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Premonsoon Groundwater Quality of Keonjhar Urban Area for Drinking and Domestic Use

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ABSTRACT

Study of groundwater quality is very important for a growing urban area like Keonjhar, the headquarter of the mineral rich Keonjhar District. For this purpose, sixty six groundwater samples were collected during pre-monsoon period of 2022 and analyzed for physico-chemical parameters. The results show that groundwater of the study area is acidic to alkaline in nature and falls under moderately hard to very hard category. Piper's trilinear diagram depicts the dominant facies to be Ca-Mg-HCO_3 type and Ca-Mg-HCO_3-Cl type. As per Bureau of Indian Standards (BIS) specifications, ground water of the area is generally suitable for drinking purpose, save the places where fluoride concentration exceeds the permissible limit. Thus, fluoride problem is an emerging issue for the groundwater scenario of Keonjhar which needs to be addressed urgently.

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1. INTRODUCTION

Water is one of the most vital resources for the sustenance of humans, plants and other living beings. Safe potable water is absolutely essential for healthy living. From the dawn of civilization, people have depended on ground water which is the ultimate and most suitable fresh water resource for human consumption. As the population increases, the demand of water for domestic, agricultural and industrial uses increases too. When these demands exceed the naturally renewable supply, water shortage occurs in the area. According to the World Health Organization, drinking water must be free of chemicals and microbial contaminations which are harmful to human health.

Physico-chemical analysis of water is very important in public health studies as the quality of groundwater plays an important role. Previous study on the quality of groundwater in Keonjhar city for agricultural use has found severity of nitrate contamination (Madhav et al., 2020). The present work is to study the quality of groundwater of Keonjhar town and its environs to assess its suitability for drinking and domestic use.

2. STUDY AREA

Keonjhar district, situated in the northern border of Odisha, is bounded by latitudes 21°01′N and 22°10′N and longitudes 85°11′E and 86°22′E. The district is bounded by Singhbhum district of Jharkhand in north, Mayurbhanj and Baleswar districts in east, Jajpur and Dhenkanal districts in south and Sundargarh district in west. The study area comprises Keonjhar town and its environs extending from 21°35′30″N to 21°41′30″N latitude and 85°33′E to 85°41′E longitude covering an area of around 150 km^2.

Keonjhar area experiences tropical to subtropical climate with temperature ranging from 45°C to 10°C and average annual rainfall of 1530 mm from south west monsoon. The area is mainly drained by river Aradei, a small tributary of Baitarani river. The drainage pattern is mostly dendritic in nature.

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3. GEOLOGY

The area consists of several major lithologic groups ranging in age from Archaean to Proterozoic. According to general geological succession of rocks given by Saha et al. (1988), Singhbhum Granite of Archaean age (3.3 Ga) forms the basement of the area. It is overlain by quartzitic sandstone, BHJ, BHQ and mafic lava belonging to Iron Ore Group. These are intruded by basic intrusives known as Newer dolerite (1.6–0.95 Ga). These geological formations suggest high runoff and low infiltration, resulting in a higher density of streams and rivers (CGWB, 2020).

4. HYDROGEOLOGY

Ground water occurs both under unconfined as well as semiconfined to confined conditions in the area. The unconfined or phreatic aquifers constitute the weathered regolith zone of the hard rocks from which groundwater is extracted through dugwells or shallow tubewells. The semiconfined and confined aquifers comprise deep seated intersecting fracture system in the crystalline hard rocks. According to study conducted by CGWB (1996), there are two major sets of lineaments and dykes in the area trending NW-SE and NE-SW respectively which control the occurrence and movement of groundwater. The relatively younger NW-SE trending set constitutes the prominent conduits for groundwater occurrence and the yield from borewells located in this zone is very high. In contrast, the yield from borewells in the vicinity of NE-SW dykes and lineament is relatively poor.

