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Groundwater Quality Mapping of Mulanthuruthy Panchayat Using GIS

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Abstract - *Geographical Information System (GIS) based groundwater quality mapping has been carried out in Mulanthuruthy Gram panchayat, Ernakulam. Groundwater quality for drinking water purposes was analyzed by considering the IS 10500: 2012. A total of 38 samples were collected from 10 wards of the study area. The groundwater samples were analyzed for the major parameters viz. pH, Nitrate, Nitrite, Ammonia, Chloride, Fluoride and Total hardness. The ArcGIS 10.4 was used for generation of various thematic maps and final map based on WQI. An interpolation technique called Inverse Distance Weighted method was used to obtain the spatial distribution of groundwater quality parameters. Seven thematic maps with parameters such as pH, Nitrate, Nitrite, Ammonia, Chloride, Fluoride and Total hardness having desirable and undesirable classes were integrated and the final groundwater quality map for drinking purposes has been prepared based on the WQI.*

***Key Words*: ArcGIS, Thematic maps, Interpolation technique, Inverse Distance Weighted, WQI.**

1. INTRODUCTION

Water is the basic requirement of life on earth. It is essential in the life of all living organisms (from the simplest plant and microorganisms to the most complex living system such as of human body). Ground water is an essential renewable resource which we rely on since centuries, without estimating its fate in terms of quality and quantity. It is profoundly utilized in irrigation, industries and for domestic purposes. Therefore, the quality of ground water is equally important as its quantity. Polluted groundwater can cause negative impacts in plants, animals, and humans. Kidney, liver and nerve damages, cancer etc. are some of the health effects of polluted water in human beings. Hence, it is desirable to control the intake of these potentially toxic chemicals from drinking water. Therefore, finding the potential areas, monitoring, and conserving ground water have become extremely important now.

Chemical composition of water is one of the prime factors which determines its suitability for domestic, industrial or agriculture purposes. Acceptable ground water quality shows that the ground water should be safe in terms of its physical, chemical, and bacteriological parameters. International and local agencies have established parameters to determine biological and physio - chemical quality of ground water. Keeping this in view, we made use of geo-spatial technology for mapping the spatial variability of ground water quality. Thereafter spatial variation maps of these ground water quality parameters were generated. The project assessed and mapped the groundwater quality in Mulanthuruthy Gram panchayat using an integrated approach of Geographic Information System (GIS).

Ground water samples were collected from several points randomly distributed in Mulanthuruthy Gram Panchayat. The major water quality parameters such as pH, chloride, fluoride, nitrite, nitrate, ammonia, and total hardness have been estimated for all the sampling locations.

The visual presentation of results of water quality monitoring helps us to give a clear picture of quality of water at a glance. This can be achieved by using Geographic Information System (GIS). The complex relationship between the various parameters can be easily studied if the water quality results are presented in a visually appealing manner as a map rather than a set of rows and columns of figures. The spatial distribution of water contaminants and other water quality parameters can be displayed in an effective manner using GIS. This helps authorities in taking effective measures to check water pollution and thereby to restore water quality.

2. STUDY AREA

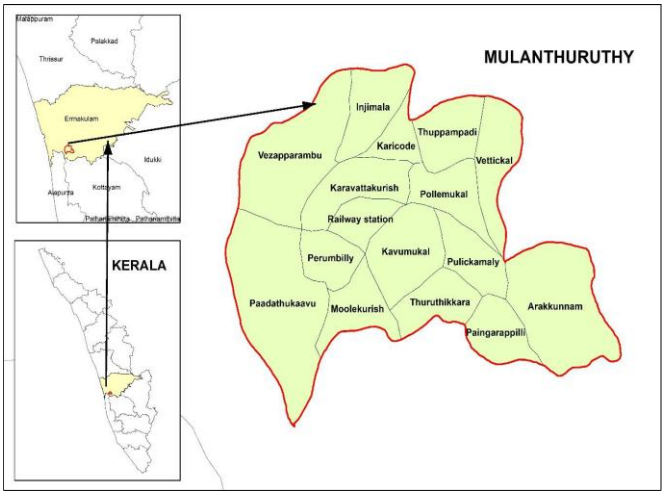

Fig- 1: Study area map

Mulanthuruthy is a small town in Ernakulam district of Kerala. The study area is about 21 km southeast of Ernakulam and 8 km east of Tripunithura. Mulanthuruthy also hold the gram panchayat and the block panchayat with same name. Location of Mulanthuruthy panchayat as per the

