PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER OF BHATHAT BLOCK OF GORAKHPUR DISTRICT USING WQI AND GIS TECHNIQUES

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Abstract - *Ground water is significant constituent of human life support system and it is utilized for domestic, industrial and watering purposes. In India, the vast majority of the population is reliant on ground water which is one of the principle wellsprings of drinking water flexibly. Anyway because of quick development of population, urbanization, industrialization and agriculture exercises, ground water assets are under pressure. Consequently, it is important to screen the water quality of physico-chemical parameters.*

This study evaluates the physico-chemical properties of ground water such as, Electrical Conductivity (EC), pH, Fluoride (F), Total Hardness (TH), Total Dissolved Solids (TDS), Magnesium (Mg), Calcium (Ca), Nitrate (NO_3), by collecting 13 water samples from hand pumps (India Mark II) which is well distributed within Bhathat Block of Gorakhpur District in November, 2019. Each physico-chemical parameter was contrasted to the acceptable minimum limit specified by the BIS Indian Standards (IS 10500:2012). Global Positioning System was utilized to plot the water sample locations and mapping of water quality was finished by utilizing Inverse Distance Weighted (IDW) Interpolation method in ArcGIS 10.2.2. This study evaluates water quality status of Bhathat Block of Gorakhpur District region and identification of filthy zones so that the proper corrective procedures can be taken.

***Key Words*: Water Quality, Inverse Distance Weighted (IDW), physico-chemical, spatial distribution.**

INTRODUCTION

In the current circumstance, in a large portion of the urban areas in India, the day by day water request is met by groundwater use, as the surface water is either lacking or contaminated. Groundwater is the primary source that is ordinarily utilized for drinking and water system purposes in rustic, urban and semi urban territories (Magesh & Chandrasekar, 14 december 2011). By and large, the investigations of physiochemical and biological parameters lead to survey the nature of groundwater (Fatombi, Ahoyo, Nonfodji, & Aminou, December 2012). Hydro chemical qualities of groundwater can likewise be examined for the groundwater evaluation (Ranjan, Ramanathan, Parthasarathy, & kumar, 01 june 2012). Geographic Information System (GIS) planning procedure is the best delegate apparatus in the evaluation of groundwater quality and its use for irrigation, drinking and constructional needs (Ravikumar & Somashekar, 27 November 2011; Srinivasamoorthy, 2011). ArcGIS Software can achieve better understanding of groundwater quality by representing the data (Thiyagarajan & Baskaran, 24 december 2011). There is a chance of changes in groundwater quality because of hydrology and geologic conditions over some undefined time frame (Pandey & Tiwari, 2009). Besides, ill-advised removal of waste or trash are one among the essential elements for groundwater contamination (Abinandan, Anand , & Subramaniam, 2014). The present study was carried out in the Bhathat block, located positioned in Gorakhpur district in Uttar Pradesh. However, the major source of drinking water for the district is groundwater which is already contaminated due to industrial establishments. The datasets for the groundwater were compared with Bureau of Indian Standards (BIS) and World Health Organization (WHO) standards to ensure the quality of the water.

1.1 Objectives of the Present Study

The objectives of the present study are given below-

- To plot the GPS points of that water sample location in map
- To assess the physico-chemical parameters of water
- To compute the Water Quality Index (WQI)
- To create spatial distribution maps of that parameters

2. STUDY AREA

Bhathat is a block positioned in Gorakhpur district in Uttar Pradesh. It has 95 villages. There are 61 Panchayats in Bhathat block. It is situated 22 KM towards North from District headquarters Gorakhpur. It is a block head quarter. It is located 289 KM from state capital Lucknow. The coordinates of the Bhathat block is 26.8980° N and 83.4886° E. The elevation of Bhathat block is 85 mt (altitude).

