwater of the study area varies from 160 to 450 mg/l in Kamdhanu Industrial area and 113 to 406 mg/l in Industrial area Delhi road, Saharanpur. It is seen that $CaCO_3$ hardness is found to be higher than BIS limit (300 mg/l) in 4 locations as shown in figure 2 and 3. The probable cause for excessive hardness appears to be the source rocks in the Himalayan foothills towards the north from where groundwater is recharged. Such sources of recharge for deep ground waters have been proposed and confirmed by Hem (1985).

Total alkalinity: the permissible limit of Alkalinity is 200 mg/l as per Indian standards. The alkalinity varies in the range of 168-564 mg/l and 230-568 mg/l in Kamdhanu Industrial area and Industrial area Delhi road, Saharanpur respectively. However, high concentration of alkalinity in drinking water is not known to cause any direct noticeable effects on human health.

The permissible limit of pH is 6.5-8.5 as per Indian standards and its range is between 7.2-9.7 only 1 value is exceeded the pH limit. Similarly, the temperature of groundwater in field conditions ranged between 23 to 27℃ which is considered as an acceptable range.

Electrical Conductivity: The permissible limit of Electrical Conductivity is from 200 to 800 µs/cm as per Indian standards. The range of Electrical Conductivity in Kamdhenu Industrial area is 395-1302 µs/cm and the range of Electrical Conductivity in Industrial area Delhi road, Saharanpur is between 445-1269 µs/cm. It is found that Electrical conductivity is higher than the permissible limit in only 3 locations.

The permissible limit of chloride is 250 mg/l as per IS and may cause bad taste and may affect palatability among the users if taken in higher concentration. Besides, its high values also indicate possible fecal contamination. The range of chloride in Kamdhenu Industrial area is 7.1-135 mg/l and the range of chlorides in Industrial area Delhi road, Saharanpur is between 25.5-113.44 mg/l. It is found that all the values are within the limits permitted by BIS Standards.

Turbidity of water exceeds the maximum Permissible limit of 5 NTU in most of the locations. The range of turbidity in Kamdhenu Industrial area is 0.7-69.2 NTU and in Industrial area Delhi road, Saharanpur is 0.38-31.2 NTU. High turbidity indicated high risk to disease-causing microorganisms such as viruses, parasites and some bacteria and carriers of a variety of materials such as pesticides, heavy metals.

Presence of above parameters in the ground water could be contributed from effluent from industrial areas of the city which are broadly categorized as Agro-based, forest based, industrial products and animal based. products. Also, sewage of the whole population of the town is also discharged in the river system added to the organic waste loads in the area. The leachates generated from the solid waste dumped in the different parts of the town also added to the pollution load in the drains resulting in the generation of foul odor in the vicinity of lotic waters. All these drains finally join the river Hindon passing outside the municipal limit of Saharanpur town [10]. There is a strong likelihood that the water infiltrating from these influent drains will join the waste effluents infiltrating through the drain beds down to the groundwater region of the area. This increases the pollution hazards of the shallow groundwater in the area considerably.

Determination of Water Quality Index (WQI): To get an extensive image of the general nature of groundwater, the WQI was utilized. WQI is characterized as a rating which reflects the composite impact of various water quality parameters on the general nature of water. The Indian standard determined for drinking water (BIS, 1991) was utilized for the computation of WQI.

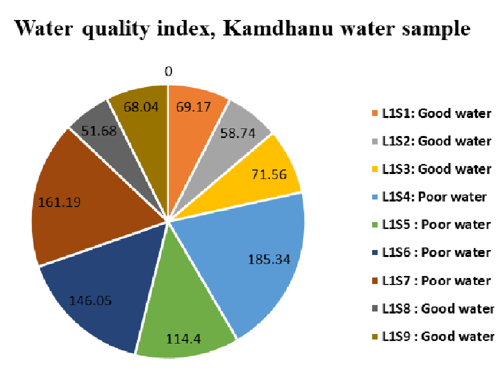

Fig. 4. Water quality index value for individual groundwater sample (Kamdhanu industrial area).

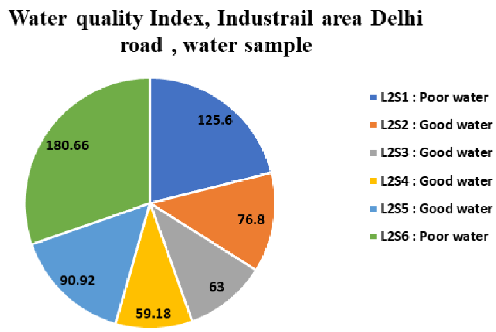

Fig. 5. Water quality index value for individual groundwater sample (Industrial area Delhi road).

