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Soil Property Mapping of Kazhakuttam Ward using Geographic Information System (GIS)

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Abstract - *Trivandrum being the capital city is one of the most developed cities in Kerala. Many major projects took birth here in the capital city during the last few years. One of the major cities in Trivandrum is Kazhakuttam which is now colloquially called as "New Trivandrum". Such a growing city does not have a proper geodatabase which could make the civil engineering works easier. The main objective of this study is to create a database of soil properties at 0.5m depth of Kazhakuttam area. Evaluation of soil properties is a very time consuming process that also relies on the memory of the personnel that are responsible for maintaining the database. If such a geodatabase is available and easily accessible, it will be of great advantage for civil engineering works especially geotechnical works. Hence this study aims to investigate the development of a Geographic Information System (GIS) to better manage and disseminate soils information, as developed from soil test results.*

Key Words: ***Soil mapping, Geographic Information system, Digital Elevation Model***

1. INTRODUCTION

Kazhakuttam is a locality in Trivandrum city, the capital of Kerala. It is located on the national highway 66 on the way to Kollam from the city and has gained significance because of proximity to Vikram Sarabhai Space Centre, KINFRA Film and Video Park, Trivandrum International Stadium and Techno Park. Kazhakuttam is a legislative assembly constituency, which is currently being represented by Kadakampally Surendran. Kazhakuttam is a corporation area which consists of 3 wards viz. Kazhakuttam ward (ward no.1), Chanthavila ward (ward no. 2) and Kattayikonam ward (ward no. 3). Kazhakuttam ward comprises of the main city area including Kazhakuttam junction and other basic amenities like hospitals, police station, commercial shops, apartments and dwellings, etc. The geographic coordinates of the study area lies between $8^0$33'30"N to 8 ^{0}36'30"N latitude and $76^0$51'00"E to $76^0$53'30"E longitude. Soil samples from 10 different locations of Kazhakuttam ward were collected and tested.

Soils can be mapped at a range of scales from very detailed at 1:1,250 to 1:5,000 by which the pattern of soils in individual fields can be identified, through to scales of 1:500,000 to 1:500,000,000 which provide only a much generalized picture of the soils of a country or continent.

1.1 Soil Properties

Soil is a natural material having variety of physical properties, most of which are not constant and it is varying from place to place. The properties of soil can be divided as index properties and engineering properties. The main engineering properties are permeability, compressibility and shear strength. Index properties of soils are those properties which are mainly used in the identification and classification of soils and help the geotechnical engineer in predicting the suitability of soils as foundation/construction material.

Therefore the properties of soil such as specific gravity, moisture content, dry density, wet density and consistency limits such as liquid limit, plastic limits and shrinkage limits are the essential for determination of engineering properties of soil, which will help to geotechnical engineer for decision making process of suitability of soil as foundation materials or construction materials. Index properties of soil are the important parameters in geotechnical engineering and they are changing from place to place both along the depth and width of the stratum. If the properties of soil are properly studied and the results of soil exploration correctly understood and intelligently applied to the design and construction of earthworks and structural foundations, failures usually can be avoided. Any field or laboratory soil testing will provide result which is too specific for a particular location to generalize over an extended area.

1.2 Geographic Information System (GIS)

Geographic information system (GIS) is a technological field that incorporates geographical features with tabular data in order to map, analyse, and assess real world problems. The key word to this technology is geography-this means that some portion of the data is spatial. . In other words, data that is some way referenced to locations on earth. Coupled with this data is usually tabular data known as attribute data. Attribute data can be generally defined as additional information about each of the special features. It is the partnership of these two data types that enables GIS to be such an effective problem solving tool through special analysis. USGS defines a geographic information system as a computer based tool for mapping and analysing things that exist and events that happen on earth. GIS operates on many levels. On the most basic level, GIS technology is used as computer cartography that is for straight forward mapping.

