Study and Analysis on Groundwater Modelling in Watershed Area of the Wainganga River Gondia District Using GIS Techniques

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Abstract- Currently, Geographic information systems (GIS) are the most significant mapping and modelling tool for groundwater analysis.The determination of the groundwater level of In a few years, the availability of groundwater will be a problem in Kati Village, Gondia District, Maharashtra, India, a case study Wainganga River watershed area pre-monsoon and post-monsoon analysis.The monsoon rains in Gondia District are concentrated in the four months of June to September, with 90.81% rainfall, 1.86% post-monsoon, 4.83% pre-monsoon, and 2.48% winter. The annual rainfall distribution in Gondia is very irregular. The main river is Wainganga, and the tributaries are Bagh.The water has a neutral to alkaline pH range of 6.6 to 8.92 and a high TDS range of 140 to 2184 ppm. The suitability of the groundwater level must be established before using GIS interpolation model techniques to evaluate it. Groundwater level monitoring, hydrology, and other fields increasingly make use of geospatial techniques for Geographic information systems (GIS). Using this method of groundwater level monitoring to gather information on water level potential position conditions in the study area is crucial for effective analysis, prediction, and validation. The result is reached through statistically significant analysis of physicochemical parameters and groundwater modelling using GIS. This study's objective is to use GIS techniques to analyse groundwater modelling in the Wainganga River Gondia District.The information can be used in the future for studies on area management, resource conservation, and restoration.

Keywords-Geographical Information Systems (GIS), Groundwater Modelling, Wainganga River Watershed Area, Physicochemical Parameters

1. INTRODUCTION

Water is the most important natural resource for human health, economic growth, and environment. Groundwater is a component of the water cycle that is stored below the land surface in saturated zones and moves slowly through aquifers. Aquifers can store water for hundreds or thousands of years. Geological formations, soil type, lineament density, slope, drainage density, rainfall form, morphology, land-use characteristics, and their inter- relationships all influence the existence and flow of groundwater (Chowdary et al., 2012). Approximately 71% of the Earth's surface is water-covered, and the oceans hold about 96.5% of all Earth's water. Around 97% of all water on Earth is saline water, which is found in oceans, seas, and saline groundwater. Less than 0.001% of fresh water is surface water in lakes, swamps, and rivers (Patle D. et al., 2019). The groundwater model is a scale model representative of a groundwater situation that can be used to predict the effects of hydrological changes in urban and rural areas, such as groundwater abstraction. Urban and rural water management is required due to the growing demand for water for domestic, agricultural, and industrial purposes. Surface waters precipitation, lakes, reservoirs, rivers, etc. are the source of groundwater in the hydrologic water cycle and Groundwater is the water that is stored beneath the earth's surface. The Geographic Information System (GIS) has been identified as one of the most effective methods for assessing land suitability based on the spatial variability of hydrogeological parameters. Since conventional groundwater exploration is resource- and time-intensive, GIS offers numerous tools for extracting information about a region's potential groundwater developments, which continue to rely on surface water. Goitsemang et al. (2020) investigated the effect of groundwater quality on water samples from the Wainganga River Watershed (WG-1/B), Kati Village of Gondia district, Maharashtra, India.

2. PROBLEM OF STATEMENT

In recent years, the groundwater in Wainganga River Watershed (WG-1/B) Kati Village of Gondia district, Maharashtra, India has decreased. Because of increased population and urban sprawl, the number of bore wells is increasing, which is affected by groundwater level and few bore wells dry during the pre-monsoon period in Kati Village of Gondia district, Maharashtra, India, this condition causes a continuous decreased in groundwater level.

3. OBJECTIVES OF THE STUDY

1. Find qualitatively strained and challenging study areas. Groundwater examinations identify water quality problems.

2. To prepare GIS-based maps from the hydro-chemical study of groundwater Wainganga River Watershed (WG-1/B), Kati Village of Gondia district.

