Impact of anthropogenic activities on groundwater quality and quantity in Raipur City, Chhattisgarh, India

R Khan¹, Indhulekha K², Y K Mawale³, Rakesh Dewangan⁴, Shubhedu Shekhar⁵, C S Dwivedi⁶ Vikal K Singh⁷ and D C Jhariya⁸*

1 Associate Professor, Department of Civil Engineering, Axis Institute of Technology and Management, Kanpur, India
2 Research Scholar, Department of Applied Geology, National Institute of Technology Raipur, Raipur, Chhattisgarh, India
3 Associate Professor, Department of Geology, Sant Gadge Baba Amravati University, Amravati
4 Scientist, Central Groundwater Board, NCCR, Raipur, Chhattisgarh India
5 Research Scholar, Department of Geology, University of Delhi, India
6 Assistant Professor, School of Geoinformatics, Central University of Jharkhand, India
7 Assistant Professor Department of Geology, Central University of South Bihar
8 Assistant Professor, Department of Applied Geology, National Institute of Technology Raipur, Raipur, Chhattisgarh, India

Email: a rubia@axiscolleges; b kindhulekha.phd2017.geo@nitrr.ac.in; c yadaokumarmawale@sgbau.ac.in; d rakeshdewangan-cgwb@gov.in; e shekhar.shubhendu@gmail.com; f chandra.dwivedi@cuj.ac.in; g vikalsingh@cusb.ac.in; h dcjhariya.geo@nitrr.ac.in

Abstract. In the present study area, anthropogenic activities such as overexploitation of groundwater, improper disposal of Municipal Solid Waste (MSW), rapid industrialization, urbanization, and chemical fertilizer use are led to groundwater resource to depletion and quality degradation. Due to the imbalance between demand and availability, management approaches groundwater quality and quantity adversely affected. To assess the effects of LULC change in groundwater quality, Nitrate was considered. Land use Land cover (LULC) map of 1999 and 2016 and groundwater quality data of 1999 and 2016 revealed that groundwater quality is highly affected in the settlement area due to anthropogenic activities. There is no earmarked site in the Raipur city for the dumping of Municipal Solid Waste (MSW). Hence, to minimize the existing groundwater problem, there is a need to adopt proper remedial measures to improve groundwater quality and quantity.

Keywords: Anthropogenic activity, groundwater quality, Raipur city, groundwater pollution.
1. Introduction
Groundwater is an essential source of water supply throughout the world. Raipur city is rapidly growing as a result of an increase in industrialization and urbanization [1,2,3]. The water demand increases, leading to overexploitation, depleting the quantity, and deteriorating groundwater quality [4,5,6]. Simultaneously, wastes generated from a wide variety of industries, agricultural and domestic activities are dumped into pits, low lying areas around the city, constituents of which percolates and pollute groundwater [7]. Due to the geologic formation’s karstified nature, the study area’s groundwater is highly susceptible to pollution [3].

The present study has been carried out in Raipur city, it is divisional, and district headquarter in Chhattisgarh. Raipur city is situated in the western part of Raipur district, Chhattisgarh, India.

2. Material and Methods
The systematic methodology has been adopted to carried-out the present study, involving detailed laboratory and field study.

2.1 Data used
In the present study, primary and secondary data have been used. Survey of India (SOI) toposheet no. 64G/11 and 64G/12 were procured from Survey of India (SOI), and LANDSAT images were downloaded from www.earthexplorer.com. A published geological map of the Geological Survey of India (GSI) and hydrogeological data from Central Ground Water Board (CGWB), NCCR Raipur, was obtained.

2.2 Methodology
To effectively carried out the present study, a systematic sample was collected from a suitable source for the assessment of Nitrate during the pre-monsoon season (May 2016) as per standard protocol recommended by APHA (2012) [8]. The locations of sample points were collected using Global Positioning System (GPS). Samples were analyzed in the laboratory of Chhattisgarh Council of Science & Technology (CGCOST), Raipur. In this study, nitrate concentration in groundwater of the year 1999 was collected from CGWB, Govt. of India. With the help of nitrate concentration, spatial distribution maps were prepared using IDW techniques in ArcGIS Software.

