SITE SUITABILITY ANALYSIS FOR LEACHATE TREATMENT IN NAMAKKAL DISTRICT USING GIS

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Abstract - *Urbanization of developing countries ultimately results in generation of enormous solid waste from both industrial and domestic sectors. The disposal of this huge MSW becomes a challenging process as the wastelands are rapidly converted into residential and industrial plots. Leachate is a concentrated liquid that originates from the solid waste at the dumping sites. Release of leachate to the environment without any treatment may pollute the soil, and both surface and ground water. As a result, improper site selection for the leachate treatment out to be a threating agent for health and environmental sustainability.*

Key Words*:* *Industrial, Domestic Sectors, Wastelands, Dumping Leachate, Environment, Treatment, GIS …*

1. INTRODUCTION

Leachates from MSW landfill sites are often defined as heavily polluted wastewater. Leachate is a liquid formed primarily by the percolation of precipitation water through the open landfill or through the cap of the completed site. some may be stored within the landfill, and the balance becomes percolate and eventually leachate. Leachates may contain large amounts of organic contaminants which can be measured as chemical oxygen demand (COD) and biological oxygen demand (BOD), ammonia, halogenated hydrocarbons suspended solid, significant concentration of heavy metals and inorganic salt. If not treated and safely disposed, landfill leachate could be a potential source of surface and ground water contamination, as it may percolate through soils and sub soils, causing pollution to receiving waters.

Solid waste is all kind of garbage, refuse, trash and other discarded solid materials which were generated from human activities especially from Residential, Commercial establishments (e.g., Restaurants, Banks) and Institutions (e.g., Hospitals, Schools) Usually wastes are managed by Municipal authorities. Nowadays, solid Waste disposal practices became a huge problem in every country with increasing concern for the environment. People generated solid wastes in the form of bottles, boxes, clothing, plastic bags and much more results in million tons of solid waste generated per year. If all of the trashes are not managed properly, they will pose a major threat to human, animals and the Environment.

1.1 About Leachate

The leachate generated from a landfill site will vary in volume and composition depending on the age of the site and stages biodegradation reached. Because of the changes in leachate composition with time, the leachate control systems should adapt to these changes. Leachate treatment is required to remove any contaminating components of the leachate and bring it to a standard whereby it can be released to a sewer, a water course, Land or tidal water. Before release, a discharge consent or agreement is required from the local authorities or environmental agency.

The consent or agreement may cover a range of potentially polluting components, for example, pH, concentration of organic material, ammonium and nitrate, suspended solids and metal content. Treatment processes for leachate are physico-chemical, attached growth processes, non- attached growth processes, anaerobic treatment, anaerobic/aerobic treatment, land treatment and leachate recirculation.

1.2 Objective

The suitable objectives of the study are

- To create various thematic maps of the study area using ArcGIS
- To perform overlay analysis and decision making using GIS
- To identify a suitable area for leachate treatment in Namakkal district

2. LITERATURE REVIEW

ROSLINA MOHAMMAD et al., (2018) Solid Waste Management (SWM) has become an issue of concern ever since humans began to build communities within a concentrated area. The greater the population density the more important is a proper waste management system. The main objective of the disposal system was to take care of the sanitation and health of the community. The degradation of the organic fraction of the wastes in combination with percolating rainwater leads to the production of a dark colored, highly polluted liquid called "leachate". If not treated and carefully disposed the movement of leachate into the surrounding soil, ground water, or surface water, may lead to severe pollution. This paper highlights the landfill management, landfill leachate generation and its characterization, and treatment methods available for landfill leachate.

EGYPT ET AL., (2013) Leachate generation is a major problem for municipal solid waste (MSW) landfills and causes significant threat to surface water and groundwater. Leachate can be defined as a liquid that passes through a landfill and has extracted dissolved and suspended matter from it. The main goal of this study is to utilize a natural low cost material "as an accelerator additive to enhance the chemical treatment process using Alum coagulant and the accelerator substances were Perlite and Bentonite. The performance of the chemical treatment was enhanced using the accelerator substances with 90 mg/l Alum as a constant dose. Perlite gave better performance than the Bentonite effluent. The removal ratio for conductivity, turbidity, BOD and COD for Perlite was86.7%, 87.4%, 89.9% and 92.8% respectively, and for Bentonite was 83.5%, 85.0%, 86.5% and85.0% respectively at the same concentration of 40 mg/l for each.