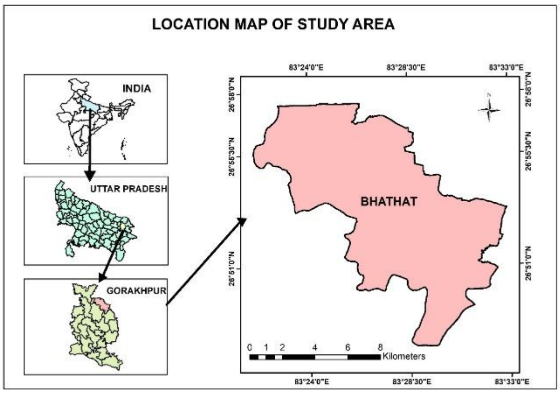


Fig -1: Location map of the study area

3. DATA AND SOFTWARE USED

3.1 Data Used

- Layout map of Bhathat block
- Ground water quality parameter
- Survey of India toposheet.: 63N/3, 63N/5, 63N/6, 63N/10, and 63J/15

3.2 Instruments

- Global Positioning System
- Water quality field kit
- Digital pH-meter
- Digital conductivity meter
- UV-Visible Spectrophotometer

3.3 Software

- ArcGIS 10.2.2
- Microsoft package
- UV-Analyst software

4. METHODOLOGY

4.1 Sample Collection

An aggregate of 13 ground water tests were gathered from India Mark II handpump which is very much dispersed inside Bhathat block of Gorakhpur district. Global Positioning System (GPS) was utilized to find the water test areas and mapping of water quality was finished utilizing Inverse Distance Weighted (IDW) Interpolation procedure in ArcGIS 10.2.2. Each example was gathered by 1 liter corrosive washed polyethylene HDPE bottle. The container was completely loaded up with water taking consideration that no air bubble was stuck inside the water test. Precautionary measure was additionally taken to keep away from test unsettling influence during move to the research facility. Electrical conductivity

(EC) and capability of hydrogen (pH) were resolved on the field itself utilizing advanced meters. Physical and Chemical parameters are analysed as consistent with the standard technique of Ground water high-quality prescribed in standard technique for the exam of water and waste water American public health association (APHA 1995). The samples were kept at a temperature beneath 4°C preceding investigation in the lab. The sampling location is shown in figure 2.

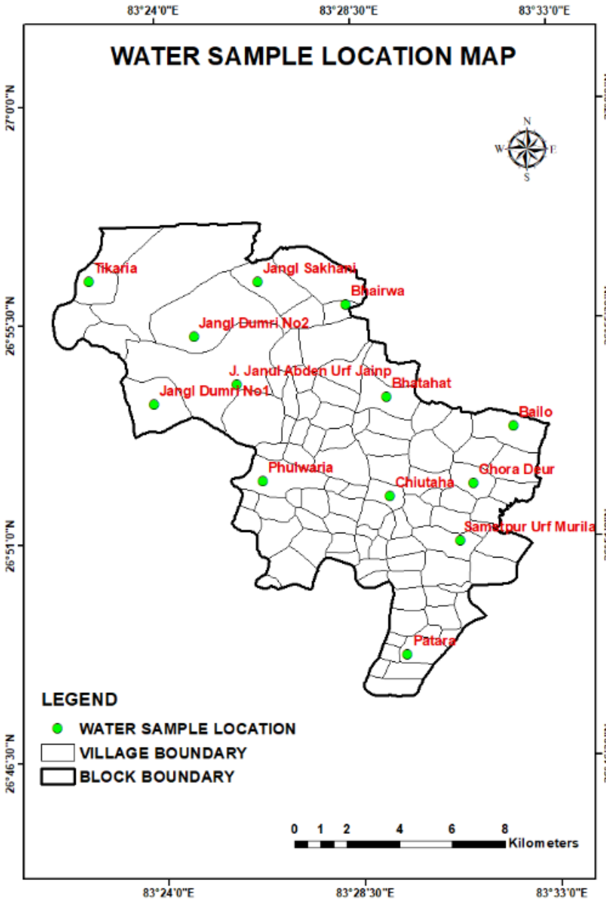


Fig -2: Water sample location map

Table -1: BIS water quality Standards (IS 10500:2012)

