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ANALYSIS OF GROUNDWATER QUALITY IN THE VICINITIES OF AMAYIZHANJAN THODU USING GIS

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Abstract - Groundwater is one of our most important natural resources. To establish a sustainable and optimal use of this natural resource its quality has to be assessed. The present study consists of an analysis of groundwater quality within the vicinities of Amayizhanjan thodu, one of the most polluted rivers in the Trivandrum city. The samples collected from the wells located along the banks of the river were tested for various physio-chemical and biological parameters. Water quality index for parameters such as pH, total dissolved solids, hardness, dissolved oxygen, biochemical oxygen demand, chlorides and total coliform has been determined. Spatial distribution maps of all water quality parameters including Water Quality Index map have been developed using Geographical Information System (GIS). Analysis reveals the present status of groundwater quality of study area and recommends that the groundwater of

the region needs field-specific treatment before putting it to use. Additionally, the authorities need to put a strict regulation of waste disposal along Amayizhanjan thodu.

Keywords: ***Groundwater quality, GIS, Spatial distribution maps, Water Quality Index.***

I. INTRODUCTION

Water is essential for living and is a precious gift of nature. Ground-water is used as the major source of drinking water in urban as well as rural parts of India. Increase in urbanization, industrialization, agriculture activity and various human activities has increased the pollution of surface water and groundwater. Since drinking water should be safe and potable, various treatment methods are adopted to raise the quality of drinking water. Water should be free from the various contaminations like organic as well as inorganic pollutants, heavy metals, pesticides etc. as well as all its physical, chemical and biological parameters should be within a permissible limit (S. Krishnaraj et al, 2015).

In this study, the groundwater quality along the banks of Amayizhanjan thodu, a river located in Trivandrum city, was analysed using Geographic Information Systems (GIS) tools. The river flows through areas of industrial importance within the city and it is highly polluted. This study aimed to check whether the pollution of the water body affects the quality of the groundwater in the nearby areas and the people residing there are vulnerable to the health problems caused by the condition of groundwater.

The common methods of assessing water quality are relying on the comparison of parameter values determined from laboratory tests with the existing local data. The usual method of analysis does not give a global vision of spatial and temporal trends in the overall water quality (P.K Singh, 2015). In this case, the water quality determination is based on an index, which assigns certain weightage factors for each tested parameter according to their significance. The water quality index is an important tool to determine and express the drinking water quality (S. Soumya et al, 2015). WQI is defined as an index reflecting the composite influence of different water quality parameters. The WQI summarizes a large amount of water quality data into simple terms, i.e., excellent, good, bad etc. which are easily understandable and usable by the public.

GIS is a tool for collecting, storing, transforming the spatial information and arriving at a decision from the real world for different purposes (N.M Okoye et al,2016). It offers an advanced method to study water quality in spatial scale. The present study uses Arc Map of Arc GIS 10.3 ®, which is an efficient GIS software. The

study aims to demonstrate the present condition of groundwater in the vicinities of Amayizhanjan thodu by developing an integrated groundwater quality map using GIS.

II. STUDY AREA AND DATA

The study area considered is banks of Amayizhanjan thodu (Fig. 1), a river flowing through the heart of Trivandrum City, Kerala. It originates near C P Nagar (8°32'6.02" N 76°57'8.97" E) and Keraladityapuram (8°33'56" N 76°55'59.22" E) which then converges at Pattoor and finally ends at Aakulam Lake (8°31'11" N 76°54'25" E), covering a distance of 19.2 km. Groundwater samples were collected along the river stretch which are more prone to contamination.

