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A study of groundwater quality and mapping using GIS techniques in Kodungaiyur, Chennai

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ABSTRACT

Groundwater quality in Kodungaiyur , Chennai district has special significance and needs great attention of all concerned since it is the major alternate source of domestic, industrial and drinking water supply. The present study monitors the ground water quality maps using GIS techniques for a part of Kodungaiyur. Physico-chemical analysis data of the groundwater samples collected at predetermined locations forms the attribute database for the study, based on which, spatial distribution maps of major water quality parameters are prepared using curve fitting method in Arc View GIS software. .GIS has been used extensively to assess the water quality all over the world, advancement of Geographical Information System (GIS) and Spatial Analysis help to integrate the laboratory analysis data with the geographic data and to model the spatial distributions of water quality parameters, most robustly and accurately. The objective of the study is to evaluate the water quality map in Kodungaiyur. For this purpose, Inverse Distance Weighed (IDW) spatial interpolation technique has been used to estimate the spatial distribution of the water quality parameters and WHO standards. The results are compared with WHO permissible limits from the point of view of the suitability of groundwater for human consumption.

Keywords— *Groundwater, Quality, GIS, Image interpretation, Thematic, Spatial distribution, Attribute database, Water quality Index*

1. INTRODUCTION

Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking and industrial effective tool to communicate information on the overall quality status of water to the concerned user community and policy maker. Thus, it becomes an important parameter for the assessment and management of ground water. In the upcoming days in future, there are possibilities for us the humans to meet up with water scarcity widely because of the increasing water usage and decreasing of pure water in the streams. It may lead to very severe disaster unless and until the awareness of purifying and using of water that is unwantedly stored in several parts of our own country is not impacted upon people living now. Likewise, this research is all about testing the ground water parameters such as hardness, chloride, calcium, Total dissolved solids, pH levels and mapping those values using GIS software for accurate plotting which are the keys to be known for the purpose of purifying it in future. The project is carried out in a place called Kodungaiyur, in the northern part of Chennai, Tamil Nadu where a large amount of water is being polluted by the nearby dump yard resulting in the formation of leachate.

2. OBJECTIVES

- To interpreting various ground water quality parameter using GIS.
- To develop an integrated groundwater quality map of kodugaiyur using GIS.
- To analyse the various parameter of various ground water quality using GIS.

3. STUDY AREA

Kodungaiyur is a residential neighbourhood in the northernmost part of the city of Chennai, Tamil Nadu state, India. It comes under Perambur Taluk of Chennai City District (Figure 1). It is located at a vast area bordering Manali to the north, Korukkupet to the east, Madhavaram Milk Colony and Madhavaram to the west, Perambur to the southwest and MKB Nagar (Vysarpadi)to the south. National Highway 5 (NH 5) touches this area in the southwest at Moolakadai. Earlier, the ward numbers were 01 (Kodungaiyur West) and 02 (Kodungaiyur East).

In the Expanded Chennai Corporation (200 wards), after delimitation of zones and wards, Kodungaiyur will fall under ward numbers 34, 35, 36 and 37 (all four wards will come under Zone No: IV as per the newly expanded corporation limits).

Fig.1: Study area

The south-western part (older part) of the locality around Kamarajar Salai is called "Periya Kodungaiyur", whereas the northwestern part (relatively recently developed part) around Manali Salai is called "Chinna Kodungaiyur." Thiruvalluvar street making the unofficial divider between these two areas. Since Kodungaiyur region covers a large area, it is separated and called as Kodungaiyur West (West of Tondiarpet High Road) and Kodungaiyur East(East of Tondiarpet High Road) Places like Kamarajar Salai, The road, SIDCO Main Road, MR Nagar, Meenambal Salai houses many business mentities (supermarkets, restaurants, banks/ATMs, fuel stations, telephone exchange etc.) whereas Kodungaiyur West (Parvathi Nagar, Seetharam Nagar, Narayanaswamy garden, Soundarya Nagar etc.) is a residential neighbourhood .P6 Kodungaiyur Police Station is on SIDCO main Road.

4. THE SCOPE OF THE STUDY

Nowadays water scarcity increases rapidly due to the decrease of ground water. The ground water is also polluted due to various artificial man-made activities. Due to this, the quality of the water is reduced. This will produce various adverse impacts on human beings, animals and plants. Therefore, it is necessary to monitor water quality.

