Site Selection for Solid Waste Disposal Using Remote Sensing and GIS Techniques in and around Salem Municipality, Tamil Nadu, India

Dr.R.Shanmugam (S.Karthik, N.Nithyakumar,. A Gowtham, S.Sivaraj),

Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

Abstract

The present work aims to find out suitable sites for urban solid waste disposal using GIS and Remote sensing and assimilate the data for an integrated study to assess the rainfall, water level, Soil, Geology, geomorphology, land use/land cover, drainage density and lineament density using appropriate methods for Salem Municipality, Tamil Nadu. The outcome generated through the GIS analysis is discussed in this section. Total area in our project including buffer zone covers 31.35 km^2. The results show that 14.92 km^2 areas are less suitable, 5.27 km^2 area is moderate suitable, 11.55 km^2 area suitable for dumping waste. Suitable categories are found at the area between Ammapet,Kumaragiri, Maniyanur, Hustampatti and also at Erumapalayam. Determination of suitable sites for the disposal of urban solid waste is one of the major problems in developing countries where the industrial development is adversely affecting the environment. The main environmental issue which should be considered in disposal of hazardous solid waste is the location of its land filling. The proposed method may be used for site selection processes in other conditions and locations where the intensity of introduced parameters shows discrepancies.

Key Words; *Solid waste, Remote sensing, buffer zone, environmental issue.*

Introduction

The rapid growth of population and urbanization decreases the non-renewable resources and disposal of effluent and toxic waste indiscriminately, are the major environmental issues posing threats to the existence of human being (Allen et al; 1997). The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses (Jilani et al; 2002). There has been a significant increase in solid waste generation in India over the years from 100 gm per person per day in small towns to 500 grams per persons per day in large towns. Presently most of the municipal solid waste in India is being disposed unscientifically (Akolkar, A.B; 2005). Generally municipal solid waste is collected and deposited in sanitary landfill, such unscientific disposal attract birds, rodents and fleas to the waste dumping site and create unhygienic conditions (Suchitra, et al; 2007).

The degradation of the solid waste results in the emission of carbon dioxide (CO2), methane (CH4) and other trace gases. The unscientific landfill may reduce the quality of the drinking water and causes the disease like jaundice, nausea, asthma (Me Bean, E. A et al; 1995 and Amar M. Dhereet al; 1995). The present study in tend to find out a suitable site for the disposal of urban solid waste generated from Salem municipality and surrounding areas with the help of Remote sensing and GIS techniques. Solid waste Management is a dilemma faced by the cities and towns in Tamil Nadu and finding a suitable landfill area is the serious problem faced by the urban centers in Tamil Nadu.

Study area

Salem Municipality is a central part of the Salem District and crossed flow over the Thirumanimuthar river, central Tamil Nadu, India has been selected for the present investigation. The study area, lies between the latitudes 11°37'54.474" N to 11°40'27.191" N and longitudes 78°08'20.483" E to 78°11'31.329" E covering an area of 11.99sq.km. In these, 1 km buffered area covers an about of 31.35 sq.km (Fig 1.1). The base map was prepared from Salem Municipality map with supporting evidence this toposheet 58 I/2 of 1:50,000 scale. The study area falls in Salem district of central Tamil Nadu. The ephemeral stream Thirumanimuthar has its source (catchment) along the southern slopes of Shervorayan hills near Adimalaiputhur and takes a course along southwest in the valley and emerges out as the main artery of Salem with southwest gradient. From Anaimedu the river takes the course through the heart of the city and swings towards southwest in the southern parts.

