COMPARATIVE EVALUATION OF BENTONITE SOIL WITH ORDINARY CLAY FOR CONTROL OF LEACHATE MOVEMENT IN SOIL

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Environmental Engineering
Sumitted By

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CERTIFICATE

Certified that Mohd Owais (1170470007) has carried out the research work presented in this project entitled **“Comparative evaluation of bentonite soil with ordinary clay for control of leachate movement in soil”** for the award of Master of Technology in Environmental Engineering from Babu Banarsi Das University, Lucknow under my supervision. This project embodies result of original work and studies carried out by student and the contents of the project do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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DECLARATION

I hereby declare that the project work entitled **"Comparative evaluation of bentonite soil with ordinary clay for control of leachate movement in soil"** is a record of an original work done by me under the guidance of Department of civil Engineering, **BABU BANARSI DAS UNIVERSITY, and LUCKNOW**. This project work is done in the fulfillment of the requirements for the master's degree. This is a bona fide work carried out by me and the results provided in this project report have not been copied from any source. The results provided in this have not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The study tries to investigate the physical and geo-environmental aspects of ordinary clay mixed with Bentonite for use as a liner in sanitary landfills. It was observed that the mixture of these liner material continually fulfills low hydraulic conductivity for an powerful long term conduct of land fill except hydraulic conductivity, the alternative exhibits an inclusive of shrinkage volume, unconfined compressive power and compressibility play an vital position in assessing long time conduct. In present study, clay and Bentonite were used as barrier. The traits are decided with suitable 2.5, 5 and 7. Five% by way of weight of clay. Out of these possibilities, mixer reduces the hydraulic conductivity, growth shear energy and decrease compressibility. Chemicals found in leachate manufacturing also are studied at Kadapa land fill web site due to the fact mixture of leachate provided in waste cloth. The present work here has two perspectives appropriateness of neighborhood soils from steadiness and Porousness qualities for use as landfill dirt liners and concentrates on mud leachate cooperation utilizing delicate earth as mud liner. The paper examines the diverse biogeochemical forms happening in leachate-tainted soils and the demonstrating of the vehicle and destiny of natural and inorganic contaminants under such conditions.

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CHAPTER 1

INTRODUCTION

1.1 Bentonite Soil

The principle undertaking of the impermeable land fill liners is to diminish the relocation of leachate to the ground water and decreased to sensible sum. The significant of landfill all through world increments and need of built waste dumps is essential. Sterile landfills have been, and keep on being the most efficient strategy for strong waste transfer. Spillage of inorganic and natural toxins from landfills after some time can impact the groundwater quality. Bentonite can likewise build the pliancy record of clayey soil. At the point when fluid cooperate with dirt minerals, the properties which are expanded and pressure driven conductivity will in general decline the water driven conductivity of liner material is not exactly or equivalent to 1x10-7 cm/sec. The low conductivity will be picked up sufficient quality and least shrinkage. From the past reference by utilization of Kaolinite kind of earth (lateritic soil) blended with bentonite utilized as liner material. Abatement of pH correspondingly lessens the level of adsorption limit of mud on solutes as clay became more prorogated, in this way diminishing connection among adsorb ate and solute. So as to sensibly predict transport of contaminations, it is critical to consider the impact of temperature on of poisons on land fill liners. Montmorillonite has huge negative charge, because of this reason, it assimilates expansive amount of hydrated captions and furthermore it retains water atoms. Bentonite can likewise build the versatility file of clayey soil. At the point when fluid connects with dirt minerals, the properties which are expanded and water powered conductivity will in general diminishing. The hydraulic conductivity of liner material is not exactly or equivalent to 1x10-7cm/sec. The low conductivity will be gained adequate quality and least shrinkage. From the past reference by use Kaolinite kind of clay (lateritic soil) mixed with bentonite utilized as liner material. Structure rules used to outline the properties of the materials utilized as abarrier in landfills. Along these lines, that geotechnical properties and appropriate to structure parameter must be determined before development. Bentonite accessible in two states, for example, sodium bentonite and calcium betonite, of water adsorption limit given by higher feline particle trade of a liner material will result in a more prominent measure of inorganic contaminants being expelled from the leachate.

Figure 1.1 Bentonite soil

1.2 Types of Bentonite soil

Sodium bentonite

Sodium bentonite expands when wet, absorbing as much as several times its dry mass in water. Because of its excellent colloidal properties, it is often used in drilling mud for oil and gas wells and boreholes for geotechnical and environmental investigations. The property of swelling also makes sodium bentonite useful as a sealant, since it provides a self-sealing, low permeability barrier. It is used to line the base of landfills. For example various surface modifications to sodium bentonite improve some rheological or sealing performance in geo environmental applications, for example, the addition of polymers.

Figure 1.2 Sodium bentonite powder

Calcium bentonite

Calcium bentonite is a useful adsorbent of ions in solution, as well as fats and oils. It is the main active ingredient of fuller's Clay probably one of the earliest industrial cleaning agent Calcium bentonite may be converted to sodium bentonite (termed sodium beneficiation or sodium activation) to exhibit many of sodium betonite properties by an ion exchange process. In common usage, this means adding 5–10% of a soluble sodium salt such as sodium carbonate to wet bentonite, mixing well, and allowing time for the ion exchange to take place and water to remove the exchanged calcium. Some properties, such as viscosity and fluid loss of suspensions, of sodium-beneficiated calcium bentonite (or sodium-activated bentonite) may not be fully equivalent to those of natural sodium bentonite. For example, residual calcium carbonates (formed if exchanged captions are insufficiently removed) may result in inferior performance of the bentonite in geosynthetic liners.

Potassium bentonite

Also known as potash bentonite or K-bentonite, potassium bentonite is potassium rich illicit clay formed from alteration of volcanic ash.

1.3 Drilling mud

Bentonite is used in drilling fluids to lubricate and cool the cutting tools, to remove cuttings, and to help prevent blowouts. Much of betonite usefulness in the drilling and geotechnical engineering industry comes from its unique rheological properties. Relatively small quantities of bentonite suspended in water form a viscous, shear-thinning material. Most often, bentonite suspensions are also thyrotrophic, although rare cases of rheopectic behavior have also been reported. At high enough concentrations (about 60 grams of bentonite per liter of suspension) bentonite suspensions begin to take on the characteristics of a gel (a fluid with minimum yield strength required to make it move). So, it is a common component of drilling mud used to curtail drilling fluid invasion by its propensity for aiding in the formation of mud cake.