2. METHODOLOGY

The GIS maps were created using the ArcMap 10.2, licensed version gis software of ESRI the free version of gis is QGIS which is also very user friendly. The sampling locations were plotted on the boundary map of Kazhakuttam ward. Digital elevation model of the study area was obtained and extracted from United States geological survey official website. From the DEM data obtained slope map was created. The primary data (soil properties tested) of the study area with geographical coordinates was incorporated into GIS worksheet from excel file. Using spatial analyst tools, inverse distance weighted interpolation was done to depict the soil properties at locations where data are unavailable. Thus thematic maps of soil properties at different locations of Kazhakuttam ward was created.

The soil samples were collected at 0.5m depth from 10 different sites in Kazhakuttam ward. Fig. 1 shows the location of sampling points of Kazhakuttam ward.

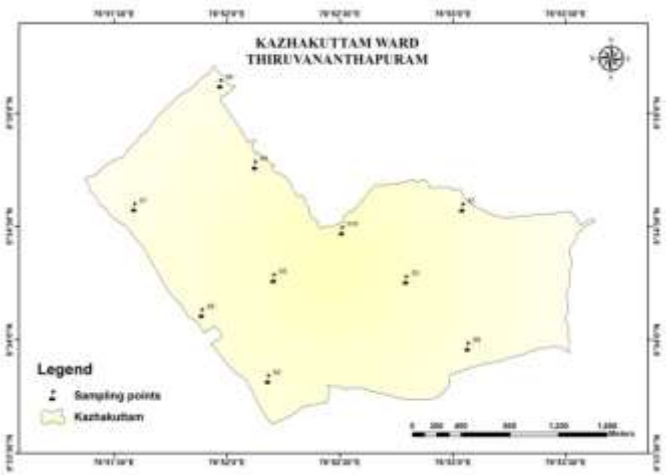

Fig -1: Thematic map showing sampling locations

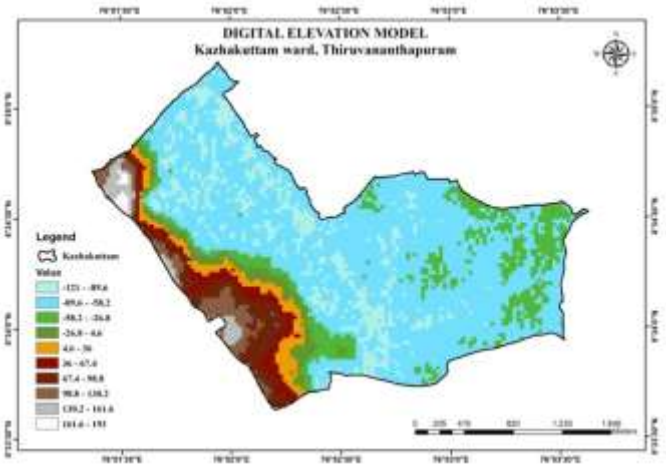

Fig -2: Digital Elevation Model of Kazhakuttam ward

DEM is used to refer any digital representation of topographic surface and is used to determine the terrain attributes such as elevation at any point, slope and aspect. The higher the elevation regions are situated in the western part and lower elevation regions are situated on the eastern part of the area.

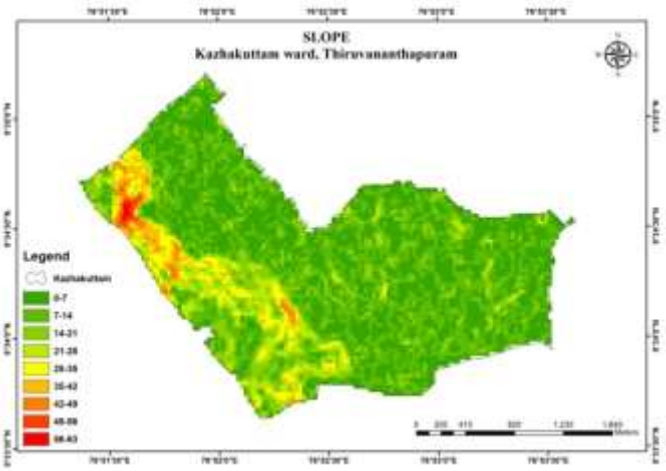

Fig -3: Slope map of Kazhakuttam ward.