PUSHPAGUJRAL ET AL., (2012) The paper discusses the characteristics of leachate generated from municipal solid waste landfilling sites of Ludhiana City, Punjab (India). Leachate samples were collected and analyzed for various physico-chemical parameters to estimate its pollution potential. This study aims to serve as a reference for the implementation of the most suitable technique for reducing the negative environmental effects of discharge leachate. All the three landfilling sites of Ludhiana city are non-engineered low lying open dumps. In older landfills, the biodegradable fraction of organic pollutants in the leachate decreases as an outcome of the anaerobic decomposition occurring in the landfill. The concentration of leachate contaminants at Jamalpur and Noorpur belt landfilling site were comparative greater than that of Jainpur land filling site which is older than both.

MURUGESAN et al., (2012) have carried out groundwater study in the Dindigul district of kodaikanal hill, which is a mountainous terrain in the Western Ghats of Tamilnadu. Ground water potential zones have been demarcated with the help of remote sensing and Geographical information (GIS) techniques. All thematic maps are generated using the resource sat (IRS P6 LISS IV MX) data and Inverse distance weight (IDW) model is used in GIS data to identify the groundwater potential of the study area. For the various geomorphic units, weight factors were assigned based on their capability to store groundwater.

3. METHODOLOGY

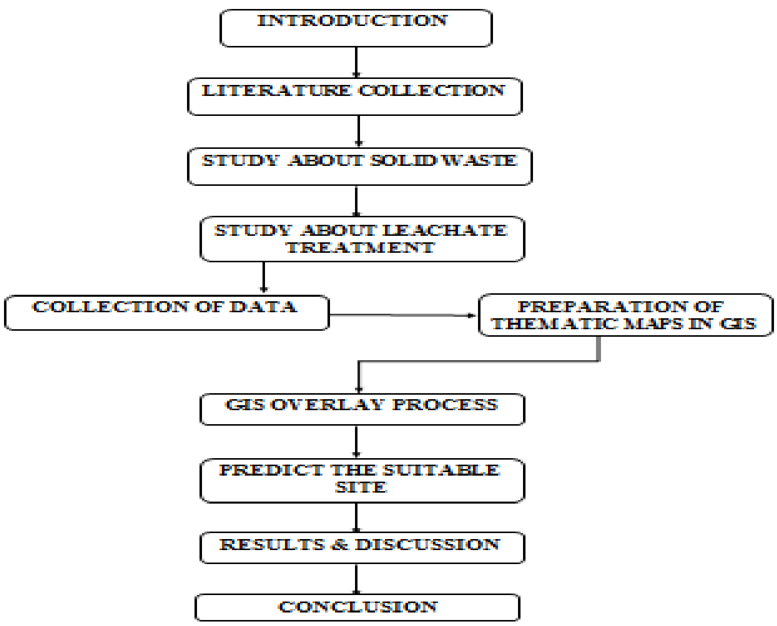

Fig -1: Methodology

4. ABOUT STUDY AREA

Namakkal district is bounded by Salem district on the north; on the east by Attur taluk of Salem district, Perambalur and Tiruchirappalli District's; by Karur District on the south and on the west by Erode district. (Namakkal District profile, South India Online) Namakkal District comes under the North Western Agro climatic zone of Tamil Nadu. It is situated in the dividing portion of two watersheds between Cauvery and the Vellar System with the Taluks of Attur, Rasipuram and Namakkal on the East and Salem, Omalur and Mettur on the West.

Tiruchengode taluk alone is placed under Western Agro-climatic zone Namakkal District, Govt of Tamil Nadu Besides the above two zones, Kolli and a few isolated hills and ridges are scattered over Namakkal, Rasipuram and Tiruchengode and along with the valleys and rolling hills, make up the characteristic topography of the district.

Fig -2: Study area map

4.1 Population of Namakkal

The fact is, last census for Namakkal district was done only in 2011 and next such census would only be in 2021. But as per estimate and projection, population of Thane district in 2018 is 18.69 Lakhs compared to 2011 census figure of 17.27 Lakhs.