1.4 Binder

Bentonite has been widely used as a foundry-sand bond in iron and steel foundries. Sodium bentonite is most commonly used for large castings that use dry molds, while calcium bentonite is more commonly used for smaller castings that use "green" or wet molds. Bentonite is also used as a binding agent in the manufacture of iron ore (taconite) pellets as used in the steelmaking industry. Bentonite, in small percentages, is used as an ingredient in commercially designed clay bodies and ceramic glazes. The ionic surface of betonite has a useful property in making a sticky coating on sand grains. When a small proportion of finely ground betonite clay is added to hard sand and wetted, the clay binds the sand particles into a moldable aggregate known as green sand used for making molds in sand casting. Some river deltas naturally deposit just such a blend of clay silt and sand, creating a natural source of excellent molding sand that was critical to ancient metalworking technology. Modern chemical processes to modify the ionic surface of betonite greatly intensify this stickiness, resulting in remarkably dough-like yet strong casting sand mixes that stand up to molten metal temperatures.

Table 1.1 Properties of Bentonite

Properties	**Values**
Liquid Limit	360%
Plastic Limit	70%
Maximum Dry Density	1.5g/ cc
Optimum Moisture Content	20%
Permeability	4.88*10s mm/S

1.5 Clay Soil

Clay is a finely grained natural rock or soil material that combines one or more clay minerals with possible traces of quartz (SiO2), metal oxides (Al2O3 , MgO etc.) And. Clays are plastic due to particle size and geometry as well as water content, and become hard, brittle and non–plastic upon drying or firing. Depending on the soil's content in which it is found, clay can appear in various colors from white to dull grey or brown to deep orange-red. Electron microscope photograph of smectite clay magnification 23,500× although many naturally occurring deposits include silts and clay, clays are distinguished from other fine-grained soils by differences in size and mineralogy. Silts, which are fine-grained soils that do not include clay minerals, tend to have larger particle sizes than clays. There is, however, some overlap in particle size and other physical properties. The distinction between silt and clay varies by discipline. Geologist sand soil scientists usually consider the separation to occur at a particle size of 2 µm (clays being finer than silts), sedimentologists often use 4–5 μm, and colloid chemists use 1 μm. Geotechnical engineers distinguish between silts and clays based on the plasticity properties of the soil, as measured by the soils' Atterberg limits. ISO 14688 grades clay particles as being smaller than 2 μm and siltparti cleans being larger.

Figure 1.3 Clay soil

1.6 Definitions and Concepts Clay

Clay can't be in all respects effectively characterized in exact terms. The word has a well known and furthermore a progression of specialized implications. The Foundation Specialist's idea of mud might be dismissed by a potter, a block producer, an agronomist, or a rancher. By and by, in the well known sense, earth is a finely-grained material which winds up sticky when within a progressively specialized sense, all dirt minerals can be viewed as fine soil particles having an articulated basal cleavage. As a result, singular mud particles are level and piece molded. When all is said in done, the expression "mud" infers a characteristic, gritty, fine-grained material which when blended with a constrained measure of water creates plastic properties. Pliancy, as identified with Soil Mechanics, is that property which enables a material to experience fast disfigurement without break volume change, or flexible bounce back. Concoction examinations of mud appear them to have basically silica, alumina, iron, alkalis, and antacid earths. The expression is in some cases used to imply a material that is the result of enduring, that shaped by aqueous activity, or that stored as a silt. As a molecule measure term, soil specialists will in general consider two microns as the maximum furthest reaches of the dirt molecule estimate. Countless investigations by Grim have appeared that practically all mud and soils are made out of particles of at least one of the accompanying three gatherings. Other mud minerals are of such minor significance to this exchange they might be disregarded here.

1.Montmorillonite gathering - The hypothetical synthesis of Montmorillonite is however the aluminums generally halfway supplanted by iron or magnesium.
2. Kaolinite gathering - The mineral, Kaolinite, has a synthetic organization.
3 .Illite gathering - This name has been connected to the across the board and plentiful clay minerals that take after muscovite mica in their synthesis and structure. The structure of minerals having a place with this gathering shifts a few what, however the general recipe, the advanced idea of the expression clay properties structure of particles of exceptionally fine size grains, ands creation of crystalline minerals comprising of basically hydrous aluminum silicates. This advanced idea of dirt concerns itself with the properties, surface, and creation of dirt without respect to its

cause. Because of the unmistakable crystalline piece, Dreary presents the expression "earth mineral" while talking about mud.

1.7 Structure of Clay Minerals

The nuclear structure of normal earth has been resolved in significant detail by Dr. Dismal and by numerous agents. In the exchange of the nuclear cross sections .of dirt's, two auxiliary units considered. One comprises of two sheets of firmly pressed oxygen's or hydroxyls in which aluminum, iron, or magnesium iotas are associated in octahedral coordination. The second unit is worked of silica tetrahedrons. In every tetrahedron. A silic0n iota is equidistant from four oxygen's or hydroxyls orchestrated in a type of a tetrahedron with a silicon molecule at the inside.

1.8 Other Materials Used For Soil Stabilization

Much has been composed and generally investigated materials utilized for adjustment of soils. Portland bond, water dissolvable salts, lime, different kinds of bituminous mixes, and different mixes of the above has been utilized with extremely victories. Each has its specific impact on the properties of various soils, all having a tendency to improve the heap conveying characteristics of the moderately. Mediocre materials accessible. Many soil adjustment labs have for a considerable length of time directed inquire about on improving the properties of soils by utilizing added substances. Massachusetts Institute of Technology, Purdue University, TexasA&M College, and the Federal and State Highway Departments are a maybe a couple among the numerous that coordinated research in this field.