S.NO.	PARAMETERS	ACCEPTABLE (mg/L)	MAX ALLOWABLE (mg/L)
1.	pH	6.5-8.5	No relaxation
2.	Electrical Conductivity (µS/cm)	Not Specified	----------
3.	Total Dissolved Solids	500	2000
4.	Total Hardness (as $CaCO_3$)	300	600
5.	Calcium (as $CaCO_3$)	75	200
6.	Magnesium	30	100
7.	Fluoride	1	1.5
8.	Nitrate	45	No relaxation

Table -2: Instruments used for determination of parameters

S.NO.	PARAMETERS	INSTRUMENTS
1.	pH	Digital pH-meter
2.	Electrical Conductivity	Digital conductivity-meter
3.	Total Dissolved Solids	Digital conductivity-meter
4.	Calcium	Titrimetric method (with EDTA)
5.	Magnesium	Titrimetric method (with EDTA)
6.	Total Hardness	Titrimetric method (with EDTA)
7.	Nitrate	UV-visible Spectrophotometre
8.	Fluoride	UV-visible Spectrophotometre

4.2 Software Used

ArcGIS is a software based on geographic information system (GIS) for working on maps and geographic data kept up by the Environmental Systems Research Institute (ESRI). It is used for creating and utilizing maps, assembling geographic data, analysing mapped data also for sharing and finding geographic information, using maps and geographic data in a scope of uses and overseeing geographic data in a database.

4.3 Georeferencing

Geo-reference means something to describe its world in physical space, that is to say, to set up its region to the extent of map projections. Specific maps may use method of distinctive projection. Geo-reference is done by collecting Ground Cross Point (GCP) and processing satellite data with it.

4.4 Water sample location mapping

Digitization implies denoting the geographical component in the spatial information by making shape files. The shape files can be polygon, point and line. The estimation of latitude and longitude of the hand siphons is imported into the GIS as point highlights. This should be possible by Add XY information alternative in the ArcGIS programming. In the wake of bringing in it as point includes, these focuses as spared as point shape files.

4.5 Interpolation

Interpolation predicts values for cells in a raster from a set number of sample data points. It very well may be utilized to foresee obscure qualities for any geographic point data, for example, height, noise levels, precipitation and chemical concentrations.

4.5.1 Inverse Distance Weighted

Inverse Distance Weighted (IDW) is a strategy for interpolation that gauges cell values by averaging the estimations of sample data points in the area of each preparing cell. The closer a point is to the focal point of the cell being evaluated, the more impact, or weight, it has in the averaging procedure.

4.6 Water Quality Index

The water quality index is one of the best techniques for giving water quality data to concerned residents and strategy creators. It advances into a significant boundary for groundwater appraisal and the board. The water quality index sums up enormous amounts of water quality data in basic terms, for example excellent, good, bad, and so on.

Three stages are followed to figure WQI. In the initial step, a weight (wi) was appointed to every one of the 28 parameters dependent on their relative significance in the general quality of drinking water (Table 3). The parameter nitrate was allocated the most extreme load of 5 because of its significant significance in the appraisal of water quality. It may not be unsafe to magnesium which is given the base load of 1 as magnesium itself.

In the second step the relative weight (Wi) is calculated from the equation as follows:

$$\mathbf{Wi = wi/\Sigma wi}$$

Where, Wi is the relative weight,

wi is each parameter 's weight

and n is the number of parameters.

Table 3 also gives calculated relative weight (Wi) values for each parameter.

In the third step, a quality rating scale (qi) for each parameter is assigned by dividing its concentration by its respective norm in each water sample according to the guidelines laid down in the BIS and the and the result multiplied by 100:

$$\mathbf{q_i = (C_i / S_i) \times 100}$$

Table -3: Relative weight of physico-chemical parameters

PARAMETERS	INDIAN STANDARDS	WEIGHT (wi)	RELATIVE WEIGHT (Wi)= (wi/Σ wi)
pH	6.5 - 8.5	4	0.17391
TOTAL HARDNESS	300 - 600	2	0.08695
CALCIUM	75 - 200	2	0.08695
MAGNESIUM	30 - 100	2	0.08695
TOTAL DISSOLVED SOLIDS (TDS)	500 - 2000	4	0.17391
NITRATE	45 - 100	5	0.21739
FLUORIDE	1 – 1.5	4	0.17391
		Σwi = 23	ΣWi = 1.0

Where, qi is the quality ranking,

Ci is the concentration of each physico-chemical parameter in each water sample in mg/l, and Si is the Indian drinking water level in mg/l for each chemical parameter in accordance with BIS 10500, 1991 guidelines.