It is observed that 4 samples out of 9 samples fall under poor water quality index in Kamdhenu industrial area and 2 samples out of 6 samples fall under poor water quality index in Industrial area Delhi road Saharanpur. GIS is considered the most useful application in addressing issues and handling geographical information in a complete manner without trailing the spatial-temporal inconsistency which is often critical in assessment and decision making [11]. The GIS technology assimilates common database processes such as query and statistical investigation, with the exclusive conception and geographic analysis benefits presented by maps and spatial databases. For the effective illustration of quality parameters various graphic diagrams have been prepared by ArcGIS, dark green represents safe limits as per standards and red colour showing high concentration of contaminants in respective locations.

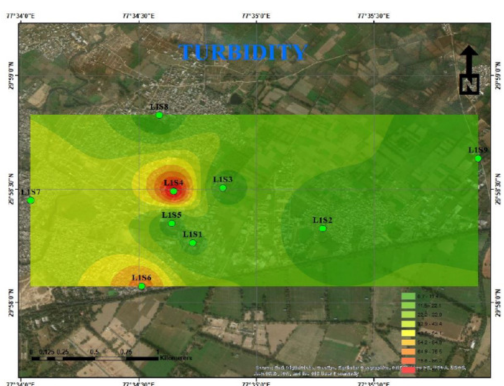

Fig. 6. Spatial distribution map of turbidity.

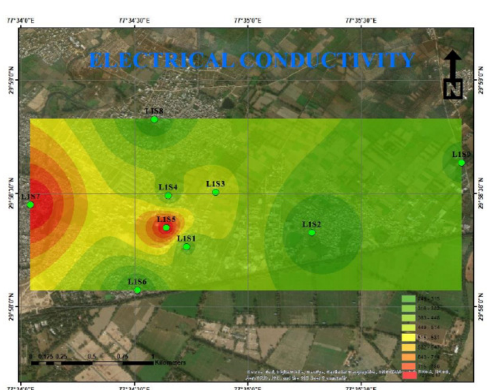

Fig. 7. Spatial Distribution Map of E.C.

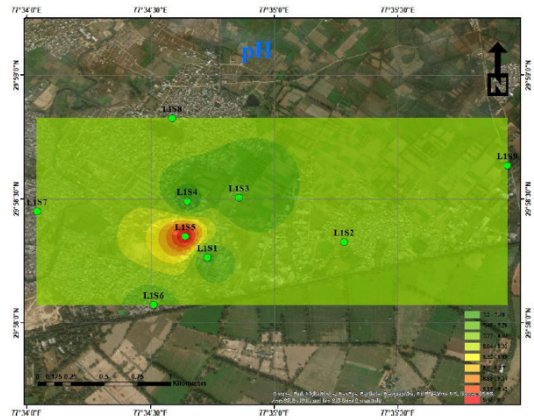

Fig. 8. Spatial Distribution Map of pH.

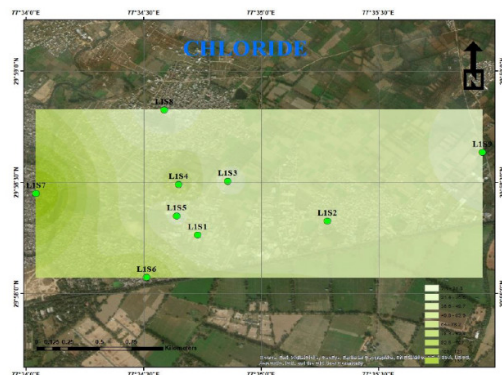

Fig. 9. Spatial Distribution Map of Chlorine.

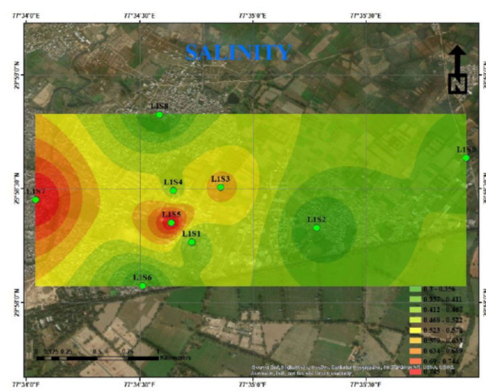

Fig. 10. Spatial Distribution Map of Salinity.