1.9 Leachate

Leachate is the fluid that channels or 'filters' from a landfill. It changes generally in structure with respect to the age of the landfill and the sort of waste that it contains. It for the most part contains both disintegrated and suspended material. Truth is told the expression "leachate" is so regularly connected to landfill leachate, both inside the waste administration industry and outside, that it is anything but difficult to overlook that leachate is the term utilized for any fluid delivered by the activity of "draining". Draining happens when water permeate through any porous material.

2.0 Chemical Composition of Leachate:

Table 1.2 Chemical Composition of Leachate

S.NO.	Description	Value
1	**pH Value**	**7.8**
2	Conductivity(milli mhos/cm)	13.62
3	Chloride(mg/l)	2569.92
4	Sulphate(mg/l)	275
5	Nitrate(mg/l	221.5
6	Phosphate(mg/l)	5
7	Calcium(mg/l)	600
8	Magnesium(mg/l)	1400
9	Sodium(mg/l)	224.6
10	Potassium(mg/l)	454.3
11	Available Iron(mg/l)	32.5
12	COD(mg/l)	800

Cation Exchange Capacity (CEC)

The CEC of the soil is received as ninety med/100gms. A scan via literature shows a cost of potential CEC of three for Kaolinite, 150 for Illite, a hundred for Montmorillonite and 20 for Chlorite. The X-ray diffraction pattern for the soil suggests the presence of Kaolinite, Chlorite and Illite-Montmorillonite aggregate. Thus there is a good correlation among the experimental value of CEC and minerals diagnosed.

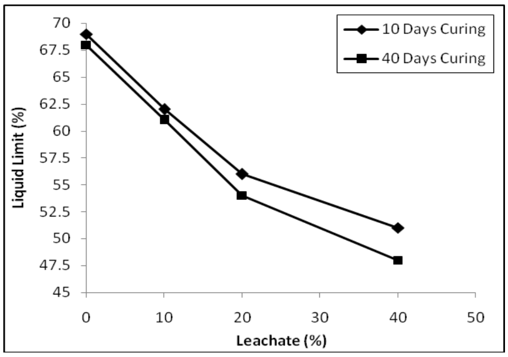

Fig. 1.4: source Variation of Liquid Limit with Percentage of Leachate

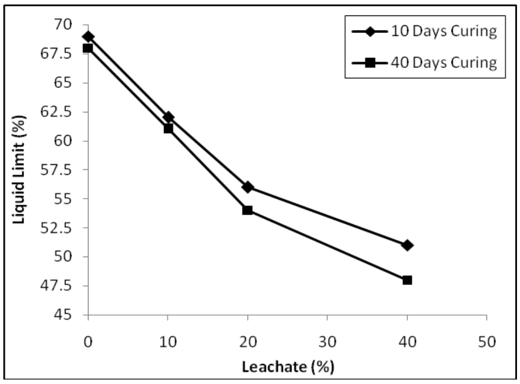

Fig. 1.5: source Variation of Plastic Limit with Percentage of leachate

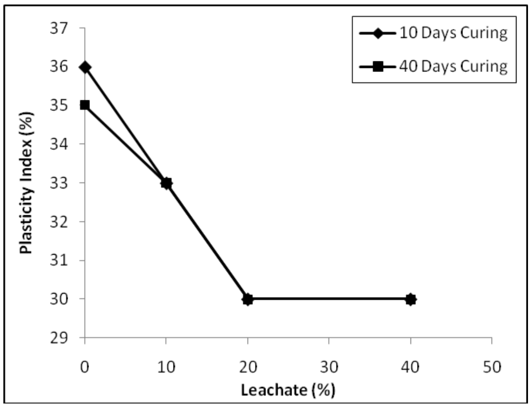

Fig. 1.6: source Variation of Plasticity Index with Percentage of Leachate

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

McDougall & White (2008) A review of the literature suggests that landfill is an essential part of an effective waste management strategy. Municipal committees must prepare for future landfill needs by formulating long term plans and allocating suitable and sustainable land for landfill. It is pivotal to note that each district has an allotted space for their waste disposal or else waste will be dumped, creating further problems that will need to be dealt with (McDougall & White 2008).

Thiruvenkatachari et al. (2008) Unmanaged dumping outside dedicated waste disposal areas leads to landfill leachate penetration of the ground, which directly affects the ground water supply. This chemical penetration also leads to a loss in composted soil, rendering the ground unfertile for long periods of time. Because of this, new research and technology is needed to help cultivate the land. In this chapter, the reported data and essential information regarding landfill principles and methods are presented. This includes the evaluation of different types of landfill leachate and liners. The effect of leachate and liners on the environment is also analyzed, along with the factors that give rise to the resulting conditions and the relative importance of these factors. Furthermore, the background of this topic will be covered through the examination of the existing research into the behavior of landfill leachate.

2.2 Principles of Waste Management

A central framework is laid by US environmental agency out that aids the creation of operational standards, which in turn assists in the controlling of the methods of waste disposal. This framework is required for both the treatment of waste and the engineering of landfill construction. The principles that govern waste disposal will help reduce the risk of pollution and lessen the negative impact that landfill waste has on the environment.

2.1.1 Landfill History

Geismar (2014) Waste is the direct consequence of many types of human activity, and has been a burden to deal with across the world and throughout history. Land filling has emerged as the simplest and most economical method of disposing with this waste. Waste is broadly classified into three main types; solid, liquid, and gas. Gaseous wastes are those that dissipate in the atmosphere, and can either be treated or untreated, depending on the composition of the gas and the regulations of the country where it is disposed. Liquid wastes are those that are disposed of into rivers or sewers, and are treated before disposal, depending on the legislation.

Milosevic (2012) In many parts of the world however, problems exist with the creation and implementation of this kind of legislation, and unmanaged liquid waste is disposed of into different bodies of water or allowed to penetrate into the ground, polluting water bodies and giving rise to many other problems.