5. MATERIALS AND METHODS

Sixty six groundwater samples from dug wells and tube wells in use, were collected covering the entire study area (Fig. 1) during pre-monsoon period of 2022 following standard sampling procedure. These were analyzed for physico-chemical parameters following American Public Health Association (APHA, 2005) guidelines. Electrical conductivity (EC) and pH of the water samples were measured by digital meters in the field immediately after sampling. Total dissolved solids (TDS) values were calculated by multiplying electrical conductivity (EC) with 0.64. Total Hardness (TH), Total Alkalinity (TA), Ca^{2+}, CO_3^{2-}, HCO_3^- and CI^- were determined by volumetric titrations. Mg^{2+} was calculated from TH and Ca^{2+} by employing standard equation. Na^+ and K^+ were estimated by Systronics make flame photometer 128 and SO_4^{2-} by Systronics make Double beam spectrophotometer 2203 in the Geochemical Laboratory, Dept. of Geology, Utkal University. Fluoride (F^-) concentration was measured through Ion-selective Electrode Method in the Chemical laboratory of Central Groundwater Board, Bhubaneswar.

6. RESULTS AND DISCUSSIONS

The summary of chemical analysis of premonsoon groundwater samples of study area is presented in Table 1. The major parameters responsible for drinking and domestic use are discussed below.

Hydrogen Ion Concentration (pH):

pH is the total hydrogen ion concentration value in water which indicates whether a solution is acidic, neutral and basic. Overall, the groundwater is slightly acidic to alkaline in nature with a pH value ranged from 6.37 to 7.9 (average 6.8)

Electrical Conductivity (EC):

EC measures the ability of water to conduct an electrical current. The conductivity of water is affected by temperature and is directly related to the amount of dissolved mineral content. In simple terms, electrical conductivity is the inverse of the electrical resistance of one cubic centimeter of a material at the standard temperature of 25°C. EC values ranged from 146 to 1990 µSiemen/cm (average 825.5 µSiemen/cm) in pre-monsoon season 2022. The highest value of EC is observed near St. Xavier high school.

Total Dissolved Solid (TDS):

TDS is an essential quality parameter of ground water. It includes inorganic salts such as HCO_3, Cl, SO_4, NO_3, Ca, Mg, Na, and K, along with a small amount of dissolved organic matter. TDS values ranged from 87.4 to 1273.6 mg/l (average 516.5 mg/l). The highest value of TDS is observed near St. Xavier high school.

Chloride (Cl):

The Cl concentration is high in groundwater due to leaching of some evaporate mineral like halite that