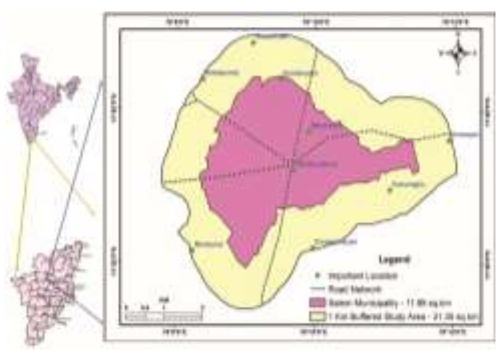

Fig. 1 Base map of the Study Area

Methodology

Salem municipality map collected from municipality office Salem District. The base map was prepared using taluk map of 1:75,000 scale. In the present study base map showing drainage and Road network from toposheets. 58E/11, 12, 15 and 16 of 1:50,000 scale. Toposheet collected from survey of India (SOI) in Chennai. These maps were scanned in to GIS environment, map registration and digitization of the boundary. The study area is extract the drainage, and road network map was prepared toposheets using ArcGIS software.

Primary data generation at the field, 6 schlumberger's vertical electrical sounding were conducted in various location of the study area. Vertical Electrical Soundings (VES) are commonly used to determine the vertical differences in apparent resistivity caused by different geological units (Zohdy et al., 1974). For a particular set of readings, the measurements are taken at a specific point such that the value of constant (K) progressively changes. In this method, the observation point remains the same whereas the spacing between the electrodes is gradually increased, by which the influence of the material at depth on the measurement becomes more pronounced. Thus, the apparent resistivity values are obtained at progressively larger electrode separations and the apparent resistivity values at the surface reflect the vertical distribution of resistivity values (Bhattacharya and Patra, 1968). The depth and thickness of various subsurface layers and their relative water holding capabilities can be unraveled using this method.

Secondary data or collected data like Satellite data, geology and soil maps, rainfall and water level data collected from various departments as www.GLCF, Geological survey of India, Soil survey of India and public work department. Detailed secondary data collection analysis and interpretations.

After attributing the data base map was created and there after various thematic maps like geomorphology, soil, land use/land cover, geology, drainage, rainfall, water level, soil thickness, populations and road map were created and weightage allocate to them based on the key parameter. The weightage assigned for different themes are shown the Table 1. For getting a suitable site for the disposal of solid waste 1 km buffer zones were created around the Municipality area. Various coverages in these themes were assigned a suitability score and converted in to raster format using Spatial Analyst in the Arc Map.

Sl.No.	Themes	Weightage
1	Geology	8
2	Geomorphology	8
3	Land use/land cover	8
4	Soil	8
5	Soil Thickness	8
6	Rainfall	7
7	Water level	7
8	Drainage Density	7
9	Lineament Density	7

Table 1 Weightage assigned for each theme

Results and Discussion

Rainfall Data Analysis

Among the eight rain gauge station data analyzed only two stations Yercaud showed a good response of rainfall and Groundwater recharge relationship as they are directly related. Three stations namely Valappadi, Salem-Junction and Peddanayakkanpalayam show a moderate dependence of recharge upon rainfall as the other three stations, namely Salem show that the poor dependence of direct recharge into the groundwater aquifer of the study area.

The Average annual rainfall spatial distribution map (Fig.2) result shows that entire study area fell in low rainfall category. Therefore, based on rainfall, study area fully more suitable for soiled waste deposal.