3. Results and Discussion
3.1 Variation in Nitrate ion concentration from the year 1999 to 2016
According to the spatial distribution map of the year 1999 and 2015 (Figure 1a. and 1b.) the nitrate concentrations has increases 64.11% and 0.09% area respectively for 0.83 mg/L to 30.11 mg/L and 120.62 mg/L to 208.00 mg/L ranges of nitrate concentration (Table 1.).

3.2 Nitrate Status
According to the spatial distribution map of the year 1999 and 2016 (Figure 2c. and 2d.), the nitrate concentrations has increased 64.11% and 0.09% area, respectively, for 0.83 mg/L to 30.11 mg/L and 120.62 mg/L to 208.00 mg/L ranges of nitrate concentration (Table 1.).

Table 1. Change in Groundwater quality data from the year 1999 to 2016

| Parameter | Range          | Area in 1999 (%) | Area in 2016 (%) | Change in area 2016 (%) |
|-----------|----------------|------------------|------------------|-------------------------|
| Nitrate   | 0.83 to 30.11  | 24.65            | 88.76            | +64.11                  |
|           | 30.11 to 50.50 | 42.37            | 10.18            | -32.19                  |
|           | 50.50 to 75.42 | 29.95            | 0.68             | -29.27                  |
|           | 75.42 to 120.64| 3.04             | 0.09             | -2.95                   |
|           | 120.64 to 208.00| 0                | 0.09             | +0.09                   |
Figure 1a. Nitrate concentration in groundwater during year 1999.

Figure 1b. Nitrate concentration in groundwater during the year 2016.
3.3. Groundwater depletion due to change in Land Use Landcover

3.3.1 Evaluation of LULC map. The present study reflected a drastic change that occurred from the year 1999 to 2016 in LULC (Table 2.). Figure 2. and 3. shows the Land use/land cover map of the year 1999 and 2016 and change analysis rate (Table 2.). Comparison of LULC 1999 to 2016 indicates that the anthropogenic activity like settlement (net increases 16.2%), road (net increases 0.8%), open land (net increases 14.8%), vegetation (net increases 0.3%) and industry (net increases 3.1%) area is largely expended. The cultivated land, which is used for paddy, vegetables, fruits, and other mixed crops, has largely decreased (net decrease of 34.0%) from 56.8% (1999) to 22.8% (2016). In 1999 the industrial area was 2.1%, but the 2016 area reached a net increase of 3.1%. Surface water bodies (lake and drainage) area also decreases due to an increase in settlement infringement. There is the expansion of settlement in the study area, which is mainly encroached over the cultivated land.

3.4. Impact of Land Use Land cover change in groundwater quality

The groundwater quality is strongly influenced by land use land cover change. Therefore, evaluation of groundwater quality is needed to ensure its safer use. To assess LULC for 1999- and 2016-year, satellite imageries have been utilized in this study. Physico-chemical parameters of groundwater for 1999 and 2016 were analyzed and found that nitrate concentration in the year 1999 was confined between 75-120 mg/L while in the year 2015, nitrate concentration is stretched to 0.03 to 208.00 mg/L.

A relationship between LULC change and groundwater quality has been subjectively established and found that Nitrate pollution is mainly confined in the settlement area in Raipur city. This study shows that Nitrate pollution in the groundwater results from anthropogenic activities in the study area because, in the year 2016, nitrate concentration has mainly been increased in the settlement area.
Figure 3. Land use and land cover map for the 2016 year.

Table 2. LULC changes from year 1999 to 2016

| Class    | Area in Year 1999 (%) | Area in Year 2016 (%) | Change in area 2016 (%) |
|----------|-----------------------|-----------------------|-------------------------|
| Settlement | 27.5                  | 43.7                  | +16.2                   |
| Cultivation | 56.8                  | 22.8                  | -34.0                   |
| Industry  | 2.1                   | 5.2                   | +3.1                    |
| Drainage  | 2.3                   | 1.1                   | -1.2                    |
| Vegetation | 2.9                   | 3.2                   | +0.3                    |
| Open land | 3.7                   | 18.57                 | +14.87                  |
| Road      | 2.8                   | 3.6                   | +0.8                    |
| Lake      | 2.2                   | 1.78                  | -0.4                    |