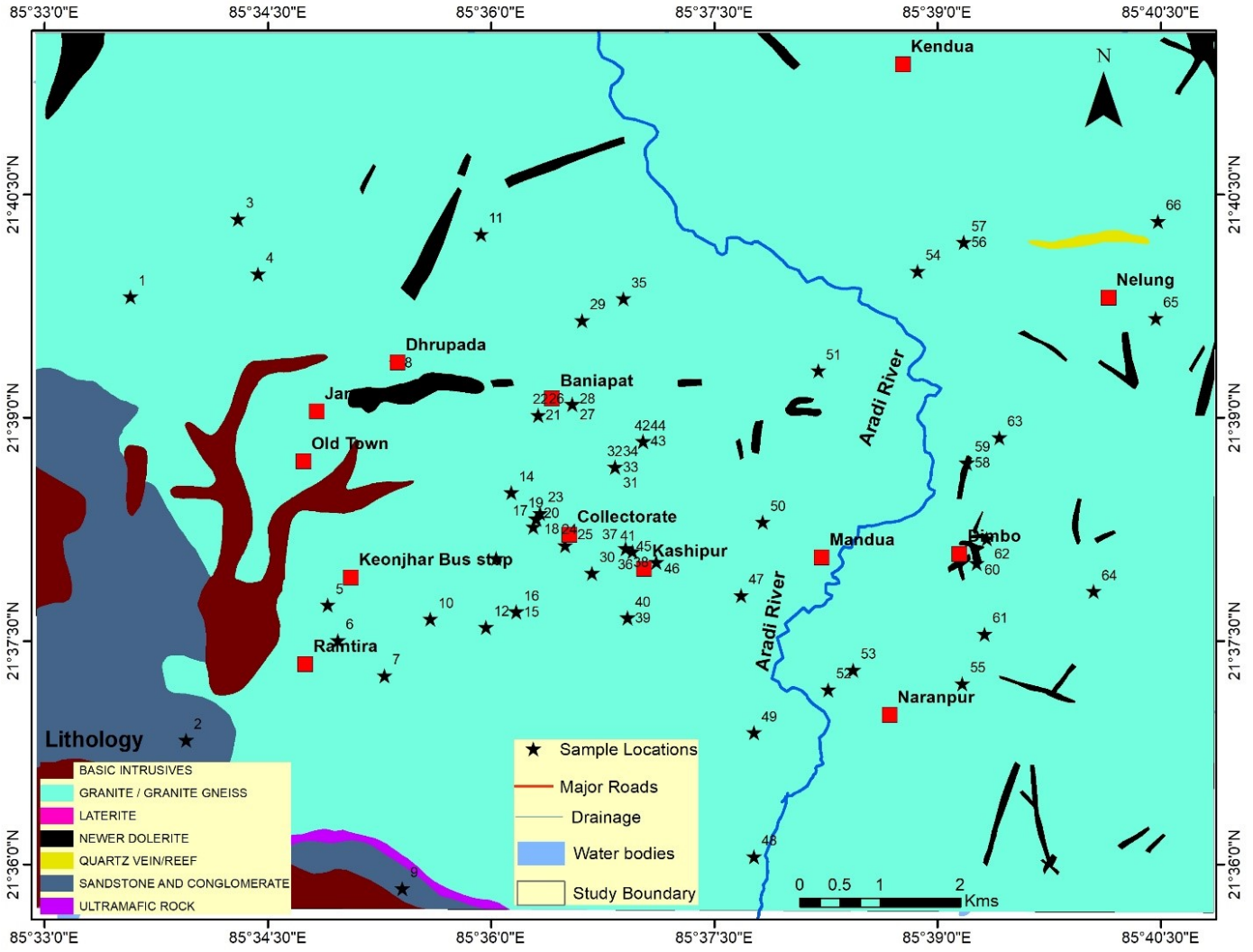

Fig. 1. Map of study area showing sample locations.

will contribute significant amount of Na and Cl to groundwater. In the present study Cl value ranges from 30 to 470 mg/l (average 136.59 mg/l). The highest contamination of Cl is observed near to the St. Xavier high school .

Fluoride (F):

The concentration of Fluoride up to 1.5 mg/l is beneficial for reducing dental cavities in children during the calcification period (Srinivasa, 1997). The concentration of F ranges from 0.11–4.5 mg/l. As many as 16 out of 66 groundwater samples were found fluoride contaminated with greater than the maximum permissible limit of 1.5 mg/l (BIS, 2012). If water with fluoride concentration above 1.5 mg/l is consumed for a prolonged period, it can cause acute to chronic dental fluorosis, resulting in discolored teeth ranging from yellow to brown (Brindha et al., 2011).

The spatial distribution of pH, TDS, Cl and F in the ground water of study area are shown in Figs. 2 and 3.

Drinking and Domestic Use:

Drinking and domestic consumption are the most important fields of water use. Drinking water standards have been enunciated by Bureau of Indian Standards (BIS, 2012) on the lines of World Health Organization (WHO, 2004). On comparison with BIS (2012) standards, it is found that all chemical parameters except fluoride are within permissible limit in the groundwater of study area (Table 1).

Hardness of water is due to the presence of divalent metallic cations out of which Ca^{2+} and Mg^{2+} are the most important (Todd, 1980). These ions react