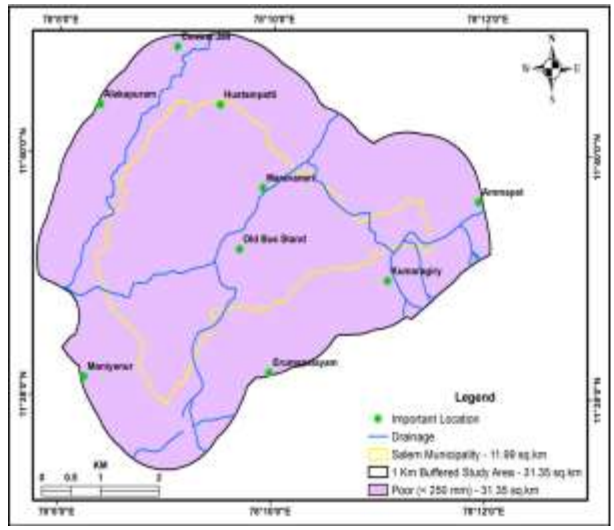

Fig. 2 Annual Average Rainfall Map

Water Level

Average water level spatial distribution map (Fig. 3) result shows that spatially 0.79 km^2 area falls in (shallow depth of groundwater) poor class category. Majority of the study area fall in moderate water level an area about 23.60km^2 and rest of the area 6.94 km^2 area falls in deeper depth of groundwater class category. Overall groundwater level fluctuation study reveals that near to Shervorayan hills of the study area was noticed in shallow depth to water level of the study area. Deeper depth of water level was noticed in nearby Kumaragiri small hill side of the study area so for that location more suitable site for waste disposal.

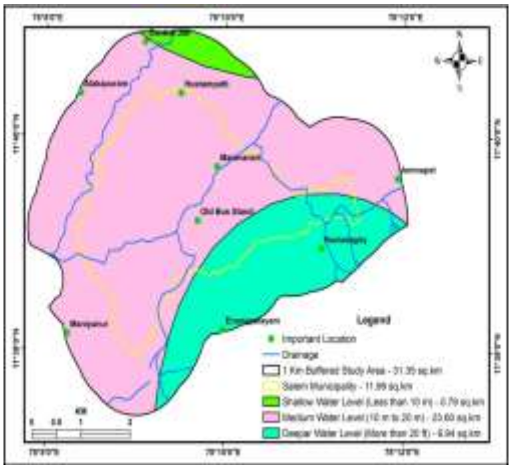

Fig. 3 Annual Average Water Level Map

Geology

The geology map was collected from Geological Survey of India (GSI). The Geology map of the study area is given by Fig. 4. The map was traced, scanned, digitized GIS platform. In the field, the rock samples were collected and identified to assess the hydrogeophysics and hydrogeochemistry characteristics of groundwater. The study area is mainly underlined by Charnockite and Hornblende-Biotite-Gneisses. Charnockite is the dominant group of rocks covering major parts of the study area, followed by the Hornblende-Biotite-Gneissic rocks. The assessment of qualitative nature of groundwater in any terrain may be almost impossible without an understanding of the Petrography, Stratigraphy and Structural characteristics of various geologic units. The Upper Thirumanimuttar sub basin is characterized by Charnockite, Fissile Hornblende–Biotite Gneiss, Alluvium and Pyroxenite.

The ultrabasic complex of this area is unique in its occurrence. The chromiferous layer forms the NW portion which the entire ultramafic complex of dunite, peridotite, potassic members, basic granulites and magnesite mineralization occur. They occur amidst the highly-metamorphosed rocks of granulite and amphibolite facies that have been subjected to repeated periods of deformation. The geological sequence established by Periakali (1982).

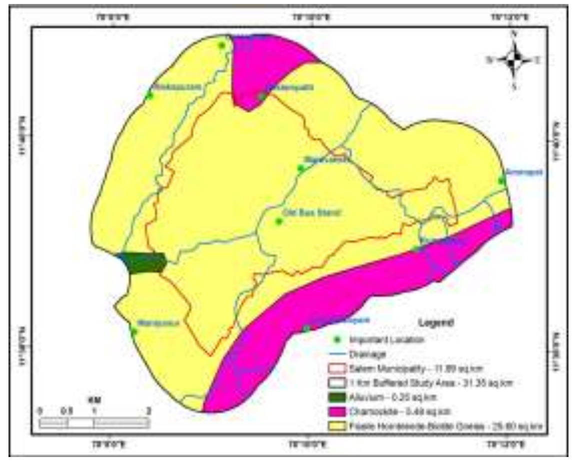

Fig. 4 Geology Map

Geomorphology

Geomorphology map (Fig. 5) was prepared using image interpretation elements from LANDSAT TM data of the year 2013. The interpreted image was validated in the field. Geomorphological units are highly helpful for selecting the groundwater potential zone (Ghayoumian, 2007). In the present investigation, it is used for classifying various landforms. Based on geomorphology, the landforms such as floodplain, buried pediment deep, buried pediment shallow, pediments and pediplain were identified and its groundwater potential zones were demarcated (Jagadeeswara Rao et al., 2004). These landforms act as groundwater storage reservoirs and some of them act as recharge and run-off zones (Jai Sankar et al., 2001). Buried pediments shallow covers larger area in the study area, which cover an area of 94.12 Km^2.

