

Groundwater Quality Monitoring System using GIS

A Case Study for Madurai District

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Abstract -- Water is the basic element of social and economic infrastructure and it is essential for healthy society and sustainable development. Due to rapid increase in density of population, fast urbanization, industrialization and agricultural activities, demand for water is increasing day by day. As a result surface water and ground water level is decreasing continuously. Groundwater is the favorite alternative for surface water and it is facing threats due to anthropogenic activities in our country, which leads to degradation in quality. Hence, monitoring of ground water quality has become indispensable. It is not possible to monitor the quality of ground water in every place by conducting the survey and it also take large amount of time to perform various analysis. But by using GIS, analysis can be done by integrating multiple data and maps can be generated for separate parameters in year wise. Thus the GIS based models help in understanding yearly distribution and provide a database for future use. In this paper, ground water quality analysis was carried out for Madurai district, using GIS and the required data were collected from Public Work Department, Madurai. Query based analysis is performed to display suitable wells. The strategically analyzed results are presented in a GIS based maps.

Keywords: Groundwater quality, GIS, Query analysis.

I. INTRODUCTION

A. Introduction

Water is the life line without which life on planet is impossible. Every living being including the animals and the plants require water to meet with their daily needs. However, complete requirement of the human beings are not met from the surface water only and as such they have to depend upon the underground water that may or may not be potable. It is imperative to study the geo-chemistry of ground water being used as potable water. Ground water is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a

usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally, natural discharge often occurs at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal, and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology. Groundwater is often cheaper, more convenient and less vulnerable to pollution than surface water. Therefore, it is commonly used for public water supplies. In Madurai region the groundwater could be spoiled due to waste disposal and Improper Agricultural practices. The groundwater quality in and around Madurai is potable. All the people used the groundwater for domestic purposes. The Agricultural communities utilized the groundwater for farming in their lands. But today the scenario is completely different. In many part of Madurai region, groundwater usage is obsolete. The number of monitoring wells within the corporation limit is very less. The water level is affected in these regions because of increased structures and bore wells. This in-turn will affect the water quality. Therefore water quality monitoring is necessary in Madurai district.

II. STUDY AREA & DATA USED

A. Study area

In this paper, we have chosen the study area as Madurai district which located in south India.

Geographic location of Madurai city

Longitude 77 °48' and 78°35' East

Latitude 10 °25' and 9°65' North

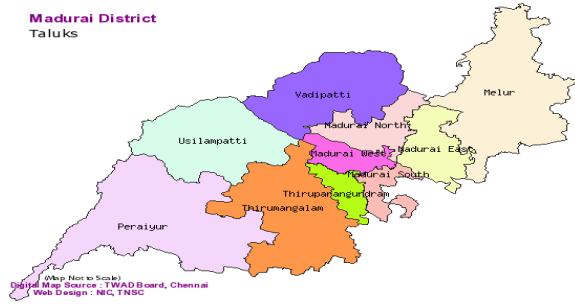


Fig 1. Study area

Taluks taken for case study are Melur, Vadipatti, Thirumangalam, Usalampati, Peraiyur, Madurai North and Madurai South.

B. Satellite data

Satellite data usually covers large area, hence it is used for spatial analysis purpose.

1) Imagery used:

The satellite data used in this paper is a raster data of Madurai area taken from the LANDSAT 7 satellite which is 30 m resolution.

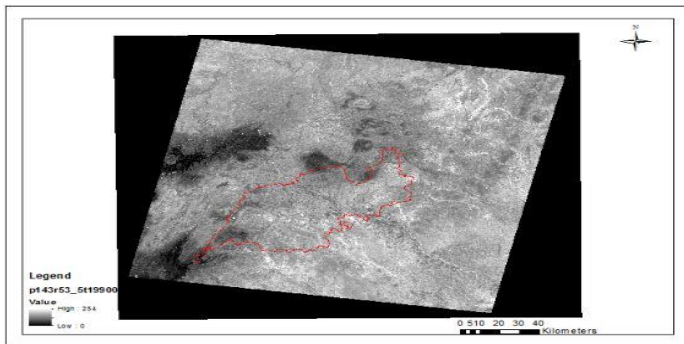


Fig. 2. LANDSAT 7

C. Water quality datasets

The Public Work Department (PWD) has water quality measure for 59 wells across the Madurai district. The water quality parameters are pH, Total Dissolved Solids (TDS), Turbidity, Nitrates (NO₃), Fluoride (F), Total Hardness (TH), Alkalinity, Chlorides (Cl), Sodium (Na), Potassium (K), Sulphates (SO₄), Chemical Oxygen Demand (COD). The work is carried out for monitoring the ground water quality which is suitable for drinking purpose. For the following parameters analysis was performed pH, Total Dissolved solids (TDS). Total Hardness (TD), Chloride (Cl).