5. MATERIALS AND METHODS

5.1 Satellite Data

The governments and business around the world operate the imaging satellites that collect the images of the Earth and other planets collectively known as satellite images. For the study, Landsat satellite images of kodungaiyur, Chennai, India were acquired from USGS, Landsat 1 images were used. (Figure 2).

In the Landsat program, the first satellite that was launched on July 23 1972. The Landsat program is operated by the USGS, and data from Landsat 1 is collected and distributed by USGS. It has sun-synchronous, near-polar orbital characteristics at an altitude of 917 km and it can complete 14 orbits per day (each circle 103.4 mins)

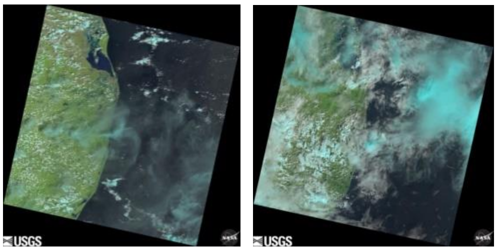

Fig. 2: Satellite data of study area

5.2 Ground water sample collection and analysis

The study is carried out using data collected from 12 observation bore wells for the year 2018 in Kodungaiyur. (Figure 3).One litre capacity of pre-cleaned poly-ethylene bottles was used for the collection of samples from different sources.

Fig. 3: Sample collection location

The samples were analysed for various physicochemical parameters. After the collection of the samples, the samples are preserved and shifted to the laboratory for analysis. The physicochemical analysis was carried out to determine Ca, TDS, TH, Cl-, and pH and compared with standard values recommended by the World Health Organization (WHO, 1993). As groundwater in

Kodungaiyur is not used for drinking purpose and, previous studies report that pollution is mainly due to sewage, the water quality testing in the present study is restricted to measurement of hardness/salinity (TDS, TH) and determination of potential contamination by sewage. The major indicators of sewage contamination, Cl- is considered for the analysis. The disturbance of soil during house building can also lead to an amount of nitrate leaching similar to the one observed when grassland is ploughed for agricultural purposes.

5.3 Attribute database

Fieldwork was conducted and groundwater samples were collected from predetermined locations based on the land use change and drainage network maps of the study area. Map showing sampling points overlaid on satellite imagery as shown. The water samples were then analysed for various physicochemical parameters adopting standard protocols. The water quality data thus obtained forms the attribute database for the present study

6. RESULTS AND DISCUSSIONS

The following mapping is done using the IDW method (Inverse Distance Weighting) for showing the variation of parameters. In interpolation with the IDW method, a weight is attributed to the point to be measured. The amount of Weight is dependent on the distance of the point to another unknown point. Since the location of sample collection points is far away for about 2 km from the dump yard location, the values change gradually. The variation in values and quality of the parameters increases and decreases according to its property and its distance from the leachate production area.

The acceptable limit of chloride is 250 mg/L and the permissible limit is 1000 mg/L. In the study area it is seen that the places near the dump yard have the chloride content at a minimal level (figure 4). As the places getting far away from dump yard the chloride level and its values are increasing. Since the dump yard has the extreme production of leachate in and near it, there is no possibility of the chloride levels to be higher. As a result places such as RV Nagar, Sastri Nagar, Erunkancheri has the greatest value of chloride since it is far away from dump yard compared to Krishnamoorthy Nagar, Cauvery nagar, thendral nagar, aishwarya nagar as ithese places are near the dump yard. The maximum alkalinity value and chloride value is highlighted below. Maximum alkalinity value is 1250 and minimum alkalinity value is 86 mg/L. The mean average value of chloride in the study area is 10.

