Assessment of Groundwater Quality in Ayiroor River Basin, South Kerala,India using Geospatial Techniques

Dissertation Submitted to the University of Kerala
in partial fulfilment of the requirements for the degree of
Master of Science in Environmental Sciences

Submitted by

ALEENA JOSE

Candidate code: 61519100001

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All Saints' College

University of Kerala

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CERTIFICATE

This is to certify that the dissertation work entitled **"Assessment of Groundwater quality of Ayiroor river basin, South Kerala, India using geospatial techniques"** is a bonafied record of the project work carried out by **Ms. ALEENA JOSE (Reg. No. 61519100001)**, IV Semester, M.Sc. Environmental science, All saints' college, University of Kerala under my guidance and direct supervision during the period from March to May 2021. It is also certified that no part of this project has previously formed the basis for the award of any degree, Diploma, Associateship, Fellowship or other similar titles of any University.

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Certified that the dissertation entitled **"Assessment of Groundwater quality of Ayiroor river basin, South Kerala, India: using geo spatial techniques"** is a bonafide record of work carried out at Inter University Centre for Geospatial Information Science and Technology, University of Kerala by **Ms. ALEENA JOSE** of Fourth Semester M.Sc. Environmental Science, All saints' college, University of Kerala under my internal guidance in partial fulfilment of the requirements for the award of M.Sc. Degree in Environmental Science, during the year 2020-2021.It is also certified that no part of this project has previously formed on the basis for the award of any degree, Diploma, Associateship, Fellowship or other similar titles of any university.

Place: Thiruvananthapuram
Date: May 2021

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ABSTRACT

The chemistry of water is an important factor to be considered before its use for domestic, irrigation or industrial purposes. It is now generally recognized that the quality of groundwater is just as important as its quality. Taking into consideration the fact that groundwater occurs in alliance with geological materials containing soluble minerals, higher concentration of dissolved salts are normally expected in groundwater relative to surface water. The type and concentration of salts present in the groundwater depends on the surrounding geological environment, the source of groundwater and movement of groundwater through the rocks.

The quality of groundwater is controlled by several factors, viz., climate, soil characteristics, interaction with the country rocks, saline water intrusion in coastal areas and the human activities on the ground. The study of groundwater quality involves a description of the occurrence of various constituents in groundwater and the relation of these constituents to water use. The quality analysis of groundwater includes the determination of the concentration of cations (such as Na, K, Ca, Mg, etc.) and anions (such as CO_3, HCO_3, Cl, SO_4, NO_3, PO_4, etc), pH, EC, TDS, etc. The present study entitled **Assessment of Groundwater quality of Ayiroor river basin, South Kerala, India using geospatial techniques** attempts to understand various aspects of groundwater chemistry with a special emphasis on the domestic and irrigation water quality. Study area lies between east longitude 76° 39′ 32′′ and 76° 49′ 44′′ and north latitude 8° 43′ 30′′ to 8° 50′ 2′′ at Trivandrum district of Kerala and covering an area of 112 sq. km.

Most of the groundwater samples from the study area shows low pH values and this indicates an acidic nature for groundwater. Except pH, all other parameters like EC, TDS, and other major cations and anions in the study area are within the permissible limit of BIS. Thus, the chemical analysis indicates that the quality of groundwater in the study area is fit for domestic consumption, except in the regions of lower groundwater pH. Thematic maps of the above-mentioned parameters were prepared based on the Survey of India toposheets, auxiliary data and field data. GIS software, ArcGIS was used for the preparation the thematic maps. In the present study, groundwater quality zonation map was prepared based on the data generated by hydrogeochemical analysis. The parameter taken into consideration for the preparation of groundwater quality zonation map for drinking include pH, Calcium, Total dissolved salt and Chloride. The thematic maps were integrated to find out various groundwater quality zones. Numerical weighted parameter rating (WPR) approach and weighted index overlay method of GIS technique was used to delineate various groundwater

quality zones. The study area is divided into four zones such as Very High, High, Medium and Low quality zones based on the index values. The groundwater in the zones depicted as very high can be used for domestic purpose directly. The groundwater in the zones depicted as low should be treated before using for domestic purposes. Most of the study area comes under either medium or high category. The poor-quality zones are found at the north-eastern part and north- western part of the study area.

Suitability of water for agricultural utility was studied with the help of SAR, Residual Sodium Carbonate, Percent Sodium, USSL and Wilcox diagrams. In the USSL diagram most of the samples fall in C1S1 category indicating that these samples are suitable for agricultural purposes. The indices such as Residual Sodium Bicarbonate, Sodium Adsorption Ratio, Percentage Sodium, etc., also reveal the suitability of groundwater resources for irrigation purpose.

CHAPTER-1
INTRODUCTION

1.1 Introduction

Water is one of the lifesaving natural resource on earth. Without water there is no life. Water is one of the most essential natural resources for eco-sustainability and is likely to become critical scarce in the coming decades due to increasing demand, rapid growth of urban populations, development of agriculture and industrial activities especially in semi-arid regions (Hajalilou, B., and Khaleghi, F., 2009). Water covers 71% of the earth's surface mostly in seas and oceans, ocean occupies 97.25% and 2.05% polar ice caps and glaciers. Ground water is an essential and vital component of our life support system. The ground water resources are being utilized for drinking, irrigation and industrial purposes, domestic uses, power production, public purposes etc. However, due to over population, urbanization, industrialization and agriculture activities, ground water resources are being polluted. Groundwater is the most important source of water for irrigation, drinking and national purposes in town as well as city. Groundwater makes up about 20% of the world's fresh water resource, which is about 0.61% of the whole world's water, with oceans and permanent snow. Deterioration of groundwater quality due to different geogenic and anthropogenic activities is of great concern (Buchanan and Triantafilis 2009; CGWB 2010).

Water quality can be defined as the condition of the water including physical, chemical and biological characteristics with respect to its suitability of water for different purposes. Assessing the ground water quality is important to ensure the sustainable safe use of the water resources. water quality analysis is used for the monitoring of water quality whether it is suitable for use or not. Water quality analysis is to ensure whether the water is efficiently usable for designated purposes. Water quality analysis is to understanding the quality of water bodies and monitoring environmental conditions. After many years of research, water quality standards are put in the study area to ensure the suitability of water for different purposes. Water quality analysis is measured by checking the required parameters with the standards. Water quality generally encompasses the physical, chemical, biological, radiological and aesthetic characteristics of the water (Abdul et al. 2010; Ombaka and Gichumbi 2012)

Groundwater is usually considered as cleaner than surface water. But the deterioration and pollution of groundwater occurs due to various anthropogenic activities. Water quality is inherently linked with human health, poverty reduction, gender equality, food security, livelihoods and the preservation of ecosystems, as well as economic growth and social development of our societies (IAH, 2008; UNESCO, 2015). The quality of any kind of water

can be checked with the help of GIS. Geographic Information System (GIS) is a computer system that analyses and displays geographically referenced information. It uses data that is attached to a unique location (USGS). GIS has a vital role in the mapping of groundwater quality and also can monitoring the environmental changes. Consumption of groundwater, however, has increased in areas with negligible surface water resources and GIS is used as a tool to identify the source of water quality pollution by urbanization (Schoeller, 1965; Enwright and Hudak, 2009; Nas and Berktay, 2006; Lee et al., 2003; Lasserre et al., 1999; Selvam et al., 2016; Gopinath et al., 2016). By analysing the quality of water, can find the various parameters those influencing the quality of water and whether the water is potable or can use for any other purposes.

Groundwater pollution is one of the most main environmental and ecological issues in the current world (Vodela et al. 1997; Kanak Mohair et al. 2017). Groundwater quality depends on the parameters like pH, TDS, TH, Ca, Mg, Na etc. Groundwater pollution is one of the most main environmental and ecological issues in the current world (Vodela et al. 1997; Kanak Moharir et al. 2017). GIS software is an effective tool in water quality analysis and important in managing environment. As such, the objective of this study is to explore the groundwater quality in ayiroor river.

1.2 Global Scenario of Water

Our earth is also called as “Blue planet” in which 70% of earth’s surface is covered by water, only 2.5 % of the world is fresh water. Of this only 0.3 % of water is available in rivers, lakes, and reservoir and 30 % of water is the ground water. The rest of the water is stored as glaciers, ice caps etc. The usage of water is increasing everywhere in every year. Currently 69% of all water is used by humans for agricultural purposes and 23% of water is used for industrial purposes and 8% of water is used for domestic purposes like household, drinking water and sanitation. From 23% of water that is used for industrial activities, 59% of total water used in high income countries while 8% of total water is used in low-income countries. These global averages of water vary a great between regions. Nowadays increased usage of water leads to the decreased water resources so availability of water is getting reduced., water availability is decreased to 60% in developed countries in the year of 1950 and 30% in developing countries in the year 2000. It is estimated that water availability will be decreased to 57-58% in developed countries and 23- 24% in developing countries by the year of 2025.

1.3 National Scenario of Water

India accounts for 4% of the world's water resources. India could experience average precipitation of 1,720 cubic meters per year and most of the rain occur during its monsoon seasons. It is estimated that about 38000 million litres per (mld) of wastewater are generated in urban centres due to high population. Because of increase in population the demand of freshwater for all the users will be unmanageable. In India, deterioration of water quality due to change or increase in overall salinity of the groundwater and or presence of high concentrations of fluoride, nitrate, ion, arsenic, total hardness, and a few toxic metals noticed in large areas in several states.

At different locations in India there is a large variation in the amounts of rainfall received. Perusal of the water level data of pre-monsoon 2018 for the country reveals that the general depth to water level of the country ranges from 5 to 20 m bgl and in major parts of the country water level is observed to be in the range of 5 to 10 m. In isolated pockets and in few states such as Assam, Andhra Pradesh, Maharashtra, and Odisha were noticed with very shallow water level of less than 2m bgl. Depth to water level is generally deeper and ranges from about 10 – 40 m bgl in major parts of north-western states of India. The peninsular part recorded a water level in the range of 5 to 20 m bgl. When compare the water level fluctuation of pre-monsoon 2018 with pre-monsoon 2017 shows that there is both rise and fall in water level in almost the entire country. The analysis of water level data in 2018 indicates more than 50% of the wells analysed have registered decline in ground water level in major part of the country, mostly in the range of 0 to 2m (CGWB).

1.4 Kerala Scenario of Water

Kerala is a tiny strip of land located in the south-western flank of Western Ghats, of India between North latitudes 80 18' and 120 48' and East longitudes 740 52' and 770 22', occupying only 1.2% of India's total land area. Kerala receives an annual average rain fall of 3m and has a variety of natural and man-made freshwater resources. Rapid economic growth, high population density and human interventions reduced the natural resilience of almost all water bearing systems like hills, forests, wetlands etc. Irrigation and drinking water requirements and hydroelectric power projects were reduced the yield or productivity of freshwater sources during summer months. When analysing the available data, it reveals that during the last 100 years, the per capita water availability in Kerala has decreased by about 5 times (D. Padmalal, 2019).

As per the 2011 Census, about 62% of the population of Kerala depends on groundwater for the purpose of drinking alone. The latest estimate (2008-09) of the Groundwater Resource Potential

formations at various depths. Geology of the ayiroor river basin is shown in (Figure 4.1). It mainly comprising of 4 rock types namely Khondalite group of rocks, Charnockite group of rocks, migmatite complex, Sandstone and clay with lignite intercalations and some portion is covered by Water bodies, tank and river. The major rock type is sandstone (intercalated with clay and lignite), which covers an area of 60.35 square kilometers or 53.57% % of the area of the basin which mainly seen on the north western part of the basin with tank, water bodies and river. The second major rock type is khondalite group of rocks which covers an area of 23.24 square kilometers or 20.63% of the area of basin seen on the north eastern part of the basin with minor patches of charnockite group of rocks and some migmatite. Migmatite complex, is the another most abundant rock type in ayiroor basin, which covers an area of about 22.46 square kilometres or 19.93% of the basin which mainly seen on the central part of the basin. Charnockite group of rocks which covers an area of 0.75 square kilometers or 0.66% of the area of basin and tank, water bodies and river covers an area of 5.72 square kilometers or 5.07% of the area of basin. Geological map of the ayiroor basin is shown as Fig 4.2.

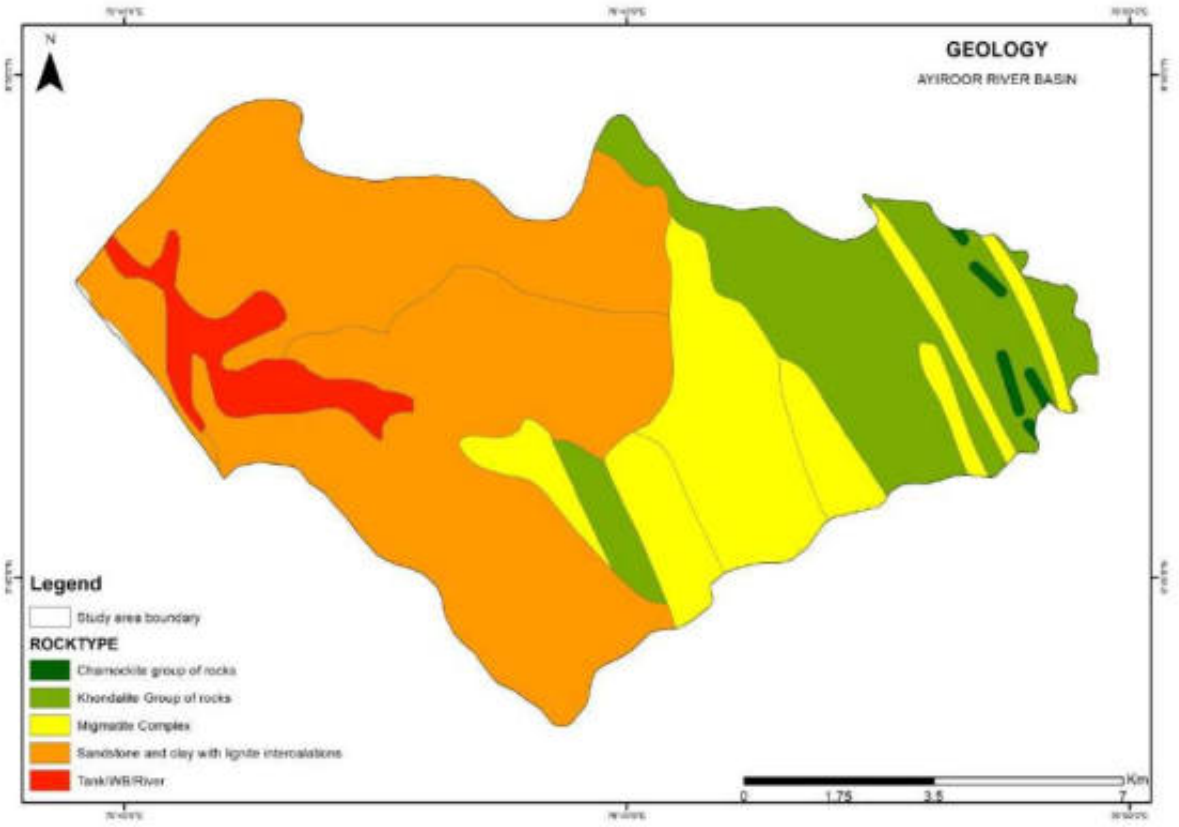

Fig.4.2 Geology of the study area

4.3. Geomorphology

According to the Ground Water Information Booklet of Trivandrum, the district is classified into three distinctive topographic units from west to east such as lowland (coastal

plains), midlands and highlands. Physiographically, the district has a very rugged topography. Ayiroor river basin consists of three geomorphological units, such as coastal plain, Pedi plain, plateau. The plateau (Lateritic)-dissected is the main geomorphological unit found in this basin, it covers about an area of 89.32 square kilometres (79.30% of the area of basin) and the second main geomorphological unit found in the basin is coastal plain which covers an area of 10.32 square kilometres (9.16% of the area of basin) followed by the Pedi plain which covers an area of 7.64 square kilometres (6.78% of the area of basin) and water bodies covers an area of 5.22 square kilometres(4.63% of the area of basin). Geomorphological map of the ayiroor basin is shown as Fig 4.3.

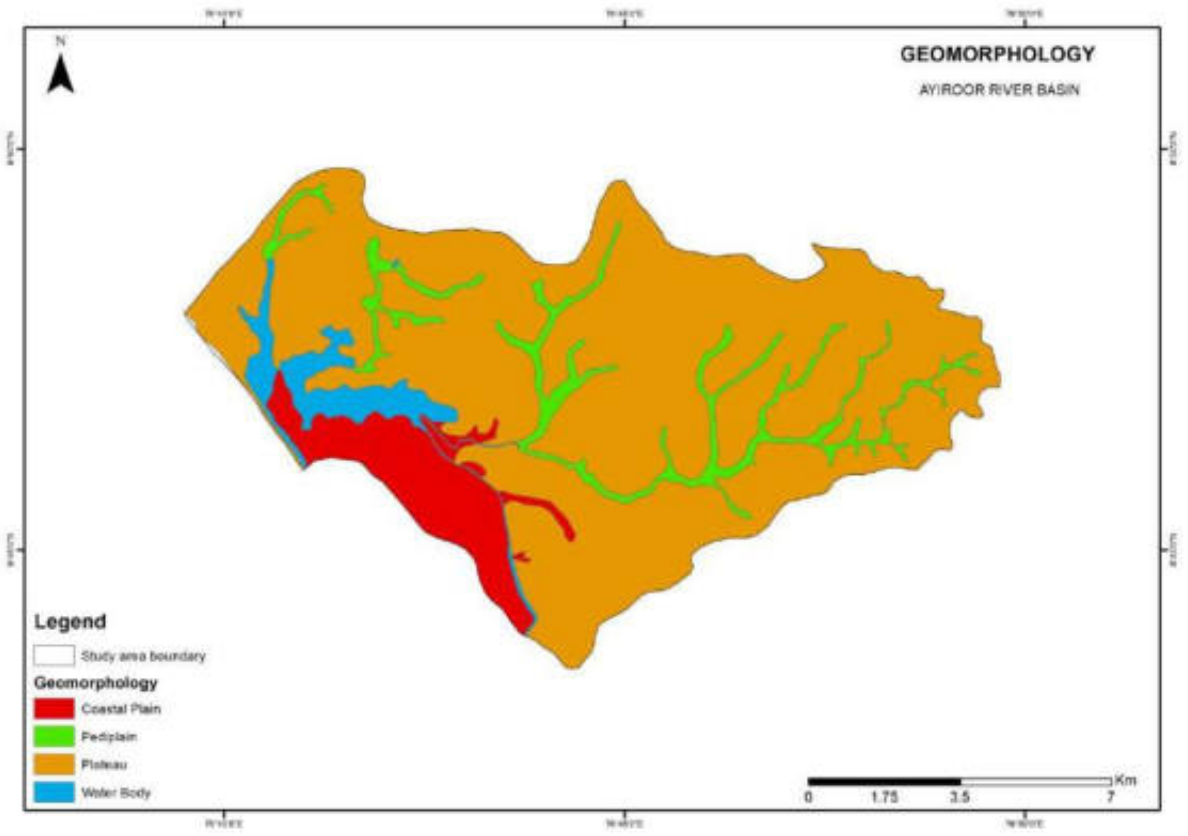

Fig. 4.3 Geomorphology map of the study area

4.4. Land Use

Land use and land cover patterns provide information about soil moisture, infiltration and runoff, which are controlled by the nature of surface material. In general land use means the land which is used for agriculture, mining purposes etc. Land cover means removing the upper layer of the soil and used for constructions like buildings, lakes etc. (Prabhu & Venkateswaran, 2015). Ayiroor river basin shows many land use classes such as agriculture,

Built-up (Cities/Town/Villages), Double crop (Kharif+Rabi), Wastelands and Water bodies. Agriculture is the major land use which covers an area of 96.92 square kilometers (86.07%) followed by wastelands which covers an area of 8.33 square kilometres (7.39%)of the total area of basin and Built-up (cities/towns/villages) covers an area of 5.26 square kilometres (4.66%) of the total area of basin. The remaining area is followed by water bodies which covers an area of 1.55 square kilometres (1.37%) and double crop (kharif+Rabi) which covers an area of 0.46 square kilometres (0.40%) of the total area. Land use map of the ayiroor river basin is shown as Fig 4.4.