Geographic coordinates are 9°44'3''N– 76º23' 24" E and 9º90'08" N – 76º39'00" E, respectively. The study area map illustrating all the wards of Mulanthuruthy Panchayat is given in figure 1.

For administrative purposes, the panchayat is divided into 16 wards. The name and details of area covered by each ward is given in table 1. The panchayat covers an area of 2147 hectares. The study area for the project has been selected as Mulanthuruthy panchayat since groundwater is the main source of water used by local people for drinking, domestic and agricultural purposes.

Table - 1: Details of area covered by the wards of Mulanthuruthy panchayat

Ward no.	Ward name	Area (hectares)	Percentage
1	Vezhaparambu	101.41	4.72
2	Inchimala	125.29	5.84
3	Karikode	102.79	4.79
4	Pollemugal	89.92	4.19
5	Thuppampady	120.02	5.59
6	Vettickal	212.27	9.89
7	Arakkunnam	270.36	12.59
8	Pulikamaly	153.9	7.17
9	Paingarapilly	195.74	9.12
10	Thuruthikara	135.43	6.31
11	Kavummugal	58.37	2.72
12	Railway station	66.69	3.11
13	Perumpilly	72.86	3.39
14	Moolekuriz	180.03	8.39
15	Padathukavu	179.42	8.36
16	Karavattekuriz	82.5	3.84
Total		2147	100

3. SAMPLE COLLECTION AND TESTING

As part of the study, the groundwater samples from existing open wells and bore wells of 38 locations in the survey area, representing 4 to 5 samples from 10 wards which are used for drinking, irrigation and other domestic purposes were collected during the months of January to March 2020. The locations of 38 wells all over the study area were geographically determined by using GPS services in Google Maps. Bottles used for water sample collection were first thoroughly washed with the water being sampled and then were filled. After collection of samples, the samples were preserved and shifted to laboratory for analysis.

Physio-chemical analysis were carried out to determine parameters such as total hardness, pH, chloride, nitrate, nitrite, fluoride and ammonia according to the standard experimental procedures for water quality testing. The parameters for testing samples were limited to the above mentioned seven on the basis of the features and development of the area, as there were no industries, factories or any hazardous elements which disturbed and causes potential contamination of groundwater. Then the results were compared with standard values recommended by Indian Standard Specification for drinking water IS 10500: 2012 (TABLE 1 – 4).

The study area consists of sixteen wards out of which we collected samples from 10 wards viz. Arakkunnam, Paingarapilly, Moolekuriz, Kavummugal, Pulikamaly, Vettickal, Pollemugal, Perumpilly, Railway station and Thuruthikara.

4. WATER QUALITY INDEX (WQI)

Water quality index (WQI) provides information about water quality in a single value**.** WQI is commonly used for the detection and evaluation of water pollution and may be defined as a reflection of composite influence of different quality parameters on the overall quality of water (Horton, 1965). Here attempt has been made to calculate the water quality index of the study area based on physio - chemical data.

For the purpose of calculation of WQI of the study area, 7 water quality parameters have been selected. They are pH, ammonia, nitrite, nitrate, chloride, fluoride and total hardness. The higher values of these parameters would increase WQI value. Calculation of WQI was carried out in this study by Horton's method.

The WQI was calculated by using the expression given:

$$\mathbf{WQI = \sum W_i q_i / \sum W_i} \quad \text{.....(1)}$$

where,

q_i = Quality rating of n^{th} water quality parameter;

W_i = Unit weight of n^{th} water quality parameter;

The quality rating (q_i) is calculated using the expression:

$$\mathbf{q_i = [(V_n - V_{id}) / (S_n - V_{id})] \times 100} \quad \text{.....(2)}$$

where,

V_n = Estimated value of n^{th} water quality parameter at a given sample location;

V_{id} = Ideal value for n^{th} parameter in pure water;

S_n = Standard permissible value of n^{th} water quality parameter.