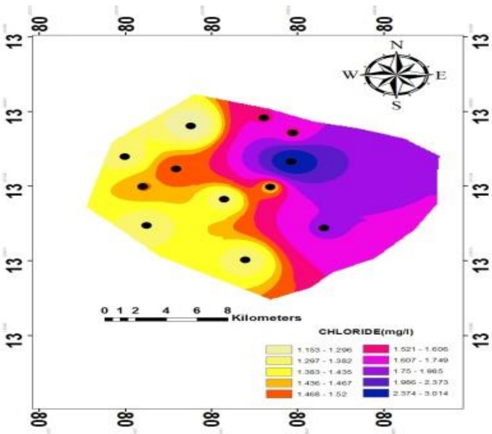

Fig. 4: Spatial distribution maps for Chlorides

The acceptable range of total dissolved solids is 500 mg/L and the permissible limit is 2000 mg/L. In the study area location since there is a dump yard near it, the TDS values tend to get higher in nearby places (figure 5). The places far away from the dump yard location have the total dissolved values at a minimum level. The places such as moolakadai, RV Nagar, Erukkancheri, Sastri Nagar which are far away from the dump yard location has lower total dissolved solids values. And the places near the dump yard such as Cauvery Nagar, tendral Nagar, Aishwarya Nagar and Krishnamoorthy Nagar has higher total dissolved solids values. Maximum TDS value obtained in the location is 3330 mg/L and the minimum TDS value is 523 mg/L. The maximum value of the location is greater than the permissible limit and the minimum value of the location is acceptable. Finally, the mean average value obtained in the location is 1070 mg/L and a standard deviation of 260.45

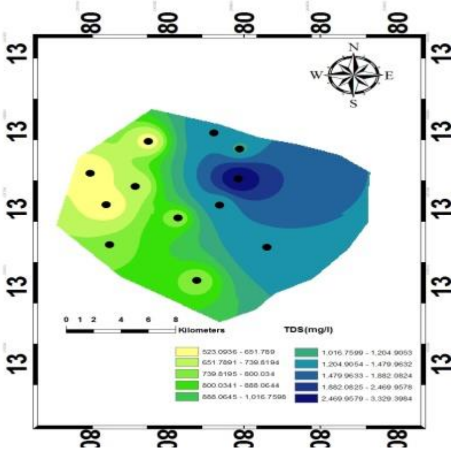

Fig. 5: Spatial distribution maps for TDS

The acceptable range of calcium is 75 mg/L and the permissible limit is 200 mg/L. Near the dump yard location, the calcium content tends to be higher and lower in places far away from the dump yard location (figure 6). The maximum and minimum values of calcium content in the study area is given below. Maximum calcium value was found to be in erukkancheri and Krishnamoorthy nagar as 104 mg/L and minimum calcium value was found to be in RV nagar as 40 mg/L. It is clearly seen that maximum values of calcium are found in nearby spots of dump yard location and minimum values of calcium are found in faraway spots of dump yard location. The mean average value is 100 and the standard deviation is 70.20

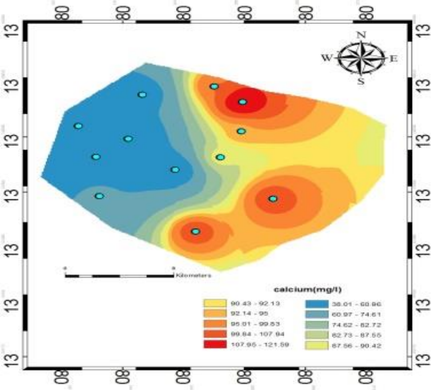

Fig. 6: Spatial distribution maps for calcium

The acceptable range of hardness is 200 mg/L and the permissible limit is 600 mg/L. According to hardness, it increases as the nitrate content increases (i.e) near the leachate production by the dump yard (figure 7). The maximum and minimum values of hardness in the study area is given below . Maximum hardness value was found to be in erukkancheri is 304 mg/L and krishnamoorthy nagar as and minimum hardness value was found to be in RV nagar as. 304 mg/L is clearly seen that maximum values of calcium are found in nearby spots of dump yard location and minimum values of calcium are found in faraway spots of dump yard location. Mean average value is 100 and the standard deviation is 70.20 and means average value 200 and a standard deviation is 242.89

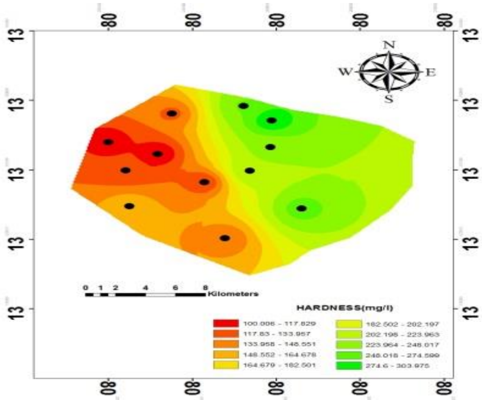

Fig. 7: Spatial distribution maps for hardness

Basically pH level should lie between 6.5 and 7.5 as per IS10500. The acceptable range is 6.5 to 8.5. According to pH, it decreases as the nitrate content increases (i.e) near the leachate production by the dump yard (figure 8). The maximum and minimum values of pH in the study area is given below.Maximum pH value was found to be in erukkancheri is 7.92 in RV Nagar and Krishnamoorthy nagar as and minimum hardness value was found to be in tendral nagar as 4.98. It is clearly seen that minimum values of pH are found in nearby spots of dump yard location and maximum values of pH are found in faraway spots of dump yard location. Mean pH value should be 6.76 and hence it is not completely affected.