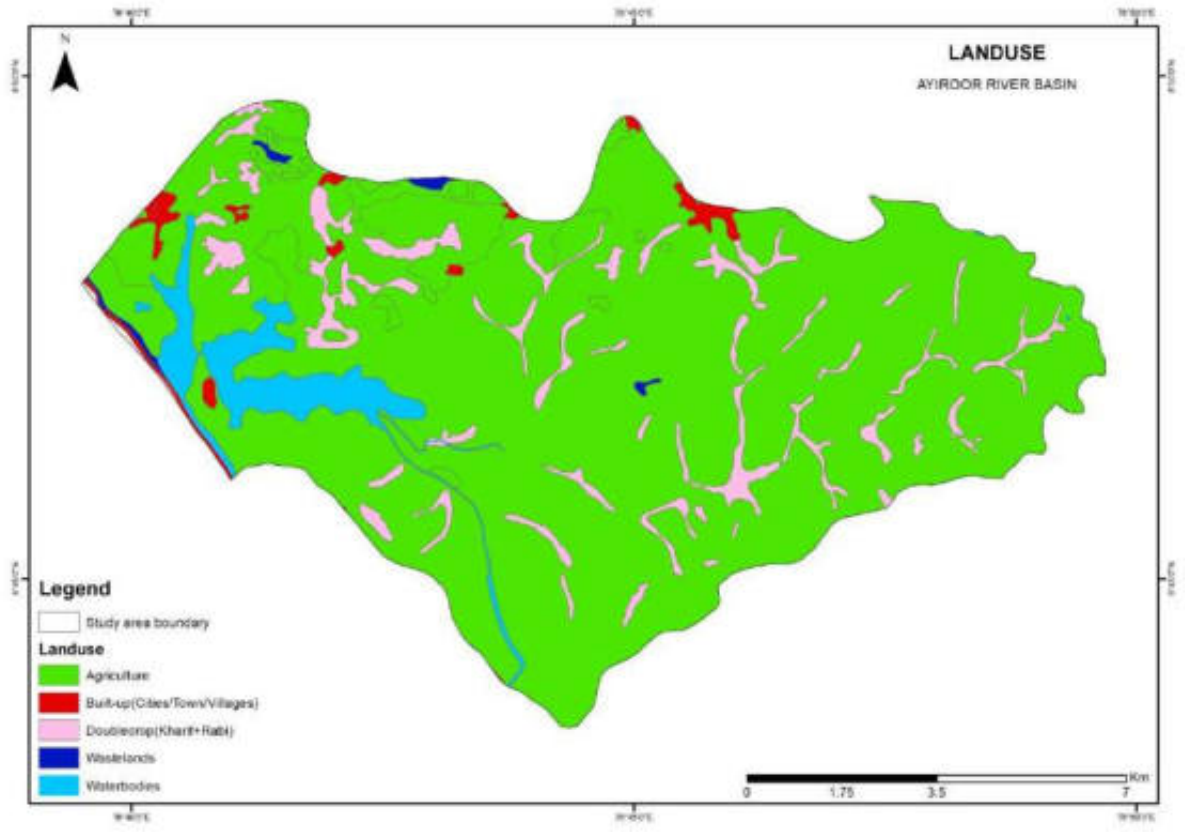

Fig 4.4 Land Use/ Land cover map of the study area

4.5. Slope

The slope is the rate of change of elevation. It can be gentle or steep. Slope is explained by horizontal spacing of contour. The closely spaced contours represents steeper slope and spaced contours represents gentle slope. The slope influences direction and amount of surface runoff or subsurface drainage and is directly proportional to the runoff. Therefore, the groundwater recharge will be lesser in the areas with steep slope. The slope in degrees was estimated from the Digital Elevation Model (DEM), which was obtained from the contour in the topographical map. The identified slope categories of the study area vary from 0 to 28 degree and are classified

into four classes like, 0 – 7, 7.1– 14, 15 – 21 and 22– 28 degrees. The concentration of major chemical parameters varies according to the slope .Slope map of the ayiroor river basin is shown as fig 4.5.

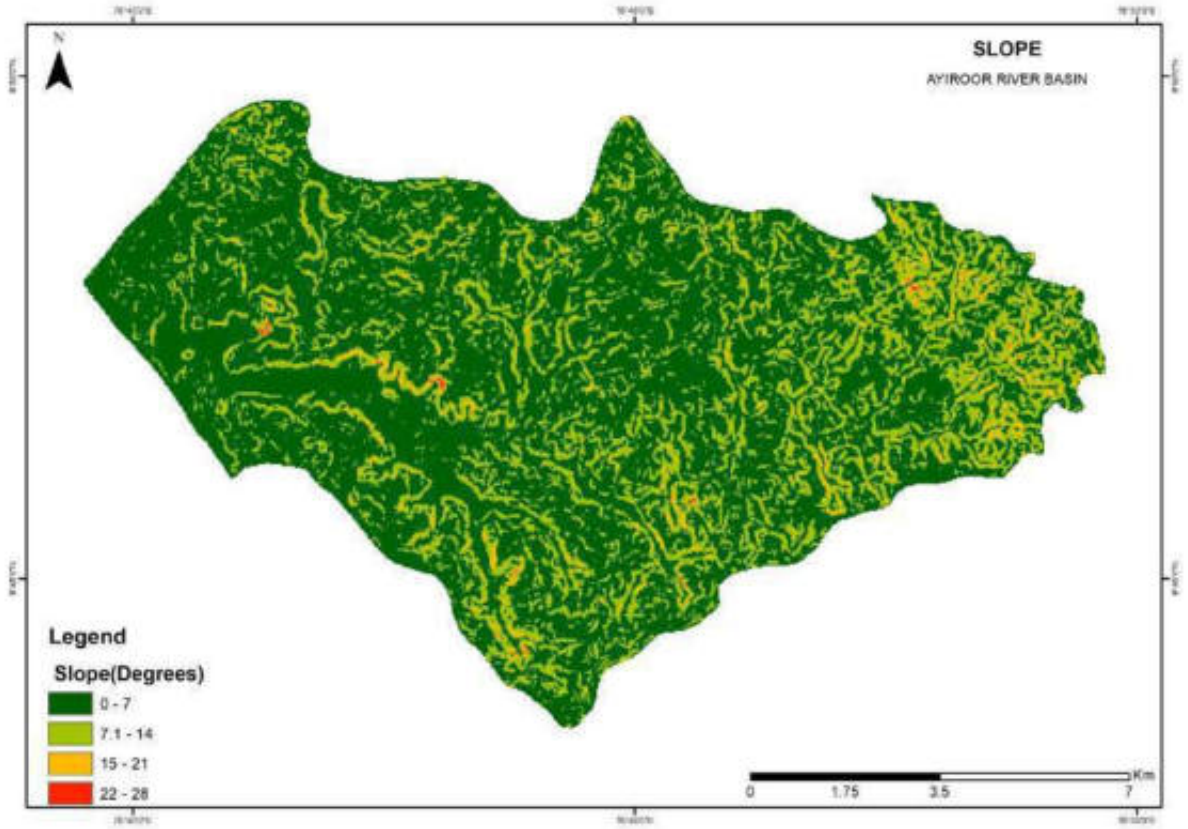

Fig 4.5 slope map of the study area

4.6. Soil Texture

Soil texture of a particular area determines the depth of water table and thus giving an idea about the groundwater condition of that particular area. Ayiroor river basin comprises of two types of soil texture, such as gravelly clay, sandy and remaining part is covered with waterbody. Gravelly clay is the major texture type found in the basin which covers an area of 88.73 square kilometres or (78.77% of the area of basin). The second type of texture found in the basin is sandy clay which covers an area of 16.85 square kilometers or (14.95 % of the area of basin) and the remaining part of the area is followed by water bodies which covers an area of 6.94 square kilometres or (6.16 % of the area of basin). Soil texture map of the ayiroor river basin is shown as fig 4.6.

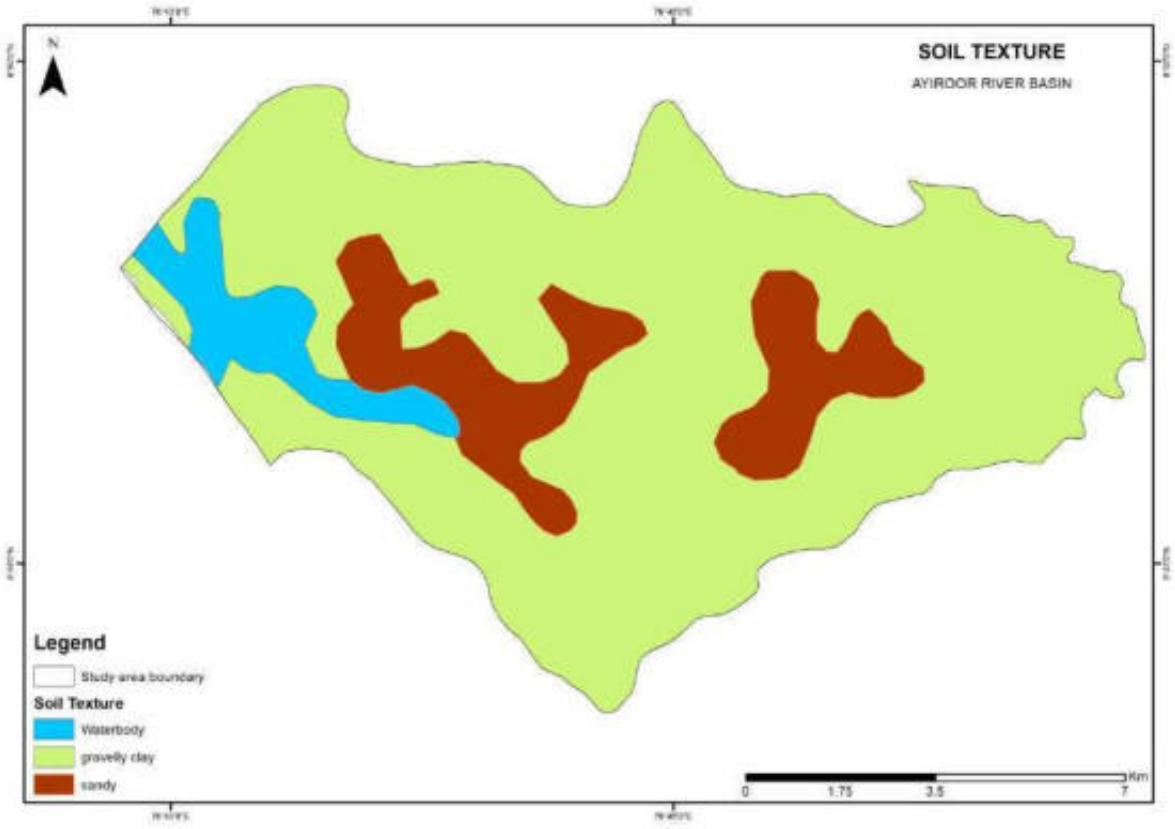

Fig 4.6 soil texture map of the study area

4.7. Overview of the study area

GIS is used for the analysis of the physiographical parameters like geology, geomorphology, land use, and slope and soil texture. In the study area, geology mainly comprises of 4 rock types namely Khondalite group of rocks, Charnockite group of rocks, migmatite complex, Sandstone and clay with lignite intercalations in which major type of rock found in the basin is sandstone. There are three geomorphological units found in the basin such as coastal plain, Pediplain, plateau in which the plateau is the main geomorphological unit found in this basin.,. Agriculture is the major land use class in the study area and the slope of the study area varies from 0 to 28 degrees. Soil texture of study area includes gravelly clay, sandy and remaining part is covered with water body in which Gravelly clay is the major texture type found in the basin.

CHAPTER 5
METHODOLOGY

5.1 Introduction

Geology, geomorphology, geochemical parameters like pH, TDS, Calcium and chloride are provide the valuable information of the groundwater quality analysis, therefore these parameters are considered as the controlling factors of groundwater quality. Thematic maps of the above-mentioned parameters were prepared based on the Survey of India toposheets, auxiliary data and field data. In GIS software, ArcGIS were used for the preparation of thematic maps.

5.2 Data sources

- Survey of India Toposheets
  58D/9SE (1:25000 scale)
- Auxiliary data
- Field data

All the geochemical datas collected from IIUCGIST, Karyavattom campus, University of Kerala. This study was conducted during December 2018. Thirty groundwater samples were collected from ayiroor river basin lying in Urban, and Rural settings. These samples were collected only from dug wells of the study area. The samples were directly collected in pre-cleaned polyethylene bottles of 1 L capacity and stored. Electrical conductivity, pH and total dissolved solids for the collected samples were measured in the field immediately after sampling using water analysis kit. The concentrations of major ions in the water samples were determined at the laboratory using the standard analytical procedures described in (APHA (2012), Trivedi and Goel, (1986). The ionic charge balance equation and ionic balance error computation methods (Mathhess, 1982; Domenico and Schwartz, 1990) were used to check the accuracy of all chemical analyses. These methods considered the relationship between the total cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and the total anions (Cl^-) for each groundwater analysis and calculated the error percent/reaction error/cationic and anionic balance (E) of samples as

$$E = \frac{\sum cations - \sum anions}{\sum cations + \sum anions} \times 100$$

Where the sum of major cations and anions are expressed in meq/L. The reaction error of all groundwater samples was less than the accepted limit of ±10% (Mathhess, 1982), thus supporting the precision of the data.

6.9.4 U. S Salinity Diagram

The U.S salinity diagram (Fig 6.23) based on EC values and SAR values enables quality rating of irrigation water. Based on SAR values of irrigation water are classified into four classes. According to the USSL salinity diagram 21 samples are C1S1 category which indicates that those samples are suitable for agricultural purposes whereas, 5 samples are falls under C2S1 category which indicative of medium alkalinity. And 3 samples are falls under C3S1 category which indicate high salinity and low alkalinity and one sample falls in C3S2 it indicates high salinity and medium alkalinity Table 6.14 showing the classification of water based on EC. (Wilcox, 1955)

Electrical Conductivity	Class
0 -250	C1 Low Salinity hazard
250- 750	C2 - Medium salinity hazard
750 - 2250	C3 High salinity hazard
> 2250	C3 High salinity hazard

Table 6.10: Classificaion based on EC (Wilcox, 1955)

6.9.5 Wilcox Diagram

Wilcox (1955) diagram uses sodium percentage and EC values for classifying irrigation quality. In the diagram, X axis shows electrical conductivity, is measured in units of micromhos/cm and Y axis shows sodium percentage (Fig.6.24). The sodium percentage (Na%) is calculated by using following formula:

$$Na\% = \frac{Na^{2+}+K^{+}}{Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}} \times 100$$

For the study area, the chemical data of groundwater samples are plotted in the Wilcox's diagram (Fig.6.24). It is observed that 26 water samples are excellent to good category in the study area.2 samples falls under permissible to doubtfull category and 2 samples are good to permissible category. Sodium along with carbonate forms alkaline soil; while sodium with chloride forms saline soil; both of these are not suitable for the growth of plants (Pandian and Shankar, 2007). The quality classification of irrigation water based on the values of sodium percentage proposed by Wilcox (1955) suggests that the groundwater of study area is very good to good category.

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Delineation of Suitable Sites for Dumping Solid Wastes in Ayiroor River Basin,South Kerala, India Using GIS And Remote Sensing Technique

Dissertation Submitted to the University of Kerala
in partial fulfilment of the requirements for the degree of
Master of Science in Environmental Sciences

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ANAKHA P K

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2019 - 21

RESEARCH CENTRE AND POST GRADUATE DEPARTMENT OF ENVIRONMENTAL SCIENCES

All Saints' College

University of Kerala

Thiruvananthapuram

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CERTIFICATE

This is to certify that the dissertation work entitled **"Delineation of Suitable Sites for Dumping Solid Wastes in Ayiroor River Basin, South Kerala, India Using GIS and Remote Sensing Techniques"** is a bonafide record of the project work carried out by **Ms. ANAKHA P K (Reg. No.61519100002)**, IV Semester, M.Sc Environmental science, All Saints' college, University of Kerala under my guidance and direct supervision during the period from March to May 2021. It is also certified that no part of this project has previously formed the basis for the award of any degree, Diploma, Associateship, Fellowship or other similar titles of any University.

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CERTIFICATE

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TABLES

FIGURES

ABSTRACT

Solid waste dumping is a serious problem faced nowadays because most solid wastes are not dumped in the suitable areas. Uncontrolled open dumping and improper waste management causes various problems, including contaminating ground and surface water, attracting insects and rodents, increasing flooding and generation of toxic gases. This study was conducted to select potential areas for suitable solid waste dumping sites using GIS and Remote Sensing, which are environmentally suitable. The present study titled **"Delineation of Suitable Sites for Dumping Solid Wastes in Ayiroor River Basin, South Kerala, India Using GIS and Remote Sensing Techniques".** Study area lies between east longitude 76° 39′ 32′′ and 76° 49′ 44′′ and north latitude 8° 43′ 30′′ to 8° 50′ 2′′ situated in the northern part of Trivandrum district and southern part of the Kollam district of Kerala and covering an area of 112 km^2.

Geology, geomorphology, land use, soil texture, mean depth to water table, slope, relative relief and clay percentage are provide the valuable information of the site suitability analysis, therefore these parameters are considered as the controlling factors of site suitable for solid waste dumping". Most important criteria considered for this study is mean depth to water table. The deeper water level is found in the southern part of the basin which is highly suitable area for solid waste dumping. Land use and clay percentage is also important criteria considered. Agricultural, double crop and water bodies are least preferred and wasteland is highly preferred. Areas with high clay percentage are more suitable. Other than Steep slope and foot slope are suitable for solid waste dumping. Sites having low relative relief highly suitable than high relative relief. Geomorphological unit like plateau is highly suitable than coastal plain and water bodies. Rock type like Charnockite is highly suitable than other rock type in the study area. Thematic maps of the above-mentioned parameters were prepared based on the Survey of India toposheets, auxiliary data and field data. GIS software, ArcGIS were used for the preparation those thematic maps. Thematic layers were subjected for ranking and weightage and overlay analysis carried out. The resultant raster layer is divided into three zones such as Not suitable, Moderately suitable and Highly suitable based on the index values. The site depicted as highly suitable can be used for dumping solid waste. The site depicted as not suitable should be prohibited from dumping waste. The most of the study area comes under moderately suitable category and other area includes not suitable and highly suitable zones. The zones are highly suitable zones found mainly at the southern part of the study area and the major portion of the study area comes under moderately suitable zone.

CHAPTER 1
INTRODUCTION

1.1 Introduction

Waste is a material discharged and discarded from each stage of daily human life activities, which leads to adverse impacts on human health and the environment (Bringi, 2007); whereas, solid waste refers to the leaves/ twinges, food remnants, paper/cartons, textile materials, bones, ash/dust/stones, dead animals, human and animal excreta, construction and demolishing debris, biomedical debris, household hardware (Babatunde et al., 2013). Solid waste is a global environmental problem in today's world both in less developing and developed countries. Increasing population, rapid economic growth and the rise in community living standards accelerate solid waste generation in the world (Elmira et al., 2010). Solid waste has become a global environmental and health issue in the contemporary world both in developing and developed countries (UNEP, 2005; United Nations, 2017). Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes (Tchobanoglous et al., 2002). Landfill is the only easy and cost effective management system used in many parts of the world to dispose of solid wastes (Yadav, S. K. 2013). Landfilling is the process that the solid wastes which cannot be recycled or further used are placed in a landfill (Rema, 2010).

The most important problem facing now a days is solid wastes generation and its increasing amount is mainly due to rapid economic growth, population increase and rise in community living standards. Insufficient dumpsites leading to a creation of patches of dumpsites all over the places; and an inadequate organized system of waste handling for a major part of the city (Ramachandran J et al., 2015). Since solid waste is the main problem facing now a days, its disposal is also taken into concern. Proper landfill site selection is the fundamental step in sound waste disposal and the protection of the environment, public health and quality of life. (Ball, J. 2005). Most solid waste disposal sites are found on the boundary of the urban areas where there are water bodies, crop field, settlement, around road, etc. These are suitable sites for the incubation and spread of flies, mosquitoes and rodents. They transfer diseases that affect human health (Abul, 2010). Unscientific solid waste disposal can develop contamination of surface and groundwater through leaching surface waste deposits, air pollution, soil contamination, spreading of diseases and uncontrolled release of methane (Visvanathan & Glawe, 2006). The decomposition of solid waste produces landfill gases such as methane (CH4), carbon dioxide (CO2) and other trace gases (MeBean et al. 1995; Suchitra 2007; IPCC-AR5 2014). The unscientific solid waste dumping degrade the quality of drinking water through the penetration

of leachate into groundwater (Tripathi et al. 2006); and cause various diseases like jaundice, nausea, asthma, miscarriage, infertility etc. (El-Fadel et al. 1971). Solid wastes indiscriminately thrown around human environment also results in aesthetic problems and nuisance (Hammer, 2003). The Contamination of groundwater and soil is the major environmental risk related to unsanitary landfilling of solid waste. The people in and around the dumping site are depending upon the ground water for drinking and other domestic purposes. The soil pollution arises due to the leaching of wastes from landfills. (Raman et al.,).

Site selection for waste disposal is meant for a long period of time and should be done scientifically without disturbing the environmental factors (Asha and Vinod, 2016). Locating proper sites for solid waste disposal and selecting appropriate landfill sites far from residential areas, roads, cultivated areas, rocky terrains, water bodies, environmental resources and settlement is the main issue for the management of solid waste. Inadequate management of solid waste coupled with hot climatic conditions adversely affects the environment at the local level as well as global facet (Taylan et al. 2007; Sumathi et al. 2008).

A number of studies have been carried out by researchers in identifying the potential solid waste disposal site by using GIS and remote sensing techniques (Sumathi et al.,2008; Nishanth et al., 2010; Ebistu and Minale, 2013; Alanbari et al., 2014; Karthiheyan and Yesodha, 2016; Sunder Rajan et al., 2014 and Asha and Vinod, 2016). RS and GIS play an important role in solid waste management. With the help of remote sensing we can cover a very large area for study. For site selection process we require satellite image of study area. It covers a large region and also fine resolution. GIS helps in creating geo database which is very helpful to take a decision. GIS uses both the map data as well as attribute data. We can see the situation at a glance; it is such an effective tool (Kashid et al., 2015). Therefore role of Geographic Information Systems (GIS) in solid waste management is very large one. GIS (geographic information systems) are ideal for preliminary site selection studies because it can manage large volumes of spatially distributed data from a variety of sources and efficiently store, retrieve, analyze and display information (Siddiqui et al., 1996). GIS is a tool that not only reduces time and cost of the site selection but also provides a digital data bank for future monitoring of the solid waste dumping site. (Gizachew et al.,2012; Kontos et al., 2005). Various technical, environmental, economic, regulative, political, and social factors need to be considered when deciding the suitable landfill site.

This study aimed to determine the most appropriate solid waste disposal site for the Ayiroor river basin, Southern Kerala. GIS is utilize to evaluate the entire region based on certain evaluation criteria for the analysis of landfill site suitability and which includes selection criteria such as; Land use, Soil texture, Lithology / Geology, Slope, Geomorphology, Relative Relief,

are seen on the south-eastern part of the basin with narrow bands of Charnockite. The area covered by tank/ waterbody/ river covers an area of 5.72 Km^2 and about 5.08% area of the basin. Lithological map of the Ayiroor river basin is shown as Fig 4.4.