The unit weight (W_i) is calculated using the expression:

$W_i = k / S_n$ ……(3)

where,

S_n = Standard permissible value of n^{th} water quality parameter

k = Constant of proportionality

$$k = \frac{1}{\frac{1}{\sum_{i=1}^{n} Sn}} \text{……(4)}$$

In this study, we have calculated the WQI of the study area as a whole by using the raster calculator tool in ArcGIS 10.4. Initially, Horton's method of weighted arithmetic water quality index was selected for calculation. The constant of proportionality and unit weights of the selected parameters were then calculated.

Thereafter, the main equation along with these constant values was inputted into the raster calculator tool in ArcGIS for finding out the WQI value. The standard values of water quality parameters and their corresponding ideal values and unit weights are given in Table 2. The classification of water quality based on Weighted arithmetic WQI method is given in table 3.

Table - 2: Standard values of parameters and their corresponding ideal values and unit weights

Parameters	S_n	V_{id}	K	W_i
pH	8.5	7	0.3153488	0.0370999
Nitrate (ppm)	45	0	0.3153488	0.0070078
Nitrite (ppm)	45	0	0.3153488	0.0070078
Ammonia (ppm)	0.5	0	0.3153488	0.6306976
Total Hardness (ppm)	200	0	0.3153488	0.0015767
Fluoride (ppm)	1	0	0.3153488	0.3153488
Chloride (ppm)	250	0	0.3153488	0.0012614

Table - 3: Classification of water quality based on weighted arithmetic WQI method

WQI	Status
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very Poor
Above 100	Unsuitable for drinking

5. ArcGIS

ArcGIS is a geographic information system (GIS) for working with maps and geographic information maintained by the Environmental Systems Research Institute (Esri). ArcGIS software version 10.4 was employed in the current project. The obtained water quality data were, consequently, in non – spatial database form. Therefore, they were stored in excel format and linked with the spatial data by join option in ArcMap.

We could not complete the collection and testing procedures of the other wards before the lockdown conditions that took place due to outbreak of COVID 19 pandemic. Since the sampling points selected were spread evenly across the survey area, they were enough for completing the project without much difficulty. 38 samples from the above-mentioned locations were taken for analysis. The Map of Study Area was generated by Google earth software and ArcGIS 10.4. Initially, a scanned 2D map of the survey area was collected. The digitized and labeled map of survey area was generated using Georeferencing tool and shapefile created in ArcGIS.

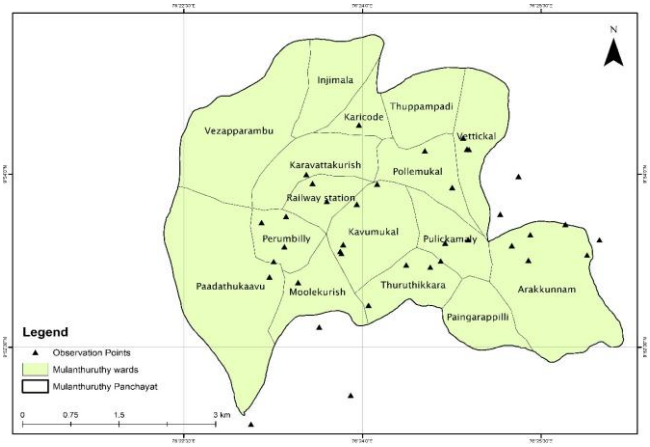

Fig - 2: Digitized and labelled map of Mulanthuruthy panchayat with observation points

The digitized and labeled map of survey area is shown in figure 2. Kriging, Inverse Distance Weighted method (IDW), and Radial Basis Functions (RBF) are three well-known spatial interpolation techniques commonly used for characterizing the spatial variability and interpolation

between sampled points and generating prediction maps. In this study, IDW was used for generation of thematic maps based on the 7 selected parameters. Inverse distance weighted interpolation tool is used when the set of points is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear-weighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value

