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Groundwater Quality in Western Ghats of Coimbatore Districts: A Study With Special Reference to Remote Sensing

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ABSTRACT

The main objective of the research work is to manage the modelling of Urban Development of Coimbatore Districts by using GIS, GPS, and Remote Sensing. Remote sensing data namely IRS 1BLISS I for the years 1995 and 2005 and IRS ID LISS III for the year 2015 interpreted through supervised classification in DIP environment to arrive at land use/cover classes. A total of 24 groundwater samples were collected from boreholes ranging in depth between 6 to 16 m BGL from 2015. To study the impact of this rapid urbanization and overall land-use transition, a GWQI was prepared within GIS. The growth between the years 1995 - 2005 was relatively low compared with the years 2005 - 2015. Around 156.67 km^2 area was added to the Residential, Commercial land category in ten years (1995 – 2015). It is found that urban areas are increased 130% due to population growth cum rapid economic progress. About 51% of barren lands converted into other uses, particularly 42.33% to urban areas.

Keywords: *Remote sensing, Land use/ cover, Groundwater Quality, GIS, GPS*

Introduction

Coimbatore is naturally filled with eco-system such as hills, plains, forests, evergreen fields, drought-prone areas, river bodies and tanks. Hence, most of the cities of Coimbatore benefited from the southwest monsoon. The temperature in Coimbatore is moderate throughout the year. This study analyses the water total Hardness, Calcium and Magnesium, Sodium and potassium, Chloride, Sulphate, Phosphate-phosphorous, Nitrate-nitrogen and Fluoride. The spatial analysis of water quality data and the formulation of the GWQI, the raster GIS format will use, since it provides a simple data structure, easy and efficient overlay analysis, sufficient representation of high spatial variability, and unified grid cells for several attributes. Water samples were collected from 24 bore wells inthe study area. The hadrochemical data obtained from laboratory analysis of the water samples linked to the spatial database of the borewell locations. Concentration maps are representations for the spatial variability of a particular water quality parameter and are prepared by spatial interpolation of the originally scattered concentration measurements (point data).

Statement of the Problems

The twice over fold population growth is evidenced in Coimbatore Corporation, South India in the last decade. Coimbatore Corporation has been experiencing rapid urban growth leading to the quick loss of Agriculture land and Vegetation. It has considerable influence on land structure planning, socio-economic planning, transportation, market, industrial planning, and management. An attempt to study the said stress was made in this research to bring out the solution. The study aimed at the management modelling of the urban development of Coimbatore Corporation using Geographic Information System (GIS), Global Positioning System (GPS) and Remote sensing. Remote sensing data namely IRS 1BLISS I for the years 1995 and 2005 and IRS ID LISS III for the year 2015 interpreted through supervised classification in DIP (Digital Image Processing) environment to arrive at land use/land cover classes. The growth between the years 1995 - 2005 was relatively low compared with the years 2005 - 2015. Around 156.67 km^2 area was added to the Residential, Commercial land category in ten years (1995 – 2015). However, the urban growth during 2005 – 2015 was considerably higher when compared with the years 1995 - 2005. Even though the Government and Coimbatore Corporation takes utmost care in supplying hygienic water to the public, the water has been polluted for a certain period. Hence, the researcher has attempted the reason for groundwater pollution and how the groundwater quality can improve?

Material and Methods

Coimbatore is administered by the Coimbatore Municipal Corporation and the administrative capital of the Coimbatore district. The longitude of Coimbatore lies between 76º65' E – 77º 29' E. The latitude lies between 10 º 22' N – 11 º 41' The total area of Coimbatore Corporation is 257.3 square kilometres The extent of Coimbatore city until recently limited to 105.6 square km when it consisted of 72 administrative wards. In 2011 July, the city precincts reorganized by downsizing the wards and adding adjacent administrative areas from neighbouring regions.The city now comprises 100 wards and a regional extent of 257.3 square km. A total of 24 groundwater samples were collected from boreholes ranging in depth between 6 to 16 m Below Ground Level (BGL) from 2015. To study the impact of this rapid urbanization and overall land-use transition, a groundwater quality index (GWQI) was prepared within a geographical information system (GIS). The GWQI integrates the different water quality parameters to give a final index value that can use for Spatio-temporal comparisons. The land-use transitions were closely monitored from 2005 to 2015 using multispectral satellite images. The settlements of Kalapatti, Vilankurichi, Saravanampatti, Sriram Avenue, Civil Aerodrome, Coimbatore, RS Puram, Gandhipuram, Kovaipudur, and Ukkadam lie within the nonsustainable zone. Zones of sustainable and unsustainable groundwater use demarcated for better decision making related to municipal landallotment in this rapidly urbanizing region.