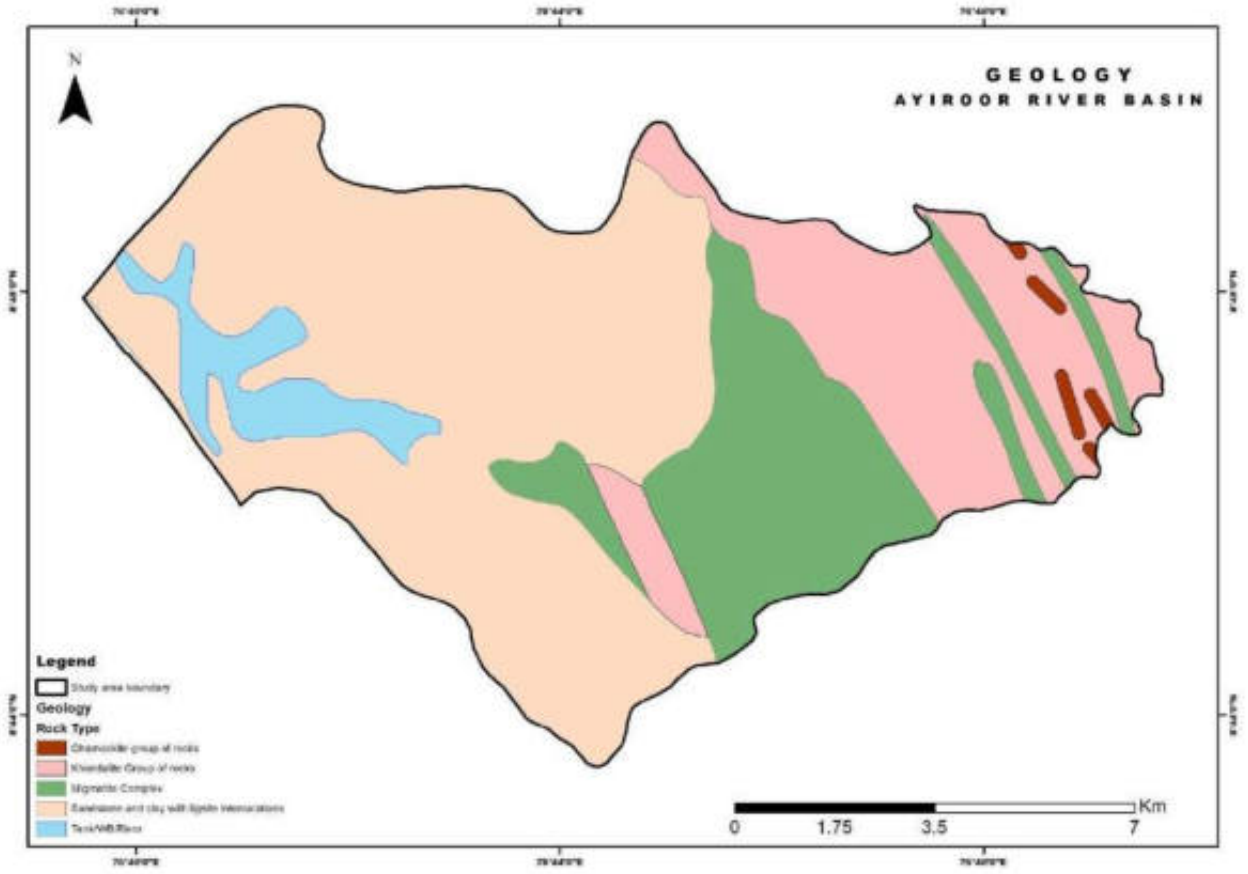

Fig 4.4: Geology map of the study area

4.5 Slope

The slope is the rate of change of elevation. It can be gentle or steep. Slope is explained by horizontal spacing of contours. The closely spaced contours represent steeper slope and distantly spaced contours represents gentle slope. Foot slope and gentle slope is more suitable for solid waste dumping than high slope. Areas with high slopes have high risk of pollution through leaching. The slope influences direction and amount of surface runoff or subsurface drainage and is directly proportional to the runoff. Therefore, the groundwater recharge will be lesser in the areas with steep slope. The slope in degrees was estimated from the Digital Elevation Model (DEM), which was obtained from the contour in the topographical map. The identified slope categories of the study area vary from 0 to 28 degrees and are classified into three classes like 0 - 9.3, 9.4 - 19, 20 - 28 degrees. Slope map of the Ayiroor river basin is shown as Fig 4.5.

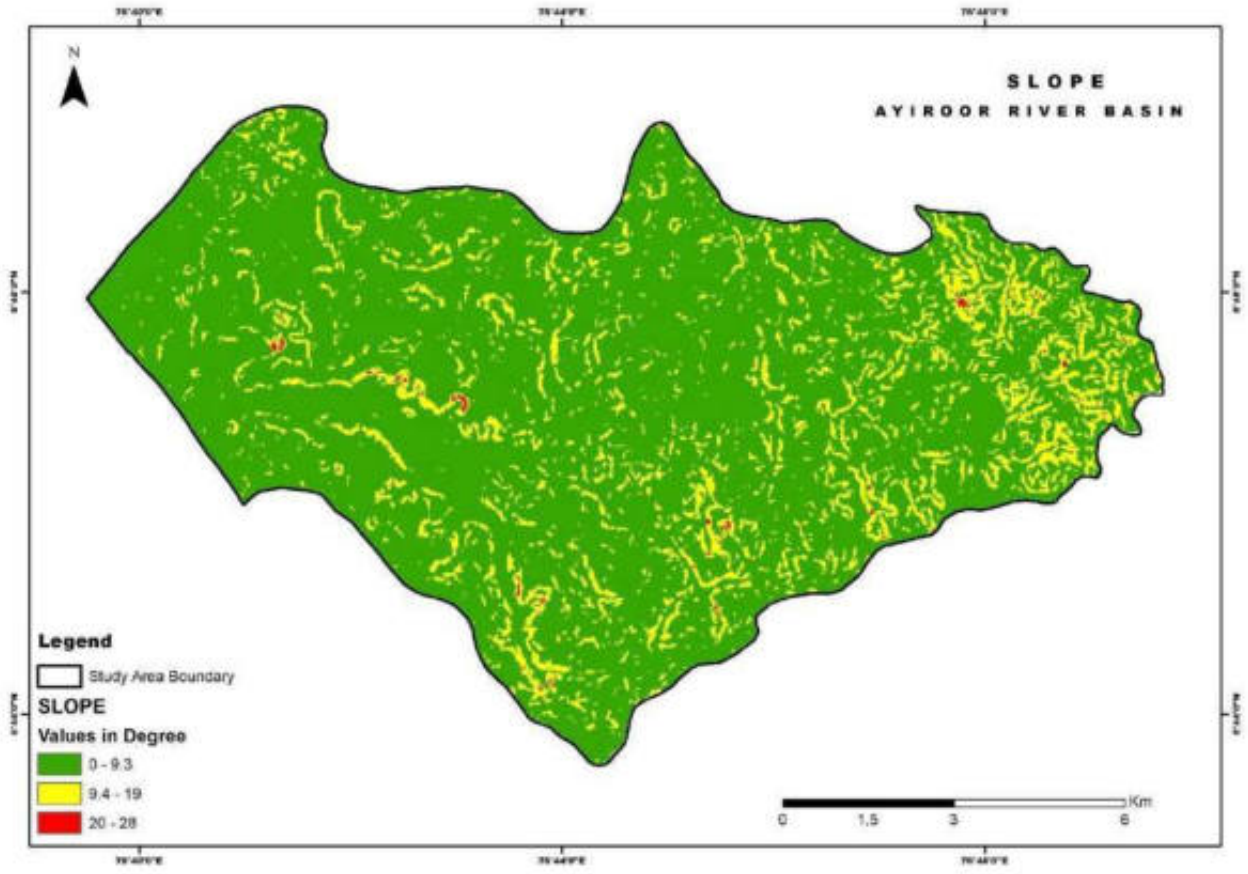

Fig 4.5: Slope map of the Study area

4.6 Clay percentage

Clay is a type of fine-grained natural soil material containing clay mineral (Olive et al., 1989). Clay is used as a natural seal as a barrier in landfills against toxic seepage being impermeable to water. Clay barriers are generally used as liners and capping materials for landfill sites. They isolate potentially polluting wastes from the surrounding environment. Clay % of the study area was collected from IUCGIST. In this study area, clay percentage varies from 0.01 to 4.2 % and are classified into three classes with equal interval such as, 0.014 – 1.4%, 1.5 – 2.8%, 2.9 – 4.2%. Lowest class having the range of 0.014 to 1.4% covering majority of the study area. Other two classes are observed as patches in and around the northern part of the study area. Clay percentage map of the Ayiroor river basin is shown as fig 4.6

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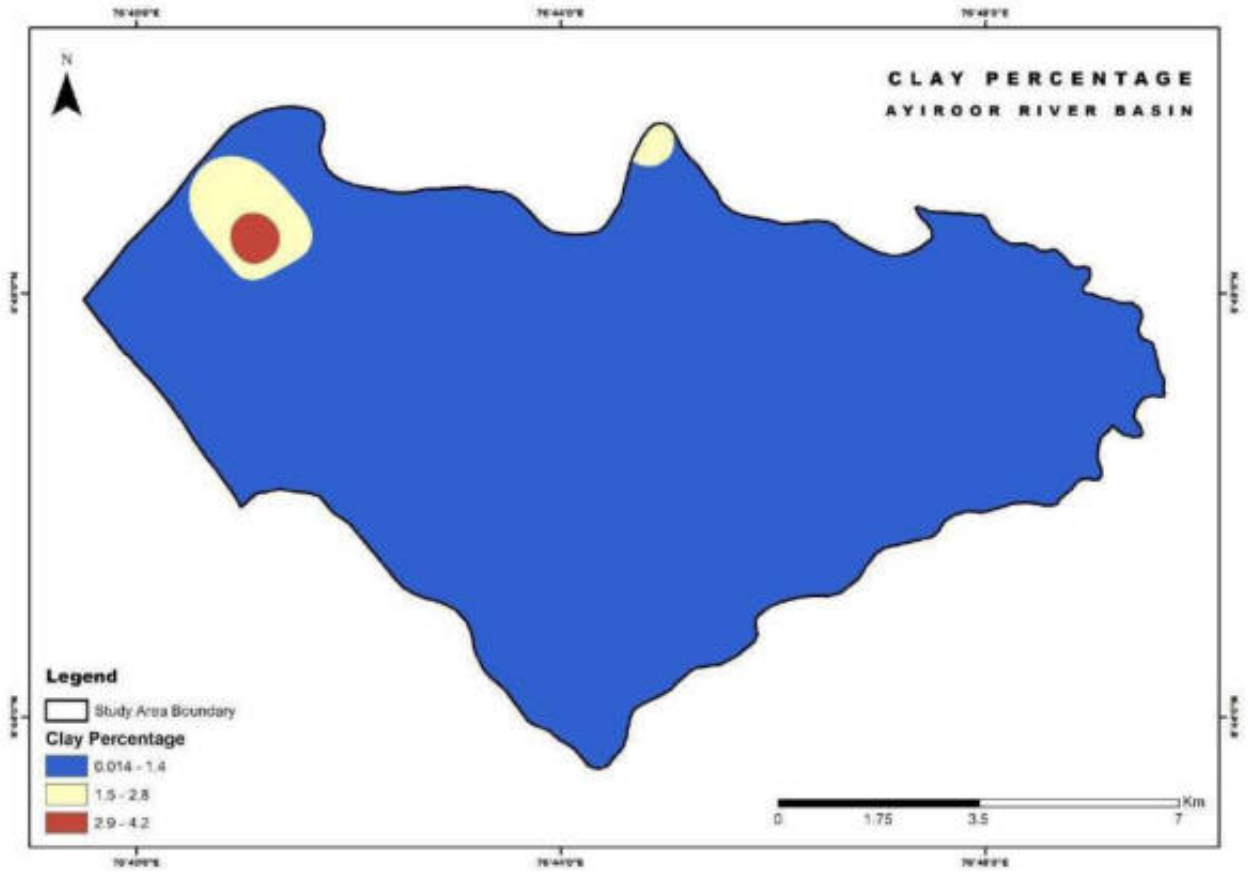

Fig 4.6: Clay percentage map of the study area

4.7 Mean depth to water table

During pre-monsoon period (May 2015), the depth to water table ranges from 4.65 m (AY 22) to 28.8 m (AY 16) and the mean depth to water table is 11.10m. The deeper water level is found at the southern part of the basin. During post-monsoon season (November 2015), the depth to water table ranges from 3.65 m (AY 10) to 26.85 m (AY 16) and the mean depth to water table is 11.10 (Table 4.1). The Spatio-temporal changes in the depth to water table shows (Table 4.1) that the deepest mean water table is at May month and the shallowest mean water table is at November month. The spatial variation of depth to water table shows in the figures 4.7 to 4.9. The mean depth to water table at every location was found out from the seasonal data and is depicted in figure 4.9. The mean depth (Fig 4.9) to water table ranges from 4.38 m to 27.83 m.

Location	Pre-monsoon Water table (m)	Post-monsoon Water table (m)	Mean Depth to Water table (m)
AYR 1	8.3	7.62	7.96
AYR 2	9.3	9.2	9.25
AYR 3	7.87	7.5	7.685
AYR 4	13.19	9.32	11.255
AYR 5	14.25	9.48	11.865
AYR 6	27.5	22.26	24.88
AYR 7	17.1	16.03	16.565
AYR 8	11.52	7.6	9.56
AYR 9	10.54	9.15	9.845
AYR 10	5.1	3.65	4.375
AYR 11	6.6	4.98	5.79
AYR 12	8.7	6.15	7.425
AYR 13	15.2	11.58	13.39
AYR 14	28.07	26.2	27.135
AYR 15	25.2	16.6	20.9
AYR 16	28.8	26.85	27.825
AYR 17	18.7	17.4	18.05
AYR 18	5.8	9.55	7.675
AYR 19	9	11	10
AYR 20	6.4	6.27	6.335
AYR 21	8.24	6.59	7.415
AYR 22	4.65	4.2	4.425
AYR 23	8.8	7.3	8.05
AYR 24	8.8	5.6	7.2
AYR 25	8.7	7.5	8.1
AYR 26	8.38	8	8.19
AYR 27	8.3	7.55	7.925
AYR 28	8.66	5.5	7.08
AYR 29	11	10	10.5
AYR 30	6.7	6.2	6.45