Slope identifies the maximum rate of change, from each cell to its neighbours. An output slope raster dataset can be calculated as either a percentage of slopes or a degree of slope. The higher elevation regions are situated in the western part and lower the elevation are situated in the eastern part of the area. Fig. 3 shows the variation in slope in degrees in the study area.

The soil samples were taken from 10 different sites across the study area (Kazhakuttam ward) at a depth of 0.5m below the ground surface. The top soil was removed to collect the soil at 0.5m depth. Thus the soil does not contain plant debris and other litters. The sample number along with name of the site from the sample was collected, geographic coordinates of the location and type of soil prevailing over the area is shown in Table 1.

Table -1: Sampling sites

Sample no.	*Site name*
S_1	Chittattumukku
S_2	Menamkulam
S_3	Perumann road
S_4	Near Al - Saj Convention centre
S_5	Kazhakuttam Police Station
S_6	Vettu road junction
S_7	Kurisadi junction
S_8	KHRI
S_9	Kariyil
S_{10}	Near Ulloorkonam

The soil properties like particle size (percentage of gravel, percentage of sand, percentage of silt and percentage of clay), natural moisture content, compaction characeristics

(maximum dry density and optimum moisture content), specific gravity, engineering properties (permeability and shear strength), consistency characteristics (liquid limit, plastic limit, shrinkage limit and plasticity index) were tested. Table 2 shows the sampling locatios and type of soil there.

Table -2: Sampling location and type of soil

Sample	*Latitude*	*Longitude*	*Type of soil*
S_1	$8^0$34'35.11" N	$76^0$51'35.37" E	SP
S_2	$8^0$33'49.61" N	$76^0$52'10.91" E	SP
S_3	$8^0$34'15.94" N	$76^0$52'47.63" E	CI
S_4	$8^0$34'46.27" N	$76^0$52'7.45" E	CI
S_5	$8^0$34'16.34" N	$76^0$52'12.44" E	SW
S_6	$8^0$35'7.77" N	$76^0$51'58.25" E	CL
S_7	$8^0$34'35.02" N	$76^0$52'2.55" E	CL
S_8	$8^0$33'58.22" N	$76^0$52'3.98" E	CL
S_9	8^0 34'7.06" N	$76^0$51'53.31" E	SW
S_{10}	$8^0$34'28.88" N	$76^0$52'30.54" E	SC

3. RESULTS AND DISCUSSION

The thematic maps of soil properties tested are shown below. The percentage gravel content varied from 0% to 14% across the area. At 0.5m depth from 3 sampling locations gravel was found. The percentage of sand varied from 10% to 100% across the area. At 0.5m depth all samples were found to have sand proportion. The percentage was found using Sieve Analysis Method (IS 2720 Part 4).

The percentage of silt varied from 0% to 42% across the area. At 0.5m depth except at sample collected from Kazhakuttam police station, all other samples were found to have sand proportion. The percentage of clay varied from 0% to 68% across the area. The percentage was found using Hydrometer Analysis Method (IS 2720 Part 4).

Fig. 4 shows the variation in natural water content across Kazhakuttam ward using IDW interpolation technique. The natural moisture content varied from 2% to 35.26% across the area. All samples had moisture content present in them. The percentage was found using oven drying method.