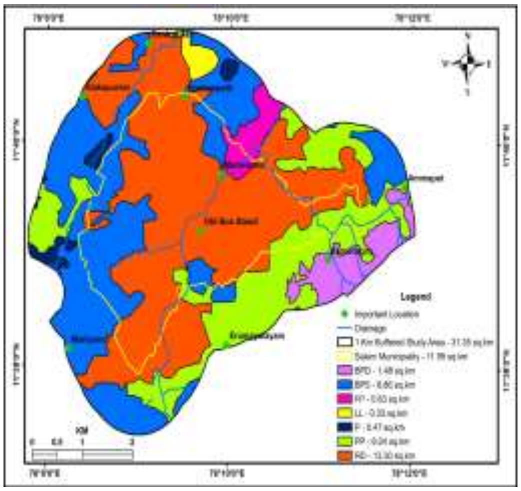

Fig. 5 Geomorphology

Land Use and Land Cover

Land use maps are the basic tools for the planning and show various artificial uses of land. The classification is useful for the present and in future planning. The term land use relates to the human activity associated with a specific piece of land, while land cover relates to the type of features present on the subsurface of the earth. Urban buildings, lakes, residual hills, rocky out crop are all examples of land cover types. Agricultural and mining activities are a few land use categories. For example, vegetation in the form of agricultural crop and forest are classified based on the contextual evidence. The land use classification adopted in the present study is based on NRSA (National Remote Sensing Agency) classification (1996).

The land use-land cover map was prepared by using latest cloud free satellite data. Using ERDAS software, the land use and land cover map was prepared.

Fallow lands are inferred by the absence of vegetation in the first phase. They show a grayish, yellow tone and fine to medium texture. They differ from similar wasteland units such as land without scrub, by their field pattern. Moreover they are mainly seen to be surrounded by agricultural lands. The fallow land occupies an area of 3.94 Km^2.

Land with scrub is a type of wasteland. Most of the study area has land with scrub. It is identified by its dark red color, medium to coarse texture and as isolated patches spread over the investigation area (7.39 Km^2).

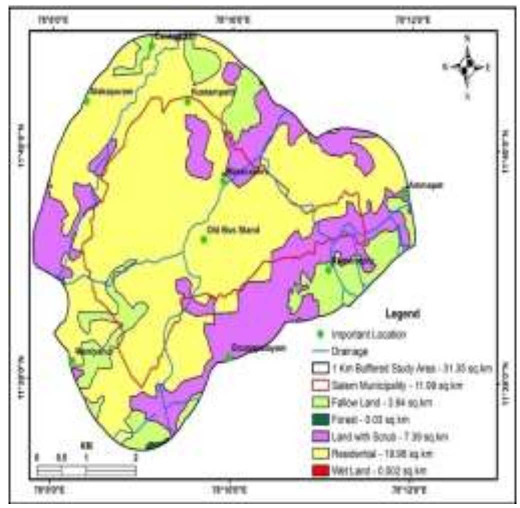

Fig. 6 Land use/ land cover Map

Lineament

The long linear natural feature was interpreted using the image interpretation elements and edge enhancement techniques in ERDAS imagine software. The prominent directions of these are NE-SW shown in Fig. 3.7. Buffering of 10m, 20m and 30m of lineaments have been done and a separate layer has been created. The output map is designated as multiple lineaments buffered map (Fig. 3.7).