Table 4.1: Depth to water table belowground level (m) in Ayiroor river basin

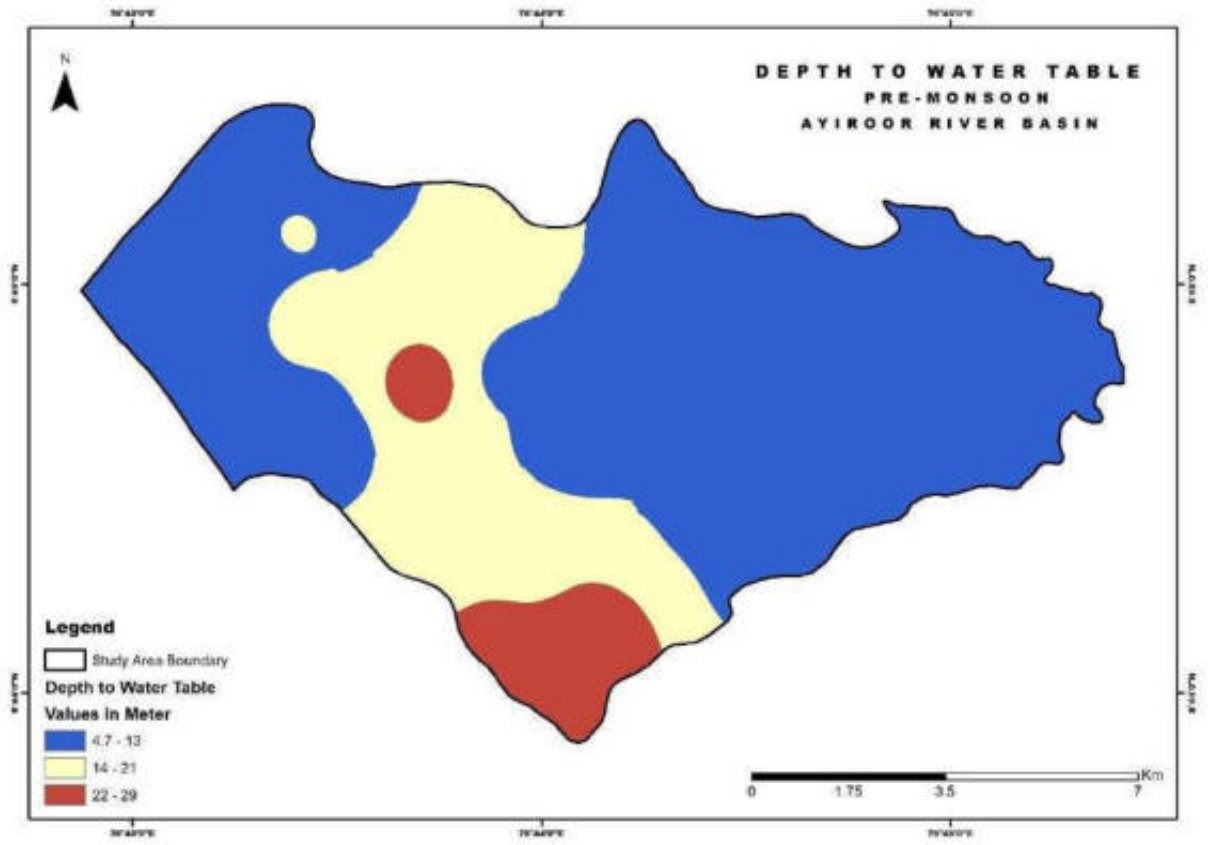

Fig 4.7: Depth to water table during Premonsoon

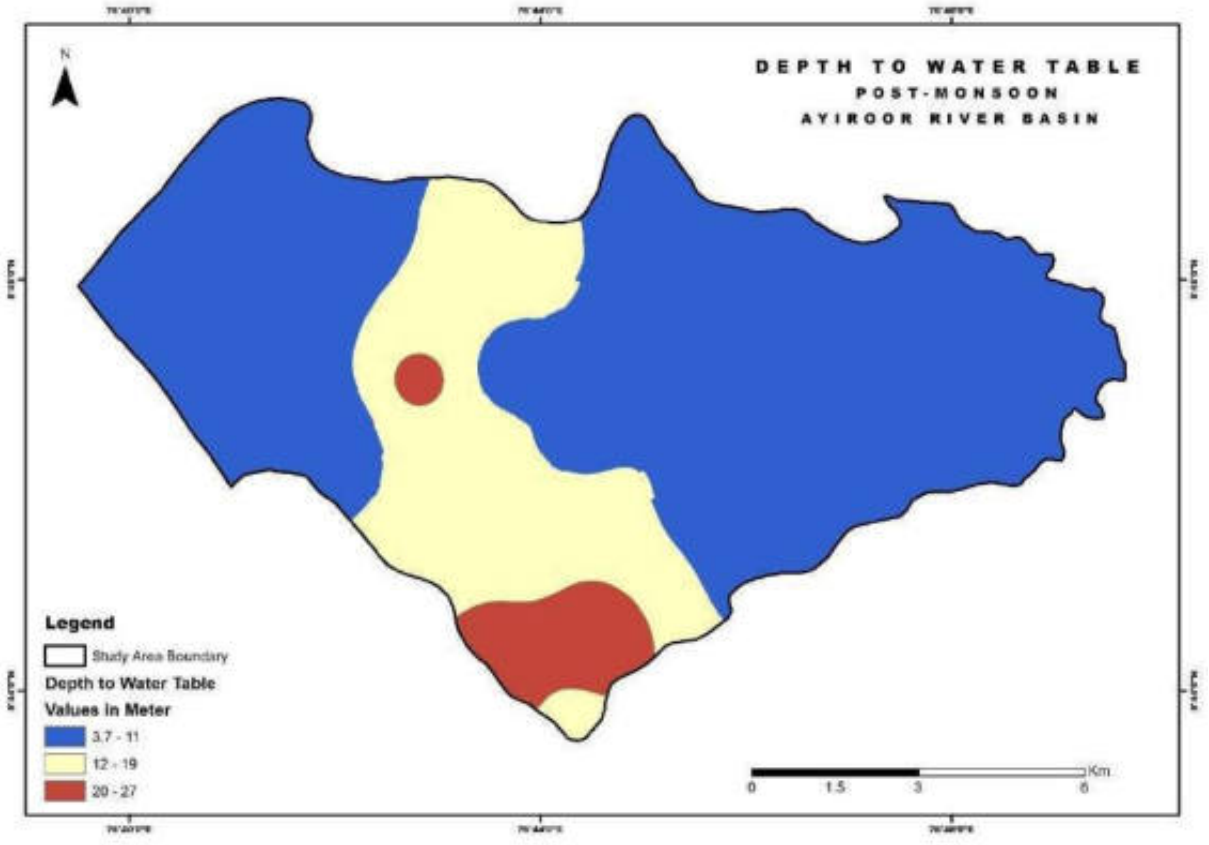

Fig 4.8: Depth to water table during Postmonsoon

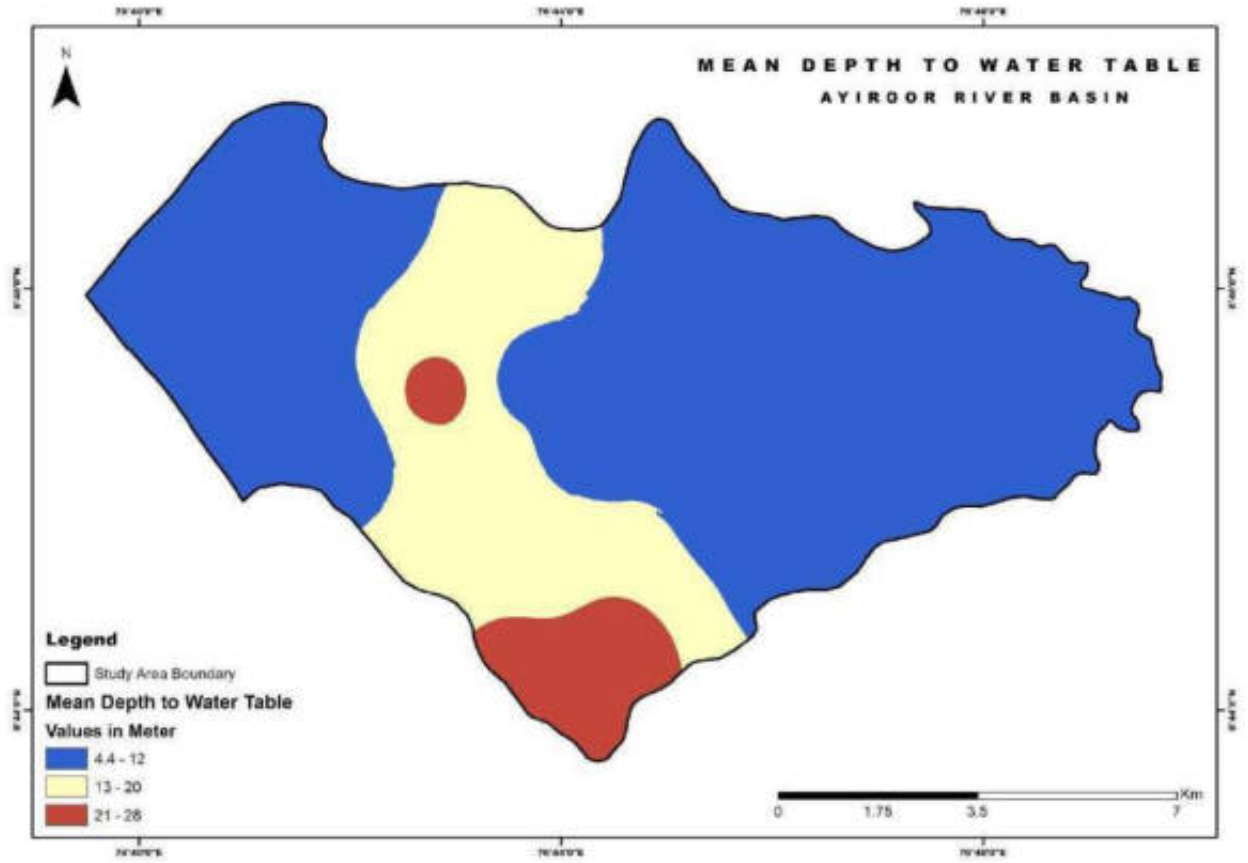

Fig 4.9: Mean depth to water table map of the study area

4.8 Relative Relief

Relative relief termed as 'amplitude of available relief' or 'local relief' is defined as the difference in height between the highest and the lowest points (height) in a unit area. It is an important morphometric variable used for the overall assessment of morphological characteristics of any terrain. The spatial variation of relative relief was found out by dividing the entire basin into grids of $1km^2$ and finding out the relative relief of each and every grid. Later the grid values were used to prepare contours of relative relief. The relative relief varies from 18 to 80 m/km^2 (Fig 4.10) and are classified into three classes such as 18-29m/Km^2 ,40-59m/Km^2, and 60-80m/Km^2. Western part of the basin shows low relative relief whereas the eastern parts are characterized with higher values of relative relief. The Spatial variation of relative relief is shown in fig 4.10.

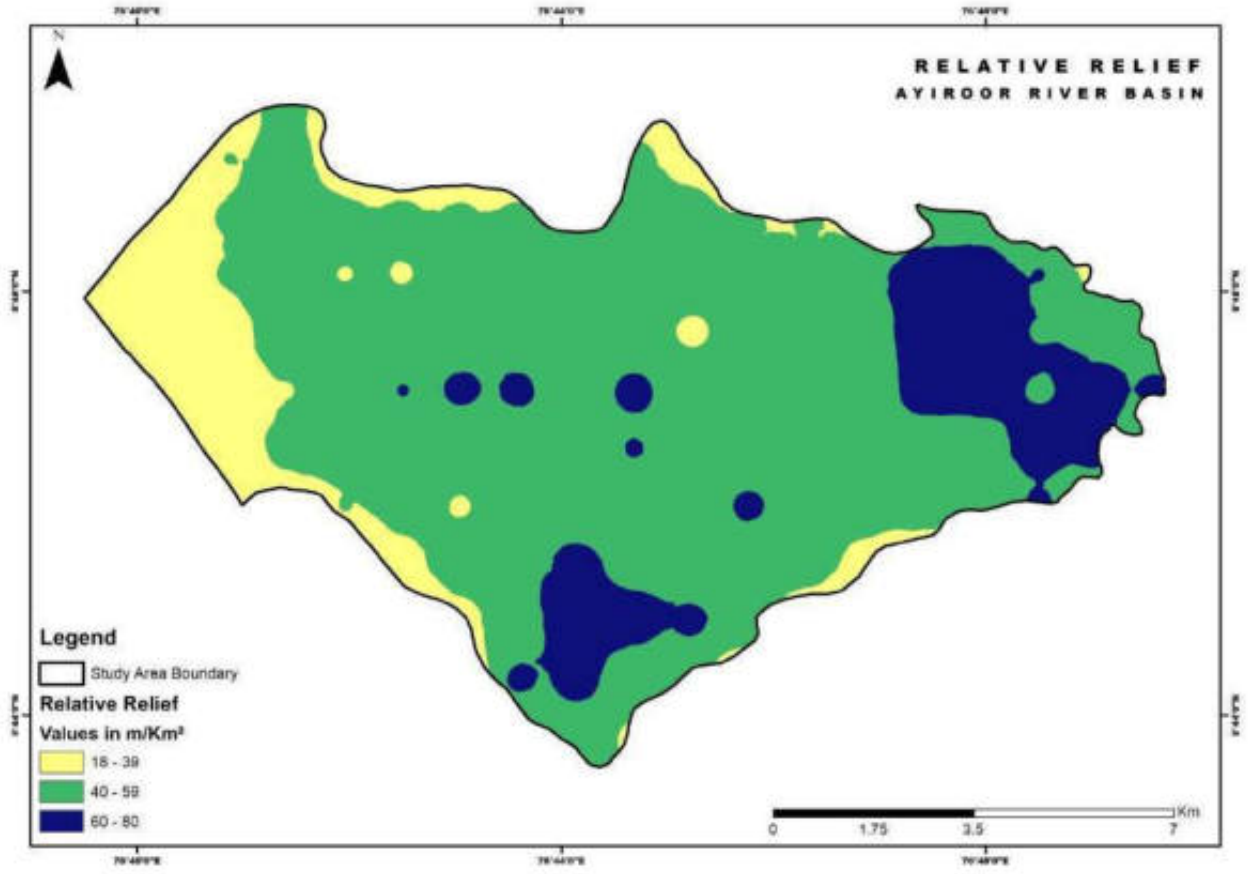

Fig 4.10: Relative relief map of the study area

4.9 Soil Texture

Soil texture of a particular area determines the rate of soil infiltration or water intake to the groundwater body and thus giving an idea about the groundwater conditions of that particular area. Chemical analysis of soil points out the parent rock from which it was derived by weathering. Infiltration rate of a particular area can be studied with the help of soil texture analysis. In order to study the spatial variation in the textural properties of the soil, secondary soil data were used which is collected from IUCGIST.

Gravelly clay is the major texture type found in the basin which covers an area of 88.73 square kilometres or (78.77% of the area of basin). The second type of texture found in the basin is sandy clay which covers an area of 16.85 square kilometres or (14.95 % of the area of basin) and the remaining part of the area is covered with water bodies having an area of 6.94 square kilometres or (6.16 % of the area of basin). Soil texture map of Ayiroor river basin is shown as fig 4.11.

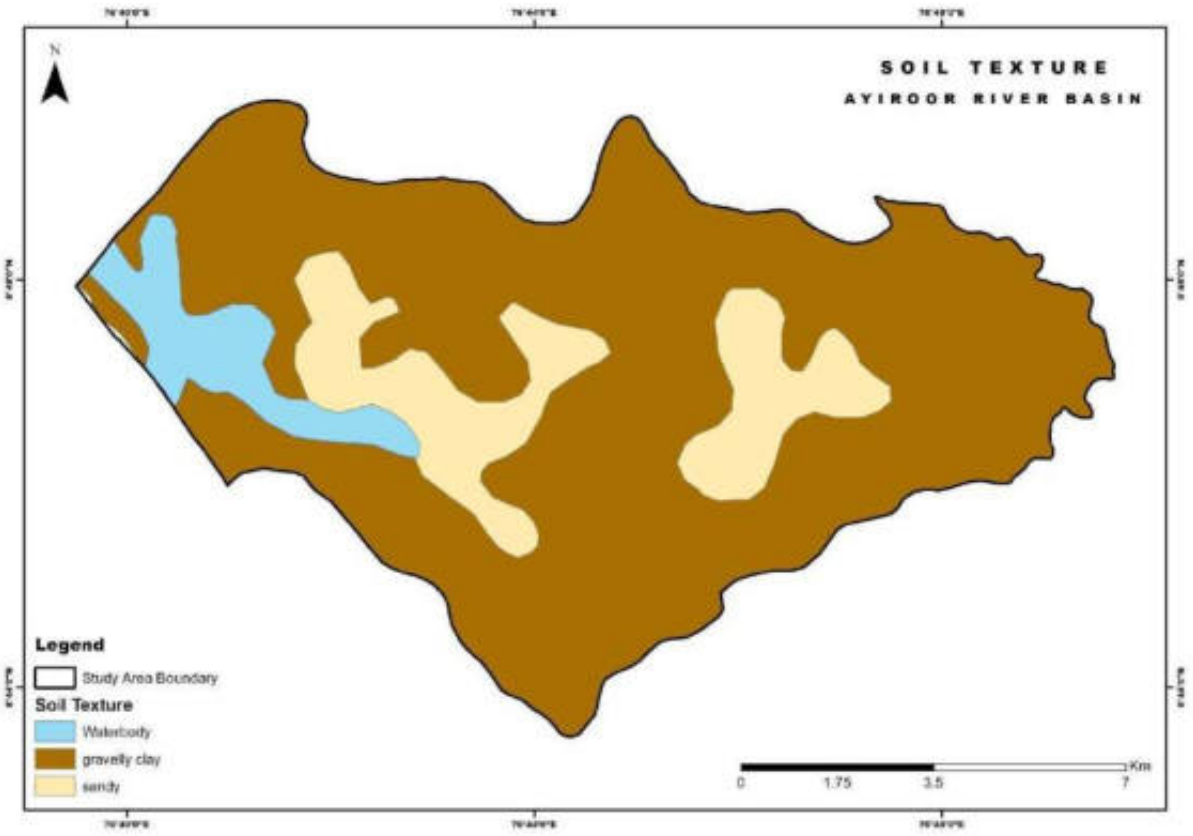

Fig *4.11: Soil texture map of the study area*

4.10 Overview of the Study area

From the data analysis, the physiographical parameters such as geology, geomorphology, land use, slope, relative relief and soil texture revealed its general information about the study area. The plateau is dominant geomorphic unit (Fig 4.2) and Sandstone and clay with lignite intercalations is the major rock type (Fig 4.4) found in the basin area. The major land use of the study area is agriculture (Fig 4.3). Soil texture of a particular area determines the rate of soil infiltration or water intake to the groundwater body and thus giving an idea about the groundwater conditions of that particular area. The Gravelly clay is the major texture type found in the basin (Fig 4.11). Due to the presences of western ghats, slope shows inclination towards the Arabian sea. The study area experiences the slope ranging from 0 to 28 degrees (Fig 4.5). Western part of the basin shows low relative relief whereas the eastern parts are characterized with higher values of relative relief. The relative relief varies from 18 to 80 m/km^2 (Fig 4.10). The mean depth to water table ranges from 4.38 m to 27.83 m (Fig 4.9). The clay percentage varies from 0.01 to 4.2 % (Fig 4.6). Clay is used as a natural seal as a barrier in landfills against toxic seepage being impermeable to water. Clay barriers are generally used as liners and capping materials for landfill sites.

CHAPTER 5
METHODOLOGY

5.1 Introduction

This paper presents a method based on Geographical Information Systems (GIS) modelling to identify suitable sites for solid waste dumping by using set of criteria which is relevant for the study. Several factors were considered in the analysis including Land use , Soil texture, Lithology / Geology, Slope, Geomorphology, Relative Relief, Clay percentage, Mean Depth to Water table etc. Thematic maps of the selected criteria were developed using GIS software, ArcGIS. ArcGIS is a geographic information system (GIS) for working with maps and geographic information maintained by the Environmental Systems Research Institute (ESRI). The overall analysis needs different sets of data. Parameters like water level data, Geology, Soil texture, Clay%, and Geomorphology were collected from IUCGIST, Karyavattom campus, University of Kerala.

The field data collection was conducted during 2015. Thirty groundwater samples were collected from the study area from lying in Urban, and Rural settings.

For the preparation of study area map layers like drainage, water body, landmarks and transportation networks were digitized from Survey of India toposheets of 1:25000 scale through various analysis like georeferencing, rectification, projecting and digitization. For the general understanding of the slope of the study area slope map were prepared using ArcGIS software from ASTER DEM (30m) which is download from United States Geological Survey (USGS) website. For the Preparation of Relative relief, the ASTER DEM were used for the analysis. The spatial variation of relative relief was found out by dividing the entire basin into grids of $1km^2$ and finding out the relative relief of each and every grid. Then, the spatial variation was interpolated using IDW techniques in GIS Platform.

Land use map were prepared using the unsupervised classification and verified with available datasets in the centre and which was performed in ArcGIS Platform. Landsat Imagery were used for the analysis was downloaded from USGS website. With the help of Landsat imagery and google imagery the major land uses in the study area were interpreted and classified. The Resultant layer was in Raster format. For the area calculation the raster data were used to converted into vector data. All the themes were subjected for the Ranking and Weightage with reference to its importance in the study area as suggested by subject expert. For applying the ranks, datasets were reclassed.

The Solid waste dumping site suitability was determined by overlaying all the thematic layers under weighted overlay method using spatial analyst tools of ArcGIS. Weighted index overlay analysis (WIOA) is a simple and straight forward method for a combined analysis of multiclass

maps. The advantages of this method are that the human judgment can be integrated with this analysis. A weight represents the relative importance of a parameter and the objective. There is no standard scale for a simple weighted overlay method (SARAF & CHOUDHURY, 1998).

5.2 Data sources

- Survey of India Toposheets
  58D/9SE (1:25000 scale)
- Auxiliary data
- Field data

5.3 GIS Data Types

In the present study, the GIS data used are classified as follows. Basically, all the GIS data used in this study are classified as:

- Topographical data
- Satellite data
- Collateral data

5.3.1 **Topographical data**

Topographic maps are a detailed record of a land area, giving geographic positions and elevations for both natural and man-made features. Topographic data are information about the elevation of the surface of the Earth. Topographical maps, also known as general purpose maps, are drawn at relatively large scales. These maps show important natural and cultural features such as relief, vegetation, water bodies, cultivated land, settlements, and transportation networks, etc. The topographic map is a two-dimensional representation of the Earth's three-dimensional landscape.

5.3.2 **Thematic data**

A thematic map is also called a special-purpose, single-topic, or statistical map. These are maps which depict information on a particular topic or theme. The detail portrayed on a thematic map may be physical, statistical, measured, or interpreted, and sometimes requires specialist knowledge by the map user.

For the purpose of the study, satellite image from Landsat 8 Operational Land Imager (OLI) was used. Landsat 8 is an American Earth observation satellite launched on 11 February 2013. It is the eighth satellite in the Landsat program; the seventh to reach orbit successfully. Originally called the Landsat Data Continuity Mission (LDCM), it is a collaboration between NASA and the United States Geological Survey (USGS). It comprises the camera of the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) which can be used to study Earth surface temperature and is used to study global warming. (Li et al. (2021). Landsat 8's Operational Land Imager (OLI) improves on past Landsat sensors and was built, under

contract to NASA, by Ball Aerospace & Technologies. OLI uses a technological approach demonstrated by the Advanced Land Imager sensor flown on NASA's experimental Earth Observing-1 (EO-1) satellite. The OLI instrument uses a pushbroom sensor instead of whiskbroom sensors that were utilized on earlier Landsat satellites. The pushbroom sensor aligns the imaging detector arrays along Landsat 8's focal plane allowing it to view across the entire swath, 185 kilometres (115 mi) cross-track field of view, as opposed to sweeping across the field of view. With over 7000 detectors per spectral band, the pushbroom design results in increased sensitivity, fewer moving parts, and improved land surface information. OLI collects data from nine spectral bands. Seven of the nine bands are consistent with the Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) sensors found on earlier Landsat satellites, providing for compatibility with the historical Landsat data, while also improving measurement capabilities. Two new spectral bands, a deep blue coastal/aerosol band and a shortwave-infrared cirrus band will be collected, allowing scientists to measure water quality and improve detection of high, thin clouds.

SATELLITE DATA	**Source**	**Sensor**	**Resolution**	**Year**
	LANDSAT 8	OLI	30m	2020

Table 5.1 Details of Satellite data used for Land use Classification

Slope and relative relief map of the study area prepared using ArcGIS software from ASTER DEM (30m) which is download from United States Geological Survey (USGS) website). The Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA) jointly announced the release of the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 3 (GDEM 003), and the ASTER Water Body Dataset (ASTWBD) on August 5, 2019. The first version of the ASTER GDEM, released in June 2009, were generated using stereo-pair images collected by the ASTER instrument onboard Terra. ASTER GDEM coverage spans from 83 degrees north latitude to 83 degrees south, encompassing 99 percent of Earth's landmass. The improved GDEM V3 adds additional stereo-pairs, improving coverage and reducing the occurrence of artifacts. The refined production algorithm provides improved spatial resolution, increased horizontal and vertical accuracy. The ASTER GDEM V3 maintains the GeoTIFF format and the same gridding and tile structure as V1 and V2, with 30-meter postings and 1 x 1degree tiles. Version 3 shows significant improvements over the previous release. However, users are advised that the data contains anomalies and artifacts that will impede effectiveness for use in certain applications. The data are provided "as is," and neither

NASA nor METI/Japan Space Systems (J-space systems) will be responsible for any damages resulting from use of the data. An additional global product is now available: the ASTER Water Body Dataset (ASTWBD). This raster product identifies all water bodies as ocean, river, or lake. Each GDEM tile has a corresponding Water Body tile. The GDEM and ASTWBD are available for download from NASA Earth data and Japan Space Systems. This ASTER product is available at no charge for any user pursuant to an agreement between METI and NASA. This DEM was then used for the creation of Relative relief and slope thematic maps.

DEM	Source	Resolution
	ASTER DEM	30m

Table 5.2 Details of DEM used for slope and relative relief data

5.3.3 Collateral data

Collateral material represents data/information that an interpreter may use to aid in the interpretation process. Material contained within a Geographic Information System (GIS) that is used to assist an interpreter in an analysis task can be considered collateral data. In the present study includes the datasets like Geology, Geomorphology, Mean depth to water level. Geology and geomorphological layers prepared from maps published by GEOLOGICAL SURVEY OF INDIA.

The Geological Survey of India (GSI) is a scientific agency of India. It was founded in 1851, is a Government of India Ministry of Mines organization, one of the oldest of such organizations in the world and the second oldest survey in India after Survey of India (founded in 1767), for conducting geological surveys and studies of India, and also as the prime provider of basic earth science information to government, industry and general public, as well as the official participant in steel, coal, metals, cement, power industries and international geoscientific forums. Depth to water level data was collected from the Inter University Centre for natural Resources management (IUCGIST).

5.4 Procedure for Preparing the Spatial Data

The procedure for preparing the spatial data for the entire study area is discussed as follows:

1. Satellite data processing using image-processing software like ArcGIS
2. Generation of thematic maps viz., land use/land cover by visual interpretation of satellite imagery, google Imagery and SOI Toposheets.
3. Generation of Thematic maps showing physical characteristics of the study area. The themes extracted from SOI toposheets are road network, drainage, waterbody, River basin and place names.

ESTIMATION OF CARBON SEQUESTRATION POTENTIAL OF TREE SPECIES - A CASE STUDY FROM A COLLEGE CAMPUS IN KERALA

Dissertation submitted to the University of Kerala
in partial fulfilment of the requirement for the degree of
Master of Science in Environmental Sciences

Submitted by
ANCHU.M. S
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2019 -21

RESEARCH CENTRE AND POST GRADUATE DEPARTMENT OF ENVIRONMENTAL SCIENCES
All Saints' College
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May 2021

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27.07.2021.

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ABSTRACT

Urban green areas, particularly trees, have great potential to sequester carbon from the atmosphere and mitigate the impacts of climate change in cities. Large university campuses offer prominent area where such green area can be developed in order to offset the increasing green house gas emissions, as well as other benefits. All Saints' College, Thiruvananthapuram is spread over 26 acres with dense tree plantations in and around the college. The present study is a sustainability initiative to inventory the tree species on the college and assess their total carbon sequestration potential (CSP). Individual trees on the college were measured for their height and girth, and estimates of carbon storage were performed using technical support. There is a total of 25 different tree species on the college with the total CSP equivalent to approximately 18 tons. The results also reveal that *Samanea saman* was the predominant species on the college with CSP equivalent to 4.735 tons, followed by *Peltophorum pterocarpum* with carbon storage of 1.843 tons. The present work highlights the role of urban green spaces, not only as ornamental and aesthetic plantations but also in mitigating the impacts of climate change at a local level. Current study points out the need for establishing a green cover in higher education institutions so as to act as local carbon sinks.

CHAPTER 1

INTRODUCTION

Carbon is an indispensable component for sustaining life and it can be found naturally in organic and inorganic forms with a very small exchange rate between them. Carbon is present in the nonliving environment as carbon dioxide gas in the atmosphere, as dissolved carbon in water and in carbonate rocks, coal, petroleum, natural gas, and dead organic matter. Carbon is primarily and profoundly found in the atmosphere as CO2, CH_4, and chlorofluorocarbons.