Samples analyzed in the laboratory for physicochemical attributes like pH, Electrical Conductivity (EC), Total Hardness (TH), Total Dissolved Solids (TDS) and major cations like calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and anions like bicarbonate (HCO_3), carbonate (CO_3), chloride (Cl), nitrate (NO_3), sulfate (SO_4), and phosphate (PO_4) in the laboratory using the standard methods given by the American Public Health Association (APHA 1995). The results were evaluated by the drinking water quality standards given by the World Health Organization (WHO 2004). **The** pH of the samples was measured using Sistroids digital pH meter. The instrument was calibrated using pH 4, 7 and 9.2 buffer solutions. The electrode head withdistilled water having a conductance of fewer than 2 ohms/cm. This then placed in the water sample taken in a 100 ml beaker and the pH read directly. Total Hardness determined by EDTA titrimetric method. 100 ml of the water sample titrated against the standard EDTA (0.01M) solution using Eriochrome Black T as the indicator at a pH of 10 (ammonia buffer used). The results expressed in ppm or mg/l calcium carbonate.

Groundwater quality index generation

Groundwater quality index generation usually involves three processes: (a) assortment; (b) equivalence; and (c) aggregation of the parameters to be incorporated in the index. The selection of the parameters that will make up the index depends on several factors,such as the purpose of the index, the importance of the parameter and the availability of data. For this study, the GWQI proposed by Babiker et al. (2007) was used for quality assessment. To generate the index, seven parameters listed in World Health Organization guidelines (WHO 2004) for drinking water quality were selected from the main dataset. Six parameters (Cl, Na, Ca, Mg, SO_4, and TDS) can be categorized as chemically derived contaminants that could alter the water taste, odour, or appearance and affect its ''acceptability'' by consumers (WHO 2004). Thresholds for maximum desired concentrations have been proposed for these chemicals, but fixed guidelines have not been established. NO_3^- categorized under chemicals that might inflict ''potential health risk'' and a guideline value of 50 mg/l assigned (WHO 2004). The above-mentioned groundwater quality parameters also good indicators of changing land-use conditions on the surface. TDS is used as a general indicator for poor water quality. Sodium, chloride, and nitrate concentrations in groundwaterdirectly related to the presence of septic systems (Panno et al. 2000; Venkatramanan et al. 2016). Major ions, such as chloride, sulfate, and individual nitrogen species have been used as chemical marker species to indicate groundwater recharge from sewage (Eiswirth et al. 1995). Sodium, chloride, and nitrate concentrations have also been found to be associated with animal tes including poultry (Krapac et al. 2000; Venkatramanan et al. 2017). The nutrient content of manure (mainly nitrogen, phosphorous, and potassium) is generally much higher in poultry than other livestock, hence poultry manure is a rich source of nutrients especially nitrate in groundwater (WHO 2006; Pionke et al. 1990; Venkatramanan et al. 2018a; Selvam et al. 2013a,b). Magnesium concentrations in groundwater increased by domestic/sewerage wastewater (Voznaya 1981). Sulfate concentrations have been reported to increase with the age of urban development because of urban fertilization and oxidation of soil-held sulphides with land clearings (Appleyard 1995; Venkatramanan et al. 2018b; Selvam 2014). The basic statistics of the seven selected water quality parameters together with their WHO maximum desirable concentrations.

Index Calculation

$$C = (X' - X) / (X' + X) \quad \text{......} 1$$

Where,

The observed concentrations (X') of each pixel in the primary concentrationmap then related to its WHO maximum desirable concentration (X)

$$r = (0.5 \times C^2) + (4.5 \times C) + 5 \quad \text{......} 2$$

Where,

C stands for the contamination index value for each pixel in the normalized difference map and r stands for the corresponding rank value. The rank map rates the contamination index values from 1 to 10. Rank 1 indicates the minimum impact on groundwater quality, while rank 10 indicates maximum impact.