The SI is first determined for the calculation of the WQI for each chemical parameter, which is then used to calculate the WQI according to the equation

$$\mathbf{SI_i = W_i q_i}$$

$$\mathbf{WQI = \sum SI_i}$$

where SIi = subindex of the ith parameter;

qi = concentration-based rating of the ith parameter,

The calculated WQI values are divided into five types, "excellent water" into "water, inappropriate for drinking."

Table -4: Water quality status dependent on WQI

WQI VALUE	WATER QUALITY
< 50	excellent
50 - 100	good water
100 - 200	poor water
200 - 300	very poor water
> 300	Water unsuitable for drinking

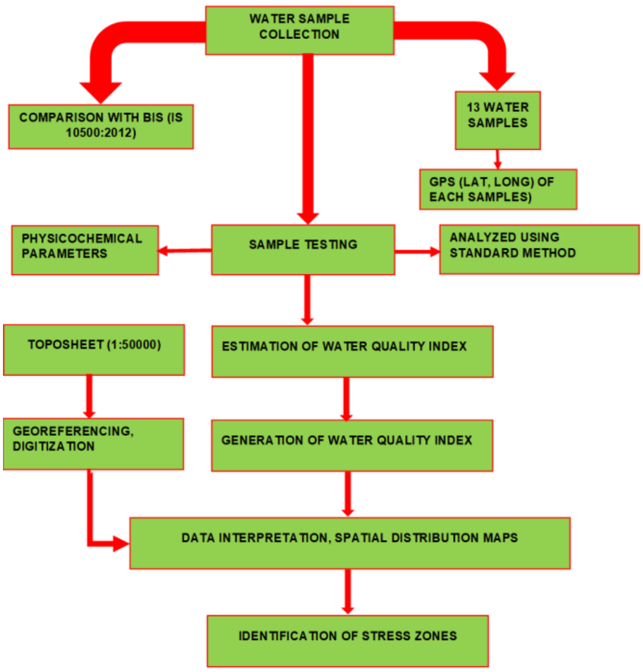


Fig -3: Flow chart for determining the water quality using GIS Technique

5. RESULT AND DISCUSSION

Table -5: Geochemical analysed data of the collected water samples

LOCATION	pH	EC (µS / cm)	TDS (mg /L)	TH (mg /L)	Ca (mg / L)	Mg (mg/ L)	NO_3 (mg/ L)	F (mg/ L)
Jangl Sakhani	7.33	513	308	500	263	58	0	0.85
Jangl Dumri No2	7.59	337	202	250	158	22	0	1.05
Bhairwa	7.75	281	169	180	126	13	0	0.57
J. Janul Abden Urf Jainp	7.62	348	209	260	158	25	2.23	0.9
Bhathat	8	278	167	150	116	8	1.24	1.4
Jangl Dumri No1	7.63	378	227	160	147	3	0	1.06
Bailo	7.61	389	233	250	126	30	0.16	0.83

Phulwaria	7.58	362	217	300	147	37	0.28	1.24
Ghora Deur	7.58	360	216	230	137	23	0	0.93
Chiutaha	7.72	291	175	180	137	10	0	0.79
Patara	7.7	414	248	210	116	23	0	3.03
Samstpur Urf Murila	7.7	361	217	220	137	20	0	2.2
Tikaria	7.66	353	212	250	137	27	0	2.32