All the activities including energy consumption and waste management have their equivalent carbon emission and they positively contribute to the carbon footprint of the campus. Carbon sequestration is the reverse process, at which the emitted carbon dioxide will get sequestrated according to the type of Carbon sequestration employed. Even Though there are many natural sequestration process are involved in campus, the major type of sequestration among them is the Carbon sequestration by trees. A tree absorbs atmospheric carbon dioxide through the biochemical process of photosynthesis and stored as carbon in their leaves, trunk, branches and roots, the process called carbon sequestration.

Tree cover in urban areas around the world, is declining and impenetrable cover is increasing due to the demand of the area for development. The pace of urbanization is adversely affecting the green cover in the urban areas. With expanding urbanization in the twentieth century, the incorporation of trees into urban settlements has also expanded - to the point that the management of all trees within the urban area is considered a distinct discipline of forestry (Kaya et al., 2012). Carbon storage and sequestration by urban trees in the United States was quantified to assess the magnitude and role of urban forests in relation to climate change. Urban tree field data from 28 cities and 6 states were used to determine the average carbon density per unit of tree cover (Nowak, et al., 2013).

Anthropogenic causes of warming in the globe have become a biggest topic of concern in front of the world because of the life-threatening changes that could result from increase in global heat and temperature. Even if planets average temperature increased by 2.0°C could be

very harmful to environment, and some of the models which are predicting change of up to 5.0°Cwhich is warmer than average temperatures of history (IPCC, 2007).

The ever-increasing temperatures at the global level will lead to various changes including increase in atmospheric gaseous form of water, different losses from forests and alteration in vegetation occurrence and composition, increased ocean acidification, extreme flooding, an increase in weather events, and ever altering ecosystems that will potentially alter biological diversity (King, 2005). The gas of most concern is CO2.Although CO2is not a so harmful greenhouse gas, it is discharged in the very large amounts from artificial processes. Many different manmade activities of global climate change which have been recognized. These include change in land-use, deforestation, and discharge of various greenhouse gases that strengthen the greenhouse gas effect (Mannion, 1998).

Before the Industrial Revolution, the concentration of greenhouse gases (GHGs) in the atmosphere remained relatively constant. Except for slow changes on a geological time scale, the absorption and release of carbon was kept in balance. During that time, changes in biomass and soil organic carbon were the main sources of fluctuation in atmospheric levels of carbon. By clearing forests and burning fossil fuels more rapidly than the carbon can be sequestered, industrialization may have altered this equilibrium. Currently, human activity is directly or indirectly responsible for the release of six to seven billion metric tons of carbon annually. Since before the Industrial Revolution, CO2concentrations in the atmosphere have increased from 280 parts per million (ppm) to nearly 380 ppm in 2005. CO2 emissions from energy use are projected to increase between 40 to 110 percent between 2000 and 2030.Increases in atmospheric CO2 concentration may be generating increases in average global temperature and other climate change impacts. Although some of the effects of increased CO2 levels on the global climate are uncertain, most scientists agree that doubling atmospheric CO2 concentrations may cause serious environmental consequences. Rising global temperatures could raise sea levels, change precipitation patterns and affect both weather and climate conditions (EPA 2012).

According to the Inter governmental Panel on Climate Change (2006), the major five carbon pools of a terrestrial ecosystem involving biomass are above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter(IPCC,2016). Therefore, there are three ways in which urban green spaces can repress atmospheric carbon. Firstly, auto trophs

take up carbon dioxide from the atmosphere—a part of which is released back into the atmosphere and the remainder is stored in the plant tissues above and below ground, resulting in the plant growth in the form of biomass. Therefore, all autotrophs convert atmospheric carbon dioxide into biomass, but trees, specifically, are considered to be the major sinks or sponges of carbon. The carbon assimilated by trees is retained for longer duration with .little leakage into the atmosphere. Annual rates of carbon sequestration largely depend on the tree size at maturity, life span and their growth rates (Nowak, et al., 2002). After the trees die, the biomass either enters the food chain or the soil as soil carbon (Suryavanshi, *et al*., 2004). Secondly, the soils are also chief contributors to the carbon stocks. Litter and woody debris are not a major carbon pool as they contribute only a small fraction to the total carbon stocks. Thirdly, urban vegetation reduces the demand for cooling the building by providing shade and evapo-transpiration, and demand for heating living spaces by reducing wind speed. This substantially reduces burden on fossil fuel burning for electricity generation, thus offsetting carbon emissions (Jo, 2002).

The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol (Chavan, and Rasal, 2010; Ravindranath, *et. al*., 1997). Biomass production in different forms plays important role in carbon sequestration in trees. These carbon pools are composed of live and dead above and below ground biomass, and wood products with long and short life and potential uses. Above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter are the major carbon pools in any ecosystem (FAO, 2005; IPCC, 2003; IPCC, 2006).

Urbanization drastically alters the ecosystems structure and functions, disrupts cycling of C and other elements along with water. It alters the energy balance and influences climate at local, regional and global scales. In 2008, urban population exceeded the rural population. In 2050, 70% of the world population will live in urban centers. The number of megacities (10 million inhabitants) increased from three in 1975 to 19 in 2007, and is projected to be 27 in 2025. Rapid urbanization is altering the ecosystem C budget. Yet, urban ecosystems have a large C sink capacity in soils and biota. Judicious planning and effective management can enhance C pool in urban ecosystems, and off-set some of the anthropogenic emissions. Principal components with regards to Carbon sequestration include home lawns and turfs, urban forests,

green roofs, park and recreational/sports facilities and urban agriculture (Rattan and Augustin, 2013).

Due to urbanization, the condition in the cities as per the environment point of view is at the risk and alarming. However, the roadside plantations/tree avenues in the urban cities play a role not only for improving climatic conditions but significantly contributing to increase area under vegetation in the country. Trees growing along the roadside, either planted or grown naturally, are performing the ecological function not only to reduce the pollution load but also sequester carbon and help mitigate climate change (Da Silva *et al*., 2010; Singh and Singh, 2015). Additionally, the trees in the urban environment are contributing toward many benefits, e.g. social benefits (recreational opportunities, improving physical/mental health) aesthetic benefits (landscape variations through different colors/textures/forms and densities of plants); climatic benefits (cooling, wind control, air pollution reduction, atmospheric carbon storage, impact on climate) and economic benefits (increased property values, tourism, providing fruits and small timber). In accordance with the 74th amendment of the Indian Constitution in 1992, the municipal and urban development authorities are responsible for creating and maintaining parks and other recreational spaces in city areas (Granville, 2009).

There are different approaches for calculating the biomass and carbon stocks. One of them is a destructive way to directly estimate biomass. Fonseca *et al*. (2011) determined carbon directly in various components (leaves, branches, stems, structural roots and soil) in single-species plantations of two tropical native species and showed how site and species-specific data contribute to the overall goal of improving carbon estimates and providing a more reliable account of the mitigation potential of forestry activities on climate change. Another approach is a non-destructive method to develop an allometric equation that will allow us to estimate a tree mass from a few simple measurements, and then the application of this equation to the trees in a forest.

There are a variety of options for terrestrial sequestration, including restoring mined lands, afforestation, reforestation, rangeland improvement, improved tillage practices, and wetlands restoration. Since forests contain more carbon per hectare than grasslands, planting trees instead of grass when restoring mined areas or planting trees on cleared areas can significantly increase carbon sequestration over time. Because terrestrial sequestration projects

can be implemented rather quickly, the Department of Energy's Sequestration Program had an active effort to promote terrestrial carbon sequestration as an early entry approach to reducing atmospheric GHG levels, with particular interest in restoring mine lands (Litynski *et al*., 2006); however, there is currently no active programs.

For every terrestrial CO2 storage project, monitoring, verification, and accounting (MVA) of the stored CO_2 will be an important activity. MVA for terrestrial carbon sequestration refers to monitoring the growth of plant species and the buildup of carbon in the soil, verifying that the carbon buildup is stable, and accounting for the amount of carbon that has been stored. It will not be possible to obtain credit for the carbon stored in terrestrial carbon storage projects without robust MVA protocols to verify the amount of carbon that is being sequestered. This manual covers land types and management methods that can maximize carbon storage in vegetation and soil. It also covers the analytical techniques necessary to monitor, verify, and account for terrestrially stored carbon, which is required for this carbon to be traded. The status of GHG trading and the institutions involved are also covered. Finally, results from the Regional Carbon Sequestration Partnerships (RCSPs) terrestrial field trials are discussed as examples of what can be done. This manual is aimed at individuals and organizations considering terrestrial sequestration projects and those considering regulations/legislation governing carbon emissions caps (National Energy Technology Laboratory, 2010).

MAJOR OBJECTIVES OF THE STUDY

* To identify the tree species in the campus

* To estimate the Total Carbon sequestrated by each individual trees from the study area.

*To estimate the average carbon sequestration per day of each individual trees.

*To find out the species with higher and lower average carbon sequestration.

CHAPTER 2

REVIEW OF LITERATURE

In 2016, Potadar Vishnu R and Satish S Patil, was carried out the study in and around university area of Aurangabad city to know the CO2 sequestration from selected ten tree species. Selected tree species were *Ficus benghalensis, Eucalyptus citriodora, Mangifera indica, Delonix regia, Azadirachta indica, Ficus racemosa, Emblica officinalis, Acacia nilotica, Dalbergia sissoo* and *Annona squamosa*. It is found that *Ficus benghalensishas* a great potential to store the carbon and carbon dioxide whereas *Annona squamosa* has least potential of carbon sequestration from selected tree species.

According to Suryawanshi M N, *et al..(*2014)Total standing biomass of selected tree species was in 8000 m2 hectares. The total of 462 numbers of 10 trees species present in selected area of North Maharashtra University, Jalgaon. Total biomass and carbon sequestrated in the tree species have been estimated using non-destructive method. The above ground and belowground organic carbon (tones/tree) and total organic carbon of each species were calculated. The calculated total organic carbon has been compared with allometric model. *Moringa olifera* species was found to be dominant sequestrated 15.775 tons of carbon and having 14 trees followed by *Azadirachta indica* 12.272 tones. The species *Eucalyptus citriodora* has lowest carbon sequestration potential i.e. 1.814 tones.

The present study is a sustainability initiative to inventory the tree species on the Amity University Campus Noida and assess their total carbon sequestration potential (CSP) by Richa Sharma , *et al*..(2021). The above- and below-ground biomasses were estimated using the non-destructive sampling method. Individual trees on the campus were measured for their height and diameter at breast height (DBH), and estimates of carbon storage were performed using allometric equations. There is a total of 45 different tree species on the campus with the total CSP equivalent to approximately 139.86 tons. The results also reveal that *Ficus benjamina* was the predominant species on the campus with CSP equivalent to 30.53 tons, followed by *Alstonia scholaris* with carbon storage of 16.38 tons. The study reports that the ratio of native to exotic species is 22:23 or almost 1:1.

In 2017, Shital Gharge and Geetha S. Menon carried out a study on "Carbon Sequestration Potential of Trees and Soil in Swami Shantiprakash Garden, Ulhasnagar" and found that the total carbon sequestration potential of trees and soil from Swami Shantiprakash garden in Ulhasnagar. The garden under study covers an area of 1.90 acres (approximately 0.77 ha) and houses around 171 trees belonging to 29 genus. GIS interpretation of the garden was also piloted to predict the biomass. The colour scheme in the GIS map represents the vegetation density. Greener colour towards the north indicates higher density followed by yellow for moderate and red for scarce vegetation. The AGB (443.0058Kgs), BGB (115.1819Kgs) of all the trees was summed up to the Total biomass of 555.81982Kgs. The organic carbon of the standing live tree was 0.277 tons. *Samanea saman* (15) contributed around 190.0939Kgs while *Polyalthia longifolia* (72) contributed 191.4615 Kgs of biomass, together accounting to 68% of the total biomass. Maximum CO2 was sequestered by *Polyalthia longifolia* (0.3509 tons) and *Samanea saman* (0.3484tons). However trees of Samanea were huge belonging to higher DBH class and may show decreased potential in future due to ageing, as compared to Polyalthia that are young trees belonging to lower DBH Classes. Carbon stock of the soil (SOC) was studied depth wise and found to be 41.39ton ha-1, 28.65 ton ha-1and 30.52 ton ha-1for depth at 10 cm, 20 cm and 30 cm, respectively. The sustainable development of the urban trees is important to protect the developing world from the adverse effects of climate change and global warming.

Ananthi Selvara *et al* (2016), was focussed on the study of estimation of carbon sequestration potential, physicochemical and microbiological properties in selected types of trees such as *Mangifera indica L.* (Mango), *Manilkara zapota L.* (Sapotta), *Cocos nucifera L.* (Coconut) and *Tectona grandis L.* (Teak) maintained under different years viz., 5, 10, 15 and 20 years. Based on the study the highest total organic carbon was recorded in soil cultivated with teak (0.69 to 1.11 %) followed by sapotta (0.36 to 1.07 %), mango (0.64 to 0.85 %) and coconut (0.57 to 0.81 %) in 0-20 cm depth of 20-year-old trees. Whereas standing biomass, standing carbon and equivalent CO2 were recorded high in teak (17.93 to 365.87 t ha-1) followed by coconut (9.14 to 285.68 t ha-1), mango (1.85 to 80.74 t ha-1) and sapotta (2.86 to 24.45 t ha-1) in 20-year-old trees.

According Balbhim Chavan and Ganesh Rasal (2012), Carbon sequestration by green plants is a suitable way to reduce atmospheric CO2. In the present investigation aboveground and belowground carbon se questration potential of *Mangifera indica* from nine sectors of Aurangabad city was measured. The total standing aboveground biomass and belowground biomass of *Mangifera indica* are 82.83tha-1 and 21.54tha-1 respectively, while total standing biomass of *Mangifera indica* in 2847 hectares of Aurangabad is 104.41tha-1. The sequestered carbon stalk in aboveground and belowground standing biomass of *Mangifera indica* are 44.73 tha-1 and 11.63 tha-1respectively while, total sequestered carbon of *Mangifera indica* in 2847 hectares area is 56.36 tha-1. The newly developed allometric equations for *Mangifera indica* on the diameter class basis for AGB as a function for DBH and height have shown high correla.

Ankit Arya *et al*..(2017) have been estimated total biomass and carbon sequestered in the major tree species using a non-destructive method. The carbon stock estimated for three major tree species in Gandhinagar and Mahesana towns indicate that *Azadirachta indica* has maximum carbon sequestration potential as compared to *Acacia sp*. and *Cassia sp*. The maximum of carbon stock was present in Girth at Breast Height (GBH) size >180 cm which is followed by GBH size 90 to 180 cm. The total number of trees in Gandhinagar town is much higher as compared to Mahesana town; therefore estimated carbon store of dominant tree species in Gandhinagar town is very high as compared to Mahesana town which is more arid as compared to Gandhinagar.

Dharmendra Dugaya *et al*.,(2019) have discussed one such example from Indian Institute of Forest Management, Bhopal campus where the amount of carbon stored, and carbon dioxide sequestered by the trees along roadside has been estimated. Importance Value Index was calculated separately for each species. Biomass and carbon stock of woody vegetation was assessed using a non destructive method. Leucaena *leucocephala, Schleichera oleosa, Dalbergia paniculata, Acacia catechu* and *Ficus religiosa* recorded high biomass carbon content. The average stem density was 295 stems ha-1. Species-wise calculated average CO2 equivalent in the sample observed increasing trend with the increase in girth class from 20cm to 60cm but showing reduced trend in trees with girth class above 60 cm. The probable reason for reducing trend could be the variation in wood density of species towards the lower value of high girth size species such as *Bombax ceiba, Samanea saman, Holoptelea integrifolia, Dalbergia paniculata, Lagerstroemia parviflora* and *Ficus religiosa*. The analysis can be useful for selection of tree

species with high wood density for planting in urban areas of central India to adequately mitigate pollution, especially the vehicular pollution. The incorporation of the same in the management plan of the urban green spaces would benefit the optimum utilization of carbon sequestration potential. Moreover, the suitable bamboo species, which is characterized as species of the understory of tropical dry deciduous forests, may be considered for the planting as gap filing and sequestration of carbon in urban areas.

According to P.K. Pilania *et al*.,(2014)Trees act as a sink for CO2 by fixing carbon during photosynthesis and storing surplus carbon as biomass which alter through time as trees grow, die and decay. There is uncertainty about the extent of carbon stored in forests by trees. 28 species belonging to 20 families were studied to demonstrate relationship among carbon sequestration which was half the tree biomass. Total carbon sequestration was 448.044 tonnes dominated by *Tectona grandis L.F., Butea monosperma*(Lam) *Taub* and *Diospyros melanoxylon Roxb*. The deviation in carbon sequestration was observed due to girth, height, biomass, native place and economic importance of species. Statistically a positive correlation of 0.966 was found between the total number of trees and total carbon sequestration.

R. Ostadhashemi *et al*.,(2014) estimated the above ground biomass and carbon storage in multi-species plantations in which they used species-specific equations method and three other generic methods in Astara county located in northern Iran in a total area of 1,757 ha. Based on species-specific allometric equations, total aboveground biomass was calculated and varied between 81.13 and 98.21 t·ha–1 for *Acer velutinum*, 68.36 and 83.44 t·ha–1 for *Quercus castanifolia,* 71.88 and 119.22 t·ha–1for *Tilia begonifolia*, 56.07 and 61.98 t·ha–1 for *Fraxinus excelsio*r and from 37.92 to 51.34 t·ha–1 for Prunus avium. There was a significant difference between the mean values of total aboveground biomass estimation obtained by species-specific equations and the three generic methods for *Alnus subcordata, Pinus taeda* and *Pinus nigra.* Results indicated that using generalized methods produced more reliable and accurate estimations for native species than for exotic species for rapid biomass and carbon estimation in order to decide on plantation development in the area.

CHAPTER 3

STUDY AREA

The site selected will be All Saints' college Thiruvanathapuram. 10 acres of campus with lush green vegetation used for the study. Higher tree species diversity at college will make the procedure easier. Trees located from canteen block to auditorium block was selected for estimating the carbon sequestration potential.

Figure :1- College Lay out- GOOGLE VIEW

CHAPTER 4

MATERIALS AND METHODS

4.1. Tree height and Girth

A non-destructive method of biomass estimation was used to measure the tree height and Girth of individual trees of the college. Individual trees greater than 15cm in girth and height (above 150cm) were enumerated. Tree girth were measured by measuring tape, by using the girth calculate diameter. Field data were recorded in spreadsheets and species level identification of trees was obtained through visual observation and species level identification of trees were obtained through visual observation. The doubtful samples are identified with the help of teachers.

4.2. Estimation of carbon sequestration

Carbon sequestration is the process involved in the long-term storage of atmospheric carbon dioxide. Trees remove carbon dioxide from the atmosphere through the natural process of photosynthesis and store the carbon in their leaves, branches, stems, bark, and roots.

Dr. Rajesh Reghunath
Director

UNIVERSITY OF KERALA

(Re-accredited with 'A' Grade by NAAC)

Inter University Centre for
Geospatial Information Science and Technology

CERTIFICATE

This is to certify that the dissertation entitled **"LEAF AREA INDEX MODELLING FROM SENTINEL-2 DERIVED VEGETATION INDICES AND ITS PERFORMANCE EVALUATION ACROSS DIFFERENT FOREST TYPE IN TRIVANDRUM DISTRICT"** is an authentic and genuine record of original research work carried out by Ms. ANCY VARGHESE in the Department of Environmental Sciences under my guidance and supervision. She has effectively utilized the Geo-informatics lab facilities available in this Centre. I further certify that no part of this work has been submitted earlier for the award of any other degree, diploma, fellowship or other similar titles.

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ABSTRACT

Leaf area index is a very critical parameter in process based models of vegetation canopy response to global environmental changes. IN present study attempts to model the leaf area index from Sentinel-2A derived vegetation indices and its performance evaluation across different vegetation types in Trivandrum district. Field data of LAI were collected from Peppara wild life sanctuary, Bonaccard, Vithura, Neyyar wild life sanctuary, Kutta para, in Trivandrum district Southern Kerala. The generation of indices is preprocessed in SNAP software to calculate Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDII), Green Normalized Difference Vegetation Index(GNDVI), Simple Ratio(SR), Infrared Simple Ratio(ISR), Enhanced Vegetation Index(EVI), Soil Adjusted Vegetation Index(SAVI), Modified Soil Adjusted Vegetation Index(MSAVI). Data from 15 sample plots of LAI were measured by CI-110 Digital Plant Canopy Imager in the study area. LAI was modelled based on different reflectance of bands and different vegetation indices from Sentinel-2 data and LAI field data. The study generated prediction modelled through conventional linear regression. The result indicate that linear regression model predicted LAI with better coefficient of determination using NDVI, GNDVI,SR vegetation index variables compared to the univariate approach. The predicted linear regression model was used to estimate spatial map of LAI.