Fig. 1. Location of Amayizhanjan Thodu

The river network has been digitized from toposheets 58/D14 and 58/D15 of scale 1: 50000, geo-referenced and rectified using Arc Map of Arc GIS 10.3 ®. A buffer

distance of 250 m from the river network is taken as the study area and groundwater samples were collected from wells in the area. To ensure enough spatial representative of water sampling, the river path has been divided into several sections. Samples were collected from six different locations such that there is one point from each section where the river is highly polluted. Six samples were collected as two sets. The first set of three samples were collected on 29th January 2020 and the second set on 5th February 2020. The manually collected samples were carried in sterilized bottles of 5L capacity and sample ID had been marked in every bottle. Each sampling site was positioned by recording the geographic coordinates of the location using Global Positioning System. Additional details like images of the well, date and time of sampling, whether the water is used for drinking purpose etc. were collected and recorded with the help of a mobile application "Mwater portal" All the samples were collected during the pre-monsoon period. Chemical analysis was carried out immediately after the samples were collected or after keeping them at 4^0 C temperature.

III. METHODOLOGY

A. Groundwater quality parameters

The collected water samples were subjected to various tests and analysed for different water quality parameters such as pH, total dissolved solids (TDS), hardness, dissolved oxygen (DO), biochemical oxygen demand (BOD), chlorides and total coliform. The experiments were carried out based on standard procedures (IS 3025 and IS 1622) and results were compared with Indian Standard Specifications for drinking water (IS 10500 – 2012).

pH is a measure of how acidic/basic water is. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. As per IS specifications for drinking, the acceptable limit of pH is 6.5 – 8.5. pH was determined using pH paper with standard colour code references.

TDS is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro- granular suspended form. The sample is filtered and the filtrate evaporates in a weighed dish on a steam bath, the residue left after evaporation is dried to constant weight in an oven at either 103-1050°C. The increase in weight over that of the empty dish represents the total dissolved solids and includes all materials, liquid or solid, in solution or otherwise which pass through the filter and not volatized during the drying process.

Hardness is the amount of dissolved calcium and magnesium in the water. Hard water is high in dissolved minerals, largely calcium and magnesium. There are two types of hardness; temporary and permanent hardness. Temporary hardness can be

reduced by boiling the water and permanent hardness can be removed by treatment using ion exchange or reverse osmosis. Total hardness is determined by titration method. The sample was titrated against standard EDTA solution with ammonia buffer and Eriochrome Black-T indicator till the wine red colour turns blue.

DO is used as an indicator of the health of a water body, where higher dissolved oxygen concentrations are correlated with high productivity and little pollution. The Winkler Method was used to measure DO content of the samples. The samples prepared were titrated against sodium thiosulphate till pale yellow colour appears and it was continued after adding starch solution as indicator till the blue colour disappears.

BOD is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at a certain temperature over a specific time period. The methodology of BOD test is to compute a difference between initial and final DO of the samples incubated for 5 days at 20^0C.

Chloride is one of the most common anions found in tap water. Chloride is determined in a natural or slightly alkaline solution by titration with standard silver nitrate using potassium chromate as an indicator. Silver chloride is quantitatively precipitated before red silver chromate.

Total coliform in a water sample is the total number of both faecal and non-faecal bacteria. Presence of coliform is a clear indication of water pollution however the bacteria itself is not considered harmful, but it indicates the presence of harmful disease-causing organisms. Detection of coliform bacteria has been done using multiple tube fermentation test. It requires a culture media and dilution water.

B. Water Quality Index (WQI)

WQI is an index representing the water quality. It is determined by equation (1) and (2) (C. D Mora-Orozco et al, 2017).

$$Q_i = V_i \times W_i \quad (1)$$

$$WQI = \sum Q_i \quad (2)$$

where,

Qi is the Quality rating of i^{th} parameter for total of n water quality parameters

V_i is the Actual value of water quality parameter obtained from laboratory test

W_i is the Weightage factor of each parameter.

Weightage factor refers to the significance of each of the parameters in the overall quality of the water. It depends on the permissible limits of each of these parameters

in drinking water. So in this study, the weights are given in such a way that factors having high permissible limits are given less weightage and those with low permissible limits are given high weightage. The weightage factors of different water quality parameters are shown in Table 1.