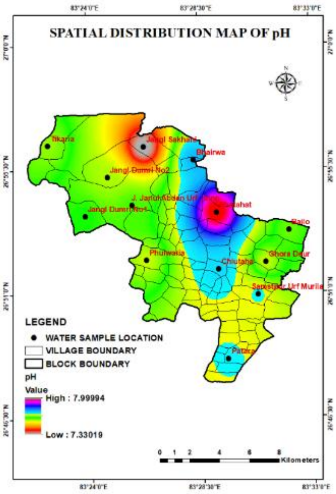


Fig -4: Spatial distribution map of pH

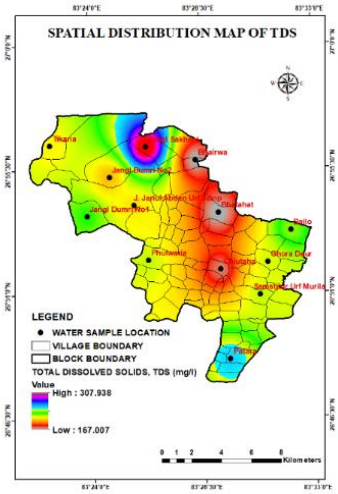


Fig -5: Spatial distribution map of TDS

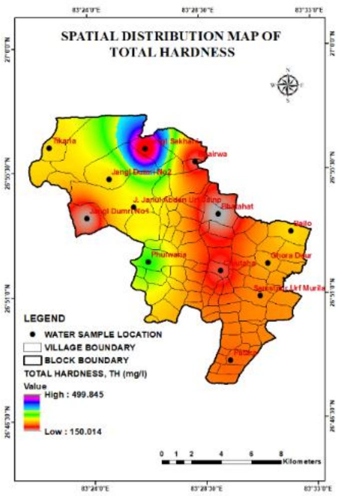


Fig -6: Spatial distribution map of TH

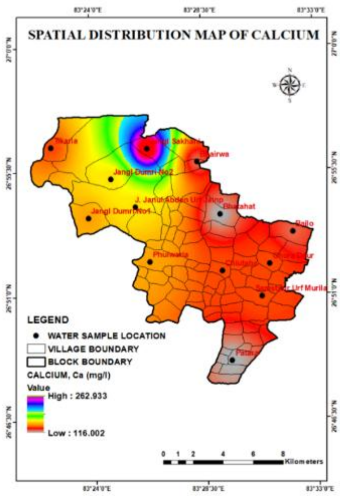


Fig -7: Spatial distribution map of Ca

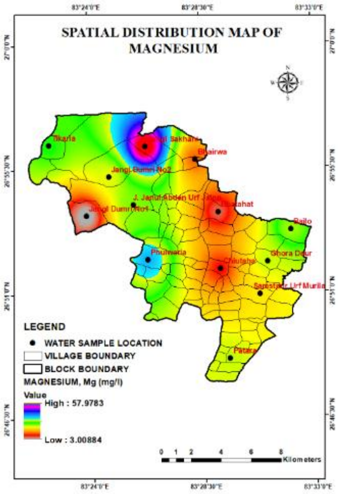


Fig -8: Spatial distribution map of Mg

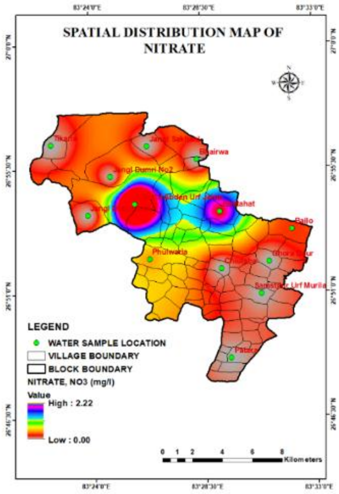


Fig -9: Spatial distribution map of NO_3

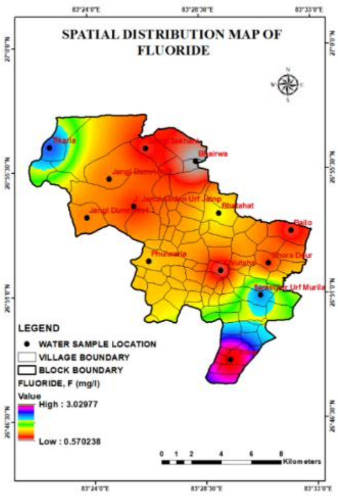
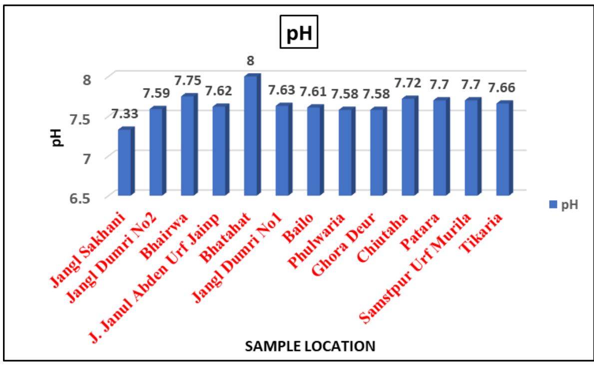