Thiruvenkatachari et al (2008) the disposal of waste is seen as a major problem in most of the developing countries, with most waste being disposed of into landfill. This also true for solid waste in many developed nations, however, as in 1999, the main method of waste disposal in Western Europe was landfill. Despite policies to promote reuse and reduction of waste within the European Union, more than half of its member states dispose of 75% of their waste through landfill with Ireland disposing of 92% this way. While the proportion of waste that is land filled is expected to decrease, the actual volume of municipal solid waste (MSW) is increasing significantly, at a rate of 3% per year for many developed nations, creating ongoing waste disposal and groundwater pollution problem Modern landfills use liners made of plastic and other non-porous materials to stop the pollution from garbage leaking into the soil. Many landfills are located in areas with deposits of clay and other natural resources, which act as a liner. A system of drainage pipes is installed by the landfill operators to direct leachate, or liquid waste, into nearby wells and ponds where these liquid wastes are tested and treated after a landfill is full, the ground water around these landfills is quality tested for many years.

Bella et al (2011) A landfill is similar to an airtight storage container in that garbage does not break down very easily, as can be seen by the slow break down rates of biodegradables such as paper or grass clippings. Once classified as closed, landfill sites are often transformed into parks, ski slopes and gold coursed, however they are never built upon due to the impact of settling. Newer types of landfill have been developed, such as bioreactors which make use of leachate air to encourage biodegrading inside the landfill. Much more waste can be stored in bioreactors than in traditional landfills, and reported that the methane gases produced by the breakdown of organic waste in the bioreactor can be used as an energy source. This methane has similar properties to natural gas, so can be used as fuel, or used to generate electricity by burning. Previous research has shown that around 14% of all waste is burned, 31% is recycled, and 55% is stored in landfill. Recycling is recommended by the EPA to save natural resources and protect the environment from pollution. Recycling also helps in decreasing the need for landfill, which in turn lessens the problems created by waste management. Recycling can be encouraged by placing bins in the home and calling for a national reduction in the disposal of waste through the garbage system, as well as through legislation. It has been shown that if proper national legislation is adopted, recycling can significantly reduce waste and environmental pollution Certain guidelines for the disposal of dangerous and household waste have been laid out by the government-sponsored hazardous waste disposal facility. The specified waste materials include chemicals, fertilizers, medicines, insect killers and suppliers of automotive and such other materials.

(Thomsen et al. 2012). Reported that the harmful effects of waste on the environment can be avoided by storing unwanted waste in various disposal facilities. Rather than dumping local waste in holes and pits – which are typically unlined and offer no protection to the groundwater supply - it can be dealt with in specialist facilities where its spread and treatment can be regulated, and its impact on the environment reduced. To ensure this, various policies and agencies must be created in developing countries. Many aspects of waste management have the potential to pollute or damage the environment, including the collection, storage, treatment, transport, and disposal of waste. Unmanaged groundwater also has the potential to pollute the environment, as the leachate migration that takes place at landfill sites is hard to control, and may end up contaminating the groundwater and causing wider problems. Therefore, adequately managing the leachate and groundwater is vital in mitigating damage to the environment.

Milosevic (2012) Considered that human wastes can be identified as wastes that are produced by the human use of different non-toxic substances such as paper and food, but also waste related to toxic substances such as batteries, paint, healthcare waste, asbestos, and sewage sludge. Solid wastes can be classified into the broad categories of commercial and non-dangerous industrial wastes, household waste, construction and demolition waste, toxic industrial waste, human and animal waste, and waste related to healthcare.

2.1.2 Landfill Types Landfill can be classified into four main types, such as sanitary landfills, municipal solid waste (MSW) landfills, construction and demolition waste landfills, and industrial waste landfills.

2.1.2.1 Sanitary landfills

(Milosevic 2012). Sanitary landfills are used in the areas where it is a major requirement that discarded waste must be isolated from the environment The waste is considered safe when it is completely degraded; chemically, physically and biologically (**Diamantis 2013**). Modern technology is used in sanitary landfills to prevent the leakage of dangerous substances. In sanitary landfills, two main types of methods are used **(Bella et al. 2011**). These are the trench method and the area method, with the trench method being considered more appropriate in areas of low waste. Both methods make us of the cell principle, using soil to cover compacted waste. (**Thomsen et al. 2012**). Both methods are illustrated.

2.1.2.2 Municipal Solid Waste (MSW) Landfills

Geismar (2014) This type of landfill uses a synthetic plastic lining to isolate waste from the surrounding environment, and is contains household garbage collected and managed by the local and state governments The allowed contents of MSW sites have been specified by the Environmental Protection Agency (EPA), with materials such as paints, chemicals, batteries, cleaners, motor oil, and pesticides being banned **(Al-Jarallah & Aleisa 2014**). Some household appliances are safe for disposal in an MSW site, but dangerous wastes such as bulk liquids or wastes that have free liquids, yard waste and scrap tires are not **(Thomsen et al. 2012).**

2.1.2.3 Construction and Demolition Waste Landfills

Construction and demolition are used to dispose of materials used in the construction, renovation, and demolition of roads, bridges and buildings. These wastes mostly include gypsum, wood, asphalt, bricks, soil rock, glass, concrete, trees, and other building components **(Geismar 2014).** These contribute to pollution of the environment and when burned can emit toxic gases. It is essential for Construction and Demolition wastes to meet the operating, sitting, design and closure and post closure requirements. They are even prohibited from accepting debris that is minced **(Milosevic 2012**). The best way to avoid these wastes is to keep proper estimate of the raw materials that are needed for construction projects. Recycling these types of wastes does not only help in saving money but also helps reduce the amount of waste disposed of in landfills **(Thomsen et al. 2012).**

2.1.2.4 Industrial Waste Landfills

Gallas et al. 2011 The industrial wastes produced mostly by manufacturing companies generate methane which is considered to be a natural byproduct, the decomposition of which can generate clean and useable energy. However, if these Municipal Agricultural & Commercial wastes were recycled rather than dumped, they could also be used to create useful products **(Milosevic 2012**)

2.1.2.5 Landfill liner

Naik (2008) Land filling has becoming a widespread practice in the modern societies due to its effectiveness at providing long term waste storage if built and managed using proper engineering tools and techniques. The use of landfill sites has increase to protect societies from the health issues associate with waste storage Modern landfills are highly engineered and controlled systems that utilize liners to minimize the impact of waste materials, particularly solid waste (**Rio et al. 2009).** It is important to minimize the impact of solid waste, as they can have a significant adverse effect on the environment and the health of the human beings and other living things in the surrounding area. The liners are typical made of compacted clay, geosynthetic clay, geomembrane, geotextiles or combinations of all these **(Nagendran et al. 2006**). The liner system is broadly used by modern societies due to its ability to create a barrier between waste and the environment .These systems also include the draining of the leachate so that it can be collected and sent to treatment facilities. Landfill sites that use the liner system are designed to be reliable and robust, remaining active for years or even decades **(Thiruvenkatachari et al**. **2008)**.