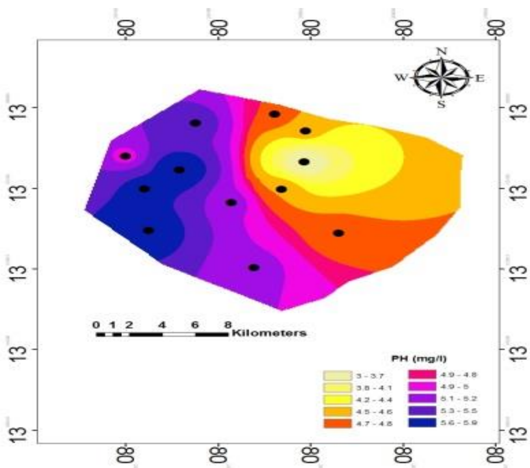

Fig. 8: Spatial distribution maps for pH

7. CORRELATION BETWEEN PARAMETERS

7.1 Correlation between calcium and hardness

Hardness is a measure of the concentration of divalent metal ion such as calcium and magnesium (Ca^{2+}, Mg^{2+}) per volume of water. Hence hardness is a sum of the concentration of the two metal ions. In most water, there is more calcium than magnesium. It definitely varies with two cases among fresh water and wastewater. Depending upon the corrosion the calcium undergoes its property will vary in proportion with the property of hardness (Figure 9).

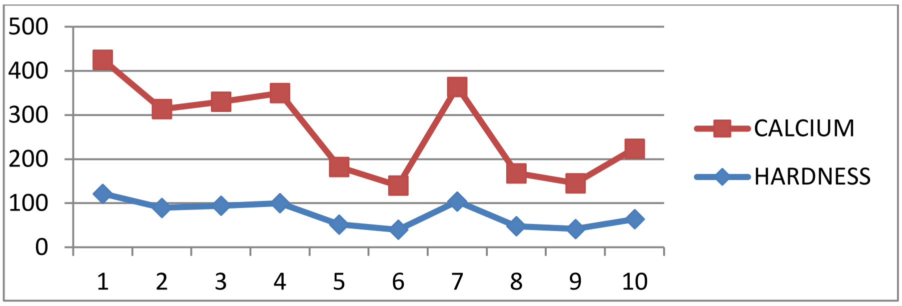

Fig. 9: Correlation between calcium and hardness

7.2 Correlation between pH and chlorides

The relationship between the diffusion of chloride and pH inspecting the other indicator can give insight into the evolution of the diffusion process. The critical chloride content is influenced by pH. Lower the pH lower will be the critical Chloride content. Chloride ion can affect the pH value. For example, Chloride originated from sodium chloride (Figure 10).

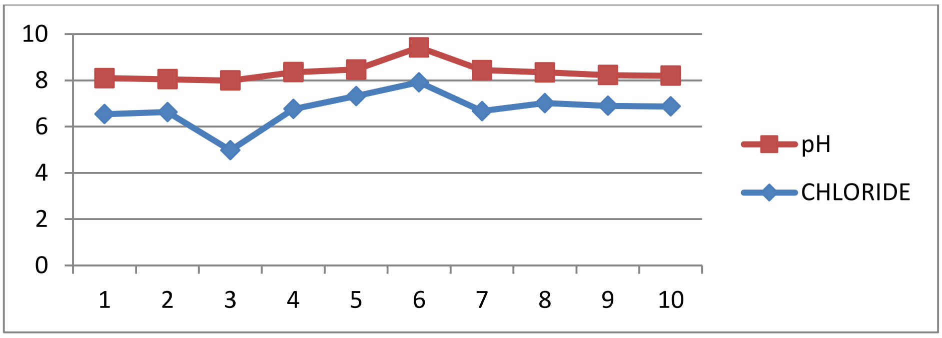

Fig. 10: Correlation between pH and chlorides

7.3 Correlation between TDS and hardness

Hardness is a part of TDS. Iron, magnesium and calcium constitute hardness. Whereas TDS is which includes all salts present in water including calcium, magnesium and iron. The higher the level of TDS, the higher the degree of hardness. Water hardness is typically reported in grains/gallon. 1 grain of hardness is equal to approximately 17.1ppm (mg/L) in TDS (Figure 11).