Fig -10: Spatial distribution map of F



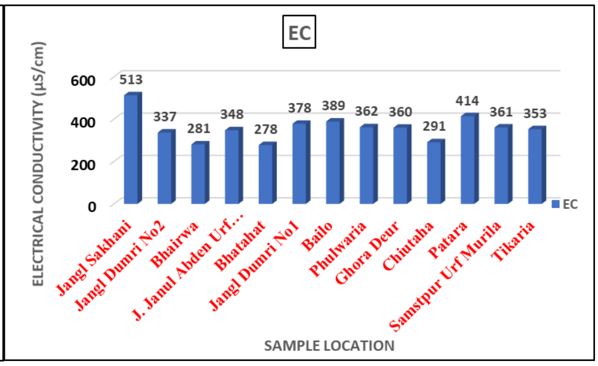


Chart -1: Variation of pH

Chart -2: Variation of EC

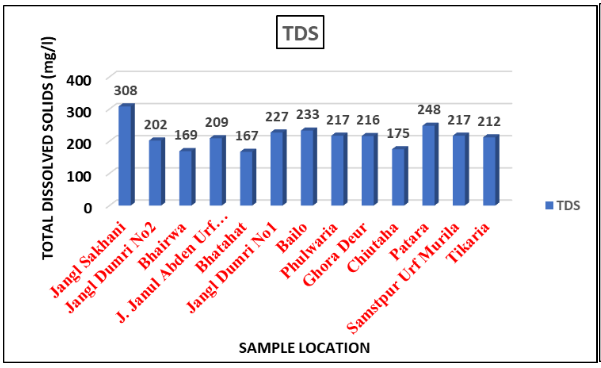


Chart -3: Variation of TDS

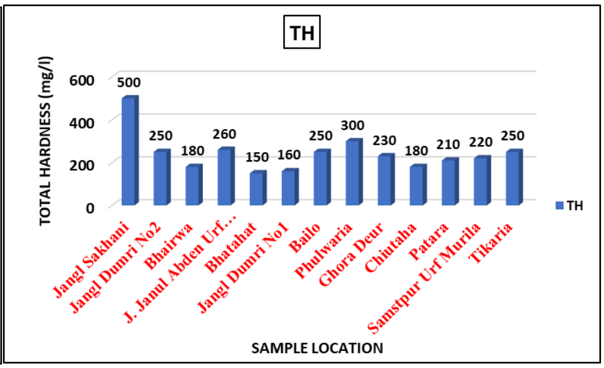


Chart -4: Variation of TH

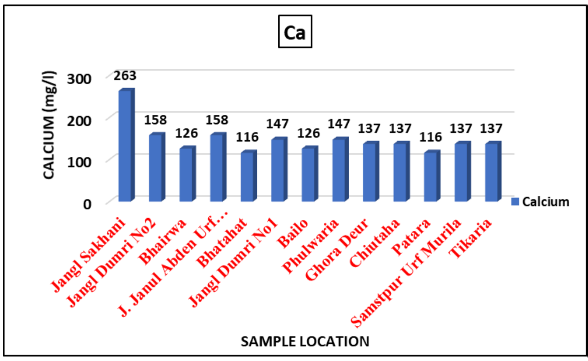


Chart -5: Variation of Ca

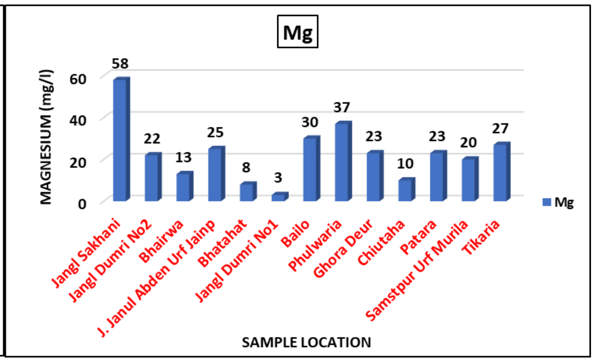


Chart -6: Variation of Mg

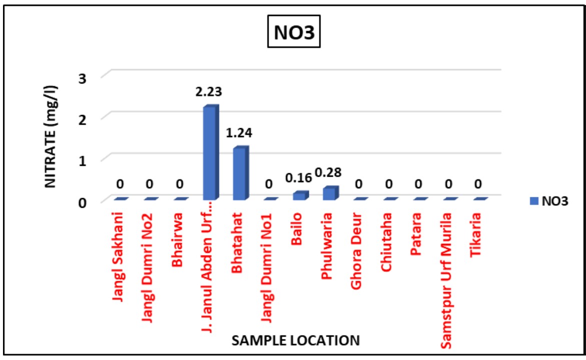


Chart -7: Variation of NO_3

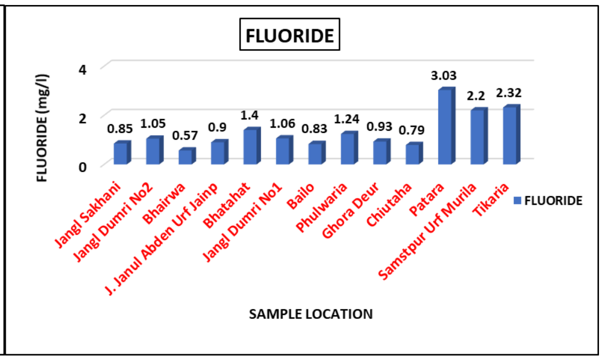


Chart -8: Variation of F

Table -6: Water quality status in sampling location

LOCATION	WATER QUALITY INDEX	WATER QUALITY
Jangl Sakhani	102.30	Poor water
Jangl Dumri No2	72.72	Good water
Bhairwa	55.20	Good water
J. Janul Abden Urf Jainp	72.65	Good water
Bhatahat	67.19	Good water
Jangl Dumri No1	64.47	Good water
Bailo	68.70	Good water