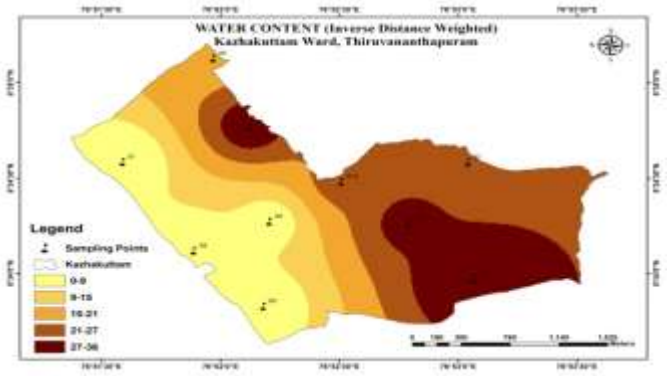

Fig -4: Thematic map for natural water content variation

Fig. 5 shows the variation in dry density across Kazhakuttam ward using DW interpolation technique. The dry density varied from 14.10% to 19.24 % across the area. The percentage was found using Compaction test (IS 2720 Part 7).

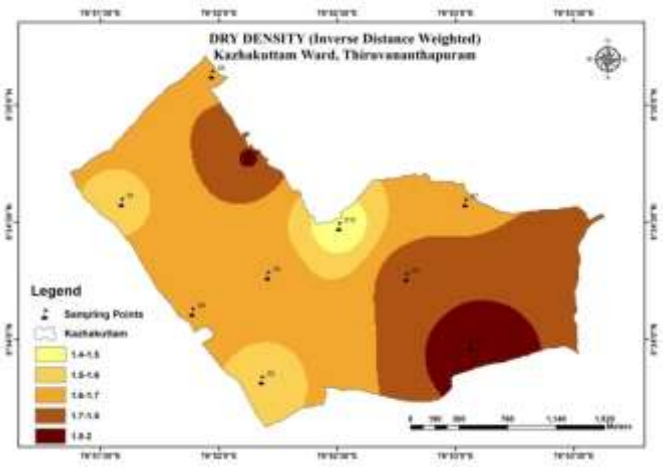

Fig -5: Thematic map for dry density variation

Fig. 6 shows the variation in specific gravity across Kazhakuttam ward using IDW interpolation technique. The specific gravity varied from 2.12% to 2.69 % across the area.

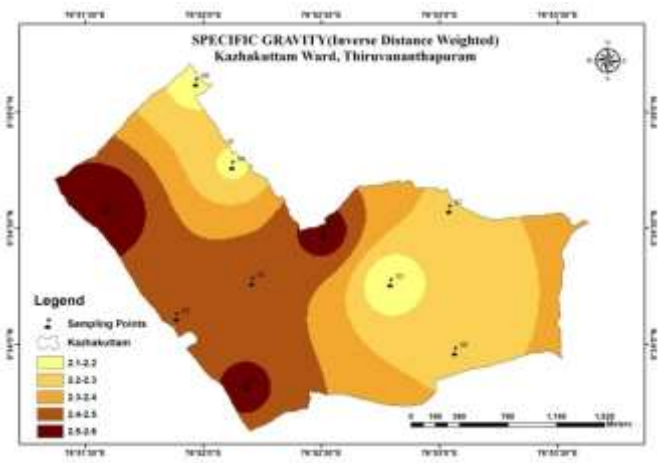

Fig -6: Thematic map for specific gravity variation

Fig. 7 shows the variation in permeability across Kazhakuttam ward using IDW interpolation technique. The permeability varied from 14.10% to 19.24 % across the area. Permeability test result was obtained from the Directorate of Soil Survey and Conservation under Survey of India, Vazhuthacaud.