2.2 Liner Classification.

Rio et al (2009) Liners are designed and constructed locally, using easily available materials. For the most part, this means locally available clay rich soils. Other materials can include bentonite enriched soils which are found with low clay content, stretchy artificial membranes, and geosynthetic clay liners comprising of bentonite clay held between geosynthetic membranes .During construction, two main methods are used; one is keeping the materials separate, and the other is using them together in the form a double layered barrier. If hazardous conditions are present in the site, then the construction of a multilayer of barriers should be 2011). This shows that there are certain types of liners, and each of them has a specific use. Some of the types of liners, and the areas where their construction is emphasized.

2.2.1 Single Liners

Single liners are the simplest type of liner system, constructed with basic materials and techniques, usually with low permeability. Due to their simplicity, they are not that effective at fulfilling the needs of present day landfill sites. Therefore, modern pits tend to emphasis the implementation of newer and more efficient liner technology **(Rio et al. 2009**). Despite this, single liners sites are already being constructed in Kuwait, with some already operational. This is a problem because in most cases if any one of the single liners fails then the soil becomes contaminated.

2.2.2 Composite Liners

Composite liners are constructed with a geomembrane placed on the top of the compacted clay liner, and are more widely used worldwide. This liner is used the most due to the protection it offers, provided by the separate components. The geomembrane decreases the conductivity of the liner, as well as increasing the required leakage rate. The composite clay in this liner provides protection in case of liner failure by decreasing the advection and diffusion rates, which increases the breakthrough time of contaminants.

2.2.2.1 Double and Multi Systems

Unlike single and composite liner systems which only have a single geomembrane, barrier systems, known as double- or multi-barrier, have two geomembrane, which are often set within the drainage medium around them. This is the most effective system as it has a backup plan for all possible malfunctions. In the case of a failure in the upper most layer of the liner, the drainage system would immediately detect the leakage and the leachate would pass into a collection system, protecting the groundwater. Multi barriers systems are often considered for use when large amounts of solid waste must be kept isolated from the environment. This is the most complex barrier as it has number of single and composite layers constructed within it **(Ayub & Khan 2011**).

2.2.2.2 Compacted Clay Liners (CCL)

If natural clay is found in the area of the landfill its low permeability can be utilized as a barrier to prevent the migration of contaminants and protect the groundwater. Using these clay layers by themselves is not recommended, especially if uncompacted, as it is often not possible to prove there aren't any hydraulic imperfections **(Rio et al. 2009).** Therefore, Compacted Clay Liners are used in combination with additional mineral layers and geomembrane to form an effective protective layer. The compacted mineral layers should have a minimum thickness of 1m and a hydraulic conductivity of less than 10-9m/s. The natural clay should also be mixed with bentonite, and through the process of compaction any voids or defects in the clay will be reduced **(Naik 2008**). The construction process involves lifts or layers of clay being compacted on top of each other. Adjacent lifts should be bonded well to prevent areas of high conductivity existing between layers (**Nagendran et al. 2006**). If layers are offset and bonded well, any vertical defects or discontinuities in adjacent lifts will be hydraulically disconnected. Compacted Clay Liner systems are prone to cracking under differential settlement, and are vulnerable to desiccation in dry regions, which increases the permeability of the liner **(Daniel 1993**).

2.2.2.3 Bentonite Enriched Soils (BES)

Bentonite is often mixed with local soils to improve the hydraulic properties and achieve conductivity values of 10-10 m/s. Bentonite is a useful material in that it naturally swells, sealing small cracks and preventing leakage. In this way it acts as a kind of self-healing material (**Nagendran et al. 2006)**

2.2.2.4 Flexible Membrane Liners (FML)

Flexible Membrane Liners are geomembrane liners that are flexible enough to be joined or welded together in large sections, folded, transported and unfolded on-site. They are constructed of numerous pieces, with the seams being carefully tested for faults **(Rio et al. 2009**). These tests include overall hydraulic conductivity which is recorded to be around 10-12 m/s. FML is usually made of High Density Polyethylene (HDPE) or Low Density Polyethylene (LDPE). Of the two, HDPE is usually preferred as it provides better chemical resistance then the LDPE and importantly makes site construction much easier. In some cases HDPE has a risk of cracking when settling with a low angle of friction occurs, noted to be typically 8°. LDPE on the other hand is more flexible and has an improved angle of friction, but has lower resistance compared to HDPE. Unfortunately, damage to the geomembrane due to the cracking is difficult to repair, and makes using them a risk **(Rio et al. 2009).**

2.2.2.5 Geosynthetic Clay Liners (GCL)

Low conductivity clays such as Bentonite are commonly used in the Geosynthetic Clay Liners (GCL). Layers of Bentonite clay are placed between layers of geotextiles and geomembrane. The GCL system is used for its effectiveness at protecting groundwater, but also its ease of transport and installation. **(Rio et al. 2009).** GCL systems are self-sufficient, utilizing the clay's natural ability to swell and seal any gaps between sheets, when the ground is hydrated.

2.3 Landfill Leachate.

2.3.1 Landfill Leachate Generation.

Christensen (2001) Leachate is created by liquid percolating through waste, with the chemical composition of the waste and the biochemical processes within it playing a role. As the liquid migrates through the waste, it encounters pathogenic micro-organisms and extracts solutes and suspended solids from the waste, thus becoming contaminated .Increased levels of leachate occur with increased precipitation, such as during the wetter seasons **(Chiang 1995**). The level of contamination in the Leachate is influenced by the type of waste it moves through, and the level of biodegradation of the waste. Leachate from biodegradable waste may hold a significant quantity of natural substances, including alkali nitrogen and chlorinated natural and inorganic salts. All these substances are poisonous to a number of organic entities, particularly to sea life, and can result in harm to human health **(Renou 2008**). Atmospheric conditions such as rain and snow greatly impacts leachate creation **(Frost 1977**).

