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ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 7, July 2017

Geographic Information System (GIS) Based Ground Water Quality Monitoring: Review

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Abstract: Artificial groundwater recharge plays a crucial role in managing groundwater resources sustainably. Spatial variations in groundwater quality have been studied in different parts of India using the technique of geographic information system (GIS). GIS, a tool used to store, analyze and display spatial data, is also used to investigate information regarding groundwater quality. Water samples from 76 of the bore wells and open wells covering the specific regions of India. The water samples have been analyzed for physico-chemical parameters such as TDS, TH, Cland NO3-, using standard laboratory techniques and compared to standards. For all of the above parameters the groundwater quality information maps of the entire study area were prepared using GIS spatial interpolation technique. The results obtained in this research and the GIS geographic framework is helpful in tracking and controlling groundwater emissions in the study area. In terms of water quality, mapping was coded for drinking areas, in the absence of better alternative supply and non-potable zones in the study area. Thematic layers for the delineation of artificial groundwater recharge areas is incorporated into ArcGIS. Based on their influence on groundwater recharge, the recharge map thus obtained was divided into four zones (poor, moderate, good, and very good).

Keywords: Groundwater pollution, Drinking-water, Physico-chemical parameters, Spatial interpolation.

INTRODUCTION

Groundwater is one of the most vital renewable and widely distributed resources on earth, and a major source of water supply worldwide. Water quality is a critical problem for mankind since it is directly linked to human well-being. Most of the population in India is dependent on groundwater as the only source of supplying drinking water. Groundwater is considered to be relatively safe and pollution-free, relative to surface water. Groundwater can become naturally contaminated or due to numerous types of human activities; residential, municipal, commercial, industrial, and agricultural activities can all affect groundwater quality.

Groundwater contamination may lead to poor quality of drinking water, lack of water supply, high cost of cleaning up, high cost of alternate water supply and/or potential health issues. A wide variety of chemicals present in groundwater have been reported. These include organic synthetic chemicals, hydrocarbons, inorganic cations, anions, contaminants and radionuclides. Recently there has been much interest in the importance of water quality in human health. About 80 percent of all diseases in developed countries like India are directly related to poor drinking water safety and unhygienic conditions. Groundwater is an important natural resource which is crucial to human health, socio-economic development and environment functioning.

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Severe water shortage is becoming widespread in India, particularly in arid and semi-arid regions, in several parts of the country. In several states such as Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh, Tamil Nadu, among others, over-reliance on groundwater to satisfy ever-increasing demands from domestic, rural, and industrial sectors has resulted in over-exploitation of groundwater supplies.

Geographic information system (GIS) has emerged as a powerful tool for storing, analyzing and displaying spatial data and making use of those data for decision-making in several areas including engineering and environmental fields. GIS was used in groundwater quality map classification, based on the correlation of total dissolved solids (TDS) values with some aquifer characteristics or land use and land cover. Many experiments have used GIS as a database system to create water quality maps based on the concentration values of the various chemical constituents. Evaluation of water quality requires evaluation of the physical, chemical and biological existence of water in relation to environmental conditions, human consequences, and expected uses, particularly uses that may affect human health and the health of the aquatic environment itself. Using GIS technology has made assessment of natural resources and environmental concerns, including groundwater, much simpler.

GIS is commonly used in groundwater studies to analyze site suitability, manage site inventory data, estimate groundwater vulnerability to contamination, model groundwater flow, model solvent transport and leaching, and integrate groundwater quality assessment models with spatial data to create spatial decision-support systems. In this study GIS was useful in establishing the spatial relationship between the level of pollution and its source. ArcView GIS has been used to map, query and analyze groundwater spatial patterns in north-central Texas, which comprise large percentages of urban and agricultural land use.