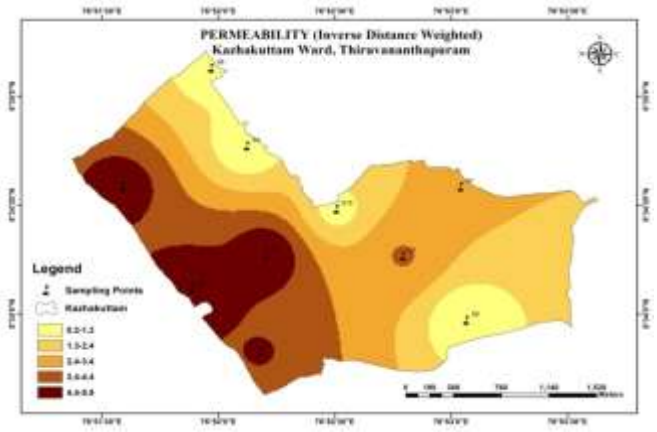

Fig -7: Thematic map for permeability variation

Fig. 8 shows the variation in shear strength across Kazhakuttam ward using IDW interpolation technique. The shear strength varied from 39.86% to 123.37% across the area. The percentage was found using Unconfined compressive strength test (IS 2720 Part10).

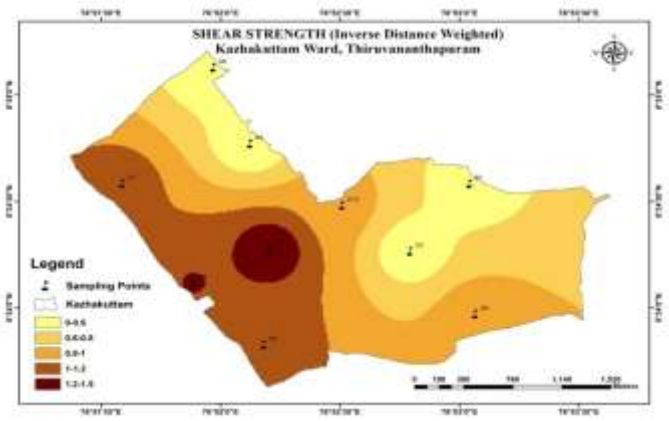

Fig -8: Thematic map for shear strength variation

Fig. 9 shows the variation in liquid limit across Kazhakuttam ward using IDW interpolation technique. The liquid limit varied from 0% to 47.34% across the area. The percentage was found using Atterberg's test (IS 2720 Part 5).

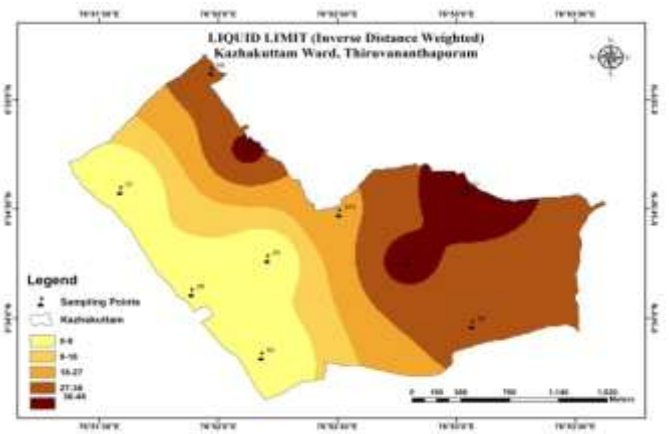

Fig -9: Thematic map for liquid limit variation

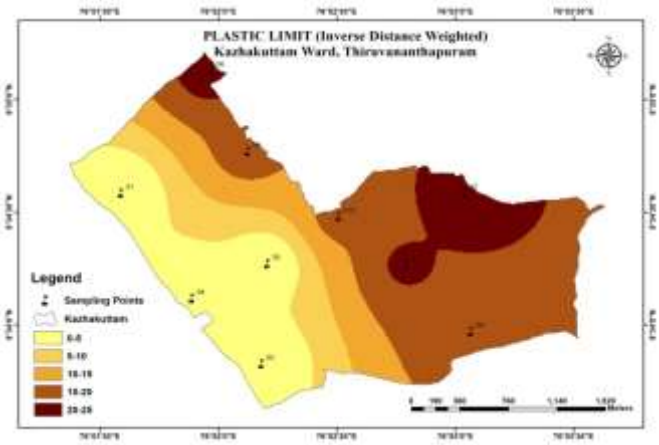

Fig -10: Thematic map for plastic limit variation

Fig. 10 shows the variation in plastic limit across Kazhakuttam ward using IDW interpolation technique. The plastic limit varied from 0% to 24.5% across the area. The percentage was found using Atterberg's test (IS 2720 Part 5).