4.2 Waste Generation Location

Table -1: Different types of waste

Types	Total units	Waste Generation
Houses & Commercial Establishments (Organic / Inorganic / Recyclable)	17427 House holds	13.50 Mts
Hotel & Restaurants (Organic)	3	42.00 Mts
Markets (Organic)	2	2.50 Mts
Slaughter House (Organic)	1	0.50 Mts
Kalyanamadapam (Organic)	14	2.00 Mts
Demolition waste (Inorganic)	--	0.50 Mts
Bio medical	72	2.65 Mts

In the above table it is shown that out of the total waste generation in Namakkal town limit, the major amount of waste generation consisting of houses and commercial establishment (organic/inorganic/recycle) is 13.50 MT and other wastes like hotels and restaurants, markets, slaughter houses and marriage hall demolition waste and bio-medicals accounts to 9.65 MT. Hence it is evident that the majority of wastes come out of houses and commercial establishments rather than other sources.

Table -2: Waste generation per day

S.NO	TYPES OF REFUSE	KG/CAP/DAY
1.	Residential refuse	0.3 to 0.6 kg/cap/day
2.	Commercial refuse	0.1 to 0.2 kg/cap/day
3.	Street sweepings	0.05 to 0.2 kg/cap/day
4.	Institutional refuse	0.05 to 0.2 kg/cap/day

Table -3: Waste generation per month

S.NO	TYPES OF REFUSE	KG/CAP/month
1.	Residential refuse	9 to 18 kg/cap/month
2.	Commercial refuse	3 to 6 kg/cap/month
3.	Street sweepings	1.5 to 0.6 kg/cap/month
4.	Institutional refuse	1.5 to 0.6 kg/cap/month

Table -4: Waste generation per year

S.NO	TYPES OF REFUSE	KG/CAP/YEAR
1.	Residential refuse	109.5 to 219 kg/cap/year
2.	Commercial refuse	36.5 to 73 kg/cap/ year
3.	Street sweepings	18.25 to 7.3 kg/cap/ year
4.	Institutional refuse	18.25 to 7.3 kg/cap/ year

Collected waste is transported by pushcarts and tricycles to the transfer point from where Lorries transport the waste to the Kosavampatti compost yard and disposal site for aerobic composting, vermin-composting and disposal. The collected waste is transported by pushcarts and tricycles to the transfer point from where Lorries transport the waste to the Kosawampatti compost yard and disposal site for aerobic composting.

Table -5: Generation of waste for last five years

Types	2015	2016	2017	2018	2019
Houses & Commercial Establishments (Organic / Inorganic / Recyclable)	8.1 Mts	9.6 Mts	11.2 Mts	12.7 Mts	13.50 Mts
Hotel & Restaurants (Organic)	28.7 Mts	31.8 Mts	35.3 Mts	38.7 Mts	42.00 Mts
Markets (Organic)	1.21 Mts	1.76 Mts	1.9 Mts	2.13 Mts	2.50 Mts
Slaughter House (Organic)	0.09 Mts	0.18 Mts	0.32 Mts	0.41 Mts	0.50 Mts
Kalyanamadapam (Organic)	0.78 Mts	0.8 Mts	1.2 Mts	1.78 Mts	2.00 Mts
Demolition waste (Inorganic)	0.35 Mts	0.16 Mts	0.28 Mts	0.44 Mts	0.50 Mts
Bio medical	1.16 Mts	1.46 Mts	1.7 Mts	2.34 Mts	2.65 Mts

5. GEOGRAPHIC INFORMATION SYSTEM

5.1 General

GIS is a combination of software, hardware and experts for storing, retrieving, transforming and displaying the spatial data. Data are stored digitally in GIS, therefore, they need less space compared to traditional systems like paper maps. In addition, it is possible to combine different maps and data and do several analyses in short time. This feature makes GIS different from other graphical software's like AutoCAD.

5.2 DATABASE MANAGEMENT SYSTEM

The source maps for soil, geology, geomorphology, lineament are published maps of state ground and surface water resources data centre, Chennai in 1:500000 scale. Contour map is derived from the Survey of India (SOI) topographical maps bearing no 58E/11, 58E/14, 58E/15, 58E/16, 58I/2, 58I/3, 58I/4, 58I/6, 58I/7 and 58I/8 in 1:50000 scale. The source maps are scanned and digitized. The final hard copy out-put is prepared using Arc View software

6 MUNICIPAL SOLID WASTES

6.1 General

The abysmal state of and challenges in municipal solid waste management (MSWM) in urban India is the motivation of the present study. Urbanization contributes enhanced municipal solid waste (MSW) generation and unscientific handling of MSW degrades the urban environment and causes health hazards. In this paper, an attempt is made to evaluate the major parameters of MSWM, in addition to a comprehensive review of MSW generation, its characterization, and collection.