The literature survey shows that several scholars in the region have carried out studies on groundwater efficiency of both the bore wells and open wells. Many studied only physico-chemical parameters, while others analyzed the parameters in a mixed state; while some studied these waters ' bacteriological status. Further, only the identification of hydro-chemical factors was recorded. One cannot detect spatial variation of the groundwater quality from the literature survey. Furthermore such a study was not carried out in the city of Gulbarga. This study aims at visualizing the spatial variation of certain physico-chemical parameters via GIS.

The research work's main aim is to perform a groundwater quality evaluation utilizing GIS, based on available physico-chemical data from 76 locations in Gulbarga Region. The aim of this evaluation is (1) to provide a summary of the present groundwater quality, (2) to evaluate the spatial distribution of groundwater quality parameters such as Hardness, TDS, $NO3^-$, and Cl^-; and (3) to produce groundwater quality zone chart.

In the groundwater samples used for drinking purposes and their levels at different locations of the analysis, numerous physico-chemical parameters such as chloride, nitrate, TDS, and hardness were examined. The rapid growth of urban population led to unplanned settlements where access to sewerage is scarce and the only options available for sewage disposal are pit latrines or septic tanks. Sewage and nitrate can enter the aquifer by sewage overflow, and on-site drainage systems such as septic tanks, which is common practice in Gulbarga district, are the main sources of nitrate and other contaminants in urban groundwater. Human nitrate sources may have a considerable impact on groundwater quality due to the high concentration of potential sources in a

ISSN (Online) 2394-2320

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Vol 4, Issue 7, July 2017

smaller area than agricultural land. Table 1 shows a number of important parameters of drinking water quality and their respective permissible limits as recommended by WHO and IS. Some groundwater samples found values above desirable limits for chloride, hardness, nitrate, and total dissolved solids (TDS). The values for the different sample positions and interpolated surfaces were plotted. We developed thematic maps of water quality for chloride, nitrate, TDS and hardness within the study area, showing areas that fall within the drinkable area, where there was no better alternative source and non-potable zones.

Parameter	WHO (mg/L)	ISI (mg/L)
Total dissolved solids (TDS)	450-500	500
Hardness (TH)	400-500	600
Chloride (Cl^-)	200-215	250
Nitrate(NO_3^-)	40	45

Table 1. Drinking water: Parameters and recommended permissible limits.

S/No.	Parameter	Rank	Criteria	Remarks
		1	< 500	Desired
1	TDS	2	500 - 1000	Acceptable
		3	> 1000	Not Acceptable
		1	< 500	Desired
2	TH	2	500 - 1000	Acceptable
		3	> 1000	Not Acceptable
		1	< 250	Desired
3	Cl^-	2	250 - 1000	Acceptable
		3	> 1000	Not Acceptable
		1	< 45	Desired
4	NO_3^-	2	45 - 100	Acceptable
		3	> 100	Not Acceptable

Table 2. Criteria for acceptability and rejection in water quality.

LITERATURE REVIEW

This research is an attempt to integrate mapping strategies focused on CWQI and GIS to achieve an accurate, easy, and useful performance for monitoring water quality in coastal ecosystems. The data sets collected were translated to basic maps using the coastal water quality index (CWQI) and the overlay mapping methodology based on the Geographical Information System (GIS) to demarcate safe and contaminated regions. Multiple-parameter analysis revealed low quality of water in Port Blair and Rangat Bays [1]. This literature examined the water samples using normal laboratory procedures for physico-chemical parameters such as TDS, TH, TA Chloride, Fluoride, and WQI. Additionally, visualization of groundwater quality based on geographic information systems in the form of visually interacting contour maps was built using ArcGIS version 9.0 software to delineate spatial distribution in the physicochemical characteristics of groundwater samples. The final comprehensive map shows three target groups such as the research area's outstanding, fair and bad groundwater quality zones and provides guidance on groundwater suitability for domestic purposes [2]. In this research, the GIS program was used to examine the effects of different data layers on the distribution of groundwater emissions in the Nigerian city of Uyo (topographic slope, variability of the groundwater level, soil porosity, and land use activities). Spatial variability map of the various groundwater quality parameters was developed using software interpolation process. There is a good correlation exist between some of the pollution indicators [3]. An attempt was made to analyze the groundwater quality spatial variability focused on an applied review of physico-chemical parameters and the use of the Geographic Information System (GIS). The spatial distribution maps of Hardness, pH, TDS, HCO3, SO4, NO3, Ca, Mg, Cl, and F is developed using GIS contouring techniques for ArcView. From the Water Quality Index map it is inferred that the quality of the water is predominantly good to excellent despite the mining and heavy industry [4]. A case study in Udaipur district of Rajasthan, west India, demonstrates the existing technique. Originally, this analysis listed ten thematic levels, i.e., topographic height, land slope, geomorphology, vegetation, groundwater depths pre- and post-monsoon, annual net runoff, annual rainfall,