2.3.2 Landfill leachate composition.

The composition of leachate is dependent on the location and conditions of the landfill, including the type of waste stored and how old the landfill is. Therefore, while generalizations can be made about normal waste and leachate, each leachate should be considered as distinct. Recent studies have indicated that landfill leachate holds a higher toxin load than crude sewerage. **Christensen et al. (2001)** created a rundown of the biogeochemistry of Leachate plumes produced by city, business and industrial waste masses **(Chiang 1995).** A good understanding of leachate is required understand the nature of leachate plumes**. Al-Salem (2009**) reported there are four groups of pollutants likely to be found in landfill leachate;

1) Dissolved organic matter including methane, measured by COD and TOC
2) Heavy metals
3) Particular organic compounds
4) Inorganic compounds

The natural substances found in Leachate are measured through analysis of parameters such as COD, BOD and TOC. The dissolved natural carbon and inorganic constituents are generally calcium, magnesium, sodium, potassium, alkali, iron, manganese, chloride, sulfate, and bicarbonate **(Christensen 1994**). The extent of these constituents varies profoundly between one landfill to another, with average sulfate fixations running from 8 to 7750Mg/l, iron from 3 to 5500Mg/l, chloride from 150 to 4500 Mg/l and arsenic from 0.01 to 1Mg/l (**Christensen 1994).**

2.3.3 Landfill Leachate Migration.

Rein hard (1984). Leachate migration is also influenced by the way in which waste is stored. Compacted waste has reduced permeability, but the layering of waste and topsoil in the site can create stream ways through which leachate can flow **(Rein hard 1984).** It was discovered by **Christensen (2001**) the length of time that rainwater can remain in a landfill site varies from a couple of days to a few years. This is reflected in the transitory nature of Leachate "springs", which can show up in wet seasons but vanish in dry seasons, leaving stained soil. Because of this, assessments of leachate generation must focus periods towards the end of wet seasons or after high periods of precipitation. Transport of contaminated leachate through the landfill to the groundwater and surface water happens through two main methods: advection and hydrodynamic dispersion. Advection is the mass of dissolved contaminant that is transported with the flow of groundwater (**Frost 1977**). Thus, understanding of the groundwater stream directs the advection, whose rate and bearing relies upon subsurface topography, geography, extraction wells, porosity and pressure driven conductivity. Darcy's law can describe the average linear speed of advection migration: the adjective transport (Darcy's drainage speed) and mass flux are described by expecting the solute to moves with the normal and adventives stream **(Christensen 1994**). Dispersion is the flow of Leachate created by the mixing of liquids and the variability in the substance and physical properties of the environment (**Christensen 1994).** In water treatment frameworks, contaminants may not be caught due to sorption. The rate at which this occurs needs to be ascertained in order to assess the effectiveness of the treatment and the real mass of contaminant present (**Lin 2000).** Sorption may happen through particle trade; however, natural contaminants are not adsorbed by particle trade, but rather by Van der Waals force and hydrophobic holding **(Deng 2006**).

2.3.4 Treatment of Leachate.

Christensen (1994) Currently, the most widely used method of Leachate treatment is reinfusion and release into a municipal water treatment facility This method is effective in that it increases the rate of leachate deterioration and creates landfill gas .This decreases the overall volume of leachate, but unfortunately also condenses the contaminants inside the fluid **(Lopez 2004**). The landfill gas created presents an opportunity though, as its primary constituents are methane and carbon dioxide, meaning it can be used as a fuel asset **(Renou 2008**). Leachate is also released into to local watercourses, but due to restrictions placed on the chemical composition of the leachate released this way, it must be pretreated first **(Li 1999).** Leachate can be dealt with on-site or transported to specialist treatment facilities (**Christensen 1994).** Treatment normally involves using activated sludge to break up the organic substances, but in many cases is still not environmentally safe at this stage so is transported to neighborhood sewers (Christensen 1994). To effectively address the issue of leachate treatment, it is important to also deal with old and neglected landfill sites that were constructed before proper regulations were put in place, and therefore lack an impermeable covering (**Deng 2006**). These old sites can have a large impact on the soil as they can contain a variety of manufactured and natural types of matter, whose deterioration creates considerable contamination (**Lopez 2004)**.

2.4 Impact of under designed Landfills on Surrounding Soils.

In this section, firstly the stress state of a soil is reviewed followed by the problems associated with under designed landfills.

2.4.1 Introduction

Richards (1974) Generally, unsaturated soil is a combination of three main components; soil particles, air and water. The unsaturated soil is strongly inclined by the state of the stress in the pore water pressure (Richards 1974). The pore water pressure is negative and a change of pore – water pressure generates a change in the volume and strength of the soil. The negative pore – water pressure is called "total soil suction" in geotechnical engineering. The total suction is consisting of metric suction and osmotic suction. The metric suction is defined as the difference between the pore air pressure (us) and pour water pressure (uw) (Estabragh and Javadi 2012). The metric suction (ua - us) is related and controlled by a capillary effect and adsorption of water (Richards 1974). The individual capillaries can be defined as the pores between soil particles with an equivalent radius and a meniscus. In the large pores air first replaces some of the water, which forces the water to flow through the smaller pores with increased porosity to flow path. Lustrated the effect of metric suction in the unsaturated soil particles.

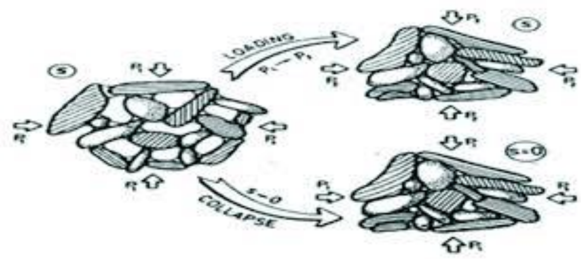

Figure 2.1 the effect of metric suction in the unsaturated soil.