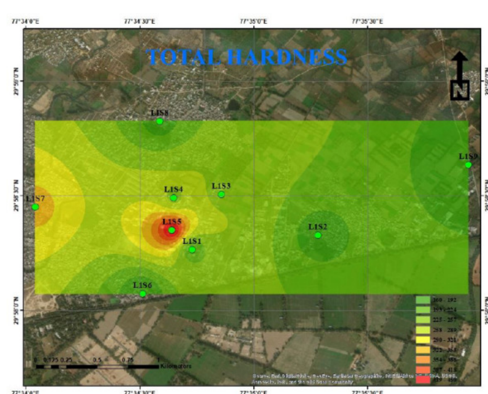

Fig. 11. Spatial Distribution Map of Total Hardness.

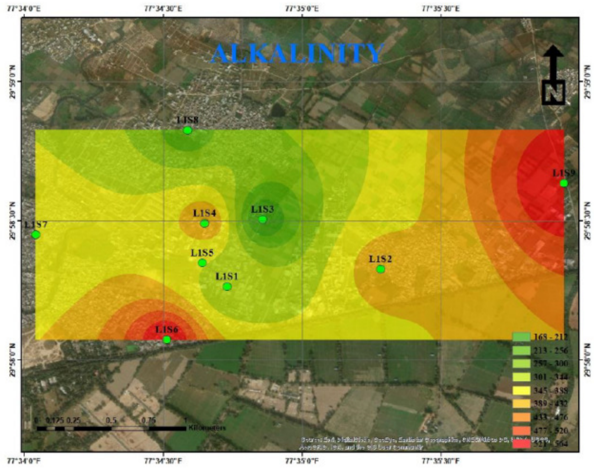

Fig. 12. Spatial Distribution Map of Alkalinity.

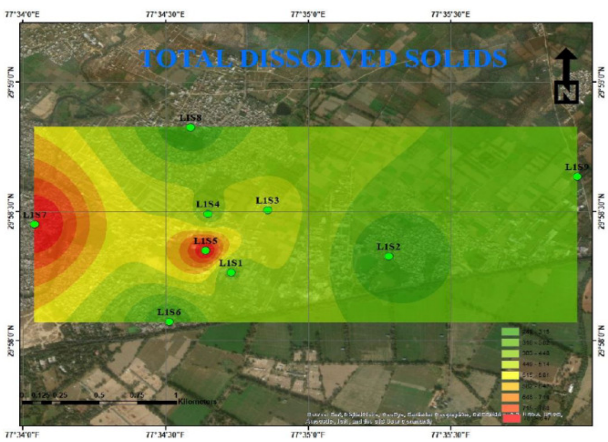

Fig. 13. Spatial Distribution Map of TDS.

IV. CONCLUSION

From this study it is observed that nine samples were falling below suitable drinking water conditions while six samples were not appropriate for drinking as per the WQI standards. In the industrial areas of the Saharanpur city 60% area falls under good category and 40% area falls under the poor category as per WQI classification for drinking purpose. The deeper aquifers (greater than 30-meter depth) are not polluted and the water is good quality for drinking as per BIS: 10500 Standards. It can be said that the shallow aquifer of the Saharanpur City may be considered to be affected. At some places on Saharanpur near Kamdhenu Industrial Area and at Industrial Area Delhi road, there are indications of contamination of groundwater due to ongoing industrial activities. The degradation of ground water quality has been generally confirmed from the data of chemical analysis of groundwater samples in these localities where there was a noticeable increase in the overall salinity of ground water along with high concentration of electrical conductivity, total dissolved solids, total hardness and alkalinity.

The bar charts have provided an idea of the temporal variations in the composition of groundwater with the $CaCO_3$ hardness, TDS, alkalinity, turbidity and electrical conductivity showing high values with respect to the quality criteria laid down by Bureau of Indian Standards for drinking (BIS: 10500). The reasons for the high concentration of these physio-chemical parameters can be attributed to the direct disposal of industrial effluents to nearby drains.

V. FUTURE SCOPE

Many new hand pumps were planned to be installed in the city and some were around the main pollution suspected area. More analysis could be done, along with water quality index, the chemical impurities and metals contamination. Also, the concentration of impurities that are being transported from one-point source to another could be determined via a hydrological model. The results obtained from this study could benefit the department of water and sanitation to improvise their water policy. This study signifies to provide awareness on the level of pollution of the drinking water in the city.

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Conflict of Interest. Authors have no conflicts of interest to disclose.

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