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Vol 4, Issue 7, July 2017

and proximity to the surface water bodies. The key factor research approach analyzed these thematic layers to pick prominent layers for groundwater prospecting. Based on their relative importance in groundwater incidence, chosen seven thematic layers and their characteristics were given appropriate weights on the Saaty scale [5]. Close study was carried out under this literature using the Geographical Information System (GIS) to consider the spatial variability in surface water and groundwater content. Approximately forty-three groundwater samples and seven surface water samples were obtained from the research area during February 2009, and the samples were examined for various physical and chemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Alkalinity, Hardness, Na+, K +, Ca 2 +, Mg 2 +,Cl —, HCO3--, CO3-2, SO4-2, NO3-and F [6]. This chapter discusses the groundwater contamination level evaluation relating to a solid waste disposal site in Chennai, India. A three dimensional model integrated with GIS was generated using FEFLOW to simulate the concentration of contaminants around the site of solid waste disposal. The model predicts the future spatial and temporal distribution of contaminants around the site of waste disposal [7]. This study indicate that the application of GIS is an efficient and low cost tool to study and select appropriate dumping site so as to facilitate decision making processes and in this study GIS is used for solid waste management [8]. This paper presents a modeling method based on Geographical Information Systems (GIS) to identify a set of criteria that needs to be considered for the city's proposed MSW landfill site. The GIS system is used to produce site appraisal spatial details. The thematic maps is digitized and analyzed using GIS tools. Supervised classification was done to represent land use as per SWM. In the siting phase many considerations were included including geology, water resources, land usage, natural areas, air quality and groundwater quality [9].

CONCLUSION

Spatial distribution review of groundwater quality in the study area showed that many of the collected samples do not follow the drinking water quality standards recommended by WHO and ISI with about half of the city having non-potable groundwater. The results obtained provided the necessity to make the media, local administrator and government informed of the low groundwater quality situation that prevails in the region. The Government needs to make a practical and realistic proposal for the development and implementation of an efficient groundwater quality management program. Public awareness of the current quality problem and their participation and support in city authorities ' actions is very critical for this. Seeing that the groundwater will have the biggest share of water supply systems in the future, measures are needed to protect groundwater safety. The present groundwater status requires the implementation of methodologies for the continuous monitoring and necessary groundwater quality improvement

The recommendations for preventing further deterioration of groundwater quality and the strategy for protecting the same in future are as follows.

(1) The quantification of domestic waste reaching the numerous water bodies located in the city would help to construct effective sewage treatment plants and reduce sewage contamination in the groundwater.
(2) Continuous monitoring of the groundwater table level and a consistency assessment can reduce the risk of further depletion.
(3) Structural engineers, experts, contractors and the general public should be consulted on the condition of groundwater which does not follow the water quality criteria laid

down in IS 456 to 2000 (Bureau of Indian Standards, 2000) and urge them to prevent the use of untreated groundwater.

(4) Groundwater recharge systems shall be established in various parts of the town. Forming storm water drains that connect to systems that recycle reservoirs to improve their recovery capacity.

(5) Identification of locations and systems for recharging groundwater. Geographical information system (GIS) with the spatial and non-spatial data required can be used very well as the tool for this purpose. We need to build recharging structures.

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