6.2 Urbanization and Solid Waste Generation in India

6.2.1 Urbanization

The consequences of burgeoning population in urban centers are more noticeable in developing countries as compared to the developed countries. The population of urban India was 377 million (Census of India, 2011a), which accounts for 31% of the total population. A global case history reveals that when a country's urban population extends beyond 25% of the overall population (as in the present case), the pace of urbanization accelerates.

Table -6: Waste Generation

Description	Details
Per capita waste generated (gms/day)	400
Waste Generated (tonnes per day)	21
Waste Collected (tonnes per day)	21
Lorry	5
Auto Model Van	2
Collection capacity of the Vehicles (tonnes)	15

6.2.2 Generation and Collection

In India, rapid urbanization and uncontrolled growth rate of population are main reasons for MSW to become an acute problem. It is anticipated that population of India would be about 1,823 million by 2051 and about 300 million tons per annum of MSW will be generated that will require around 1,450 km2 of land to dispose it in a systematic manner, if ULBs in India continue to rely on landfill route for MSW management.

Planning Commission Report reveals that 377 million people residing in urban area generate 62 million tons of MSW per annum currently and it is projected that by 2031 these urban centers will generate 165 million tons of waste annually and by 2050 it could reach 436 million tons.

6.3 Solid Waste Management Practices and Challenges in India

In India, MSWM is governed by MSWR. However, majority of ULBs do not have appropriate action plans for execution and enactment of the MSWR. Unfortunately, no city in India can claim 100% segregation of waste at dwelling unit and on an average only 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment. Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps.

6.3.1. Segregation

There is no organized and scientifically planned segregation of MSW either at household level or at community bin. Sorting of waste, is mostly accomplished by unorganized sector and seldom practiced by waste producers. Segregation and sorting takes places under very unsafe and hazardous conditions and the effectiveness of segregation is reasonably low as unorganized sector segregates only valuable discarded constituents from waste stream which can guarantee them comparatively higher economic return in the recycling market.

6.3.2. Collection

Waste produced by houses is usually transferred into communal bins that are fabricated from metal, made from concrete or in combination of both. Street sweepings also find its way to community bins. These community waste bins are also used by other essential commercial sectors in the vicinity of disposal bins along with household waste except where some commercial complexes or industrial units engage municipal authorities for transfer of their waste to disposal site by paying some amount.

6.3.3. Reuse/Recycle

This entails activities like collecting those materials from the waste, which could be gainfully retrieved and utilized for making new products. Since unsegregated waste is dumped at community bins, its optimal recycling is not possible. However, rag-pickers usually sorted out and took and sell recyclable material like plastics, glass, etc. In Pondicherry, almost all recyclable material is sorted out by rag-pickers and absorbed in material stream through recycling.

6.3.4. Transportation

Modes of transportation for MSWM practised in India are: bullock carts, hand rickshaws, compactors, trucks, tractor, trailers, and dumpers. In smaller towns trucks having 5–9 ton capacity are used without adequate cover system. Stationary compactors, mobile compactors/closed tempos, and tarpaulin-covered vehicles are used in the transportation of MSW and about 65, 15, and 20% of waste is transported through these compacters, respectively.

6.3.5 Open Dumping

In India, MSW generated is usually directly disposed on low lying area in routine way violating the practices of sanitary land filling. Almost no ULBs have adequate sanitary land filling facility and MSW is dumped in the outskirts of town along the roads. Unscientific dumping is prone to flooding and major source of surface water contamination during monsoon and ground water contamination due to percolation of leachate

7. LEACHATE

One of the major pollution problems caused by the MSW landfill is landfill leachate, which is generated as a consequence of precipitation, surface run-off and infiltration or intrusion of groundwater percolating through a landfill, biochemical processes and the inherent water content of wastes themselves. Leachate is the liquid residue resulting from the various chemical, physical and biological processes taking place within the landfill. Landfill leachate is generated by excess rainwater percolating through the waste layers in a landfill. Generally, leachate may contain large amounts of organic matter (biodegradable, but also refractory to biodegradation), as well as ammonia-nitrogen, heavy metals, chlorinated organic and inorganic salts, which are a great threat to the surrounding soil, groundwater and even surface water . However, the organic content of leachates is often measured through analyzing sum of parameters such as COD, BOD (biochemical oxygen demand) and TOC and dissolved organic carbon.