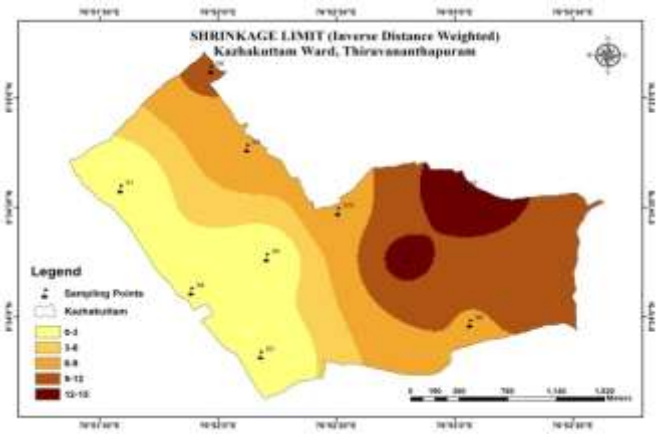

Fig -11: Thematic map for shrinkage limit variation

Fig. 11 shows the variation in shrinkage limit across Kazhakuttam ward using IDW interpolation technique. The shrinkage limit varied from 0% to 14.52% across the area. The percentage was found using Atterberg's test (IS 2720 Part 5).

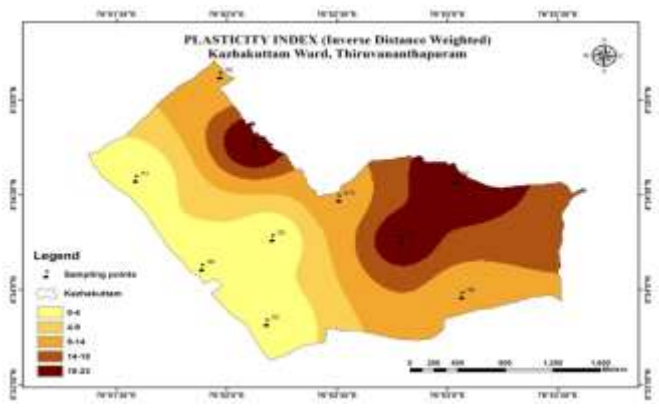

Fig -12: Thematic map for plasticity index variation

Fig. 12 shows the variation in plasticity index across Kazhakuttam ward using IDW interpolation technique. The plasticity index varied from 0% to 22.84% across the area. The percentage was found using Atterberg's test (IS 2720 Part 5).

3. CONCLUSIONS

Index and engineering properties of soils present over Kazhakuttam regions was estimated for creating a database and represent these properties in the form of soil maps using Geographic Information System (GIS). Soil samples from 10 different regions in Kazhakuttam ward was collected and tested as per IS specifications. Geographic Information System (GIS) is cheaper and faster technique than the traditional ones in delineating and mapping soil properties. Such a soil map of Kazhakuttam city will be beneficial for Consultancies, builders, geotechnical aspirants and other related organizations.

- The soil types and properties of Kazhakuttam area varied drastically from point to point. Sandy soil was found in the coastal regions of Kazhakuttam area whereas as we go farther from coastal area, clayey soil was found.
- Similarly the index and engineering properties of soil also varied widely form point to point.
- The thematic maps created using ArcMap 10.2 gives an idea of the different properties of soil found in the study area (Kazhakuttam ward).
- These maps also help in getting ideas of soil properties at locations where soil samples are not tested.
- This helps in the reduction of pre-construction works in the study area by construction agencies as they get an idea of the soil properties prevailing over the area. Thus, reducing the cost and time for soil investigation.
- The analysis demonstrated the capability of ARCGIS tools in visual representation of the spatial trends of different soil properties. IDW interpolation techniques have been used to create thematic maps of the data.

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