3. To establish the inter-relationship between physicochemical parameters with standard parameters using the statistical approach for groundwater.

4. The primary goal of this research is to use Geographic Information Systems (GIS) to evaluate the quality of groundwater using pre- and post-monsoon physico-chemical data from the Wainganga River Watershed region.

4. METHODOLOGY AND ANALYSIS

Studying the groundwater's physicochemical characteristics, including its temperature, pH, conductivity, dissolved solids, nitrates, chlorides, and fluorides. The results of the analysis were compared to thresholds established by the BIS and the WHO.

Table 1: Data analysis for parameters and methods

Sr. No.	Parameters	Equipment/ Method
1	pH/Temp/EC	pH/Temp/EC Digital meter
2	TDS	TDS meter
3	Chloride	Mohr's Method Using Titration
4	Fluoride	SPADNS Method
5	Nitrate	Spectrophotometer or Colorimeter Method

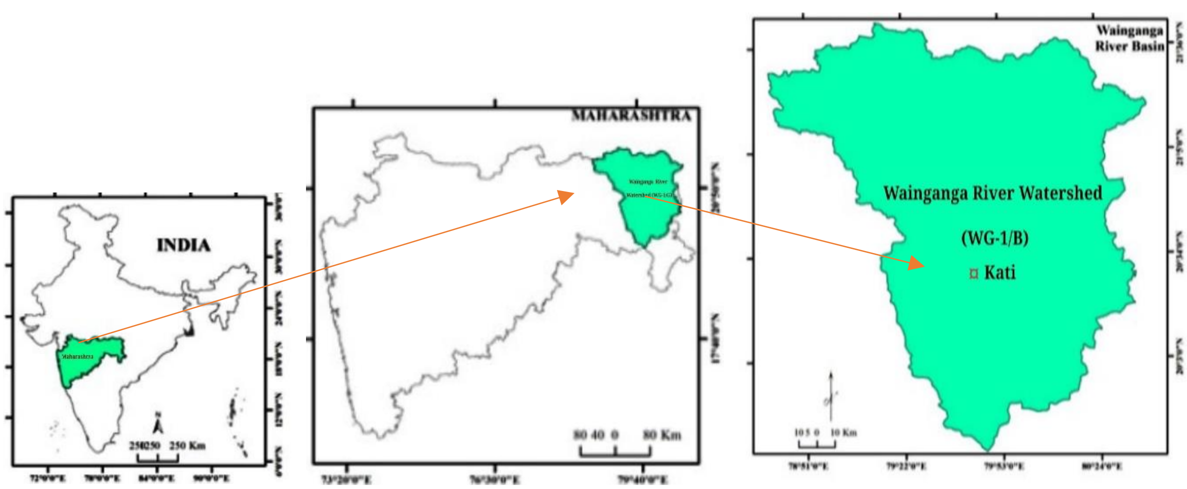

Figure 1: Study area of Wainganga River Watershed, Kati Village, Gondia District

Groundwater samples have been carefully collected from the Wainganga River Watershed (WG-1/B) in Kati Village Gondia District, during both pre- and post-monsoon seasons. For the drinking water tests, samples were taken from several regions with varying levels of use, including the village's major market, residential neighbourhoods, and schools. Grab sampling was used to gather samples from the research region. The samples' temperature, pH, TDS, and conductivity were among the parameters that were measured on-site using a Eutech Cyberscan 660 multiparameter analyzer. For further examination, samples were gathered in 1-liter polyethylene bottles and kept in the lab at 40°C. Utilising APHA guidelines, a laboratory chemical analysis was performed. Double distilled water was utilised to make the solutions, and AR grade reagents were employed for the analysis. To determine the correlation between any two examined parameters, analysis has been done.

5. RESULT

5.1 Result of Physicochemical Analysis

The results of analysis data of physicochemical parameters and GIS modeling. A statistical study has been done for the average values of parameter and GIS mapping have been studied for Kati Village. All the parameters are compared with water quality standards suggested by ICMR, BIS10500:2012, and WHO. The samples from Kati Village, Wainganga River Watershed has been analyzed for physicochemical parameter during premonsoon and post-monsoon seasons.