3.5. Groundwater level Depletion

According to the Census of India (2011), [9] population in Raipur in the 2001 urban agglomeration population was 7,00,113, and in 2011 urban agglomeration population has increased to 11,23,558. In this study, groundwater level data from 1995 to 2016 plotted and found that the groundwater level of Raipur city is continuously declining (Figure 4.). The groundwater fluctuation graph is given in Figure 5.
3.6. Improper disposal of Municipal Solid waste
There is no earmarked site in Raipur city for the dumping of Municipal Solid Waste (MSW). This MSW contains batteries, paints, expired medicine, organic chemicals, and metals [1,10,11]. These components are very much poisonous, and uncontrolled microbial action may release more toxic elements that were not present in a free or reactive form in the waste [12]. During the infiltration of water by rainfall, water already present in the waste, or water generated by biodegradation cause the leachate to leave the dumping ground laterally or vertically and find its way into the groundwater, thereby causing
contamination of groundwater quality. During the field, it is observed that in Sarona, there is improper waste disposal in practice (Figure 6.), which is close to Kharun river.

3.7. Remedial measures to improve the quality and quantity of groundwater
To minimize the existing groundwater quality and quantitatively related problems, several remedial measures are required. There is a need to develop a proper groundwater monitoring system because groundwater is dynamic and requires continuous monitoring beneath the earth's surface. In the study area, there is a need for proper waste disposal. There is no earmarked site in the Raipur city for the dumping of Municipal Solid Waste (MSW). This MSW contains batteries, paints, expired medicine, organic chemicals, and metals. These components are very harmful, and in the form of leachate, they percolate and contaminate groundwater. In the study area, there is a strong need to develop a systematic septic system. It is observed that septic systems are improperly sited, designed, constructed, or maintained in the study area. It is also observed that sewage systems installed years back were inadequate to convert the contain quantum of water to sewage. Thus, there is a need to develop a systematic septic system in Raipur city. There is a high use of nitrogenous fertilizers in agricultural activities and gardens in the study area, which need to minimize and need to use bio-fertilizer, which is eco-friendly. In the Raipur city, it found that settlement has abruptly increased, which reduced the recharge area due to the paved area, and in the study, there is an occurrence of hard rock (limestone). Thus, to improve the quality and quantity of groundwater rainfall harvesting/artificial recharge techniques like recharge well and rooftop harvesting needs to adopt. Recycled water is reclaimed from sewage or municipal wastewater and can be reused or recycled for industrial, cultivation, and other domestic purposes. There is a strong need to implement water conservation and protection rules and regulations properly. To implement all the above remedial measures, there is a strong need to spread public awareness.

4. Concluding Remarks
The present study has been carried out to understand the quality and quantity of groundwater depletion and deterioration due to anthropogenic activities. Hence, LULC change and its impacts on groundwater quality are determined. Comparison of the LULC map of 1999 and 2016 and groundwater quality data of 1999 and 2016 revealed that groundwater quality is highly affected in the settlement area by anthropogenic activity. Improper sewage disposal and poor waste management practices have been
associated with nitrate pollution in the study area. The fast growth in population results in more withdrawal of subsurface water, and an increase in a built-up area is leaving lesser surface area available for groundwater recharge. The combined effect of these two factors results in groundwater depletion and an increase in groundwater pollutants. In this study to understand the groundwater level trend, groundwater level data from 1993 to 2016 were compared and found that the water level of Raipur city is continuously declining, where the leading cause are urbanization, agricultural activity, and industrialization. There is no earmarked site in the Raipur city for the dumping of Municipal Solid Waste (MSW). There is a need to develop a proper groundwater monitoring system, Proper Municipal Solid Waste (MSW) management, development of a systematic septic system, use of bio-fertilizers, adopting rainwater harvesting/artificial recharge technique, reclaimed wastewater for recycling/reused, strong need to implement water conservation and protection rules and regulation properly and public awareness. There is a strong need to adopt the above-suggested mitigation measure to improve groundwater quality and quantity for future perspectives. This study will help to solve the problem related to drinking and irrigation in the study area.

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