Table. 1. Water quality parameters and weightage factors

Parameter	Weightage factor
pH	0.15
TDS	0.1
Hardness	0.15
Dissolved Oxygen	0.2
BOD	0.2
Chlorides	0.15
Total coliform	0.05

Based on the WQI values, the groundwater quality is rated as excellent, good, poor, very poor and unsuitable for drinking and is shown in table 2.

Table . 2. Water quality index levels

WQI value	Rating of water quality
0-30	Excellent
31-60	Good
61-90	Poor
91-120	Very poor
Above 120	Unsuitable for drinking purpose

C. Generation of maps

A database was created using groundwater quality parameters and were given to GIS. The spatial interpolation was done based on each parameter taken and thematic maps for each were created. Inverse Distance Weighted (IDW) was the interpolation

method used for obtaining the spatial distribution of parameters. In this method, the unknown values are predicted using the known values of the measured locations, surrounding them. The method works based on the assumption that the values of unknown locations are more influenced by its nearest locations of known value. So, the predicted values will have some relationships with their closest measured points. The thematic layers of all the parameters were integrated with GIS after giving proper weightage WQI map is developed.

IV. RESULTS

The variations of water quality parameters such as pH, TDS, DO, BOD, chloride, hardness and total coliform along with WQI of ground water taken from different sampling locations are presented in Table 3. The spatial distribution of tested parameters for a buffer distance of 250 m interpolated using IDW method and the WQI map obtained are shown in Fig 2.

Table 3. Values of water quality parameters and WQI

Parameter	Sample 1 (Marappalam)	Sample 2 (Pattoor)	Sample 3 (Kannamoola)	Sample 4 (Anayara)	Sample 5 (Oruvathilkkotta)	Sample 6 (Plammoodu)
pH	7	8	7.5	7.5	7.5	7.0
TDS (mg/l)	0.4	0.1	0.1	2.1	2.6	2.8
DO (mg/l)	6.8	5.7	6.3	5.8	4.8	5.7
BOD (mg/l)	2	21	1	18	37	23
Chloride (mg/l)	34.98	39.98	69.97	24.99	37.48	49.98
Hardness (mg/l)	135	185	85	105	155	20
Coliform (/100 ml)	14	460	0	210	2400	2400
WQI	26.33	61.02	23.33	33.77	156.7	135.287