Table -7: Characteristics of leachate at different ages of landfill

Parameter	Young	Intermediate	Old
Age (years)	< 5	5-10	>10
pH	6.5	6.5-7.5	>7.5
COD (mg/l)	> 10,000	4,000-10,000	<4,000
BOD5/COD	> 0.3	0.1-0.3	<0.1
Organic compounds	80% volatile fat acids (VFA)	5-30% VFA+ humic and fulvic acids	Humic and fulvic acids
Heavy metals	Low-medium	Low	Low
Biodegradability	Important	Medium	Low

Table -8: Typical concentrations in landfill leachate comparing with sewage and groundwater

Parameters*	Young leachate concentration	Old leachate concentration	Typical sewage concentration	Typical groundwater concentration
COD	20,000-40,000	500-3,000	350	20
BOD5	10,000-20,000	50-100	250	0
TOC	9,000-25,000	100-1,000	100	5
Volatile fatty acids	9,000-25,000	50-100	50	0
				All values in mg/l

Normally, young landfill leachate (the acid-phase landfill, <5 years) contain large amounts of biodegradable organic matter. More than 95% of the dissolved organic carbon (DOC) consists of volatile fatty acids, and little of high molecular weight compounds. In mature landfills (the methanogenic-phase landfill), the organic fraction in the leachate becomes dominated by refractory compounds, and the DOC content consists of high molecular weight compounds.

8 GIS RESULTS

8.1 Geomorphology Map

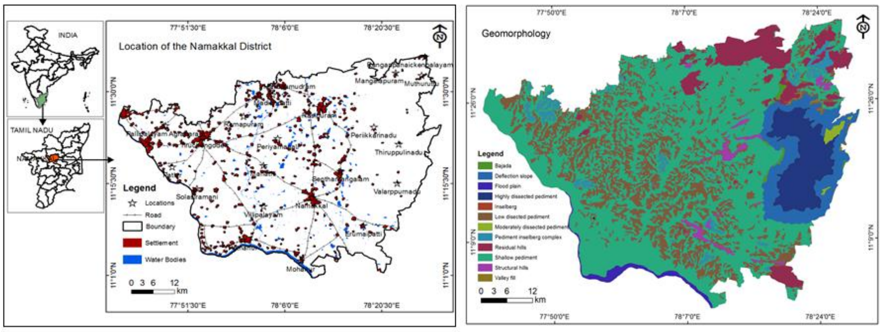

Fig -3: Location map & Geomorphology

Geomorphology is defined as the science of landforms with an emphasis on their origin, evolution, form, and distribution across the physical landscape. An understanding of geomorphology and its processes is therefore essential to the understanding of physical geography.

8.2 Geology Map

Geologic maps represent the distribution of different types of rock and surficial deposits, as well as locations of geologic structures such as faults and folds. Geologic maps are the primary source of information for various aspects of land-use planning, including the siting of buildings and transportation systems. The geology map was prepared by using already existing geological data collected from the geological survey of India map with the scale of 1:250000.

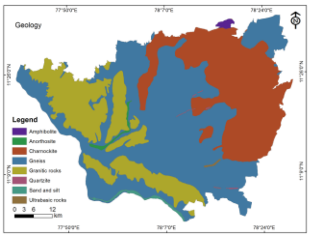

Fig -4: Geology map

8.3 Lineament Map

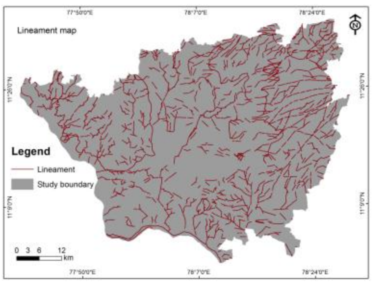

Fig -5: Lineament map

Linear features on the Earth's surface have attracted the attention of geologists for many years. This interest has grown most rapidly in geological studies since the introduction of aerial photographs and satellite images. At the beginning, to the middle of the twentieth century, several geologists recognized the existence and significance of linear geomorphic features that were the surface expression of zones of weakness or structural displacement in the crust of the Earth.