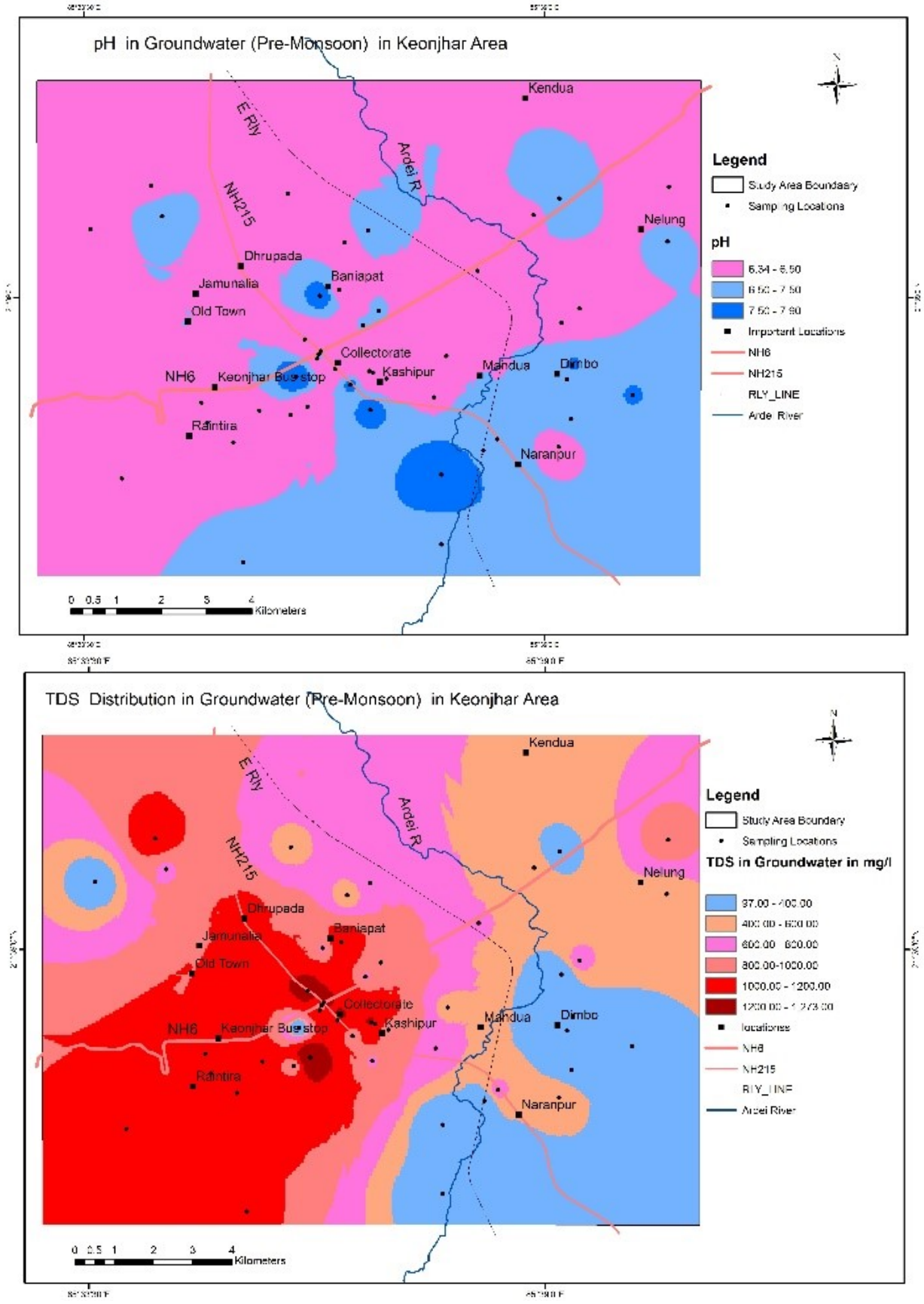

Fig. 2. Spatial distribution of selected chemical parameters in the groundwater of study area.