Table 2: Premonsoon and Postmonsoon analysis of Wainganga River Watershed, Kati Village, Gondia District

POST-MONSOON ANALYSIS									
Sr. No.	Source Type	Location	Physicochemical Parameters						
			pH	Temp	NO_3	TDS	EC	Cl	F
1	Openwell	Budha Vihar	7.7	27	167.03	1208	1258	85	0.012
2	Openwell	Pahire House	7.72	26	27.83	595	1244	60	0.414
3	Openwell	Chainlal Morle	7.39	28	24.52	236	695	190	0.009
4	Openwell	Front Of PHC	7.02	29	167.2	552	1442	315	0.152
5	Hand pump	pancham Chauhan	6.99	28	167.03	1014	1420	360	0.239
6	Hand pump	Kabir Ashram	7.37	28	14.03	206	1341	240	0.138
7	Openwell	Ganesh Uike	7.64	27	166.82	1840	1350	305	0.806
8	Openwell	Hanuman Mandir	7.5	29	68.78	1405	1384	50	0.437
9	Openwell	Namaji Urkude	7.02	28	69.37	704	1395	45	0.124
Total			**66.35**		**872.61**	**7760**	**11529**	**1650**	**2.331**
Average			**7.3722**		**96.95667**	**862.2222**	**1281**	**183.333**	**0.259**
PRE-MONSOON ANALYSIS									
Sr. No.	Source Type	Location	Physicochemical Parameters						
			pH	Temp	NO_3	TDS	EC	Cl	F
1	Openwell	Budha Vihar	7.7	24	118	230	759	226	0.534
2	Openwell	Pahire House	8.2	24	45.2	203	755	74	0.479
3	Openwell	Chainlal Morle	8.4	24	35.65	382	763	51	0.304
4	Openwell	Front Of PHC	8.1	24	183	401	756	87	0.428
5	Hand pump	pancham Chauhan	7.9	27	112	44	766	186	0.299
6	Hand pump	Kabir Ashram	7.8	27	45	327	763	194	0.345
7	Openwell	Ganesh Uike	7.7	23	55.23	281	897	95	0.294
8	Openwell	Hanuman Mandir	7.7	23	114	1782	1222	250	0.04

9	Openwell	Namaji Urkude	7.9	23	85.36	892	1394	145	0.37
Total			**71.4**		**793.44**	**11271**	**11361**	**2253**	**4.82**
Average			**7.9333**		**88.16**	**1252.333**	**1262.333333**	**250.333**	**0.535556**