6. RESULT AND DISCUSSIONS

6.1 pH

The Acceptable Range of pH as per BIS is 6.5 - 8.5. If the pH of water sample is beyond this range, it affects the mucous membrane. If water whose pH levels are less than 7 is consumed in excess quantity, it may increase the acidity of the mouth which can cause the demineralization of tooth enamel which in turn can lead to tooth decay. Any liquid with a pH of 10 or more can cause burns depending on the tissue it touches and how long the tissue is exposed. pH values greater than 11 can cause skin and eye irritations, as does a pH below 4. A pH value below 2.5 will cause irreversible damage to skin and organ linings.

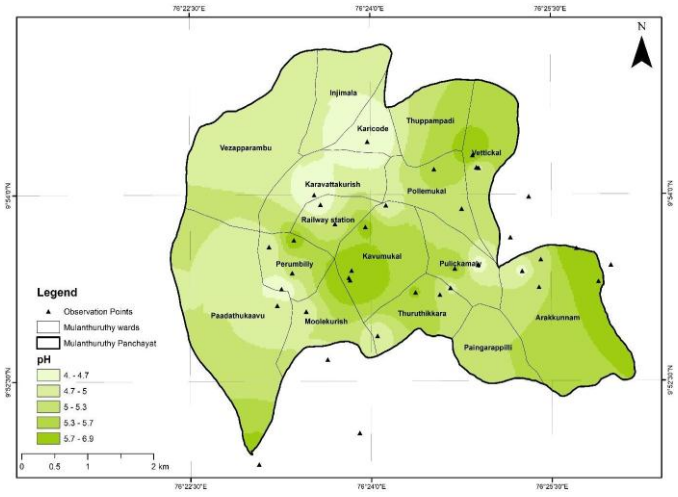

Fig - 3: Spatial variation map of pH

From figure 3, it was observed that the groundwater in wards Karikode, Karavattekuriz, Perumpilly, Pulikamaly and Arakkunnam were of more acidic in nature having a pH range of 4 – 4.7. And all the other wards of the survey area have a pH value ranging from 4.7 – 6.9 of acidic to neutral nature. Hence it can be concluded that almost all the wards of the survey area have groundwater of acidic nature and are not under the acceptable limits of BIS.

6.2 Nitrate

The Acceptable Value of Nitrate as per BIS is 45ppm. Beyond this limit, methemoglobinemia occurs. Excess levels of nitrates in water can create conditions that make it difficult for aquatic insects or fish to survive.

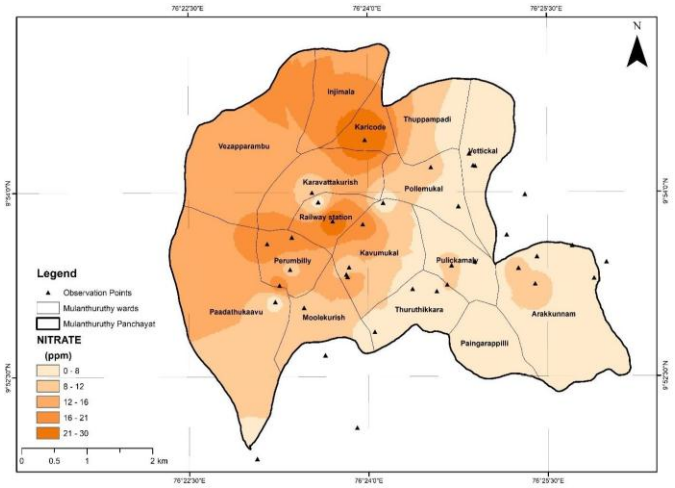

Fig - 4: Spatial variation map of Nitrate

From figure 4, it was observed that the groundwater in wards Karikode and Railway station were having higher Nitrate value ranging from 21- 30 ppm of all the survey area. And all the other wards of the survey area having nitrate value varying from 0 – 21 ppm. Hence it can be concluded that the nitrate values of the survey area are under the acceptable limits as per BIS.