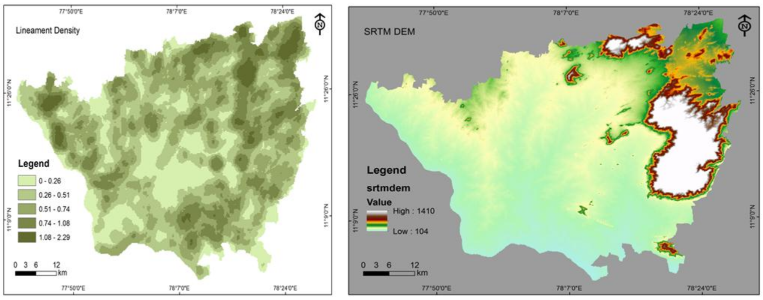

Fig -6: Lineament density & SRTM DEM data

8.4 Slope Map

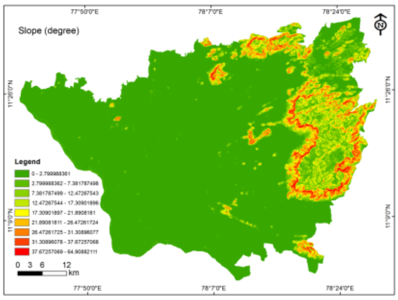

Fig -7: Slope Ratio

Slope represents the rate of change of elevation for each digital elevation model (DEM) cell. It's the first derivative of a DEM. This map provides a colorized representation of slope, generated dynamically using server-side slope function on Terrain service. The degree of slope steepness is depicted by light to dark colors - flat surfaces as gray, shallow slopes as light yellow, moderate slopes as light orange and steep slopes as red-brown

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Table -9: Rank and Weight-age for various parameters

Theme	Rank	Class	Groundwater prospect	Weight age
Lineament density, km/km^2	25	1.08-2.29	Very good	9
		0.74-1.08	Good	7
		0.51-0.74	Moderate	6
		0.26-0.51	Poor	4
		0-0.26	Very poor	3
Slope	15	0-4º	Very Good	8
		4-11º	Good	6
		11-19º	Moderate	4
		19-28º	Poor	2
		28-64º	Very poor	1
Drainage density, km/km^2	15	0-0.50	Very Good	7
		0.50-1.11	Good	5
		1.11-1.93	Moderate	3
		1.93-2.83	Poor	2
		2.83-4.43	Very poor	1
Land use / land cover	10	Agricultural land	Very good	9
		Fallow land	Good	8
		Reserve forest	Moderate	5
		River	Moderate	7
		Tank	Very good	10
		Built-up land	Poor	4
Soil	10	Alf sols	Very good	9

		Entisols	Good	6
		Inceptisols	Moderate	5
		Miscellaneous	Very Poor	4
		Reserve Forest	Moderate	3
Geomorphology	10	Bajada	Very good	10
		Deflection slope	Moderate	5
		Flood plain	Good	8
		Valley fill	Moderate	6
		Highly dissected pediment	Good	7
		Structural hill	Poor	3
		Inselberg	Very poor	2
		Low dissected pediment	Poor	2
		Moderately dissected pediment	Moderate	5
		Pediment inselberg complex	Moderate	4
		Shallow pediment	Good	9
Lithology	15	Gneiss	Very good	9
		Amphibolite	Good	7
		Charnockite	Moderate	5
		Ultrabasic rocks	Poor	3
		Quartzite	Very poor	2
		Granitic rocks	Very poor	1
		Anorthosite	Moderate	5
		Sand and silt	Good	8