The osmotic suction (π) is defined as the presence of solutes in the soil solution. The solutes could be inorganic salts or organic compounds. The clay surface charge is negative due to isomorphism substitutions of electropositive elements **(Lagaly and Koster 1993**). A force exists between the negative charge at clay surface and the exchangeable captions. This force depends on the position of the charge and the valence of the exchangeable captions **(Hasenpatt 1988).** Normally the solutions have different ionic concentration that contact with clay particles, with the captions near the surface of the clay particles trying to diffuse away to preserve electrical neutrality. This process leads to decreases of Cation concentration on the surface the clay minerals. This produces an electrostatic surface property known as Diffuse Double Layer (DDL) .the mechanism of attraction and concentration of these captions and the counter-ionic in pore.

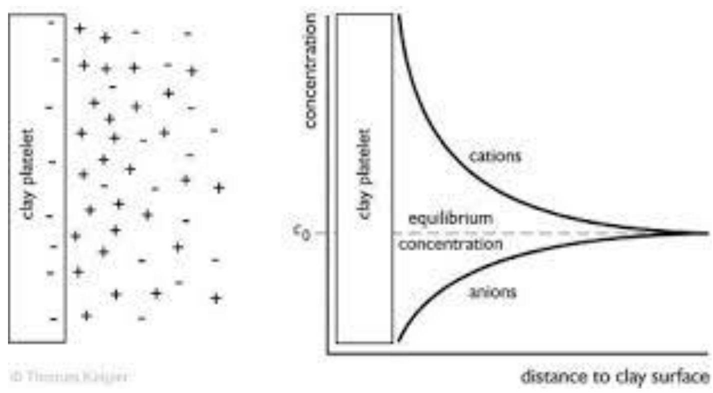

Figure 2.2 Distribution of captions and anions adjacent to a clay platelet.

2.4.2 Soil Contamination

Soil contamination is a result of either solid or liquid hazardous substances mixing with the naturally occurring soil (**Ismail et al. 2008**). Leachate contamination may lead to significant effects on the behavior of soils due to chemical reactions between the soil mineral particles and the contaminant (**Sunil et al. 2009)**. Leachate contaminated soils in are a result of a lack of awareness of environmental standards of selection, design, and management at the landfill sites. These sites are often selected at lower ground locations that have previously been used as sand and gravel quarries, due to the leveling off the ground and the normal soil surface. There sites are not carefully selected using geological or environmental surveys, and the random land filling technique is often used without application of waste separation techniques.

2.4.2.1 Consistency Limits

Attom and Al-Sharif (1998) Attributed the reduction in the plasticity index (PI) of clayey and salty sands to the addition of non-plastic material to the soil, with the non-plastic material reducing the plasticity index of the new mixture. The increase in liquid limit (LL) and plastic limit (PL) of contaminated clayey soils are mainly attributed to the increase in the double layer thickness of clay minerals **(Shah et al. 2003**). In general, contaminants may alter the mechanics of the consistency limits test when used for contaminated soils. The consistency limit tests were originally developed for natural soil-water systems (**Meegoda and Ratnaweera 1994**). Similarly, **Sunil et al. (2009)** reported that leachate-contaminated soil samples showed an increase in the liquid limit and plasticity index values due to a change in nature of the pore fluid, which is shown by an increase in the clay content of the specific surface area of the soil which leads to high adsorption of water that changes the limit values.

2.4.2.2 Compaction Characteristics

In a study conducted by Sunil et al. (2008) on contaminated lithomarge clay soil with leachate, the maximum dry unit weight (γd, max) decreased from an initial value of 15.89kN/m3 to 14.03kN/m3 and the optimum moisture content increased to 24.8% from an initial value of 20.1% when the soil was mixed with 20% of leachate by weight. Similarly**, Nayak et al. (2007)** noticed that the maximum dry density for lateritic soil is 15.47kN/m3 at an optimum moisture content of 19.52%. With the presence of leachate up to 5%, the compaction characteristics did not change much. With 10% leachate the maximum dry unit weight and optimum moisture content were 14.98kN/m3 and 25.01%. However, with a further increase of leachate content up to 20% the compaction curve had an odd shape with inferior characteristics. A recent study carried out by **Al-Fares (2011)** on contaminated silty soil with leachate shows a sudden drop of 0.4% in maximum dry unit weight when soil was mixed with leachate by weight at 15% and increased in optimum moisture content by 22%.

2.4.2.3 Strength Characteristics

Shear strength of a soil mass is the internal resistance per unit area that the soil mass can offer to resist failure and sliding along any plane inside **Das (1985**). In soils generally the relationship between stress and strain is non-linear, and volume changes develop from the applied normal and shear stresses. The most commonly used strength theory is Mohr – Coulomb failure criteria, which state that considered that a material fails because of a critical combination of normal stress (σ) and shearing stress (τf). Thus, the functional relationship can be expressed as:

$\tau f = c + \sigma \tan \phi$ (Eq. 2.1) The $\tau f = f(\sigma)$ in (Eq. 2.1) According to Coulomb, shear strength τf, is expressed in terms of cohesion (c) and angle of friction (ϕ) on linear function. Cohesion is defined as the bonding force between the fine-grained particles of a soil, and is stress-independent. Due to the comparatively large components in waste, cohesion is mostly interpreted as the interlocking of components in waste mechanics. Additionally, it is often defined as apparent cohesion, which is caused by capillary forces. The friction angle is related to the friction between the particles and is stress-dependent. **Sunil et al. (2009**) carried out triaxial tests on clean lateritic soil, which was mixed with leachate at increments of 5%, 10% and 20% by weight of soil. They found a slight increase in cohesion and a decrease in friction angle as a result of leachate contamination for specimens tested. The increase in clay content of lateritic soil after interaction with the leachate increased the cohesion and decreased the friction angle. An investigation of the effect landfill leachate has on natural soil**, AlFares (2011)** carried out direct shear tests on natural soil mixed with leachate and reported that the shear strength parameters were dependent on the contaminated leachate content in the uncontaminated soil. Their study showed an increase of cohesion from 10kPa to 17kPa for uncontaminated soil, due to increases of leachate concentration up to 5% by weight of dry soil with no significant change in the angle of friction. However, when the concentration of leachate increased up to 15% by weight of dry soil the cohesion decreased to closely reach the cohesion of the clean soil with no noticeable change in the angle of friction.