6.3 Nitrite

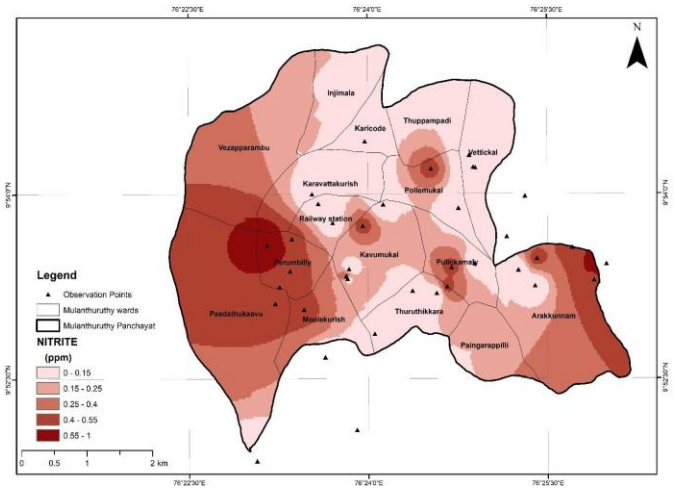

Fig - 5: Spatial variation map of Nitrite

The Acceptable Value of Nitrite as per BIS is 45ppm. Beyond this limit, methemoglobinemia occurs. Nitrite is a significant factor in various diseases in aquaculture.

From figure 5, it was observed that the groundwater in wards Padathukavu , Perumpilly, Kavummugal , Pollemugal, Pulikamaly, Arakkunnam and Vezhaparambu were having higher values of Nitrite ranging from 0.55 - 1ppm. And all the other wards of the survey area having nitrite value varying from 0 - 0.55 ppm. Hence it can be concluded that the survey area has Nitrite value under the acceptable limits as per BIS.

6.4 Ammonia

The Acceptable Value of Ammonia as per BIS is 0.5 ppm. Animals sub chronically exposed to different ammonium salts (75–360 mg/kg of body weight as the ammonium ion) in drinking-water exhibited physiological adaptation to induced acidosis, slight organ effects, or increased blood pressure. High levels of ammonia in water can have a significant environmental impact. Higher natural levels of up to three milligrams per litre, though, are often found in forests or areas with substantial iron deposits. Surface waters may naturally contain up to 12 mg/l. Higher levels than these can disrupt delicate aquatic ecosystems. Ammonia in drinking water can sometimes create an unpleasant taste and smell, which is caused by the formation of chloramines.

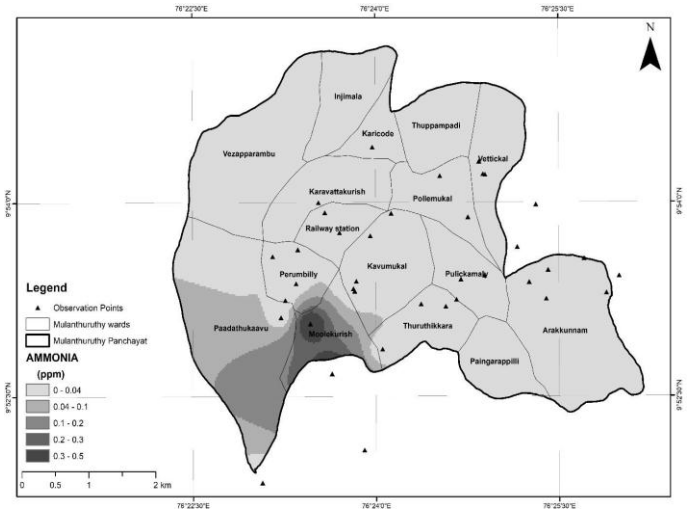

Fig - 6: Spatial variation map of Ammonia

From figure 6, it was observed that the groundwater from ward Moolekuriz were having highest Ammonia value ranging from 0.3 – 0.5 ppm. And all the other wards of the survey area having very low Ammonia value varying from 0 – 0.04ppm. Hence it can be concluded that the groundwater from the survey area has Ammonia value under acceptable limits of BIS.