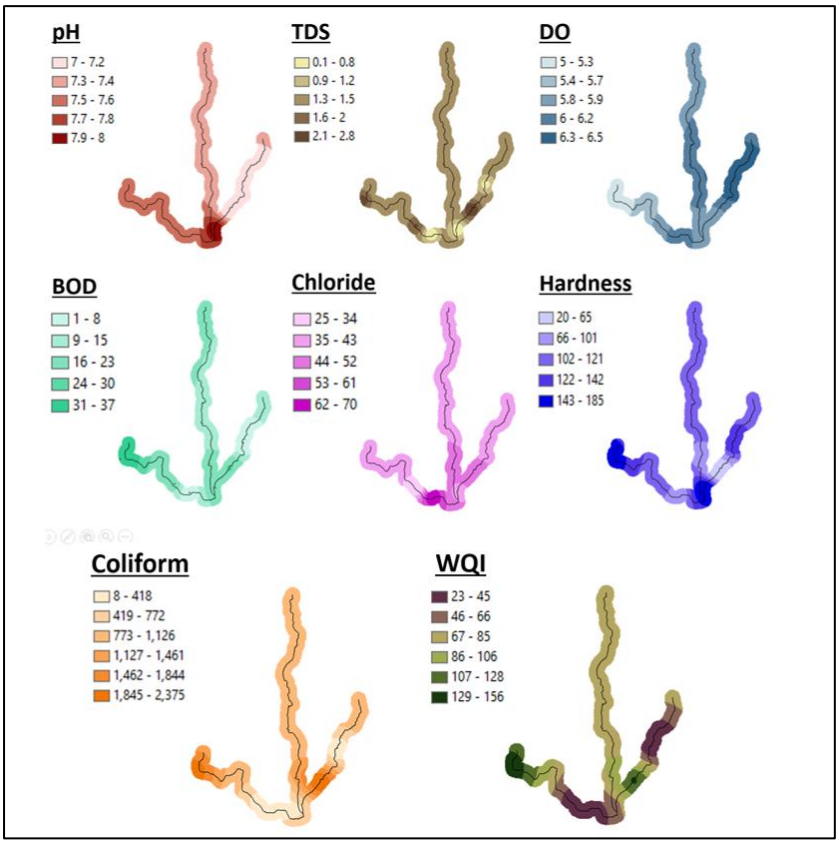

Fig. 2. Thematic maps of tested parameters and WQI map

The obtained water quality parameters were compared with drinking water guidelines of World Health Organization (WHO) and Bureau of Indian Standards (BIS) and are discussed below.

pH

pH values of analysed samples range from 7.0 – 8.0. The acceptable limit as per Indian Standard is 6.5-8.5. The values of water samples were within the desirable limit.

TDS

Either very low or very high values of TDS is not suitable for drinking since it may have an unpleasant taste. TDS is unstable if it exceeds the maximum allowable limit of 500 mg/l. Moderate values of TDS are recommended. Here it ranges from 0.1 – 2.8 mg/l which is very low and thus undesirable.

Chloride

Chloride is harmful if it exceeds the permissible limit of 250 mg/l. The chloride ion concentration in the water samples varies between 34 – 70 mg/l, which is within the permissible limit.

Hardness

Water containing $CaCO_3$ concentrations below 60 mg/l is considered as soft; 60 – 120 mg/l as moderately hard; 120 – 180 mg/l as hard and more than 180 mg/l as very hard. The hardness values of the samples range from 20 – 185 mg/l which is within the permissible limit of 200 mg/l.

Dissolved Oxygen

As an indication of slight organic contamination and microbial activities, the DO values ranged between 4.8 – 6.8. Even though a specific limit is not mentioned in the standards for Dissolved Oxygen, a minimum of 6 mg/l is widely accepted. Majority of samples failed to attain the limit.

BOD

The low DO values were reflected in high BOD loads. Just like DO, BOD does not have a specified limit but a higher value above 3-5 mg/l indicates an increased rate of organic contamination. In the current study, BOD values were observed between 1 -37 mg/l. Few samples exhibited very higher values which indicate severe contamination.

Total Coliform

The permissible limit of coliform bacteria in drinking water is 0/100 ml. The value of total coliform ranged between 0 – 2400, where it was beyond acceptable limits in the majority of samples. Sample 5 and 6 were found to be completely unsuitable for drinking.

Water Quality Index

Out of six samples collected, two samples from Marappalam and Kannamoola, where there is comparatively less pollution, were found to be of excellent quality. The quality of samples from Pattoor and Anayara was satisfactory, but those which collected from Oruvathilkkotta and Plammoodu exhibited very poor quality such that they are completely unsuitable for drinking. These two sampling sites were located in the urban parts of the city where there is a higher rate of pollution. Plammoodu is one of the major areas of commercial importance within the city and pollution at Oruvathilkkotta may have been caused by the waste disposal from one of the biggest hospitals in the area located very near to the sampling site.

V. CONCLUSION

The study examined the present status of groundwater quality of the vicinities of Amayizhanjan thodu. The results indicate that there is severe pollution in groundwater of the study area which is caused by the unauthorized discharge of untreated wastewater from houses, industries, hospitals etc. to Amayizhanjan thodu. Bacterial contamination is very high in the nearby groundwater such and is a serious threat for the people inhabiting the area. As a large number of people are dependent on groundwater, poor WQI and bacterial contamination could be considered as a definite health hazard to regular users. Thus, it is recommended that the groundwater of the region needs field-specific treatment before putting it to use, since consuming this water without proper treatment may affect the health of the inhabitants. Additionally, the authorities need to put a strict regulation of waste disposal along Amayizhanjan thodu. The study offers the requisite information for the authority to pursue a sustainable approach to groundwater management and contamination prevention.

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