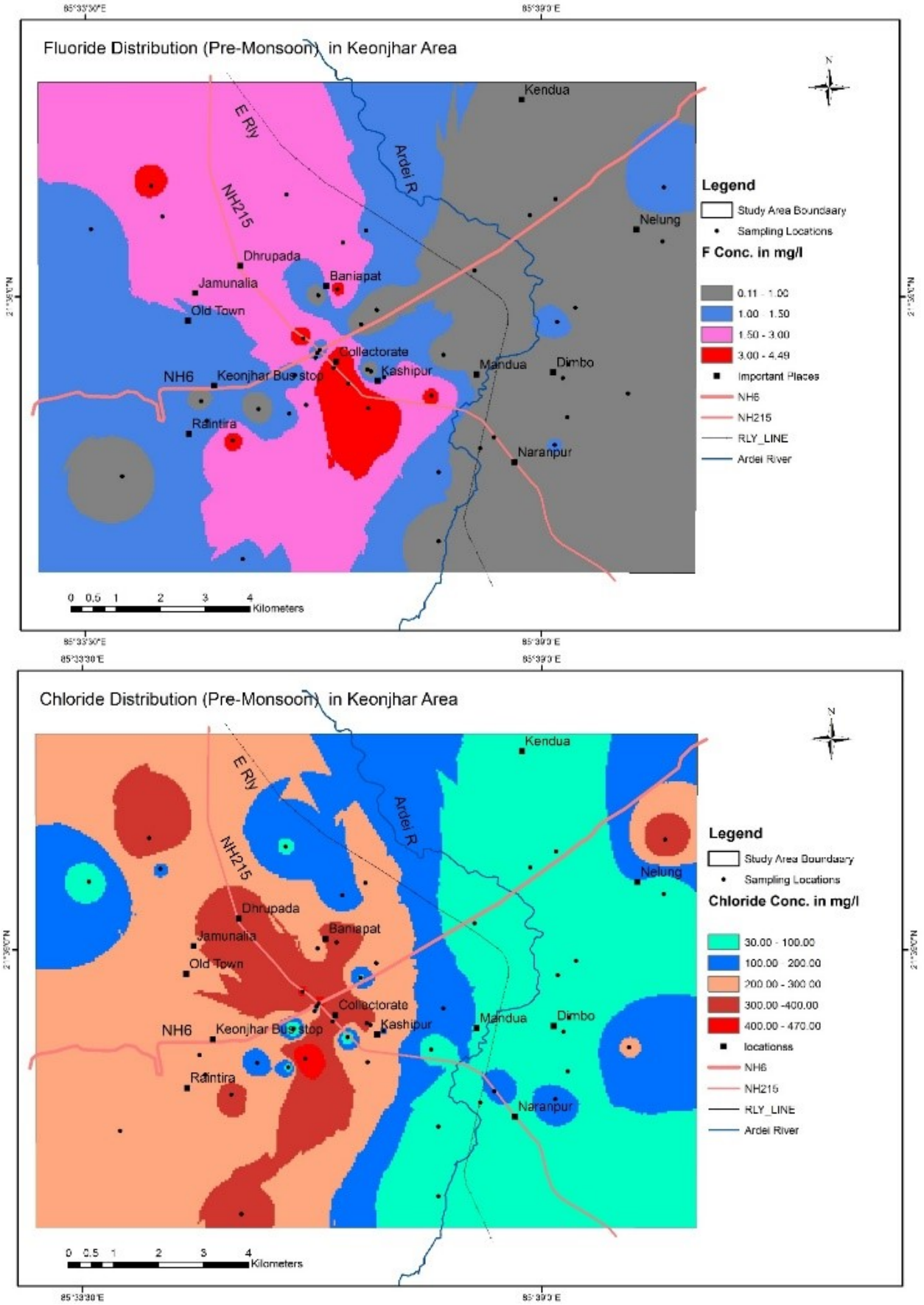

Fig. 3. Spatial distribution of selected chemical parameters in the groundwater of study area.

Table 1. Comparison of premonsoon water samples of Keonjhar with BIS (2012) drinking water standards.

Parameters	Unit	Minimum	Maximum	Mean	BIS (2012)		No. of samples below permissible limit	No. of samples above permissible limit
					Accept Limit	Permissible limit		
pH		6.3	7.9	6.8	6.5	8.5	66	NIL
EC	µS/cm	146	1990	825.5	–	–		
TDS	mg/l	87.4	1273.6	516.5	500	2000	66	NIL
Cl^-	mg/l	30	470	136.59	250	1000	66	NIL
HCO_3^{2-}	mg/l	80	350	205	200	600	66	NIL
SO_4^{2-}	mg/l	0	40	20.2	200	400	66	NIL
Na^+	mg/l	1	109.74	34.06	–	200	66	NIL
K^+	mg/l	0.03	6.94	0.82	–	–	66	NIL
Mg^{2+}	mg/l	0	82.48	31.72	30	100		
Ca^{2+}	mg/l	8	188	77.6	75	200	66	NIL
TH	mg/l	130	750	323.48	200	600	64	2
F^-	mg/l	0.11	4.5	1.10	1	1.5	50	16

Table 2. Hardness Classification of water after Sawyer and McCarty (1967).