6.5 Total Hardness

The Acceptable Value of Total Hardness as per BIS is 200ppm.Beyond this limit can cause scale formation in boilers, pipes and cooking utensils, adverse effect on domestic use, encrustation in water supply structure, and also Cathartic and diuretic effect. Exposure to hard water has been suggested to be a risk factor that could exacerbate eczema.

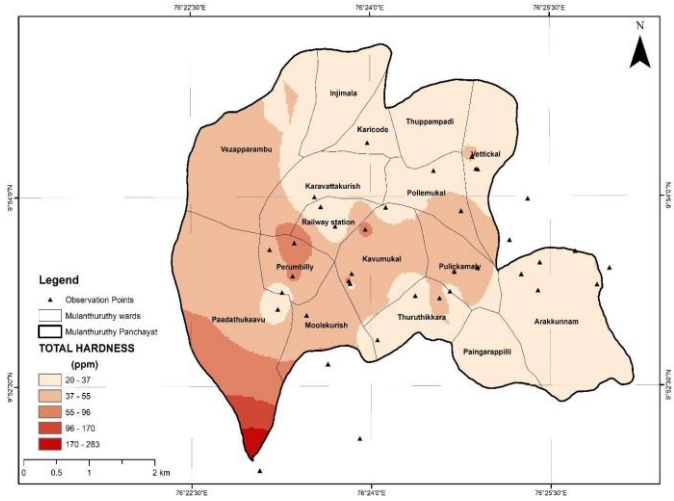

Fig - 7: Spatial variation map of Total Hardness

From figure 7, it was observed that the groundwater from Padathukavu were having the highest Hardness value varying from 170 - 283 ppm. And all the other wards of the survey area having Total Hardness value varying from 20 – 170 ppm. Hence it can be concluded that the groundwater in the survey area is having Total hardness value under acceptable limits as per BIS except some parts of Padathukavu.

6.6 Fluoride

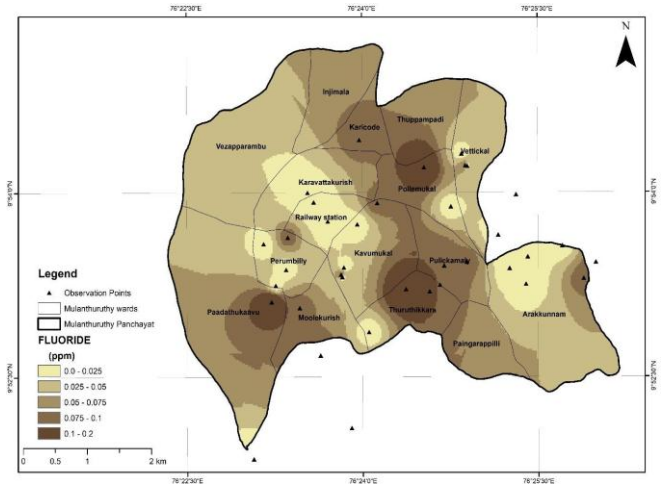

Fig - 8: Spatial variation map of Fluoride

The Acceptable Value of Fluoride as per BIS is 1ppm. Excess concentration of fluoride may lead to diseases like dental fluorosis and skeletal fluorosis. Very low doses of fluoride (< 0.6 ppm) in water promote dental caries (tooth decay).

From figure 8, it was observed that the groundwater in Padathukavu, Pollemugal, Thuruthikara, Pulikamaly and Kavummugal were having the highest Fluoride value varying from 0.1 – 0.2 ppm of the survey area. Almost all the other wards of the survey area were having Total Hardness value varying from 0 – 0.1 ppm. Hence it can be concluded that the groundwater in the survey area is having Fluoride value under acceptable limits as per BIS and have the smallest values below 0.2 ppm.

6.7 Chloride

The Acceptable Value of Chloride as per BIS is 250ppm.Although chlorides are harmless at low levels, well water high in sodium chloride can damage plants if used for gardening or irrigation, and give drinking water an unpleasant taste. Chloride is toxic to aquatic life and impacts vegetation and wildlife. There is no natural process by which chlorides are broken down, metabolized, taken up, or removed from the environment. Wildlife is also prone to high sodium levels by ingesting salt or drinking water runoff from snow and ice melt.