Assignment of weights to the rank maps of each parameter is achieved by the average rank value of each parameter's rank map. The weights assigned to each parameter indicate itsrelative importance to groundwater quality. Parameters with a high mean rate inflict a higher impact on groundwater quality and assumed to be more important in evaluating the overall groundwater quality (Babiker et al. 2007; Selvam et al.2014a,b,c). For the six

parameters categorized as chemically derived contaminants (Cl, Na, Ca, Mg, SO_4, and TDS), the average rank value was used as a weight, while for NO_3 ''2'' added to the mean rank value due to potential health risk posed by NO_3.

w = mean r, × (for Cl, Na, Ca, Mg, SO_4, and TDS) ---------------3

w= (mean r) + 2 (for NO_3)..4

where w weight, r rank value. Finally, the seven sub-indices (rank maps) aggregated to yield an index map using the ''grid calculus'' module in SAGA GIS. Here, a weighted sum index has been used. This GWQI represents a weighted averaged linear combination of factors as shown below:

$$GQI = 100 - ((r_1w_1 + r_2w_2 + \ldots\ldots + r_nw_n)/N) \text{ ------------------------ } 5$$

where 'r' stands for the rate of the rank map (1–10), 'w' stands for the relative weight of the parameter, 'N' is the total number of parameters used in the suitability analyses. Dividing by the total number of parameters involved in the computation of the GWQI averages the data and limits the index values between 1 and 100. In this way, the impact of individual parameters is greatly reduced and the index computation is never limited to a certain number of chemical parameters. The ''100'' in the first part of the formula directly projected the GWQI value such that high index values close to 100 reflect high water quality and index values far below100 (close to 1) indicate low water quality.

Seasonal variability and sustainability of groundwater Use

For the estimation of the seasonal groundwater quality variations, the coefficient ofvariation (a measure of variability in time and space expressed as: (SD/mean 9 100) of each

groundwater quality parameter in the boreholes calculated. The total variation in eachborehole then calculated as where Vn is the variation coefficient of the n parameter, and N is the total number of parameters.

$$V = \sum_{n=1}^{N} V_n$$

Finally, the point data of seasonal variation at each borehole was interpolated using the Kriging technique to obtain a map of overall seasonal variation for the watershed. The sustainability of groundwater use refers to the combined effect of the magnitude of the groundwater contamination and the seasonal variation associated with that contamination. High contamination and high seasonal variability will decrease the sustainability of groundwater use. Conversely, mild contamination coupled with low seasonal variability of groundwater quality will increase the sustainability of water use. Based on this concept, amap of sustainability of groundwater quality was developed for the Coimbatore Municipal Corporation. The groundwater quality index map (GQI) and the seasonal groundwater variability map combined in GIS to obtain the Groundwater quality sustainability map. Before overlay operation, the two maps were standardized using the 'grid normalization module' in SAGA GIS. A non-weighted sum overlay operation was performed on the two maps to obtainthe final sustainability map.

Urban Sprawl

Remote sensing data namely IRS 1BLISS I for the years 1995 and 2005 and IRS ID LISS III for the year 2015 interpreted through supervised classification in DIP (Digital Image Processing) environment to arrive at urban classes. The survey of India Toposheets 58B13 and 58A16) on 1:50,000 scales was used for digitizing the boundaries. A 12-channel hand-held GPS receiver (Garmin GPS-12) was used for determining the location of different land covers. These GPS points are used to obtain the accurate location of land cover classes for easy demarcation. Entropy calculation is based on computation. This is best facilitated by the integration of spatial measurement facilities correspondingly offered by remote sensing (RS) and geographic information system (GIS) (Sudhira et al., 2004, Ayhan et al., 2008). Satellite images provide data about the physical state of an area at a given time.

Suggestion and Conclusion

In the Coimbatore Corporation, the major sources of contamination identified in this study are poultry farms, septic tanks and cowsheds (associated with settlements), and agricultural activities (mainly paddy cultivation). Although agricultural activities and associated fertilizer application has been a major contributor to groundwaterquality degradation in the recent past, this study has shown that the increasing urbanization of the study area has shifted the dominant share of contamination toward poultry farms, used sanitation including pit latrines and septic tanks. Using a GWQI, it is possible to delineate the spatial variation of groundwater quality in the study area indicating that the water quality of the region is generally good, but deterioration has commenced with the onset of urbanization. Groundwater quality in the Coimbatore Corporation roughly follows the groundwater table. However, at some locations, there is a departure from this relationship due to heavy contaminant loading. These regions coincide with the settlements and poultry sheds. It is found that urban areas are increased 130% due to population growth cum rapid economic progress. Vegetation cover decreased 33.23% due to conversion into urban features. Water bodies in the area increased to 0.86% due to the eradication of encroachment. There is a loss of 48.5% of agricultural landsdue to demand for construction activities. About 51% of barren lands converted into other uses, particularly 42.33% to urban areas. Urban growth has accelerated towards northeastern, northern, and eastern parts, where national highways exist. Among the five zones, the South and East Zone have a higher percentage 104.94% and 102.96% of the change in the built-up area during 1995-2005 and 2005-2015 respectively, and the Central Zone has the least percentage of change (15.75%) in 2005-2015 due to already central city developed in before2005.

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