Hardness (mg/l) as CaCO3	Water Class	Number of samples
0–75	Soft	0
75–150	Moderately hard	5
150–300	Hard	24
> 300	Very hard	37

with soap to form precipitates making water unsuitable for washing clothes. Further, the precipitates from hard water leave incrustation on cook wares and water taps. The hardness classification of water (Sawyer and McCarty, 1967) is given in Table 2. The results show that all the groundwater samples of the area come under moderately hard to very hard category and thus require water-softening treatment.

6.1. Hydrochemical classification of Groundwater

Piper Trilinear Diagram:

Hydrochemical facies analysis is a valuable tool to determine the flow pattern and origin of chemical history of groundwater. The present study involves the classification of groundwater by analyzing its chemical composition and plotting the data in Piper's trilinear diagram. This diagram is useful in identifying the major hydrochemical facies by plotting the major ions in two base triangles for cations and anions, which are then projected in the diamond field. This method was first introduced by Piper (1944). The chemical data of 66 groundwater samples have been plotted on the Piper diagram (Fig. 4). It shows that the groundwater of Keonjhar is predominantly Ca-HCO_3 type followed by Ca-HCO_3-Cl type. The general predominance of cations and anions in groundwater were found in the orders of $Ca^{2+}>Mg^{2+}>Na^+>K^+$ and $HCO3 >Cl >SO_4{}^2 >CO_3{}^2$, respectively.

7. CONCLUSION

- The groundwater quality in Keonjhar town is generally good for drinking except some patches having fluoride contamination, the source of which should be properly investigated. Seasonal monitoring of fluoride concentration and potential remedies are required for the contaminated patches.
- The groundwater is found to be slightly acidic to slightly alkaline in nature and is categorized as moderately hard to very hard requiring water softening treatment for domestic use.
- Based on the Piper trilinear diagram, the groundwater types are predominantly Ca-HCO_3 type followed by Ca-HCO_3-Cl type. The general predominance of cations and anions in the groundwater are found in the order of $Ca^{2+}>Mg^{2+}>Na^+>K^+$ and $HCO3 >Cl >SO_4{}^2 >CO_3{}^2$ respectively.