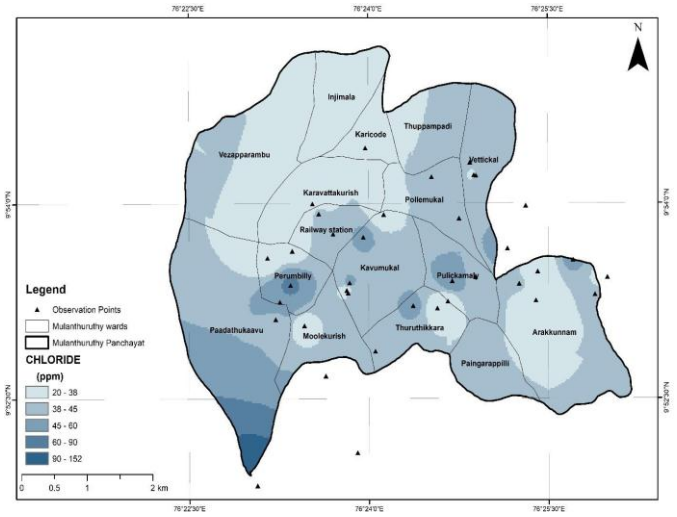

Fig - 9: Spatial variation map of Chloride

From figure 9, it was observed that the groundwater in Padathukavu were having the highest Chloride value varying from 90 - 152 ppm of the survey area. Almost all the other wards of the survey area were having Chloride value varying from 20 - 90 ppm. Hence it can be concluded that the groundwater in the survey area is having Chloride value under the acceptable limits as per BIS.

6.8 WQI

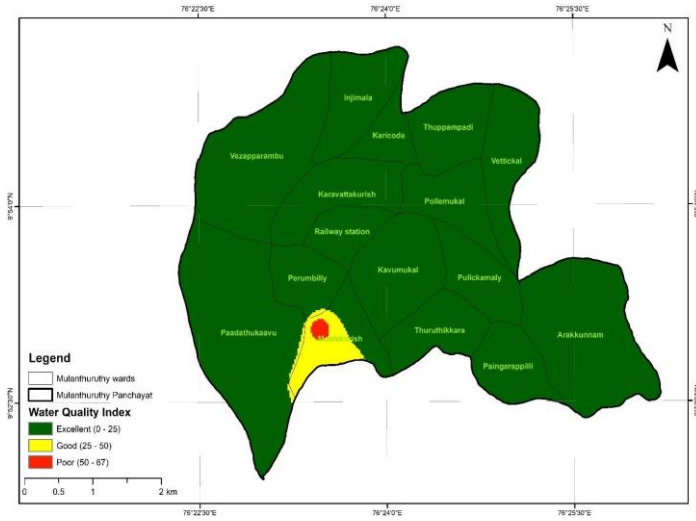

Fig - 10: Spatial variation map of WQI

WQI indicates the quality of water with reference to an index number which reflects the overall status of GWQ for drinking purposes. From figure 10, it was observed that very small area (approximately 0.063km^2) of Moolekuriz ward in the survey area is having poor water quality with WQI varying from 50-67 and its remaining area (i.e. Approximately 0.58 km^2) is having good water quality with WQI varying from 25 –50. All the other wards were having excellent water quality with WQI value varying from 0 – 25. The overall view of WQI of the present survey area exhibits lower WQI. ie. Excellent Groundwater quality. The WQI statistics is shown in table 4.

Table - 4: WQI Statistics

Id	WQI	Area in Sqkm
1	Excellent	23.15181421
2	Good	0.582627356
3	Poor	0.063274309

7. CONCLUSIONS

The present study was carried out to evaluate and characterize the quality of groundwater for domestic and drinking purpose in the Mulanthuruthy panchayat. GIS based calculation of water quality index and mapping was done to generate the overall water quality map of the survey area. The developed groundwater quality index map in this study is straightforward to comprehend and communicate information regarding water quality to the beneficiaries and local management which will make possible the proper consumption and management of groundwater.