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MICROBIOLOGICAL EXAMINATION OF MILK FROM DIFFERENT BRANDS AND RAW MILK

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the Degree of Master of Science in Environmental Sciences

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ABSTRACT

Milk is one of the utmost reasonable foundations of much nutrition like proteins and vitamins. The quality of milk is determined by facets of composition and hygiene. Due to its compound biochemical structure and high water activity, milk aids as an outstanding culture medium for the growth and multiplication of numerous kinds of microorganisms. Consequently in the processing of milk, some of them may produce unwanted effects and some microorganisms yield food infections which either transmit pathogens that will up the likelihood of infection of the consumer's food. Milk is a foremost part of human food and plays a prominent role in one's diet. The adulteration of milk is mainly due to human features and unhygienic conditions. Typically milk is polluted with diverse types of microorganisms at milk gathering places. The microbial superiority of raw milk is vital for the fabrication of excellent dairy products. There can be deterioration in milk's quality, colour, odour or flavour to a point where it is improper for human consumption. Pathogenic micro-organism in milk comprise *E. coli*, *Staphylococcus aureus*, *Listeria monocytogenes*, Clostridium, Microbacterium, Micrococcus and Streptococcus. The samples were collected from Trivandrum. Most of the samples positive for altered microbial contamination were established using biochemical examinations. Milk samples of different brands were collected from retail shops at Trivandrum and raw milk is collected from a milk society at Puthenthope, Trivandrum. Serial dilution was done to estimate the concentration or number of cells or organisms in the sample to obtain an incubated plate with an easily countable number of colonies. For characterisation and identification of microbes present in milk, the plate is prepared using EMB (Eosin Methylene Blue Agar) and MSA(Mannitol Salt Agar). This agar provides suitable conditions for the suitable bacterial growth. The observed colonies were concluded as *Streptococcus aureus, Staphylococcus epidermidis, Klebsiella sp.* and *Escherichia coli* by observing their growth in the respective plates and after checking the colony characteristics. These colonies were selected and confirmed using biochemical tests like Methyl Red Test (MR Test), Citrate Utilisation Test, Catalase Test and Coagulase test. Biochemical tests are done for the identification of bacteria species based on the differences in the biochemical activities of different bacteria. Bacterial physiology differs from one type of organism to another.

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CHAPTER 1
INTRODUCTION

Food microbiology comprehends the study of microorganisms that colonise, modify, and process, or contaminate and spoil food. It is one of the most diverse research areas within microbiology. It comprises a wide variety of microorganisms including spoilage, probiotic, fermentative, and pathogenic bacteria, moulds, yeasts, viruses, prions, and parasites. It deals with foods and beverages of diverse composition, combining a broad spectrum of environmental factors, which may influence microbial survival and growth. Food microbiology includes microorganisms that have beneficial or deleterious effects on food quality and safety and may therefore be of concern to public health (Marta Laranjo et al., 2019).

Microbiology is the use of biological, biochemical or chemical methods to detect, identify and enumerate microorganisms. Microbial cultures are a way of multiplying microorganisms by growing them in specific culture media, which may be liquid or solid, under controlled laboratory conditions. They are used to determine the type of organism, its abundance in the sample being tested, and its susceptibility to antimicrobial agents. Microbiology has many important applications in the medical, environmental, food, agriculture, chemical and biotechnology industries.

Food microbiology is the study of the microorganisms that inhibit, create, or contaminate food. This includes the study of microorganisms causing food spoilage; as well as, pathogens that may cause disease especially if food is improperly cooked or stored. Those used to produce fermented foods such as cheese, yogurt, bread, beer, and wine. Food safety is a major focus of food microbiology. Numerous agents of disease and pathogens are readily transmitted via food which includes bacteria and viruses. To ensure safety of food products, microbiological tests such as testing for pathogens and spoilage organisms are required. This way the risk of contamination under normal use conditions can be examined and food poisoning outbreaks can be prevented. Testing of food products and ingredients is important along the whole supply chain as possible flaws of products can occur at every stage of production. Apart from detecting spoilage, microbiological tests can also determine germ content, identify yeasts and molds, and salmonella.

Milk and its nutritional importance

Milk is a highly nutritious liquid formed in the mammary glands of mammals to sustain their newborns during their first months of life. A huge variety of food products are made from cow's milk, such as cheese, cream, butter, and yogurt. These foods are referred to as dairy or milk products and are a major part of the modern diet. The nutritional composition of milk is highly complex, and it contains almost every single nutrient that your body needs. (Atli Arnarson BSc, PhD — Updated on March 25, 2019). Milk is essentially an emulsion of fat and protein in water, along with dissolved sugar (carbohydrate), minerals, and vitamins.

These constituents are present in the milk of all mammals, though their proportions differ from one species to another and within species. Milk and milk products are excellent high quality foods providing both nutritional and culinary values. Milk protein is of high nutritional value because it contains all the essential amino acids—i.e., those which infants cannot synthesize in the necessary quantities. Milk's mineral content includes calcium and phosphorus in quantities sufficient for normal skeletal development, but little iron. Milk contains B vitamins as well as small amounts of vitamins C and D. However, milk is extremely susceptible to spoilage by microorganisms and the microbiologist plays a major role in the dairy industry in quality control of milk (Gunasekera TS, 2002).

Milk has always been considered an essential food for its nutritional value, especially for children and adolescents, and a significant portion of human diet is nowadays based on the consumption of dairy products, making the dairy industry one of the main global agri-food sectors for its size, economic importance, and level of technology (Griffiths, M.W 2010). However, milk is extremely susceptible to spoilage by microorganisms and the microbiologist plays a major role in the dairy industry in quality control of milk.

Normal flora of milk

The most commonly found populations include the genera, lactic acid bacteria (LAB), that include *Lactococcus, Lactobacillus, Leuconostoc, Streptococcus* and *Enterococcus.* Psychrotrophic populations, which particularly establish themselves during cold storage, are also a major component and frequently include *Pseudomonas* and *Acinetobacter* spp (Pukančíková, 2016). Other strains of non-LAB genera are also encountered in milk, as well as various yeasts and moulds (Quigley et al., 2011). Human milk on the other hand is typically dominated by *Streptococcus, Staphylococcus, Lactobacillus* and *Bifidobacterium* spp (Martín et al., 2007).

The specific composition of the milk microbiota directly impacts on the subsequent development of dairy products. Microorganisms can bring about the fermentation of milk through the production of lactate and have a variety of different impacts on the sensory, texture, flavour and organoleptic properties of resultant products (Wouters et al., 2002). Microorganisms can also negatively impact on milk quality and shelf life; for example, psychrotolerant bacteria can proliferate during refrigeration and, through the production of extracellular lipases and proteases, result in spoilage (Desmasures & Gueguen, 1997; Hantsis-Zacharov & Halpern, 2007). The microbial composition of milk can also have health-related implications in that the consumption of raw milk contaminated with pathogens can lead to, in some cases, severe illness (Oliver et al., 2009).

Necessity of milk-quality checking

Milk and products derived from milk of dairy cows can harbor a variety of microorganisms and can be important sources of foodborne pathogens. Microbial spoilage of pasteurized fluid milk is typically due to either (1) post pasteurization contamination (PPC) with psychrotolerant gram-negative bacteria (predominantly Pseudomonas) or (2) growth of psychrotolerant sporeformers (e.g., Paenibacillus) that have the ability to survive pasteurization when present as spores in raw milk, and to subsequently grow at refrigeration temperatures (Alles, Wiedmann & Martin, 2018). Post pasteurization contamination can be introduced into the fluid milk continuum at various points, but several research studies indicate that the filling equipment is an area that is particularly susceptible to contamination often due to lapses in good manufacturing practices (Eneroth et al., 1998; Ralyea et al., 1998; Gruetmacher and Bradley, 1999). Reducing PPC and thereby providing consumers with the highest quality fluid milk is not only important for the dairy industry to retain customers, but would also play a role in reducing food loss, which is a major issue in many parts of the world.

The dairy industry should be concerned about dairy food safety because (1) outbreaks of disease in humans have been traced to the consumption of unpasteurized milk and have also been traced back to pasteurized milk, (2) unpasteurized milk is consumed directly by dairy producers and their families, farm employees and their families, neighbors, and raw milk advocates, (3) unpasteurized milk is consumed directly by a large segment of the population via consumption of several types of cheeses manufactured from unpasteurized milk, (4) entry of food borne pathogens via contaminated raw milk into dairy food processing plants can lead to persistence of these pathogens in biofilms, and subsequent contamination of processed milk

products and exposure of consumers to pathogenic bacteria, (5) pasteurization may not destroy all food borne pathogens in milk, and (6) faulty pasteurization will not destroy all food borne pathogens (Oliver *et.al* 2005).

The quality of milk is determined by aspects of composition and hygiene. Due to its complex biochemical composition and high water activity, milk serves as an excellent culture medium for the growth and multiplication of many kinds of microorganisms. Therefore, in the processing of milk, some of them may produce undesirable effects and some microorganisms produce food infections which can either carry the pathogens that will increase the likelihood of infection of the consumer`s food. The smooth colonies with the entire edge. contamination of milk and milk products is largely due to human factors and unhygienic conditions. Usually milk is contaminated with different kinds of microorganisms at milk collecting places (Soomro et.al., 2002).

Milk pasteurization

Milk pasteurization was introduced as a public health measure in order to destroy human pathogens and to eliminate or reduce the activities of spoilage microorganisms. The viability of bacteria in milk after heat treatments can be assessed by using three different viability indicators: (i) colony forming unit (CFU) on plate count agar, (ii) de novo expression of a gfp reporter gene, and (iii) membrane integrity based on propidium iodide exclusion (Gunasekera TS, 2002).

Pasteurization is the process used to destroy bacteria in milk. In pasteurisation, the milk is heated to a temperature sufficient to kill pathogenic bacteria, but well below its boiling point. This also kills many non-pathogenic organisms and thereby extends the storage stability of the milk. Numerous time/temperature combinations are recommended but the most usual is 72°C for 15 seconds followed by rapid cooling to below 10°C. This is normally referred to as High Temperature Short Time (HTST) treatment.

Pathogens associated with spoilage of milk

Spoilage is a term used to describe the deterioration of a foods' texture, colour, odour or flavour to the point where it is unappetizing or unsuitable for human consumption. Microbial spoilage of food often involves the degradation of protein, carbohydrates, and fats by the microorganisms or their enzymes. Pathogenic bacteria are transmissible to humans through milk and milk products (Vasavada 1988). Common pathogens include *Bacillus cereus, Listeria*

monocytogenes, Yersinia enterocolitica, Salmonella spp., Escherichia coli O157:H7, Campylobacter jejuni. It should also be noted that moulds, mainly of species of *Aspergillus, Fusarium,* and *Penicillium* can grow in milk and dairy products. If the conditions permit, these moulds may produce mycotoxins which can be a health hazard.

The prevalence of foodborne pathogens in milk is influenced by numerous factors such as farm size, number of animals on the farm, hygiene, farm management practices, variation in sampling and types of samples evaluated, differences in detection methodologies used, geographical location, and season. However, in spite of the variation, all of these surveys demonstrated quite clearly that milk can be a major source of foodborne pathogens of human health significance (Oliver *et.al* 2005). Pathogenic bacteria in milk have been a major factor for public health concern since the early days of the dairy industry. Many diseases are transmissible via milk products. Traditionally raw or unpasteurised milk has been a major vehicle for transmission of pathogens (Vasavada, 1988). The health of dairy herd, milking conditions is a basic determinant of milk quality. Another source of contamination by microorganisms is unclean teats. The use of unclean milking and transport equipment contributed also to the poor hygienic quality (Bonfoh et al., 2003).

Milk can be contaminated with different kinds of microorganisms due to direct or indirect contact with any source of external contamination during the steps of milking, collection, packing and transport. Direct physical contact of milk with unclean surfaces such as those of milking utensils, udders and teats and the hands of milkers besides environmental factors such as the design and cleanliness of buildings and installations, the adequacy of the water supply, the manner in which the manure and other wastes are disposed of and the amount of dust in the immediate surroundings are important in so far as they may contribute to the microbial contamination of surfaces with which milk comes in to contact. Milk can be polluted by *Mycobacterium bovis, Brucella species, Streptococci* and *Coxiella burnetii*from infected cattle. Agents from human sources such as *Salmonella species, Shigella species, Corynebacterium diphtheria* and *Streptococcus* species can also be presented in milk. According to Gunasekera (Gunasekera TS, 2002), psychrotrophic microorganisms are the most important group of microbes present in milk and dairy products.

The microbe *Pseudomonas* spp. is considered as the most important psychrotrophs contributing to milk spoilage through production of lipolytic and proteolytic enzymes (Anderson M, 2011). The high level of coliform of the fresh farm milk can indicate the evidence of unhygienic

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Delineation of Suitable Sites for Dumping Solid Wastes in Mamam River Basin, South Kerala, India Using GIS and Remote Sensing Techniques

Dissertation Submitted to the University of Kerala
in partial fulfilment of the requirements for the degree of
Master of Science in Environmental Sciences

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ABSTRACT

Solid waste dumping is a serious problem faced nowadays because most solid wastes are not dumped in the ideal/suitable areas. Uncontrolled open dumping and improper waste management cause various problems, such as contaminating groundwater and surface water bodies, attracting insects and rodents, increasing flooding and generation of toxic gases. Since the solid/liquid waste dumping affects the quality of the water environment around the dumping yard as well as the down reaches, an attempt has been made here to delineate suitable sites for dumping solid wastes using GIS and Remote Sensing techniques. The present study entitled **Delineation of Suitable Sites for Dumping Solid Wastes in Mamam River Basin, South Kerala, India Using GIS and Remote Sensing Techniques** is an attempt towards this direction. Study area lies between longitudes of 76^0 46' 33" and 76^0 58' 07" and latitudes of 8^0 32'23" and $8^0$42' 33" at Trivandrum district of Kerala and covering an area of 185.96 km^2.

Numerical weighted parameter rating (WPR) approach and weighted index overlay method of GIS technique was used to delineate the safe/suitable areas for dumping solid wastes. The thematic maps selected for integration comprises geology, geomorphology, land use, soil texture, mean depth to water table, slope, relative relief and clay percentage in soil. Appropriate ranks were given to the subclasses of each parameter and the weightages were assigned to each parameter based on its ability to mitigate the ill effects of waste dumping. A buffer distance of 500m was given for the surface water bodies, stream channels and roads. The classification of study area into various suitability classes was done based on the overall index value calculated from the rank and weightage values. The resultant raster layer is divided into three zones such as Not suitable, Moderately suitable and Highly suitable based on the index values. The sites depicted as highly suitable can be used for dumping solid wastes. The sites depicted as not suitable should be avoided for dumping wastes since dumping of solid wastes at such zones can create ill effects on environment, especially in the water environment. 82.41sq km of the study area comes under the moderately suitable category.

CHAPTER 1
INTRODUCTION

1.1 Introduction

Waste is a material discharged and discarded from each stage of daily human life activities, which leads to adverse impacts on human health and the environment (Bringi, 2007); Solid waste is a non-liquid, non-soluble materials contain complex and sometimes hazardous substances. It mainly includes; garbage, rubbish, demolition products, dead animals, sewage treatment residue, manure and other discarded material, leaves or twinges, food remnants, paper or cartons, textile materials, bones, ash or dust or stones, human and animal excreta, construction debris, biomedical debris, household hardware etc. Solid waste has become a global environmental and health issue in the contemporary world both in developing and developed countries (UNEP, 2005; United Nations, 2017). Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes (Tchobanoglous et al., 2002). Landfill is the only easy and cost-effective management system used in many parts of the world to dispose solid wastes (Yadav, S. K. 2013). Landfilling is the process that the solid wastes which cannot be recycled or further used are placed in a landfill (REMA, 2010).

The most important problem facing now a days is solid wastes generation and its increasing amount is mainly due to rapid economic growth, population increase and rise in community living standards. Insufficient dumpsites leading to a creation of patches of dumpsites all over the places; and an inadequate organized system of waste handling for a major part of the city (Ramachandran J et al., 2015). Most solid waste disposal sites are found on the boundary of the urban areas where there are water bodies, crop filed, settlement, around road, etc. These are suitable sites for the incubation and spread of flies, mosquitoes and rodents. They transfer diseases that affect human health (Abul, 2010). Unscientific solid waste disposal can develop contamination of surface and groundwater through leaching surface waste deposits, air pollution, soil contamination, spreading of diseases and uncontrolled release of methane (Visvanathan & Glawe, 2006). The decomposition of solid waste produces landfll gases such as methane (CH4), carbon dioxide (CO2) and other trace gases (MeBean et al. 1995; Suchitra 2007; IPCC-AR5 2014). The unscientific solid waste dumping degrade the quality of drinking water through the penetration of leachate into groundwater (Tripathi et al. 2006); and cause various diseases like jaundice, nausea, asthma, miscarriage, infertility etc. (El-Fadel et al. 1971). Solid wastes indiscriminately thrown around human environment also results in aesthetic problems and nuisance (Hammer, 2003). The Contamination of ground water and soil

ISOLATION, BIOCHEMICAL CHARACTERIZATION AND ANTAGONISM OF *PSEUDOMONAS FLUORESCENS* IN SOIL COLLECTED FROM DIFFERENT LOCATIONS IN KERALA

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This is to certify that dissertation entitled **"ISOLATION, BIOCHEMICAL CHARACTERIZATION AND ANTAGONISM OF PSEUDOMONAS FLUORESCENS IN SOIL COLLECTED FROM DIFFERENT LOCATIONS IN KERALA"** is an authentic work carried out by ANUSHA E RAJ (Candidate Code : 61519100007) Student of All Saints' College, Thiruvananthapuram in partial fulfilment of the award of the Master of Science in Environmental Sciences by the University of Kerala.

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ABSTRACT

Plant Growth Promoting Rhizobacteria (PGPR) are beneficial bacteria that colonize the plant roots and enhance the plant growth by a wide variety of mechanisms. The use of PGPR steadily increasing in agriculture and offers an attractive way to replace chemical fertilizers and pesticides. In this study, an attempt was made to collect rhizospheric soil samples isolation and enumeration of native *Pseudomonas* population from the different rhizospheric samples and to identify the native *Pseudomonas fluorescens* strains, a potent biocontrol agent as well as PGPR in the rhizosphere under UV light and further characterize them morphologically and culturally. Most *P. fluorescens* strains showed positive PGPR activity. The study showed that *Pseudomonas* as an effective plant growth promoting bacterium. In the present study, soil samples were collected from different locations in Kerala (Trivandrum, Kollam and Kottayam) in order to isolate the soil microbes and then checking its antagonistic properties with other microbes. The observed colonies were identified as *Pseudomonas fluorescens* by checking the green fluorescence emitted by the colonies when exposed to UV light. These fluorescent colonies were selected and confirmed as *Pseudomonas fluorescens* using biochemical tests like MR test, Citrate utilisation test and Catalase test. The Methyl red (MR) test was used to identify the glucose utilizing property of *Pseudomonas fluorescens.* A change from yellow to cherry red colour indicates positive result and hence here positive result is obtained. The Citrate Utilisation test was used to identify the ability of *Pseudomonas fluorescens* to utilize citrate as its sole carbon and energy source thereby confirming that the isolated colony is of the particular species. Changes the media colour from green to blue at more alkaline pH which is an indication of citrate utilisation by the organism. Catalase test was used to identify the ability of catalase containing *Pseudomonas fluorescens* to convert Hydrogen peroxide into Water and Oxygen. Presence of thick effervescence was noted confirming the catalase utilising ability of *Pseudomonas fluorescens.* Coagulase test is used to differentiate Staphylococcus aureus (positive) which produce the enzyme coagulase, from *S. epidermis* and *S. saprophyticus* (negative) which do not produce coagulase.

CHAPTER 1

INTRODUCTION

Microorganisms are found everywhere in the environment and play a leading role in countless natural processes. Microorganisms are very small forms of life that can sometimes live as single cells, although many also form colonies of cells. These organisms are primary decomposers of organic matter, but they do other things, such as provide nitrogen through fixation to help growing plants, detoxify harmful chemicals, suppress disease organisms, and produce products that might stimulate plant growth. Soil microorganisms have had another direct importance for humans, they are the source of most of the antibiotic medicines we use to fight diseases. (Fred Magdoff and Harold vanes et al; 2009).

Microorganisms are very small forms of life that can sometimes live as single cells, although many also form colonies of cells. A microscope is usually needed to see individual cells of these organisms. Microorganisms make up a large part of the planet's living material and play a major role in maintaining the Earth's ecosystem. Microbiology came into being largely through studies of bacteria. Microorganisms can either be beneficial and are helpful in human welfare, while others are disease-causing and toxic enough to make us ill. These form a significant part of the ecosystem and participate in the production of minerals and gases like oxygen, carbon dioxide.

They also feed on the dead and decaying matter by converting the complex compounds into the simpler ones. The bio-geochemical cycle, such as the nitrogen cycle is an important example of useful microorganisms. Microorganisms are used in various industries for the production of various metabolites such as ethanol, riboflavin, lactic acid, and butanol. There are a number of microorganisms that are responsible for food spoilage, diseases and infections. Such microorganisms are known as harmful microorganisms. Bacteria are the most dangerous of all microorganisms and are responsible for several infectious diseases such as tuberculosis, cholera, diptheria, etc. Viruses are also responsible for certain fatal diseases such as AIDS, influenza, etc. Fungi are also harmful and can lead to certain skin infections and allergies.

Microbial activity is exploited for the benefit of humankind in many ways, such as:

- production of medicines

- production of food
- production of enzymes
- the clean-up of sewage and other wastes
- exciting advances resulting from developments in molecular biology techniques

Soil Microbiology

Soil microbiology is the study of microorganisms in soil, their functions, and how they affect soil properties. Soil microbiology is a relatively young science which started with our ability to sense soil microbial world using ever improving techniques in microscopy and molecular biology (Paul, 2015). It is believed that between two and four billion years ago, the first ancient bacteria and microorganisms came about on Earth's oceans. These bacteria could fix nitrogen, in time multiplied, and as a result released oxygen into the atmosphere (Canfield, Donald, 2014); Farquhar, James, 2000). This led to more advanced microorganisms, which are important because they affect soil structure and fertility (Falkowski, Paul, 2015; Jelen, Benjamin 2016). Soil microorganisms can be classified as bacteria, actinomycetes, fungi, algae and protozoa. Each of these groups has characteristics that define them and their functions in soil (Rao, Subba 1999). Up to 10 billion bacterial cells inhabit each gram of soil in and around plant roots, a region known as the rhizosphere.