D. Software used

ArcGIS is a suite consisting of a group of geographic information system (GIS) software products produced by ESRI. ArcMAP section provides an introduction and

overview to ArcMap, which is the central application used in ArcGIS. ArcMap is where you display and explore the datasets for your study area, where you assign symbols, and where you create map layouts for printing or publication. ArcMap is also the application you use to create and edit datasets. ArcMap represents geographic information as a collection of layers and other elements in a map. Common map elements include the data frame containing map layers for a given extent plus a scale bar, north arrow, title, descriptive text and a symbol legend.

III. METHODOLOGY

A. Introduction

This study methodology comprises of different stages. The initial stage is the data collection stage where the water quality for the wells are obtained from PWD (Public Work Department) and the LANDSAT 7 satellite data of Madurai district is obtained. On other side, water quality parameter for Madurai district is collected from Public Work Department (PWD) of Madurai for the period of year 2002-2012. These data are integrated into GIS. Then the spatial variation for water quality parameters are identified using interpolation tool. By performing query analysis acceptable and not acceptable wells are identified. The flow chart for the methodology is shown below.

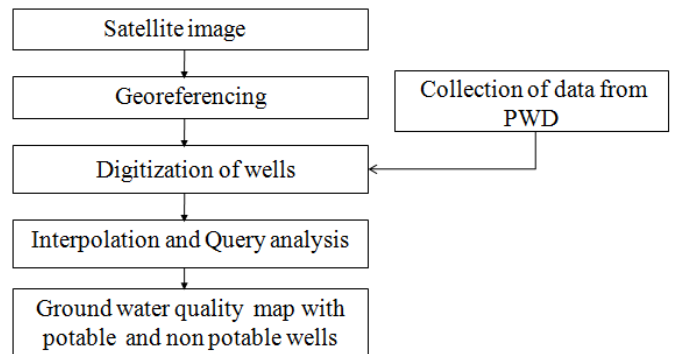


Fig.3. Methodology

B. Geo referencing

Geo-reference something means to define its existence in physical space i.e., establishing its location in terms of map projections. Different maps may use different projection systems. Geo referencing is done by collecting Ground Cross Point (GCP) and feeding it to satellite data

C. Digitization of wells

Digitization means marking the geographical element in the spatial data by creating shape files. The shape files can be point, line and polygon. The latitude and longitude value of the wells are imported as point features into the GIS. Each point in the satellite image represents the wells. This can be done by Add XY data option in the ArcGIS software. After importing it as point features, these points as saved as point shape file.

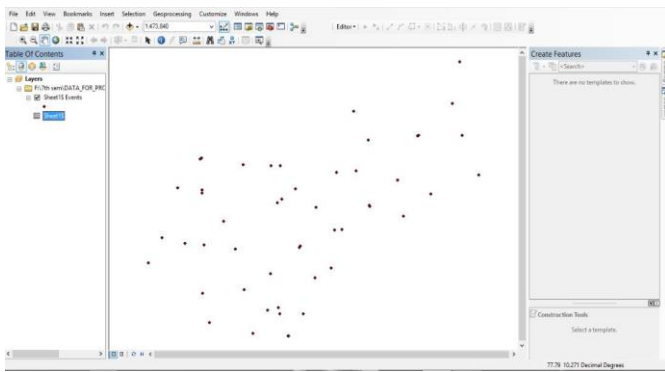


Fig. 4. Digitized wells

D. Interpolation

Interpolation is a procedure used to predict the value at the cell where there is a lack sampled point. It based on the principle of spatial autocorrelation or spatial dependency which measure degree of relationship/dependency between near distance object. Spatial auto correlation determines if values are interrelated .If values are interrelated, it determines the spatial pattern.

E. Query analysis

Query analysis is used to select the particular feature which satisfies the given condition. By developing the query related to the various conditions, the geographical area that satisfy those condition are projected. These queries are written in query builder.