Hydrogeomorphological studies coupled with hydrogeological as well as structure/lineaments have proved to be very effective tool to discern groundwater stay zones in the watershed (Bahuguna et al., 2003).

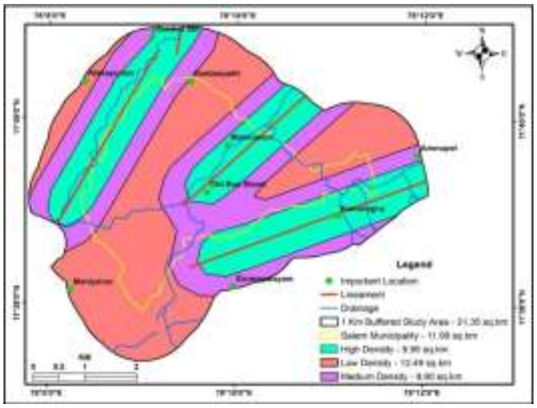

Fig. 7 Lineament with Lineament Density Map

Drainage Density

The drainage map was prepared from the toposheet collected from Geological Survey India. A drainage map was digitized on 1:50,000 scales. The drainage Density map was prepared in Arc Map, which was finally classified into different classes varying from low to very high density. The zones of high drainage density will have poor groundwater prospects and gradually the zones of lower and lower drainage density zones will have better groundwater prospects. Therefore, high drainage density location are suitable sites for waste disposal. Drainage density map is shown in Fig. 8.

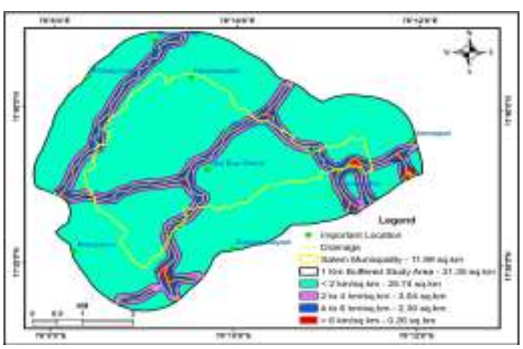

Fig. 8 Drainage Density Map

Soil Type

There are three type of Soil groups occurred in the present study area. Most of the study area fall in Red loomy soil, more are less this type of soil discriminate overall the study area. Red soil located in small patches of North and South Eastern part of the study area. The Brown colored soil occupied in small an area about 1.54 km^2. Red loomy soil is most favorable sites for waste disposal. The Soil type spatial distribution map are given in map 3.9.

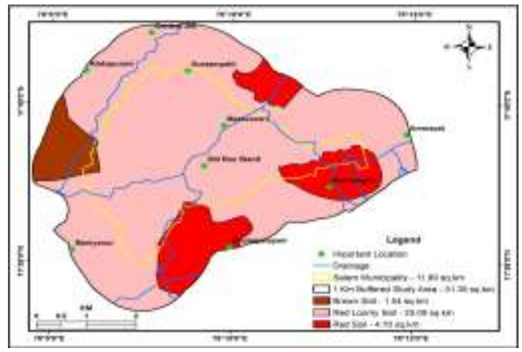

Fig. 9 Soil Type Map

Soil Thickness

The soil thickness GIS spatial distribution map reveals that locations are having less than 3 m thickness and were classified as low thickness. Spatially 27.16Km^2 area falls in the low thickness class (Fig. 10). The highest soil thickness was observed in central part of the study area. It is indicates that the high soil thickness portions not suitable for waste disposal. Low thickness areas represent the outer most side of the study area, therefore the outer study area more suitable for waste disposal.