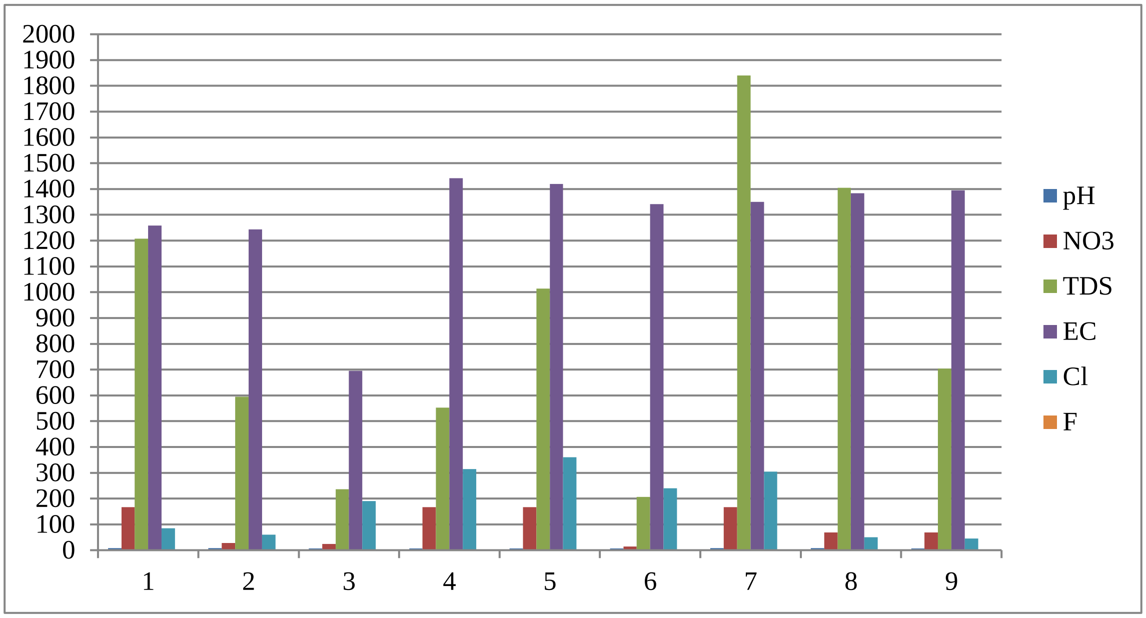

Figure 2: Analysis of Postmonsoon Graphical Representation of Kati Village

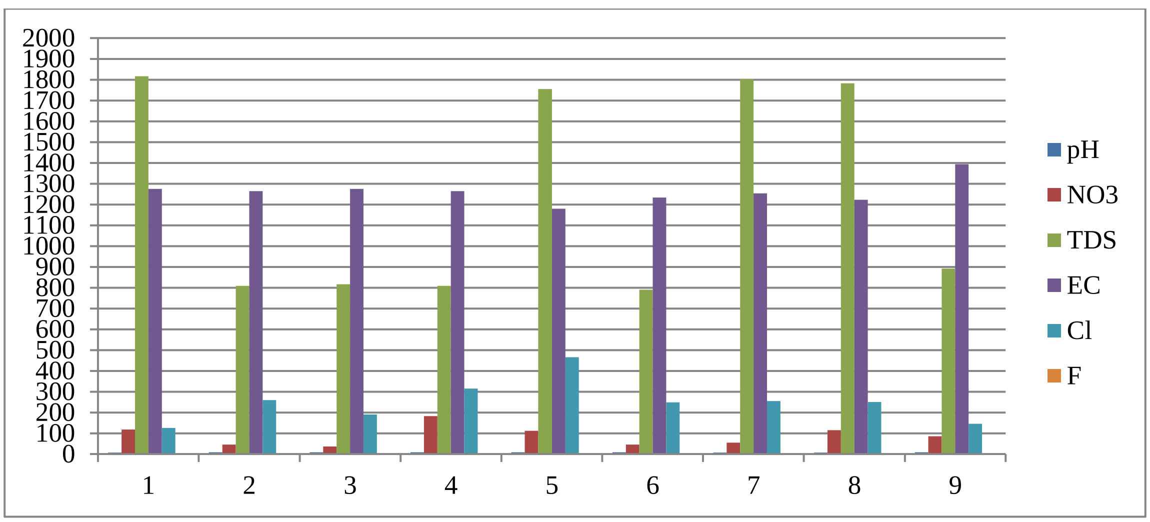

Figure 3: Analysis of Premonsoon Graphical Representation of Kati Village

Nitrate concentration of Kati Village of 8 samples except sample No. 6 are found above the ICMR, 6 samples except sample Nos. 2, 3 and 6 are found above the BIS and 6 samples except sample No. 2, 3 and 6 are found above the WHO desirable limits during premonsoon and during postmonsoon all 9 samples are found above the ICMR desirable limit, samples 8 except sample No.3 are found above BIS limit and 6 samples except sample No. 2, 3 and 6 are found above WHO limits. TDS concentrations of 7 samples except sample Nos. 3 and 6 are found above the ICMR and BIS limit and of sample Nos. 1, 5, 7 and 8 are found above WHO standard during premonsoon and during postmonsoon TDS concentration of all samples are above ICMR and BIS limit whereas sample Nos. 1, 5, 7 and 8 are above WHO standard. Chloride concentration of sample Nos. 4, 5and 7 during premonsoon and of sample Nos.