IV. RESULTS AND DISCUSSION

A. Result

GIS is used to evaluate the quality of ground water in Madurai region. Spatial variation map of major water quality parameters like pH, TDS, Chloride, Total Hardness were prepared for Madurai district for pre monsoon and post monsoon. Based on these spatial variation maps of major water quality parameters and integrated ground water quality map of Madurai district was prepared using GIS. This integrated ground water quality map help us to know the existing ground water condition of the study area. This spatial variations are found by using interpolation tool.

By developing queries the highly suitable wells, acceptable wells, non acceptable wells are also found for the years between 2002-2012. With the help of this, graph for suitable wells are plotted in arcGIS in taluk wise. As the result no wells from Maduari north and Madurai south is suitable for drinking water. Although analyzed spatial variation for these wells in previous year, no acceptable wells from these taluks

B. Interpolation Results

(i) Pre-Monsoon

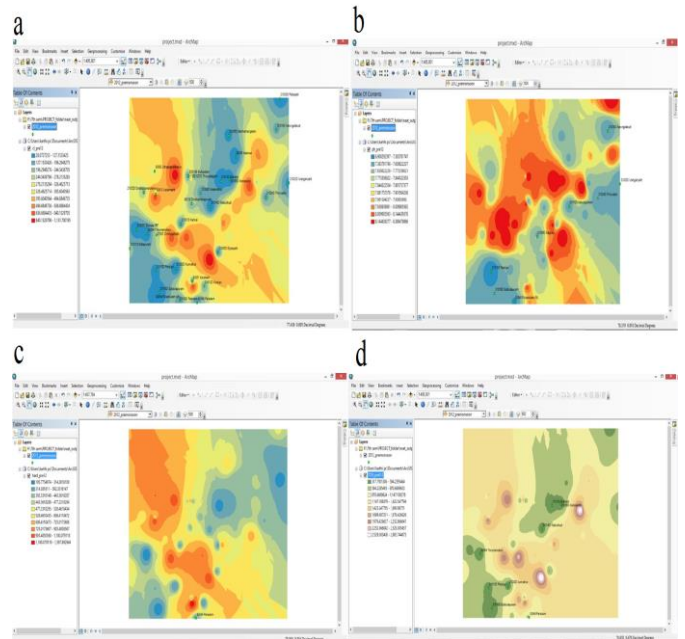


Fig. 5. a. Interpolation result for Chloride (mg/L)
 b. Interpolation result for pH
 c. Interpolation result for hardness (mg/L)
 d. Interpolation result for TDS (mg/L)

(ii) Post-Monsoon

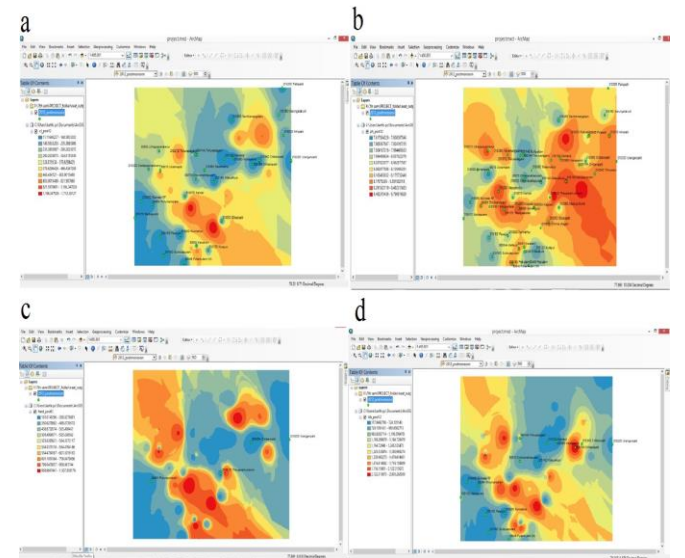


Fig 6 . a. Interpolation result for Chloride (mg/L)
 b. Interpolation result for pH
 c . Interpolation result for hardness (mg/L)
 d. Interpolation result for TDS (mg/L)

The above result shows the spatial distribution of Chloride, pH, Total hardness, TDS parameters for pre monsoon and post monsoon. The spatial pattern of water quality is varies in both pre monsoon and post monsoon. It displays the name of the wells which satisfies the drinking water quality condition. For pH, it should be between 6.5 and

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