Phulwaria	81.20	Good water
Ghora Deur	68.40	Good water
Chiutaha	59.60	Good water
Patara	103.25	Poor water
Samstpur Urf Murila	89.60	Good water
Tikaria	94.32	Good water

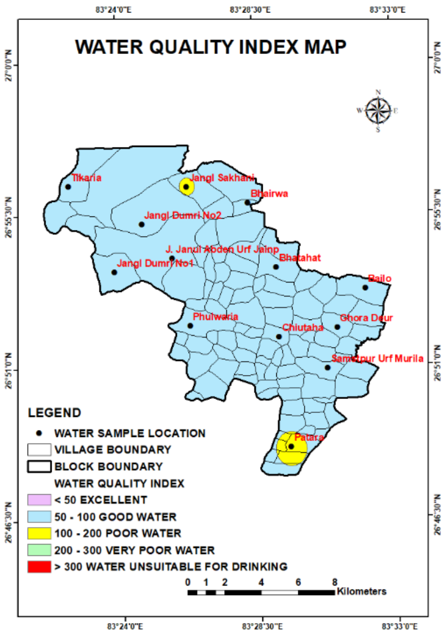


Fig -10: Water quality index map

STATISTICAL ANALYSIS

pH – In general, the term pH is used to express the intensity of the acid or alkaline condition of the solution, or it is used to measure the negative logarithm of hydrogen ion concentration. To determine the water's corrosiveness the exact level of alkalinity and pH acidity is needed. In the entire investigation the pH of the water sample ranges from 7.33 in Jangl sakhani to 8 in Bhathat. According to the IS:10500 drinking standard, the permissible pH limit is 6.5 to 8.5 and the study indicates that all water samples are safe and do not show any health hazard. Figure 4 shows spatial distribution of the pH.