Water Quality Analysis shows that:

- The spatial distribution analysis of groundwater quality in the survey area indicated that almost all the parameters were within the acceptable limits.
- As per BIS, the selected parameters such as chloride, nitrite, nitrate, fluoride and ammonia were within the acceptable limits for drinking purpose.
- Total hardness value of all the samples except for Ward Padathukavu were under the acceptable limits of BIS.
- The standard value of pH depicted by BIS, ranges from 6.5-8.5 and it was observed that majority of the survey area has groundwater with pH value less than 6.5. It is a potential problem which should be taken into consideration during the future works and the water samples from the same areas should be checked again for pH and proper measures have to be adopted to control its range.
- The WQI of 23.15 sqkm area of the Mulanthuruthy panchayat was found to be excellent.

The health concerns associated with drinking polluted water make water quality a primary concern. This study explores how maps can support water quality management as part of a common project between water management organizations. It is helpful in knowing the current state of water quality and its evolution is necessary in determining policies for the improvement of quality, uses, and supervision of the testing process.

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REFERENCES

[1] Anuparna L, Eldho Alias, Megha Clara Jose, Merin Thomas, Prof. Devika Venu, Assessment of Water Quality Index along high potential zones of Muttar river, Kalamassery, International Research Journal of Engineering and Technology, Vol 6, Issue 4, April 2019, pp.4584 - 4586.

[2] Balathandayutham K, Mayiswami C, Tamilmani D, Assessment of Groundwater Quality using GIS: A Case Study of Walayar Watershed, Parambikulam-Aliyar-Palar Basin, Tamilnadu, India, Current World Environment, Vol 10, Issue 2,2015, pp.602-609.

[3] Douglas Kwasi Boah, Stephen Boakye Twum, Kenneth B. Pelig-Ba, Mathematical Computation of Water Quality Index of Vea Dam in Upper East Region of Ghana, Environmental Sciences, Vol 3, No. 1,2015, pp.11 – 16.

[4] Fehmida Fatima S, Bindu A G, Evaluation of Groundwater Quality at Eloor, Ernakulam District, Kerala Using GIS, International Journal of Engineering and Advanced Technology, Vol 8, Issue 4C, December 2018, pp.20-24.

[5] Krishnaraj S, Sanjiv Kumar, Elango K. P, Spatial Analysis of Groundwater Quality Using Geographic Information System – A Case Study, Journal of Environmental Science, Toxicology and Food Technology, Vol 9, Issue 2, February 2015, pp.01-06.

[6] Manjula P, Unnikrishnan Warrier, Evaluation of water quality of Thuthapuzha Sub-basin of Bharathapuzha, Kerala, India, Applied Water Science 9:70, April 2019, pp.1-13.

[7] Nafyad Serre Kawoa, Shankar Karuppannan, Groundwater quality assessment using water quality index and GIS technique in Modjo river Basin, Journal of African Earth Sciences 147, June 2018, pp.300–311.

[8] Prabhu K, Sivakumar R, Groundwater Quality Mapping of Nandiaru Sub- basin, Tamilnadu, India By Using Geo Spatial Technology, Rasayan J. Chem, Vol 11, No. 2, June 2018, pp.735 – 742.

[9] Soumya Singha, Sudhakar Singha, Dr. Devatha C. P, Prof. Verma M, Assessing Ground Water Quality using GIS, International Journal of Engineering Research & Technology, Vol 4, Issue 11, November 2015, pp.689-694.

[10] Verma D. K, Gouri Sankar Bhunia, Pravat Kumar Shit, Kumar S, Jajati Mandal, Rajeev Padbhushan, spatial variability of groundwater of Sabour block, Bhagalpur district (Bihar, India), Applied Water Science 7, January 2016, pp.1997–2008.

[11] Guidelines for Drinking-water Quality third edition incorporating the first and second Addenda Volume 1 Recommendations, World Health Organization, 2008.

[12] IS 10500: 2012, Indian Standard Drinking Water - Specification (Second Revision), Bureau of Indian Standards, May 2012.