2, 4, 5, 7 and 8 are found above the ICMR, BIS and WHO limits during postmonsoon. Concentration of Fluoride during postmonsoon is found high in sample No. 2 in Pahire's well. Except these other parameters of Kati village are within the limits during both seasons as shown in Table 2 and Figures 3 and Figure 4.

5.2 Result of Statistical Analysis of GIS Mapping

1. pH In WGW area, pH concentration during premonsoon was observed that 12% (43.35 km^2) with potable water with desirable limits and during postmonsoon season it was observed that 5.12% (18.51 km^2) area of kati with desirable limit remaining area was found as non- potable zone. The average concentration of pH in WGW area was observed as potable water with desirable limits during both seasons as per the BIS and WHO standards as shown in Figure 4.

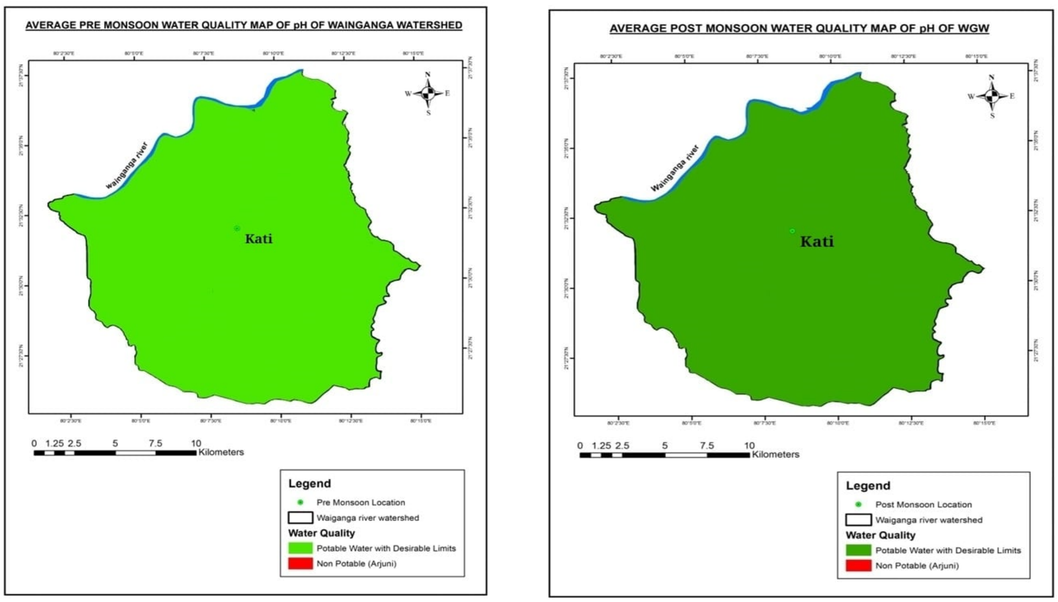

Figure 4: Premonsoon and postmonsoon Spatial Distribution of Average pH of WGW area, Kati Village

2. Electrical Conductivity (EC) The average concentration of EC in WGW area, KatiVillage was observed with desirable limit in 92% (332.38 km^2) area and in 8% (28.9 km^2) area with non-potable water in premonsoon and in postmonsoon its concentration was found in 88% (317.94 km^2) area with desirable limit and remaining 12% (43.36 km^2) area with non-potable zone as shown in figure 5.