German microbiologist Robert Koch initiated the use of solid vegetative matter (potato or apple slices) to grow bacteria and successfully isolated pure cultures in the late 1800s. This approach was greatly improved with the advent of solid media (agarose gel) opening a new world in terms of ability to grow bacteria and fungi in culture and actually observe and numerate soil microorganisms. Culture studies of microbial community relied on the assumption that the majority of soil microorganisms can grow on solid media. Using such a simple process inadvertently selected for organisms adapted to mesotrophic conditions, capable of growing on a solid surface or in liquid media, and capable of proliferating using the specific nutrient and C form in the media. The result was that the diversity of soil microorganisms was grossly underestimated using cultural techniques (Hill et al., 2000). A noted benefit of culture-based approaches includes the fact that specific soil microorganisms could be isolated from a wide range of soils, availing the living organisms to deliberate experimentation.

Microorganisms in soil

Soil microbiology is the study of organisms in soil, their functions and how they affect soil properties. The soil is an eminent gift from nature encompassing numerous essential minerals and nutrients for maintaining the vivacity of living biota such as plants, animals, and microorganisms (Kaviya, Upadhayay, Singh J. 2019). Soil microorganisms can be grouped into bacteria, actinomycetes, fungi, algae, protozoa, and nematodes. Microbes include fungi, bacteria and viruses. Farmers and ranchers often think of microbes as pests that are destructive to their crops or animals (as well as themselves), but many microbes are beneficial. Soil microbes (bacteria and fungi) are essential for decomposing organic matter and recycling old plant material. Some soil bacteria and fungi form relationships with plant roots that provide important nutrients like nitrogen or phosphorus.

Fungi can colonize upper parts of plants and provide many benefits, including drought tolerance, heat tolerance, resistance to insects and resistance to plant diseases.(Marilyn Roossinck , 2008). Biological control of plant diseases is the suppression of populations of plant pathogens by living organisms (Heimpel and mills, 2017). Amongst beneficial microorganisms isolates can be selected which are highly effective against pathogens and can be multiplied on artificial media. Application of such selected and mass-produced antagonists in high densities once or several times during a growing season is called “augmentative biological control” (Eilenberg et al; 2001).

Microbial biological control agents protect crops from damage by diseases via different modes of action. They may induce resistance or prime enhanced resistance against infections by a pathogen in plant tissues without direct antagonistic interaction with the pathogen (Pieterse et al., 2014; Conrath et al., 2015). Microbial biological control agents use a broad arsenal of modes of action which are used wherever microorganisms interact, communicate, and regulate their co-existence between microbial cells and between microorganisms and plants.

Each of these groups has different characteristics that define the organisms and different functions in the soil it lives in. Importantly, these organisms do not exist in isolation; they interact and these interactions influence soil fertility as much or more than the organism’s individual activities (Christopher Johns 2017). Apart from the dead plant or animal residues in soils, soil organic matter is composed of a significant content of living microorganisms and their dead fractions (Hoorman and Islam, 2010). Microorganisms are not only directly influenced by fundamental soil characteristics such as moisture, oxygen and chemistry but also

by each other in both beneficial and predatory ways. By becoming holistically aware of the fundamental importance of soil organisms and then developing and understand how biological processes in soil are influenced by changes in the soil environment, we can learn how to manage soil in a way that enhances the benefits provided by soil organisms. It is believed that certain microorganisms in Effective microorganism's culture including Photosynthetic bacteria and N-fixing bacteria can enhance the plant's photosynthetic rate and efficiency and N-fixing capacity as well (Pati and Chandra 1981). Vaid *et al.,* (2017).

Bacteria: Bacteria are organisms that have only one cell and are, therefore, microscopic. There are anywhere from 100 million to one billion bacteria in just a teaspoon of moist, fertile soil. They are decomposers, eating dead plant material and organic waste. By doing this, the bacteria release nutrients that other organisms could not access. The bacteria do this by changing the nutrients from inaccessible to usable forms. The process is essential in the nitrogen cycle.

Actinomycetes: Actinomycetes are soil microorganisms like both bacteria and fungi, and have characteristics linking them to both groups. They are often believed to be the missing evolutionary link between bacteria and fungi, but they have many more characteristics in common with bacteria than they do fungi. Actinomycetes give soil its characteristic smell. They have also been the source of several significant therapeutic medicines.

Fungi: Fungi are unusual organisms; in that they are not plants or animals. They group themselves into fibrous strings called hyphae. The hyphae then form groups called mycelium which are less than 0.8mm wide but can get as long as several metres. They are helpful, but could also be harmful, to soil organisms. Fungi are helpful because they have the ability to break down nutrients that other organisms cannot. They then release them into the soil, and other organisms get to use them. Fungi can attach themselves to plant roots. Most plants grow much better when this happens. This is a beneficial relationship called mycorrhizal.

Algae: Algae are present in most of the soils where moisture and sunlight are available. Their number in the soil usually ranges from 100 to 10,000 per gram of soil. They are capable of photosynthesis, whereby they obtain carbon dioxide from atmosphere and energy from sunlight and synthesise their own food.

Protozoa: These are colourless, single-celled animal-like organisms. They are larger than bacteria, varying from a few microns to a few millimetres. Their population in arable soil ranges from 10,000 to 100,000 per gram of soil and they are abundant in surface soil. They can

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ABOVE GROUND BIOMASS ESTIMATION AND MODELLING USING REMOTE SENSING TECHNIQUES - A STUDY IN AND AROUND PEPPARA WILDLIFE SANCTUARY, THIRUVANANTHAPURAM

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ABSTRACT

Forests are essential to global carbon cycle, therefore, accurate inventorying and monitoring of forest above ground biomass in local to regional scales is critical in understanding their role as atmospheric carbon content considerably. Remote sensing methodologies can provide spatially explicit, and more efficiently combined forest biomass estimates, given the potential to provide information at a wide range of spatial and temporal scales, wall to wall coverage, and use as historic archives of data.it can either infer biomass through developing relationship between field based estimation of biomass and spectral signal, or through estimation of other variables and employment of allometric analysis. This research estimates the Above ground Biomass (AGB) using field measurements and Sentinel-2A image data to construct models for estimation. It is carried out in the region in and around Peppara Wildlife sanctuary, Thiruvananthapuram. Biomass estimation potential of vegetation indices derived from Sentinel-2 imagery is also evaluated statistically, as part of the study. Forest inventory was carried out at field level and the data collected on the biophysical variables were used in allometric equations, to calculate above ground biomass. Biomass was predicted using the most optimal Vegetation Index (VI) by developing linear regression model. The study recommends the combined use of information generated from both the field-based forest inventory and geospatial approaches for better assessment of stand biomass thus significantly contributing towards operational forestry and climate change studies. Simple Linear Regression (SLR) method used to predict the AGB and the result show that Sentinel-2 data can be used for above ground biomass estimation. The sample plots were successful in establishing a model (R^2=0.74) and was used for prediction of AGB map of the study area. The coefficient of determination (R^2) and root mean square error (RMSE) were used to validate the performance of the model. This research methodology has thus proved to be cost effective and accurate, in assessing and reducing carbon losses, eventually aiding in sustainable forest management.

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CHAPTER 1

INTRODUCTION

1 Background

Considering the natural and fundamental role in the basic functioning of the biosphere by regulating global carbon cycle, forests unequivocally reduce atmospheric carbon content considerably. Despite the ravaging impact of climate change, forests are capable of stabilizing atmospheric carbon dioxide concentrations thereby mitigating the global warming and the climate change. It is estimated that 2-4 GtC of atmospheric carbon can be sequestrated annually. Repeated monitoring of AGB is an important task for sustainable and effective management of forests.

Conventionally, the AGB monitoring intensive field inventory including, taxonomical information, collateral and ancillary data analysis and mapping of the forest cover using remote sensing or other means. The conventional monitoring of AGB is labour cost, and time-intensive and sometimes inapplicable due to poor accessibility, making it practical only in relatively smaller areas. Remote sensing on the other hand, offers an efficient and economical means for AGB monitoring by facilitating forest type and canopy density stratification, which greatly helps in field inventory. Its repeated coverage offers historical data required for change detection, while its digital data format can be easily integrated in a geographic information system (GIS) for further analysis. Many researchers have used remote sensing data to monitor forest AGB in different parts of the world (Timothy *et al.,* 2016).

Traditional biomass measurement is simply to remove and weigh all the biomass occurring in quadrats, which is a labor-intensive and time-consuming practice. This method does not allow quick monitoring and, more importantly, to some extent, might be destructive to the phenomenon being investigated. Remote sensing, however, provides an alternative to biomass measurement largely because it makes objective and mostly non-destructive observations of vegetated areas at various spatial and temporal resolutions. While vegetation biomass cannot be directly derived

from remote sensing image data, remote sensing based estimation requires the use of sample plots to acquire field measurements for allometric growth equations based modelling and image interpretation for estimation.

Sentinel satellites are an Earth observation satellite constellation developed by the European Space Agency (ESA) as part of the Copernicus Program. Sentinel-2 is a wide-swath, high-resolution, multispectral imaging mission with two twin satellites (Sentinel-2A and Sentinel-2B), supporting land and climate-change monitoring. Sentinel-2A was launched in June 2015 and has offered free image data at the ESA's website as of December 2015. The Sentinel-2 MSI (multispectral imager) samples 13 different spectral bands ranging from the visible to shortwave infrared of electromagnetic spectrum, four bands at 10 m, six bands at 20 m, and three bands at 60 m spatial resolution. It has now been used for a variety of forestry applications such as fire damage monitoring, forest storage estimation, and canopy cover calculation. While some researchers have combined Sentinel-2A with radar data for biomass estimation, using such free optical sensor data alone has not been assessed. Testing the capability of Sentinel-2A data to estimate urban vegetation biomass would be interesting as Sentinel-2A data is being increasingly important for land monitoring, particularly for forestry.

This study mainly focuses on the modelling of above ground biomass estimation from Sentinel-2A image data. Quadrat biomass was calculated using the allometric biomass equations with field measurements, and then vegetation biomass models were constructed with remote sensing derived variables. Specific objectives are testing the capability of Sentinel-2A data to estimate above ground biomass and examining whether modelling can improve estimation accuracy.

1.1 Above ground biomass

Above ground biomass includes all biomass in living vegetation, both woody and herbaceous, above the soil including stems, branches, bark, seeds and foliage. Above Ground Biomass is the most visible of all the carbon pools and changes in it are an important indicator of change or the impact of an intervention on benefits related to both carbon mitigation and other matters. Accurate forest Above Ground Biomass is crucial for sustaining forest management and mitigating climate change to

support REDD+ (reducing emissions from deforestation and forest degradation and forest degradation, plus the sustainable management of forests and the conservation and enhancement of forest carbon stocks) process.

Accurate measurement and mapping of biomass is a critical component of carbon stock quantification, climate stock quantification, climate change impact assessment, suitability and location of bio energy processing plants, assessing fuel for forest fires, and assessing merchandisable timber. While above- biomass includes both live and dead plant material, most of the recent research effort on biomass estimation has focussed on the live component (live trees) due to the prominence of this component. An accurate estimate of biomass is a prerequisite for better understanding of the impacts of deforestation and environmental degradation on climate change. Above ground biomass is the most visible, dominant, dynamic and important pool of the terrestrial ecosystem, constituting around 30% of the terrestrial ecosystem carbon pool. Above ground biomass estimation, and especially forest biomass, has received considerable attention over the last few decades because of increased awareness of climate warming and the role forest biomass plays in carbon sequestration and release of greenhouse gases due to deforestation.

Remote sensing techniques provide an alternative to traditional methods for estimation, monitoring and verification of changes in areas under different land-use systems as well as in biomass production and growth rates. Remote sensing techniques provide spatially explicit information and enable repeated monitoring even in remote locations. The basic approach to applying remote sensing is to understand the relationship between the parameters of a forest stand e.g. diameter at breast height (DBH), tree height, crown cover, basal area, and even biomass stock and their spectral representation, depending on the characteristics of the study area and the sensor data used.

The greatest carbon pool of a tree is the Above Ground Biomass (AGB) but this is mainly affected by anthropogenic activities in the forest that cause degradation by decreasing the forest areas ultimately affect in the carbon stock and the sequestration of carbon dioxide from the atmosphere. Therefore the estimation of biomass and carbon is vital monitoring the amount of carbon fluxes. Forest biomass can be assessed either through field-based measurements or by remotely sensed methods. Field-based measurements known as destructive way of estimating AGB

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ABSTRACT

Toilet soaps became a part of our daily life, not only because of its cleaning properties but also due to its cosmetic aspects. People are now very much aware of the ingredients in cosmetic products and the harmful effects of chemicals in gradients and they started thinking about the benefits of plant products. The presence of artificial and chemical ingredients in cosmetic products has made people rethink about suitable alternatives. Due to the increasing awareness and importance of cleanliness and healthiness, the use of herbal products is also increasing. Herbal soaps serve as a good choice for people of all ages. In the present study antimicrobial activity of various antiseptic and herbal market soaps were determined against bacterial isolates present on the skin surface like *Escherichia coli* and *Pseudomonas aeruginosa* using agar disc diffusion method. Various microbes are deposited on the surface of skin from the dust present in an external environment which causes infection. Antimicrobial activities of various soaps on such micro flora pathogens were studied. Objective of this study is to analyze synthesized soap and compare it with commercially available soap. To achieve this goal, levels of some quality parameters of soap were determined such as volatile matter and moisture content, total fatty matter content (TMF), Alkali content and pH in soap.

CHAPTER 1

INTRODUCTION

Soap is the salt which is produced by the reaction of an alkaline substance with a fatty acid. The history of soap, which is an important part of our daily life and which we use many times a day, goes back about 6000 years. There are findings that soap was first discovered by women. Production of soap started with the addition of wood ash to fatty acids M.S. In 1790, with Nicolas Leblanc's production of NaOH, it was able to move towards more professional production. Scientific soap production was created in the 18th century with the contributions of Michel Eugene Chevreul and the soap production was turned into a real industry. Soap making basically consists of washing, cooking, liquefying and saponification stages of sodium salts formed after treatment of olive oil, pomace oil, sunflower oil, peanut oil, palm kernel oil, with alkalis.Many different methods are used in soap production and the most common being the cold process and the classical method so-called Marseille type. Other international soap making methods include the Clayton method, the Gunther Jacobs's JPC method, the Du Pont de Nemours method and the Monsavon method .Potassium soaps are obtained.

Hand washing is a simple and very effective method of protecting people from pathogens and infections. Today, there is much commercial soap with antimicrobial content that are sold for this purpose. These soaps contain antiseptic active ingredients in very low concentrations. Bacteria from environmental sources can accumulate on the skin surface and may cause skin infections. Examples of such bacteria are *Pseudomonas aeruginosa* and *Staphylococcus aureus*. The hand washing is even more important, especially when associated with possible cross-contamination of potentially pathogenic bacteria. Providing personal care and hand hygiene is very important for preventing contamination.

Soaps are cleansers for the skin and there are many benefits of herbal soap when compared to a "syndet" or a synthetic detergent bar. While both clean up the skin surface, the effects of an herbal bar made without synthetic detergents are highly beneficial as they are much more gentle and therapeutic for the skin. Herbal soaps are made using natural herbs and ingredients that are healthier and beneficial for the skin and are less likely to cause any damaging effect. One of the

many benefits of herbal soap is that it does not affect the probiotic balance of the skin. Being gentle on the skin, it does not rip the skin of moisture or sebum, the natural oil our skin produces for hydration and protection.

Some of the natural soap manufacturers also use aromatherapy and herbal treatments to offer the best skin treatment solution for your skin. Herbal bath soaps are made using skin loving oils and plant butter like coconut oil, sesame oil, sunflower oil, olive oil, shea, cocoa and Kokum kinds of butter. These highly nourishing oils undergo the process of saponification when they are mixed with an alkaline medium.

They provide the skin with extra moisture and replenish the sebum with their fatty acid content. Herbs used in the making of these soaps lend healing properties to the soap, unlike syndets that are harsh on the skin and offer little or no nourishing benefits to the skin. The synthetic detergents in these soaps are not only harmful to the skin but also to the ecosystem, as they are not readily biodegradable and pollute water bodies and harm marine life.

Chemically soaps are the combination of fats, oils (of animal or vegetable origin) and Salt [2]. Soaps are generally salts of free fatty acid made via saponification, where alkaline substances react with fatty acids in fats or oils. Other substances are then added to this salt of free fatty acid or soap base, to produce the different types of soaps we have. They are mainly used as surfactants for washing, bathing and cleaning [3]. Soaps are either non antimicrobial soaps or an antimicrobial soap, also known as an antiseptic or medicated soap. An antibacterial soap can remove 65% to 85% of bacteria from human skin [4].

Antiseptic soaps are incorporated with a specified amount of germicidal substances in addition to the ordinary soap base in order to increase their antibacterial activity. These antiseptic substances impart the ability for the soap to kill germs even after it has been used as residual antiseptic substances remain on the skin. It is proved experimentally that antibacterial soaps kill the bacteria at a specific concentration; they also have bacteriostatic activity and can inhibit the growth of bacteria. Herbal soaps are prepared by adding dried herbs, flowers and stems into the soap base. Herbs are the natural products that can be found in the treatment of almost all diseases

and skin problems owing to their high medicinal value, cost effectiveness, availability and compatibility [5, 6].

Different methods are used in soap production and the most common being the cold process and the classical method so-called Marseille type. Other international soap making methods include the Clayton method, the Gunther Jacobs's JPC method, the Du Pont de Nemours method and the Monsavon method [3].Potassium soaps are obtained when KOH base is used instead of base NaOH. Antiseptic soaps are classified as soaps used in the field of pharmacy and cosmetic soaps [2]. While soap is produced, glycerin is added which has a softening effect on the soap tissue. In addition, sorbitol is used for transparency, TiO2 for opacification, triclosan/tri-chlorocarbon for antibacterial purpose, plant-based essential oils for odor, milk/aloe vera, honey, filling oil and paling as filler for moisture and softening activity [4].Hand washing is a simple and very effective.

Hence it can be used in soap bases. The attributes of the soap include gentleness on the skin, rich lather, protection against skin disorders (including rashes, eczema, scabies), treatment of skin infection (such as ringworm), protection of even skin toning and smoothness of the skin [7] .

The soap should have good ingredients which have the ability to kill bacteria but not to damage body tissues. Number of bacteria including Gram Positive and Gram negative are deposited from the environment on the surface of skin and cause skin infection. Examples of these bacteria include *Staphylococcus aureus* [8], *Bacillus subtilis* and *Pseudomonas aeruginosa* [9]. Spread of infection by such bacteria can be prevented by use of antiseptic soaps, as it contains antimicrobial chemicals, but over use of soaps might result in antimicrobial resistance and even rendering a person more sensitive to allergies, 202 skin rashes [10]. The aim of the present research work is to compare the efficacy of locally available market herbal soaps and antiseptic soaps against skin infecting human pathogenic bacteria such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *E. coli*.

It was seen clearly that Gram positive bacteria were killed at a lower concentration of soaps than Gram negative bacteria. The most resistant bacterium of all the soaps appeared as Pseudomonas followed by Bacillus. This study suggests that selection of soaps and cleaning products depends

on their effectiveness in killing commonly encountered pathogenic microbes in day to day activities. Selection of soaps should depend on the present environment of the person and soaps having natural ingredients are better for constant long use.

Man's day to day activities include luxurious baths to laundry where soap is an integral part. Although the preparation of soap is the same worldwide, it is produced in different varieties for various purposes. The chemical composition of soap is a blend of sodium/potassium salts of the long chain fatty acids, which is made by saponification reaction by the hydrolysis of animal fat and alkali. It is also possible to utilize vegetable oils. Potassium alkali is used to make liquid soaps rather than sodium alkali as soaps produced are hard compared to potassium alkali. After hydrolysis of animal/vegetable oils, they are changed into glycerol and fatty acids. Following the release of water, the fatty acids react with the alkali to form metal salts called soaps. It is known that there are more than 100 oils that are used in soap production which occur in most varieties [Amponsah 2014 *et al.,]*. But unfortunately, most of the soaps form non-saponifiable fatty acids and cannot be suitable for soap production. In soap production, mixtures of oils are usually used to produce a high-quality product. Some components of these combinations may not undergo hydrolysis saponification and may be left out in the soap as unreacted fatty acids [Ahmed 1984 et al.,].

Skin irritation can be caused with the short chain fatty acids in soaps. As there occur a tendency to bleach the skin with the soap production, it is necessary to wash out the unreacted use of alkali. Unfortunately, for profit, most soap producers sacrifice quality and retain unreacted soap alkali [Idoko 2018 et al.,]. Sometimes, in order to produce a soap that bleaches, the alkali is left in the soap. Soap is a mixture of Na+ or K+ ions with fatty acids chemically. It is possible to classify fatty acids into saturated and unsaturated fatty acids. The most abundant saturated fatty acids are palmitic and stearic acids, whereas the most abundant unsaturated fatty acids are oleic and linoleic acids. Production of quality soap consists largely of choosing the right proportions of the right oils with their different fatty acids.

SCOPE OF THE STUDY

Our skin is a living organ, it is highly sensitive, and that is why we can feel heat/cold or touch and sensations. It also maintains the body temperature and protects our internal organs from an external environment. The probiotic friendly bacteria that reside on the surface of the skin acts as a guard killing the infectious germs our skin comes in contact with. One of the many benefits of herbal soap is that it does not affect the probiotic balance of the skin. Being gentle on the skin, it does not rip the skin of moisture or sebum, the natural oil our skin produces for hydration and protection.

Herbal soap is a natural alternative to chemical soaps. The raw materials are easily available locally .Soap base is used. Leaves, stems or roots of plants can be used in producing soaps. The best thing about herbal soaps is that they are purely made from herbs and shrubs. The natural content in the herbs does not have any side effects on the human body; instead they enrich the body with nutrients and other useful minerals. The acquisition of fresh herbs can be made by assembling them from their own garden or simply by buying from the market or from plant nurseries. It did not require any highly trained persons or expensive materials. Final product of the project is a natural bathing soap and eco-friendly products are used in the production. When analyzing the social –economic impact, this project will help in skill acquisition of the youth and be able to generate employment for the people.

AIM AND OBJECTIVES OF THE STUDY

The aim of the project work is to study and evaluate the handmade herbal bath soap. The objectives of this work are as follows.