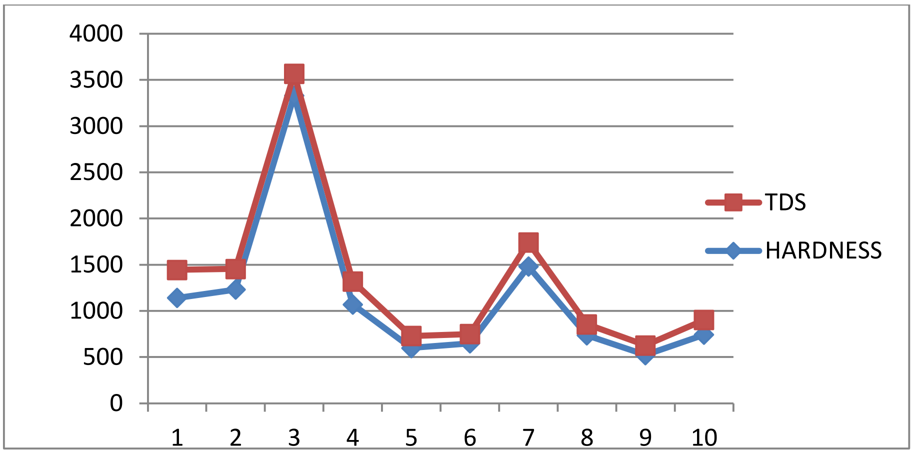

Fig. 11: Correlation between TDS and hardness

8. CONCLUSION

After the overlay of critical parameters in kodungaiyur, the final Ground- water Quality Map derived shows only a small region in the north-eastern part of the city where the groundwater is not potable. However in much of the southern and central parts and some area in the northern region of the city the water is potable. In this non-potable zone, the five parameters that are studied are above maximum permissible limits for the majority of the bore wells. The Cl- concentration for most of the samples is above 250 mg/L and the minimum value and the maximum values observed are 120 and 784 mg/L respectively. The maximum permissible level for chloride is 200 mg/L according to WHO standards. The TH is observed to be well above 500 mg/L for the majority of the sample wells in this zone. The maximum and minimum levels observed are 1480 and 649 mg/L respectively. The maximum permissible level for this parameter is 500 mg/L in WHO standards. The spatial distribution analysis of groundwater quality in the study area indicated that many of the samples collected are not satisfying the drinking water quality standards prescribed by the WHO with almost half of the city having non-potable ground water. The results obtained gave the necessity of making the public, local administrator and the government to be aware of the crisis of poor groundwater quality prevailing in the area. The government needs to make scientific and feasible planning for identifying an effective groundwater quality management system and for its implementation. For this, public awareness of the present quality crisis and their involvement and cooperation in the actions of local administrators are very important. Since in future the groundwater will have the major share of water supply schemes, plans for the protection of groundwater quality is needed. Present status of groundwater necessitates for the continuous monitoring and necessary groundwater quality improvement methodologies implementation.

Following are the recommendations for preventing further groundwater quality deterioration and strategy for protecting the same in future.

- Quantifying the domestic sewage that enters into the different water bodies located in the city, will help in planning for effective sewage treatment plant and minimizing groundwater pollution by sewage.
- Identification of groundwater recharging locations and structures. For this purpose, the Geographical Information System (GIS) with the required spatial and non-spatial data can be used very well as the tool. Designing recharging structures is to be done.
- Groundwater recharging structures are to be formed at different parts of the city. Formation of storm water drains leading to groundwater recharging structures, to increase their recharging potentials.
- Continuous monitoring of groundwater table level along with quality study will minimize the chances of further deterioration.
- Structural engineers, consultants, contractors and the general public are to be addressed about the ground- water quality not satisfying the water quality requirements as per IS 456 to 2000 (Bureau of Indian Standards, 2000) and advising them for avoiding the use of untreated groundwater.

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