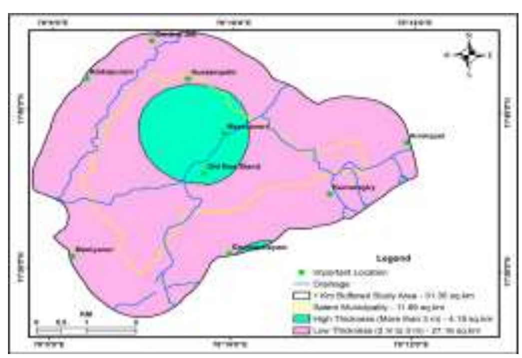

Fig. 10 Soil thickness Map

GIS Overlay Analysis

The annual average rainfall spatial distribution map, annual average water level spatial distribution map, geology map, geomorphology map, land use/ land cover map, soil map and soil thickness maps are integrated the all maps with weightage overlay index.Output map is designated as waste disposal location map provides certain clue for the waste disposal.In order to get all these information unified, it is essential to integrate these data with appropriate factor. Although, it is possible to superimpose this information manually, it is time consuming and error may occur. Therefore, numerically this information is integrated through the application of GIS. Various thematic maps are reclassified on the basis of weightage assigned and brought into the "Raster Calculator" function of Spatial Analysis tool for integration.

The outcome generated through the GIS analysis is discussed in this section. Total area in our project including buffer zone covers 31.35 km^2. The results show that 14.92 km^{2}areas is less suitable, 5.27 km^2 area is moderate suitable, 11.55 km^2 area suitable for dumping waste. Suitable area obtained in the analysis is shown in the Figure11.

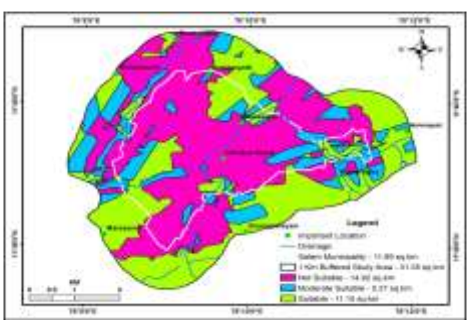

Fig. 11 Final output map of Waste disposal

Conclusion

The outcome generated through the GIS analysis is discussed in this section. Total area in our project including buffer zone covers 31.35 km^2. The results show that 14.92 km^2 areas are less suitable, 5.27 km^2 area is moderate suitable, 11.55 km^2 area suitable for dumping waste.

The rainfall data interpretation during the years 2004 to 2013 reveals the rainfall pattern and it is widely fluctuating. Average annual rainfall varied from 643 mm to 1152.95 mm. The entire study area was received in lowest rainfall during the study period.

The depth to water level was shallow during northeast monsoon season of the year 2011 to summer 2012. A gradual increase in water level from 2007 to 2011 was observed. In top most portion of the study area water level was found to be at shallow depth in all the seasons. The water level data spatial distribution map reveals that shallow depth water level was noticed at the foot hill of Shervorayan (Shallow Water Level Portion). Deeper depth of water level was noticed in and around Kumaragiri, therefore this area is classified as more suitable location for waste disposal.

Geologically Fissile Hornblende Biotite Gneiss occupies major portion of the study area followed by charnockite and Alluvium. Charnockite areas are favourable site for waste disposal. Geophysical survey result reveals that massive charnockites were observed low thickness of soil, the charnockite terrains are the most favorable site for waste disposal.

Suitable categories are found at the area between Ammapet,Kumaragiri, Maniyanur, Hustampatti and also at Erumapalayam. Determination of suitable sites for the disposal of urban solid waste is one of the major problems in developing countries where the industrial development is adversely affecting the environment. The main environmental issue which should be considered in disposal of hazardous solid waste is the location of its land filling. The proposed method may be used for site selection processes in other conditions and locations where the intensity of introduced parameters shows discrepancies.

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AUTHORS

Dr.R. Shanmu**gam Ph.D,**Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

S.Karthik, B.E. Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

N.Nithyakumar, B.E Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

A Gowtham, B.E Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

S.Sivaraj, B.E Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu

Correspondence Author –
Dr.R.Shanmugam Department of Civil Engineering, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamil Nadu