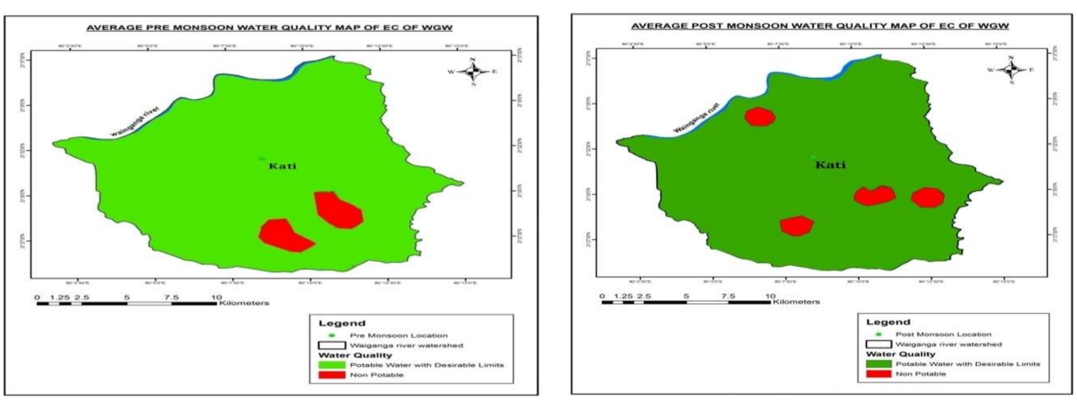

Figure 5: Premonsoon and postmonsoon Spatial Distribution of Average EC of WGW area, Kati Village

3. Total Dissolved Solids (TDS) The average concentration of TDS in WGW area, kati village during premonsoon was also observed with desirable potability in 16.5% (59.61 km^2) area and with permissible potability in 83.5% (301.68 km^2) area and during postmonsoon it was found potable water with permissible limits except kati village which were having potable water with desirable limits as shown in Figure 6.

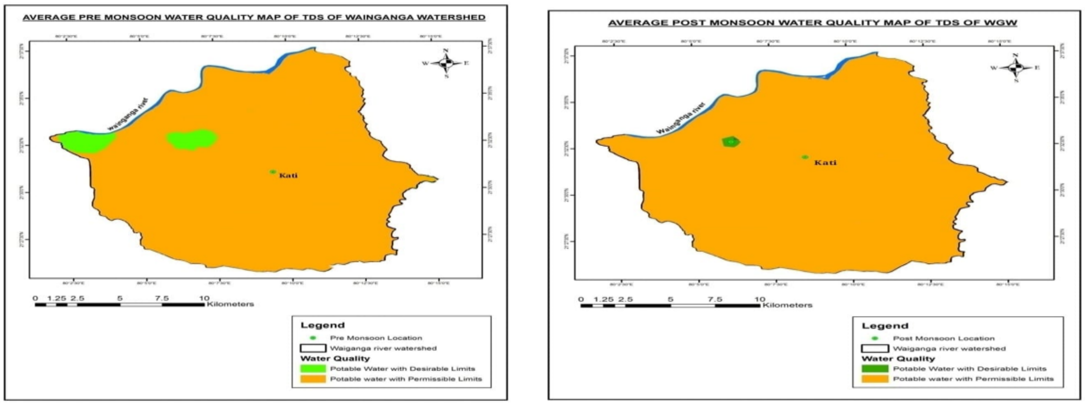

Figure 6: Premonsoon and postmonsoon Spatial Distribution of Average TDS of WGW area, Kati Village

4. Nitrate The average concentration of NO_3 in WGW area,kati village during premonsoon was found as non-potable in 30.48% (110.12 km^2) area and in 69.52% (251.17 km^2) as potable water with desirable limit and during postmonsoon only 7% (25.29 km^2) area was observed as potable water with desirable limit and remaining 93% (336 km^2) area with non-potable water as shown in Figure 7.