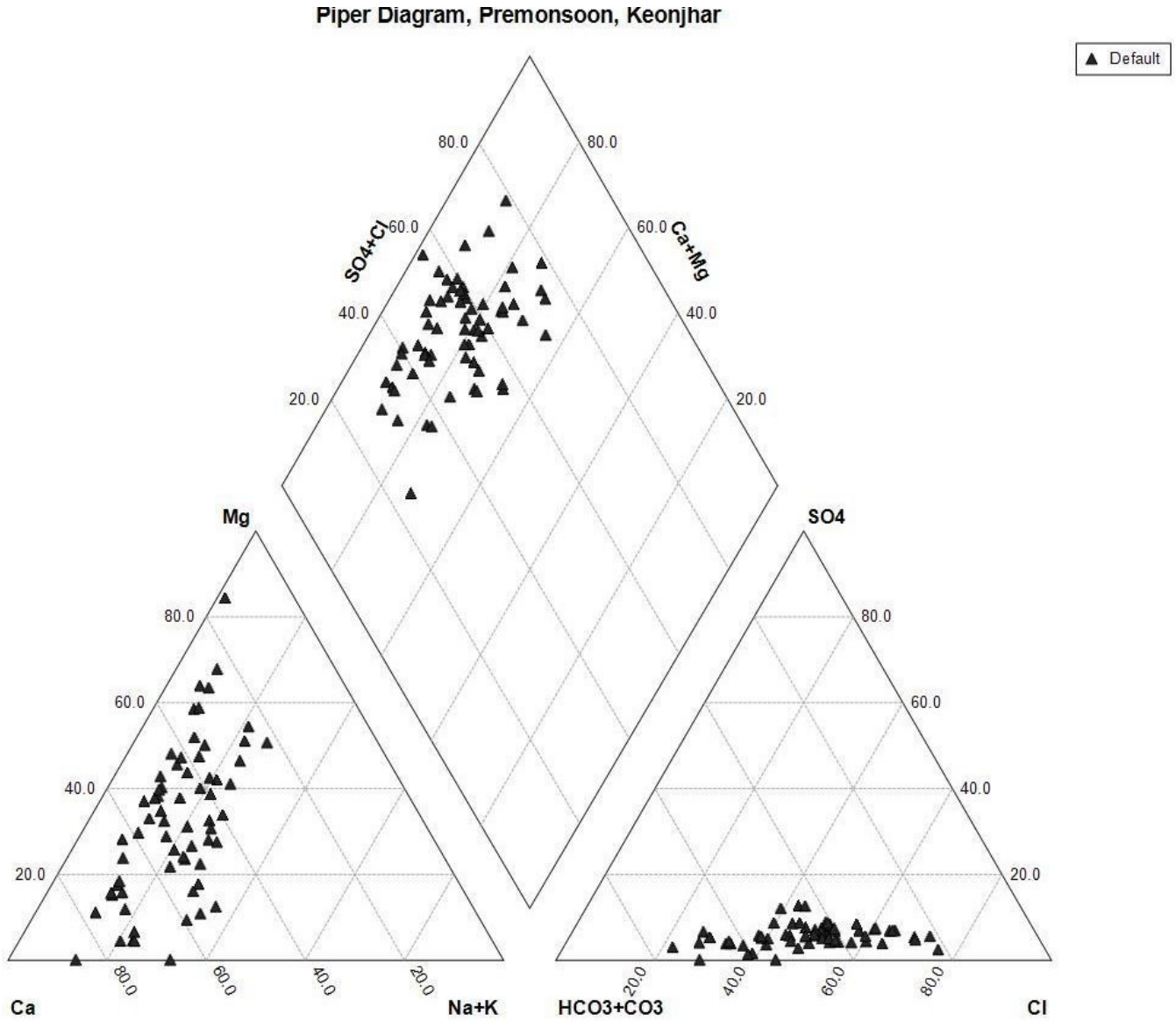

Fig. 4. Piper diagram of groundwater samples (premonsoon).

References

American Public Health Association (APHA), 2005. *Standard Methods for the Examination of the Water and Wastewater.*

Bureau of Indian Standards, 2012. *Indian Standard Drinking Water – Specification (Second Revision)*, IS 10500:2012.

Brindha, K., Rajesh, R., Murugan, R., Elango, L., 2011. Fluoride contamination in groundwater in parts of Nalgonda District, Andhra Pradesh, India. *Environmental Monitoring and Assessment* 172(1), 481–492. https://doi.org/10.1007/s10661-010-1348-0.

Central Ground Water Board, 1996. Ground water resources and developmental potentials of Keonjhar District, Orissa. Technical Reports: series "D",.

Central Ground Water Board, 2020. *Hydrogeological framework and ground water development prospects & aquifer management plan, Keonjhar District, Odisha.* Spl. publ. on Aquifer Mapping.

Madhav, S., Kumar, A., Kushawaha, J., Ahamad, A., Singh, P., Dwivedi, S.B., 2020. Geochemical assessment of groundwater quality in Keonjhar city, Odisha, India. *Sustainable Water Resources Management* 6, 1–11. https://doi.org/10.1007/s40899-020-00395-7.

Piper, A.M., 1944. A graphic procedure in the geochemical interpretation of water analysis. *Am Geophys. Union, Trans* 25, 914– 923.

Saha, A.K., Ray, S.L., Sarkar, S.N., 1988. Early history of the Earth: Evidence from the Eastern India Shield. *Mem. 8, Geol Soc India* , 13–38.

Sawyer, C.N., McCarty, P.L., 1967. *Chemistry for Sanitary Engineers.* 2nd ed., McGraw Hill, New York.

Srinivasa, R.N., 1997. The occurrence behaviors of fluoride in the groundwater of the Lower Vamsadhara River Basin, India. *Hydrol. Sci* 42(6), 877–891.

Todd, D.K., 1980. *Groundwater Hydrology.* Wiley New York.

World Health Organization, 2004. Guideline of drinking water quality in Health criteria and other supporting information. *World Health Organization* 2(336).