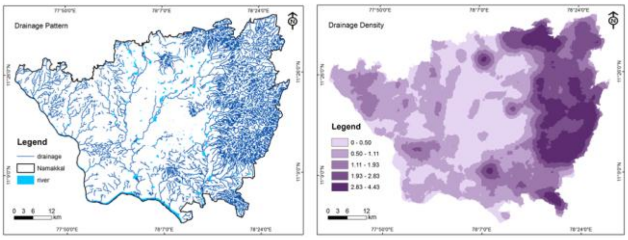

Fig -8: Drainage pattern & Drainage density

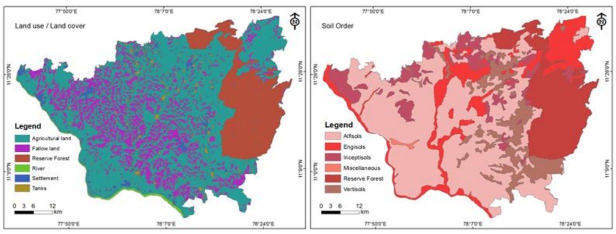

Fig -9: LULC Map & Soil order Map

9. TREATMENT METHODS

Leachate is highly complex and polluted waste water that is produced by the introduction of percolation water through the body of landfill treatment. Leachate treatment is essential as it could threaten the surrounding ecosystem when discharge as it is and when it mixes with groundwater.

9.1Biological Treatment

Biological treatment is worldwide the most common practice for leachate treatment. Biological systems can be divided in anaerobic and aerobic treatment processes. Both can be realized by using different plant concepts. In the following some of them are presented. Anaerobic biological treatment: - Parts of the landfill body used as a reactor, anaerobic filter and anaerobic sludge bed reactor (UASB).

9.2 Treatment by Reverse Osmosis Method

High concentration of COD,BOD, heavy metals,NH4---N, low BOD/COD ratio and the lack of nutrients in the methanogenic phase have restricted the application of biological treatment processes according to the nature of leachate. Due to the development of organic and inorganic contaminants high rejection rate and the properly designed membrane either as a main step in a landfill leachate treatment chain or as single Post-treatment step has shown to be an in dispensable means of landfill leachate treatment.

9.3 Adsorption through Activated Carbon

Granular activated carbon (GAC) in combination with biological pre-treatment is the leading technology for the treatment of landfill leachate for the removal of COD, absorbable organic halogens (AOX) and other toxic substances. Adsorption is the process by which molecules with particular characteristics of size and polarity are attracted and held to the adsorbing surface. Advantages and disadvantages of this process are discussed below:

9.4 Coagulation and Flocculation

Coagulation-flocculation technique treats stabilized stage and old age leachate. The main objective of this process is the removal of organic compounds from the leachate. During coagulation process, sludge is produced depending upon the characteristics of the leachate and the pollutant removal efficiency. The removal mechanism of this process mainly consists of charge neutralization of negatively charged colloids by cationic hydrolysis products, followed by incorporation of impurities in an amorphous hydroxide precipitate through flocculation. Following are the various coagulation methods:

1) Coagulation with calcium hydroxide and Alum can remove up to 69% and 54% COD and 99.9% and 94% turbidity from the leachate. Calcium hydroxide gave more removal of COD and turbidly. Ferric chloride and ferric sulfate are also used as coagulants now days.

2) Hydrolyzing metal salt coagulants namely polyaluminum chloride (PACl) has higher coagulant efficiency and relative low cost compared to the conventional coagulants. Besides, PACI poses a good structure and higher charge density which leads to decrease in dosage requirements and hence lesser sludge production. The application of PACl as a coagulant for the removal of colour, COD and ammonia from water and wastewater has been established.

3) This technique, which is characterized by its simple equipment, easy operation, and decreased amount of sludge, the coagulant is generated by electrolytic oxidation of an appropriate anode material that leads, at an appropriate pH, to the insoluble metal hydroxide which is able to remove a large variety of pollutants These metal hydroxide species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase.

9.5. Rotating Biological Contractor (RBC)

In the first phase of the aerobic system study, a cyclic-batch RBC system was used to select perforated acetate discs among three different acetate discs. These discs were selected on the basis of high COD removal (65%) and biological stability. In the second phase, the RBC's (using four stages) was operated continuously at different hydraulic retention times (HRT), at different rotational speeds, and with varying organic concentrations of the influent leachate (2500-9000mgL (-1)). 40% of the total surface area of each perforated disc was submerged in the leachate. A COD removal of about 52% is obtained at an HRT of 24h and a rotational speed of 6rpm.

10. CONCLUSION

Coagulation-flocculation technique treats stabilized stage and old age leachate. The main objective of this process is the removal of organic compounds from the leachate. During coagulation process, sludge is produced depending upon the characteristics of the leachate and the pollutant removal efficiency. The removal mechanism of this process mainly consists of charge neutralization of negatively charged colloids by cationic hydrolysis products, followed by incorporation of impurities in an amorphous hydroxide precipitate through flocculation.

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