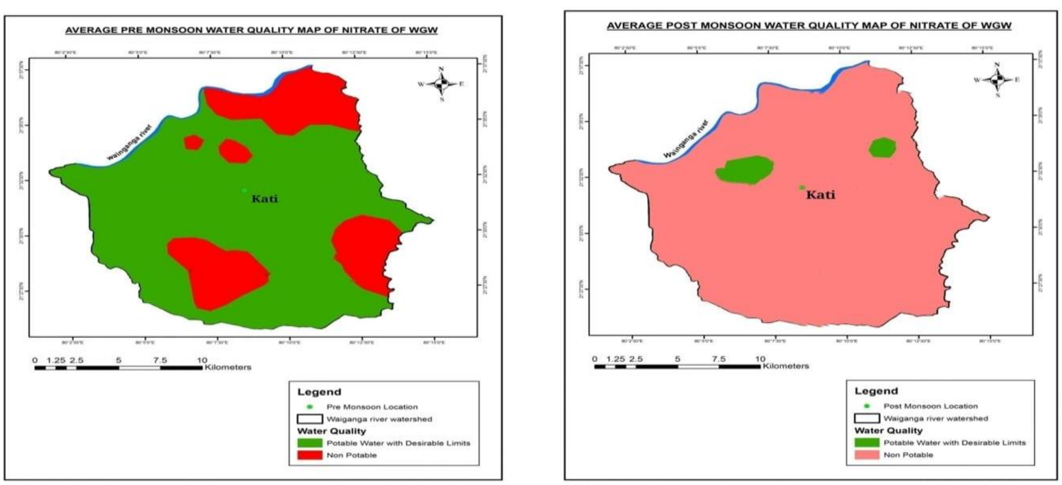

Figure 7: Premonsoon and postmonsoon Spatial Distribution of Average NO_3 of WGW area, Kati Village

5. Chloride The average chloride concentration in the Kati village area was observed with desirable limits in 87% (314.32 km^2) area and 13% (46.96 km^2) area with permissible limits in premonsoon season and during postmonsoon it was observed in desirable limits in 59.55 % (215.15 km^2)area and in permissible limits in 40.45% (146.14 km^2) area as shown in Figure 8.

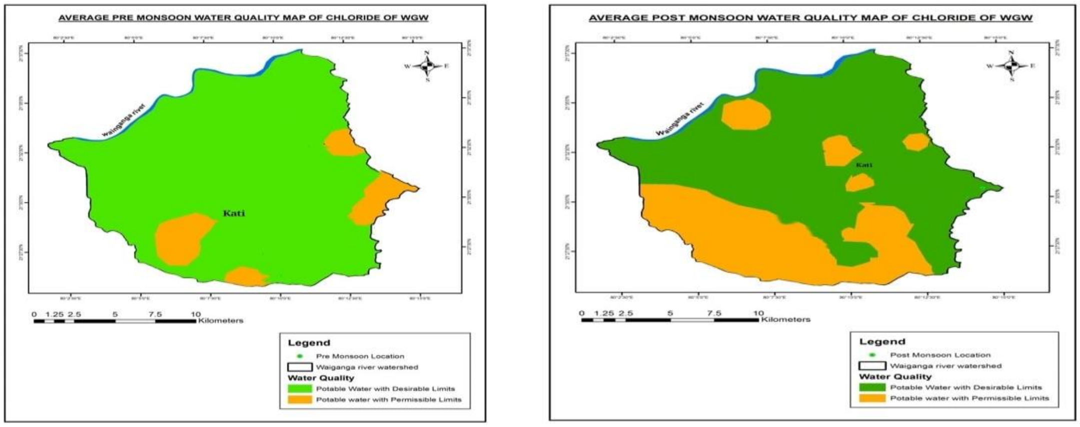

Figure 8: Premonsoon and postmonsoon Spatial Distribution of Average Chloride of WGW area, Kati Village

6. Fluoride The average fluoride concentration in the WGW area was observed during premonsoon in desirable limits in entire area during premonsoon its concentration was found within desirable limit in 98.84% (357.11 km^2) area and 1.15% (4.18 km^2) area of Kati village with permissible limit as shown in Figure 9.