Electrical Conductivity (EC) – Electrical conductivity represents the water's capacity to bear an electrical current and its closely associated concentration of dissolved salts in water. It estimates the total mass of dissolved solids in water. It expresses as ppm (parts per million) or mg/l. The water quality can be graded as bad, fair or good based on electric conductivity. In this study the higher electrical conductivity value at Jangl Sakhani is 513 µS/cm and the lower electrical conductivity value at Bhathat is 278 µS/cm (table 5).

Total dissolved solids (TDS) - Complete dissolved solids reflect groundwater's salinity behaviour. In the present study the TDS value of the water samples ranged from 167 mg/l to 308 mg/l (table 5), which is within the appropriate limits recommended by BIS. The maximum TDS registered in Jangl sakhani, and in Bhathat the minimum. Spatial distribution of Total Dissolved Solids is shown in figure 5.

Total hardness (TH) - Hardness is defined as the water property that prevents soap from forming lather and increases the boiling water point. Water hardness mainly depends on the calcium or magnesium salt, or both. Hardness while it does not have any health consequences may render water unfit for domestic and industrial use. Total hardness values varied between 150 mg/l to 500 mg/l (table 5). All samples of drinking water are within desired limitations prescribed by BIS. In Jangl Sakhani the maximum value was found, and in Bhathat the minimum. Figure 6 indicates a spatial distribution of Total Hardness.

Calcium (Ca) - The formation of calcium in water is mainly due to the presence of minerals, such as calcareous, dolomite, gypsum and gypsum. The permissible calcium level according to BIS is 75-200 mg/l. All the values of calcium in water samples are under the permissible limits prescribed by the BIS except Jangl Sakhani i.e. 263 mg/l (table 5). Figure 7 shows spatial distribution of Calcium.

Magnesium (Mg) - Magnesium amounts in water samples vary from 3 mg/l in Jangl Sakhani to 58 mg/l in Jangl Dumri No.1 (table 5) within the acceptable BIS limit (IS 10500:2012). The map of spatial variations for magnesium was obtained Figure 8.

Nitrate (NO_3) - The primary cause of nitrate in water is terrestrial legumes, food waste and animal excreta (WHO, 1983). In water, more than 100mg / l of nitrate content is bitter to taste and causes physiological distress in human bin. Organic pollution is indicated by the high nitrogen content in water. It results from the addition of nitrogen fertilizers, from the deterioration of dead plants and animals etc. The nitrate concentration in the sample ranged from 0.00 mg / l to 2.23 mg / l (table 5). Nitrate at all locations has been found to be in safe limits. The spatial distribution map of Nitrate is shown in Figure 9.

Fluoride (F) – Fluoride sources are mostly the iron, steel, phosphate fertilizer, and petroleum refining industries. Higher fluoride concentrations cause fluorosis in the bone and the dental. BIS allowable groundwater limit is 1 mg / l. However, this limit is 1.5 mg/l in temperate regions where water intake is low. Fluoride content ranged from 0.57 mg / l to 3.03 mg/l (table 5). Most water sample fluoride content values surpass the allowable limit of 1-1,5 mg/l as set out in the BIS. Figure 10 shows spatial distribution of the Fluoride.

6. CONCLUSION

The current investigation on physicochemical parameter of handpump water quality in Bhathat block of Gorakhpur district show that the concentration of pH, Electrical conductivity, Total dissolved solids, Total hardness, Calcium hardness, Magnesium hardness, Nitrate are inside reasonable constraint of drinking water standard BIS (IS 10500: 2012). In the study area, the values were found in respectable condition and does not show the alarming levels of pollutants but it need some level of treatment before utilization as the concentration of Ca hardness and Fluoride is in excess so for protection of adverse health effect on human being this should be treated.

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