- Production of quality herbal soap which are economical that can be used in our daily life
- To investigate the properties of herbal soap produced for analyzing different properties To achieve this goal, levels of some quality parameters of soap were determined such as foambility, total fatty matter content (TMF), Alkali content and pH in soap
- To analyze the antimicrobial activity of synthesized soap and to compare it with commercially available soaps

CHAPTER 2
REVIEW OF LITERATURE

Historically, soap production used to be a method to reuse animal fats, lard and sebum. Nowadays, most people use industrial soap but, mainly in poor regions, there are families and communities that produce their own soap bars (Onyegbado et al., 2002;Konkol and Rasmussen, 2015). In fact, there are regions where the access to a simple washing hand soap is not assured, which highly increases the risk of infections (Francke and Castro, 2013; Madichie,2016). There is also a growing movement to enhance artisanal production of good quality green soap, both because it is considered better for the skin and for health in general, as well as for reducing water and carbon footprints (Francke and Castro,2013)

According to Dr. Dadu (2017), choosing the right soap is essential for every one of all ages. It was said that showering and bathing is a part of a human's daily life. However, it is good to be informed about the bath products, especially soaps, which people have been using on a daily basis. Choosing the apt bath soap is a serious need or necessity since it frequently comes into contact with the skin. The skin's pH level is a major factor contributing to skin problems, in which it's a warning for everyone to avoid buying soaps with the skin pH level between 9 and 11, an example of it is a commercial soap. This may lead to skin problems. It is a must to be careful in choosing the right bath soap to apply.

Soap had been used to clean, to heal skin aches, and as a skin ointment for ages. But in the world today, the general public use soap as a purifier or aroma. If the body needs soap for cleaning, bathing, and washing then soap also needs a packaging to keep itself safe from harmful effects of environmental conditions.Carne (2016).

In the review article by Ashlesha Ghanwat et al, 2020 herbal soap containing neem , tulsi , shikakai and reetha as natural plant ingredients and this content gives or shows antibacterial antifungal & anti-inflammatory activity. In this soap, neem is main compound, and shows medicinal properties. Neem leaf and its extract exhibit immune modulatory anti-inflammatory,

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"A COMPARATIVE EVALUATION OF THE CONTENT OF VITAMIN C IN FRESHLY PREPARED AND PACKAGED FRUIT JUICES"

Dissertation submitted to the University of Kerala, in partial fulfillment of the requirement for the degree of Master of Science in Environmental Sciences

Submitted by

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Assessment of Groundwater Quality in Mamam River Basin, South Kerala, India using Geospatial Techniques

Dissertation Submitted to the University of Kerala
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ABSTRACT

The chemistry of water is an important factor to be considered before its use for domestic, irrigation or industrial purposes. It is now generally recognized that the quality of groundwater is just as important as its quality. Taking into consideration the fact that groundwater occurs in alliance with geological materials containing soluble minerals, higher concentration of dissolved salts are normally expected in groundwater relative to surface water. The type and concentration of salts present in the groundwater depends on the surrounding geological environment, the source of groundwater and movement of groundwater through the rocks.

The quality of groundwater is controlled by several factors, viz., climate, soil characteristics, interaction with the country rocks, saline water intrusion in coastal areas and the human activities on the ground. The study of groundwater quality involves a description of the occurrence of various constituents in groundwater and the relation of these constituents to water use. The quality analysis of groundwater includes the determination of the concentration of cations (such as Na, K, Ca, Mg, etc.) and anions (such as CO_3, HCO_3, Cl, SO_4, NO_3, PO_4, etc), pH, EC, TDS, etc. The present study entitled **Assessment of Groundwater Quality in Mamam River Basin, South Kerala, India using Geospatial Techniques** attempts to understand various aspects of groundwater chemistry with a special emphasis on the domestic and irrigation water quality. Study area lies between longitudes of 760 46' 33" and 760 58' 07" and latitudes of 8^0 32'23" and $8^0$42' 33" at Trivandrum district of Kerala and covering an area of 185.96 Km^2.

Most of the groundwater samples from the study area shows low pH values and this indicates an acidic nature for groundwater. Except pH, all other parameters like EC, TDS, and other major cations and anions in the study area are within the permissible limit of BIS. Thus, the chemical analysis indicates that the quality of groundwater in the study area is fit for domestic consumption, except in the regions of lower groundwater pH. Thematic maps of the above-mentioned parameters were prepared based on the Survey of India toposheets, auxiliary data and field data. GIS software, ArcGIS was used for the preparation the thematic maps. In the present study, groundwater quality zonation map was prepared based on the data generated by hydrogeochemical analysis. The parameter taken into consideration for the preparation of groundwater quality zonation map for drinking include pH, Calcium, Total dissolved salt and Chloride. The thematic maps were integrated to find out various groundwater quality zones. Numerical weighted parameter rating (WPR) approach and weighted index overlay method of

GIS technique was used to delineate various groundwater quality zones. The study area is divided into four zones such as Very High, High, Medium and Low quality zones based on the index values. The groundwater in the zones depicted as very high can be used for domestic purpose directly. The groundwater in the zones depicted as low should be treated before using for domestic purposes. The most of the study area comes under good and very good category and other area includes poor and moderately good zones. The poor-quality zones are found at the north and eastern part of the study area and the major portion of the study area comes under good water quality.

Suitability of water for agricultural utility was studied with the help of SAR, Residual Sodium Carbonate, Percent Sodium, USSL and Wilcox diagrams. In the USSL diagram most of the samples fall in C1S1 category indicating that these samples are suitable for agricultural purposes. The indices such as Residual Sodium Bicarbonate, Sodium Adsorption Ratio, Percentage Sodium, etc., also reveal the suitability of groundwater resources for irrigation purpose.

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Water is a precious resource and is basic need of our lives. About 60% of the human body is composed of water. About 97% of the total water on the earth's surface in the world's oceans and the remaining 3% belongs to lakes, rivers, polar ice caps, clouds, rain, sea ice and stored in rocks (aquifers). People use water for various purposes including domestic use, industrial requirements, irrigation, cultivation and also for many other activities. The main sources of freshwater are rivers, lakes, ponds and groundwater and others are used only after proper treatments like filtering, boiling, etc. The water found underground in saturated zones beneath the surface in the cracks and spaces in soil and in sand and rocks (aquifers) is called groundwater (USGS). The water which only 3% is freshwater and only about 1% is available for human use (WWF). Groundwater is readily available to humans and is the largest reservoir of freshwater. Water is vital for reducing the global burden of disease and improving the health, welfare and productivity of populations (UN). It is one of the most essential natural resources for eco-sustainability and is likely to become critical scare in the coming decades due to increasing demand, rapid growth of urban populations, development of agriculture and industrial activities especially in semi-arid regions (Hajalilou,B., and Khaleghi,F ., 2009). The safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction (WHO). For a healthy environment, the good quality of water is important. So water quality is an important factor to determine environmental changes.

Water use has been increasing worldwide by 1% per year since 1980s' due to increase in population growth and consumption and due to rising demand in the industrial and domestic sector. Agriculture usages consume the largest amount of water as over 30% of the world's food production comes from the irrigated lands. The industrial water use is estimated to be about 24% and the household consumption, including drinking, cooking, sanitation, and gardening, represents about 8% (Drever,1982, Giridharan et al., 2009; Sivasubramanian et al., 2013; Srinivasamoorthy et al., 2011; Selvam et al., 2015). Over 2 billion people live in countries experiencing high water stress and about 4 billion experience high water scarcity during at least one month of the year (UN report, 2019). Always water has a less expensive natural commodity due to its great abundance and this caused its over-utilization and thoughtless over-wastage. It lowers the water table and causing the depletion of the whole aquifer. Another severe problem is pollution. Water pollution refers to "Water contamination by a variety of chemical substances

or eutrophication caused by several nutrients and fertilizers" (Southwick, 1976). The current status of water resources highlights the need for improved water resource management with good quality (UN report, 2021).

Groundwater is usually considered as cleaner than surface water. But the deterioration and pollution of groundwater occurs due to various anthropogenic activities. Water quality is inherently linked with human health, poverty reduction, gender equality, food security, livelihoods and the preservation of ecosystems, as well as economic growth and social development of our societies (IAH, 2008; UNESCO, 2015). The quality of any kind of water can be checked with the help of GIS. Geographic Information System (GIS) is a computer system that analyses and displays geographically referenced information. It uses data that is attached to a unique location (USGS). GIS has a vital role in the mapping of groundwater quality and also can monitoring the environmental changes. Consumption of groundwater, however, has increased in areas with negligible surface water resources and GIS is used as a tool to identify the source of water quality pollution by urbanization (Schoeller, 1965; Enwright and Hudak, 2009; Lasserre et al., 1999; Selvam et al., 2014; Gopinath et al., 2016). By analysing the quality of water, can find the various parameters those influencing the quality of water and whether the water is potable or can use for any other purposes.

1.2 SCENARIO

1.2.1 GLOBAL SCENARIO OF WATER

Earth is also called as "Blue planet" in which 70 % of the land is covered with water. The water use increasing globally in every year. Developing countries use more water for their agricultural purposes, whereas developed nations use more water for industrial use. The global population tripled in the 20th century but at the same time the global use of water increased as six-fold. The amount of global water consumption is doubling every 20 years and as a result, at present more than one billion people on earth lack access to fresh drinking water. By the year 2025 the expected demand for freshwater will rise to 56% above that currently available. The research shows, within 2050, water demands are expected to increase by 400% from manufacturing, and 130% from household use (UNO).

1.2.2 NATIONAL SCENARIO OF WATER

India accounts for 4% of the world's water resources. India could experience average precipitation of 1,720 cubic metres per year and most of the rain occur during its monsoon seasons. It is estimated that about 38000 million litres per day (mld) of wastewater are generated in urban centres due to high population. Because of increase in population the demand of freshwater for all the users will be unmanageable. In India, deterioration of water quality due to change or increase in overall salinity of the groundwater and or presence of high

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PHYTOCHEMICAL,HISTOCHEMICAL, PROTEIN ISOLATION AND ANTI-MICROBIAL SCREENING OF *MURRAYA KOENIGII*

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the Degree of Master of Science in Environmental Sciences

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This is to certify that the dissertation entitled "***Phytochemical, Histochemical,Protein isolation and anti-microbial screening of Murraya koenigii***" is an authentic record of original research work carried out by **Ms. Rizwana M**.,, as a part of the degree of Master of Science in Environmental Sciences under my supervision and guidance. I further certify that no part of this work has been submitted earlier for the award of any other degree, diploma or other similar titles.

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ABSTRACT

The discovery of several revitalizing molecules that can stop or reduce the pathology of a wide range of diseases will be considered a major breakthrough of the present time. Available synthetic compounds may provoke side effects and health issues, which heightens the need for molecules from plants and other natural resources under discovery as potential methods of replacing synthetic compounds. In traditional medicinal therapies, several plant extracts and phytochemicals have been reported to impart remedial effects as better alternatives. *Murraya koenigii* (*M. koenigii*) belongs to the Rutaceae family, which is commonly used as a medicinally important herb of Indian origin in the Ayurvedic system of medicine. Previous reports have demonstrated that the leaves, roots, and bark of this plant are rich sources of carbazole alkaloids, which produce potent biological activities and pharmacological effects. These include antioxidant, antidiabetic, anti-inflammatory, antitumor, and neuroprotective activities. The present study provides insight into the major components of *M. koenigii* and their pharmacological activities against different pathological conditions. The study also emphasizes the need for more research on the molecular basis of such activity in various cellular and animal models to validate the efficacy of *M. koenigii* and its derivatives as potent therapeutic agents. The presence of important phytochemicals make the plant useful for treating different ailments and have a potential of providing useful drugs of human use. The quantitative determination of pharmacognostic parameters will help for setting standards for crude drugs. The total ash is particularly important in evaluating the purity of drugs. The pharmacognostic constants for the leaves of this plant, the diagnostic microscopic features and the numerical standards are reported, which is useful for the compilation of a suitable monograph for its proper identification. Microscopic and morphological characters were examined by pharmacognostic evaluation, which also includes the determination of leaf content, ash value, powder analysis and extractive values. Phytochemical screenings including qualitative chemical examination were also performed. Phytochemicals such as carbohydrates, alkaloids, sterols, tannins, volatile oils, saponins, anthroquinone glycosides and flavanoids wee reported. The organoleptic characters including colour, odour, taste and external features of bark of *M. Koenigii* were also observed.

CHAPTER 1
INTRODUCTION

Herbal medicines proved to be the major remedy in the traditional system of medicine. This prompted the development in the practices of medicinal plants. The reasons are because of their biomedical benefits as well as place in cultural beliefs in many parts of the world in the development of potent therapeutic agents. Medicinal plants have provided mankind with a large variety of potent drugs to alleviate or eradicate infections and suffering from diseases in spite of advancement in synthetic drugs , some of the plant-derived drugs still retain their importance and relevance. The use of plant based drugs all over the world is increasing. There have been records of advances made in modern (synthetic) medicine; there are still a large number of ailments or infection (diseases) for which suitable drugs are yet to be found. This have brought an urgent need to develop safer drugs (both for man and his environment) for the treatment of inflammatory disorders, diabetes, liver diseases and gastrointestinal disorder [Oladeji O , 2016].

Medicinal Plants, also called medicinal herbs, have been discovered and used in traditional medicine practices since prehistoric times. Medicinal plants may be defined as those plants that are commonly used in treating and preventing specific ailments and diseases and that are generally considered to be harmful to humans [Schulz V, Hansel R, Tyler VE, 2001]. These plants are either “ wild plant species ” those growing spontaneously in self – maintaining populations in natural or semi- natural ecosystems and could exist independently of direct human actions or the contrasting “ domesticated plant species ” those that have arisen through human actions such as selection or breeding and depend on management for their existence [Calixto JB , 2000].

Plants synthesize hundreds of chemical compounds for functions including defence against insects, fungi, diseases and herbivorous mammals. Numerous phytochemicals with potential or established biological activity have been identified. Phytochemicals are chemicals produced by plants through primary or secondary metabolism. The various

phytochemicals include alkaloids , flavonoids, carbohydrates, terpenoids, quinones, phenols, glycosides, saponins, steroids etc.

Alkaloids – Alkaloids are any of a class of naturally occurring organic nitrogen-containing bases. Well known alkaloids include morphine, strychnine, quinine,\ ephedrine and nicotine. In some plants, the concentration of alkaloids increases just prior to seed formation and then drops off when the seed is ripe, suggesting that alkaloid may play a role in this process.

The medicinal properties of alkaloids are quite diverse. Morphine is a powerful narcotic used for the relief of pain, though it's addictive properties limit its usefulness.

Flavonoids - flavonoids are a group of plant metabolites thought to provide health benefits through cell signalling pathways and antioxidant effects. These are polyphenolic molecules containing 15 carbon atoms and are soluble in water. They consist of two benzene rings connected by a short three carbon chain. Flavonoids are important antioxidants, and promote several health effects. Aside from antioxidant activity , these molecules provide the following beneficial effects: Anti-viral, anti- cancer, anti-inflammatory and anti- allergic.

Quinones – quinones are a class of organic compounds consisting of a six- carbon cyclic Dione structure containing two double-check bonds, such as p- benzoquinone, o-benzoquinone. They form a major class of cytotoxins, used in the fight against cancers.

Terpenoids - terpenoids also known as isoprenoids, are the most numerous and structurally diverse naturally produced products found in many plants [A. Ludwiczuk, M.I Georgiev, Pharmacognosy, 2017]. The therapeutic uses include antimicrobial, antifungal, antiviral, antihyperglycemic , anti-inflammatory, antioxidants, antiparasitic, immunomodulatory, and as skin permeation enhancer.

Steroids - steroids are biologically active organic compounds with four rings arranged in a specific molecular configuration. Steroids have two principal biological functions: as important components of cell membranes which alter membrane fluidity; and as signalling molecules.

Cardiac glycosides – cardiac glycosides are a class of organic compounds that increase the output force of the heart and increase its rate of concentrations by acting on the cellular sodium- potassium ATPase pump.

Their beneficial medicinal uses are as treatments for congestive heart failure and cardiac arrhythmias; due to their effects on increasing the force of muscle contraction while reducing heart rate.

Carbohydrates – These are biomolecules consisting of carbon, hydrogen and oxygen atoms. Carbohydrates provide fuel for the central nervous system and energy for working muscles.

Saponins – saponins are a class of chemical compounds found in particular abundance in various plant species. Studies have illustrated the beneficial effects on blood cholesterol levels, cancer, bone health and stimulation of the immune system. Saponins are glycosides with foaming characteristics. Saponins consist of polycyclic aglycones attached to one or more sugar side chains.

Phenols – phenols sometimes called phenolics, are a class of chemical compounds consisting of a hydroxyl group (-OH) bonded directly to an aromatic hydrocarbon group. Phenol has been used to disinfect skin and relieve itching. Phenol is also used as an oral analgesic or anesthetic in products such as chloraseptic to treat pharyngitis. Additionally, phenol and its related compounds are used in surgical ingrown toenail treatment, a process termed phenolization [Drugbank- phenol].

Medicinal plants contain a wide variety of secondary metabolites or compounds such as tannins, terpenoids, alkaloids, flavanoids ; that dictates the therapeutic potency of the plants most especially the antimicrobial activities [Evans WC, Trease GE. Trease and Evans Pharmacognosy, 2002]. The phytochemicals such as flavanoids and tannins were also revealed to be active against pathogenic bacteria such as *Bacillus cereus*, *Staphylococcus aureus* amongst others [Kumar A, Shukla R, Singh P *et al*. 2008]. The tannins present in medicinal plants make it useful in production of antiseptic soap which are commonly used in bathing or cleansing of skin surfaces [Evans WC,2002]. Saponins were reported as a major components acting as antifungal secondary metabolite. A wide range of physiological activity of saponins, steroids, phenols and tannins are found to be more

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ABSTRACT

Moringa oleifera is a medicinal plant in traditional folk medicine. Many pharmacological studies have shown the ability of this plant to exhibit analgesic, anti-inflammatory, antipyretic, anticancer, antioxidant, nootropic, hepatoprotective, gastroprotective, anti-ulcer, cardiovascular, anti-obesity, antiepileptic, antiasthmatic, antidiabetic, anti-urolithiatic, diuretic, local anesthetic, anti-allergic, anthelmintic, wound healing, antimicrobial, immunomodulatory, and antidiarrheal properties. This study is a comprehensive summary of the phytochemical and pharmacological activities as well as the traditional and therapeutic uses of this plant. *M. oleifera* has wide traditional and pharmacological uses in various pathophysiological conditions. This study evaluates the phytochemical, histochemical, gram stainig and antimicrobial activity of the leaf extracts of *Moringa oleifera*. The antimicrobial activity of the leaf extracts of *Moringa oleifera* is against *Staphylococcus aureus* and *Escherichia coli*. Different concentrations of the extracts were subjected to these organisms in which Moringa oleifera showed a higher zone of inhibition on *Staphylococcus aureus* (1.7 cm) while on E. coli (1.4 cm) in 100 mg/ml and it showed a higher zone of inhibition on E. coli (2.1 cm) while on S. aureus (2.6. cm) in 50 mg/ml . The minimum inhibitory concentration of *Moringa oleifera* extract on *E. coli* and *S. aureus* were 50 mg/ml and 100 mg/ml. The Qualitative phytochemical screening indicated the maximum presence of phytochemical constituents Tannin, Saponin, Phenol, Flavonoid and cardiac glycosides. The transverse section of leave showed xylem, phloem, Lamina, collenchyma, epidermis, Palisade, Spongy, Mesophyll, abaxial surface and Prismatic form of calcium oxalate crystal present in Mesophyll,Palisade ratio 5-6, 5-8.5, Stomatal index 10.8-14.2-18.1 for lower surface. In gram staining reaction, gram positive and gram negative bacteria are observ

CHAPTER-1

INTRODUCTION

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Moringa (*Moringa oleifera*)

It belongs to the family, Moringaceae and order, Brassicales. This medicinal plant is short, slender, deciduous, perennial tree, to about 10m tall; rather slender with drooping branches; branches and stem brittle, with corky bark; leaves feathery, pale green, compound, tripinnate, 30-60cm long, with many small leaflets, 1.3-2cm long, 0.6- 0.3cm wide. Its pods are pendulous, brown, triangular, splitting lengthwise into 3parts when dry, 30-120cm long, 1.8cm wide, containing about 20seeds embedded in the pith, pod tapering at both ends, 9-ribbed; seeds dark brown, with 3 papery wings[Verma S.C., Banerji R et al. 1976]. Native to India, Arabia, and possibly Africa and the East Indies; widely cultivated and naturalized in tropical Africa, tropical America, Sri Lanka, India, Mexico, Malabar, Malaysia and the Philippine Islands . Moringa plant parts have substantial anti-inflammatory activity.

The crude methanol extract of the root inhibits carrageenan- induced rat paw oedema in a dose dependent manner after oral administration. Moreover, n-butanol extract of the seeds of Moringa shows antiinflammatory activity against ovalbumin induced airway inflammation in guinea pigs[Mahajan S. G., Banerjee A et al. 2009] Amelioration of inflammation associated chronic diseases can be possible with the potent anti-inflammatory activity of Moringa bioactive compounds.

Moringa has diversified medicinal value, which has long been recognized in the Ayurveda and Unani system [Mughal M. H. S., Ali G et. al 1999] . Nearly every part of this plant, including root, bark, gum, leaf, fruit (pods), flowers, seed, and seed oil have been used for various ailments in the indigenous medicine13 but recent research is also showing several active constituents that makes it widely accepted for use in modern medicine. This study thus helps to evaluate the effectiveness of *Moringa oleifera* sources and their pharmaceutical values on selected human pathogens. Similarly, phytochemical properties of the medicinal plants studied were also determined.

TAXONOMIC DESCRIPTION OF *Moringa oleifera*

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Brassicales
Family:	Moringaceae Martinov
Genus:	*Moringa*


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