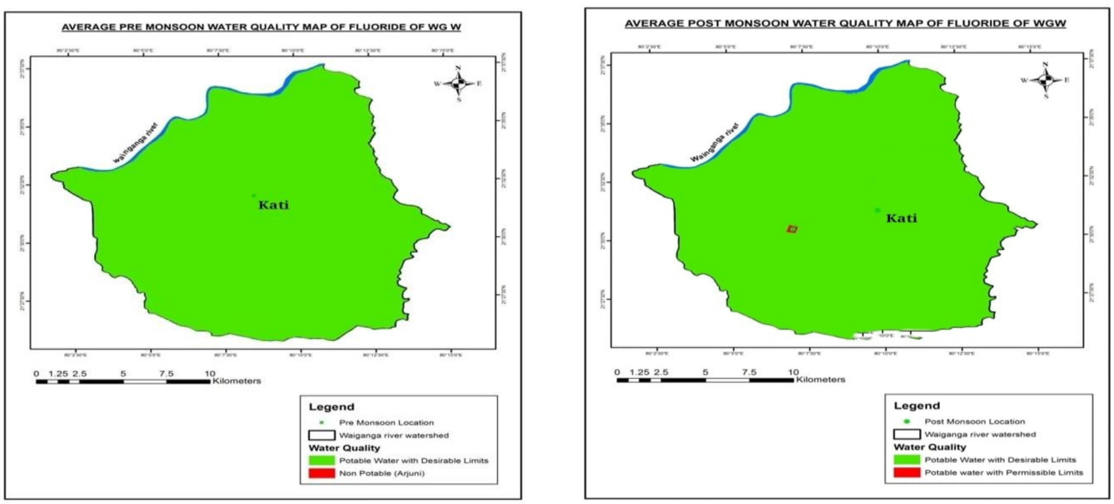

Figure 9: Premonsoon and postmonsoon Spatial Distribution of Average Fluoride of WGW area, Kati Village

CONCLUSIONS

1. Kati Village's water quality meets all WGW regulations for physicochemical parameters such pH, TDS, EC Cl, and F.

2. Water's pH fluctuates very little because carbon dioxide in the air acts as a buffer. both seasons in the WGW area whereas the average pH values of 1.32% exceed the desirable limits.

3. In WGW area, the average concentration of EC is found 5.84% during premonsoon and 5.75% during postmonsoon exceeds the limits prescribed by BIS. The presence of a large number of dissolved inorganic compounds in ionised form, as measured by electrical conductivity, is characteristic of watershed regions.

4. TDS concentration 56.94% during premonsoon and 73.45% during postmonsoon is above the ICMR desirable limit and BIS permissible limit whereas 10.75% during premonsoon and 19.65% is above the WHO standards. A high

total dissolved solids (TDS) value in a groundwater sample might be the result of a number of factors, including the percolation of sewage from homes into the water form.

5. The average concentration of nitrate in WGW area is found 74%, 14.27%, 10.87% during premonsoon and 135.15%, 51.61%, 39.3 % during postmonsoon above desirable limits of ICMR, BIS and above ICMR standard during premonsoon. Nitrate increases may be caused by the increasing cultivation of leguminous plants, the increased dumping of industrial effluent or sewage, the increased decomposition of plant and animal leftovers, or the increased use of nitrogen fertilisers. At higher dose levels, nitrate's toxicity causes effects on the heart, while at lower dose limits, it causes Methomoglobinemia.

6. In the post-monsoon period, Cl concentrations were found to be greater than the WHO threshold in 2.6% of rural water wells and pumps. During the pre-monsoon season, the concentration of Cl in 29.1% of rural water wells and pumps was found to be greater than the WHO threshold; this number was 10.62% in WGW regions.

7. Except for Kati village in the WGW region, the measured fluoride levels are well within the safe range. The existence of fluoride-rich minerals like fluorite and appetite may be to blame for the fluoride pollution in these areas. Fluorosis of the skeleton and teeth occurs when an individual consumes too much fluoride.

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