2.4.2.4 Compressibility Characteristics

Compressibility of soil is defined as an increase of stress caused by construction of foundation or other loads compresses soil layers (**Das 1985**). The compression is sometimes caused by:

(a) Deformation of particles.

(b) Relocations of soil particles, and

(c) Expulsion of water or air from the void space. In general, the soil settlement is caused by loads and may be divided into three broad categories:

1. Immediate settlement (or elastics settlement) which is caused by the elastic deformation of dry soil and of moist and saturated soils without any change in the moisture content.

2. Primary consolidation settlement which is the result of a volume change in saturated cohesive soils because of the expulsion of the water that occupies the void spaces.
3. Secondary consolidation settlement which is observed in saturated cohesive soils and is the result of the plastic adjustment of soil fabrics. It is an additional to compression that occurs at constant effective stress.

Hoeks (1983) showed the importance of the settlement of soil contaminated with leachate within the landfill because it might be a cause of a number of problems to a closed landfill sites like excessive differential settlement resulting in breakage of gas or leachate extraction pipes, which may then result in a dangerous build-up of lowland gas or cause saturation of the waste mass. **Ojuri et al. (2012)** studied the effect of high concentrations of heavy metals in the landfill leachate on the behavior of clayey soil in Nigeria.

Resmiet et al. (2011) focused in their study about the major contaminated element in leachate caused from landfill sites and carried out the consolidation tests on uncontaminated clayey soil with artificially fed lead nitrate. The soil samples soaked in various lead solutions concentration (200, 500, 1000, and 2000 ppm) were kept in containers and left for adsorption to take place, with occasional stirring. The results showed the values of the coefficient of consolidation increased with increasing sorbet concentration of lead.

2.4.2.5 Permeability Characteristics

The permeability of soil is one of the most important soil properties to geotechnical engineers, due to the factors stated below:
1. Permeability influences the rate of settlement of a saturated soil under load.
2. The stability of slopes and retaining structures can be often depending on the permeability of the soils concerned.
3. Filters made of soils are designed based up on their permeability.

Nayak et al. (2007) Reported that changes in soil structure occur after contamination with leachate, with the void ratio of soil increasing when the pore water is replaced by leachate, as pore fluid and the hydraulic conductivity raise as a result of dissolution of clay minerals by the leachate. They studied the behavior of interaction between uncontaminated lateritic soil mixed with leachate in the amount of 5%, 10% and 20% by weight. The results showed an increase in the permeability of soil that was mixed with 20% contaminated leachate to 50% mixture, which ranged from 2.69x10-5 cm/s to 5.66x10-5 cm/s. Similarly, **Sunil et al. (2008)** observed that when 5% of contaminated leachate concentration was mixed with lithomarge clay by weight, the hydraulic conductivity increased to 1.7x10-6cm/sec (6.25% increase compared with base value). At 10% leachate concentration the hydraulic conductivity of the soil tested increased to 2.3x10-6cm/sec (43.75% increase compared with base value). Similarly when the soil was mixed with 20% leachate the increase in hydraulic conductivity was about 75% when compared with the base value. A recent experimental study carried out **by Al-Fares (2011)**.

2.4.2.6 Retention Mechanism in Contaminated Soils.

Retention reactions in soils are important processes that govern the fate of chemical contaminants such as heavy metals in groundwater **(Kulikowska 2008).** Substantial metal particles may have lethal impacts on plants, creatures or people, and their poisonous quality is connected to their mobility in soil. Heavy metal mobility relies on the properties of the soil **(Trebouet 2001),** and the danger of these metals increases with increased mobility. One critical procedure influencing substantial metal versatility in soil is sorption. Sorption is the phenomenon in which metal particles, which normally bear a positive charge, are pulled in to robust particles in the soil and natural matter which bear a negative charge **(Kurniawan 2006).** This coupling is frequently reversible, and metals bound to the solids are in balance with metals in the soil water. This implies that strongly held metal particles are expelled from the soil water and get less versatile than weakly held particles **(Lyngkilde 1992).** It has long been felt that "heavy" soils, that is, high mud substance soils, have a tendency to immobilize heavy metals. Because of this, waste disposal organizations feel safe when disposing of their waste into clayey soils, providing they are managed by an environment body (**Bolong 2009). Harter (1983) and McBride (1979)** reported that the retention of metals does not increase until the pH is greater than seven. This effect is in part because of particular adsorption of the hydrolyzed metal compared to the free metal particle.. The breakthrough curves observed that the relative concentration of the heavy metals increased with the increasing number of pore volumes, Ni and Zn were the most mobile heavy metals and sorption of heavy metals was high. **Tan et al. (2006)** noticed that the breakthrough curve can be defined as desorption or mobility curve. The very acidic leachate showed good interaction with the natural pH soil especially at the top part of the column test reported **by Yong et al. (2001).**

2.4.3 Groundwater Contaminations

The groundwater system is most at risk in areas that have a shallow water table and high precipitation.

2.5 Concluding Remarks

Alhumoud & AlKandari 2008. This will assist the municipality, as it will reduce the amount of waste collected and would be essential in reducing the environmental impacts that are gradually increasing over time. These recycled materials can be extensively used for industrial purposes and for improvements in soil, as well as an energy source (**Alhumoud & Al-Kandari 2008**). This review also explored the relevant data and information on the principles of landfill construction, the types of leachate and landfill liner. It also reviewed the fundamental effects on the environment, including factors affecting it. The importance of waste disposal systems Is also critically analyzed, reflecting the urgent needs for reforms by the municipal corporation of Kuwait. In order to tackle the growing problem of solid wastes, systematic approaches on the local, national and regional levels should be explored and implemented, based on the prevailing conditions and priorities.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

Materials. The clays used in this study were the purified clay minerals Kaolinite. These particular clay minerals were chosen "because they are the most common clay minerals in Clay materials that would be used, separately or combined, for landfill sites. Clay materials containing one or more of these clay minerals can generally be obtained locally.

The clays were brought to the laboratory, where they were crushed, ground, and subjected to sedimentation to obtain the particle fraction that contained essentially pure clay minerals. The clays were saturated with Ca. The results of chemical analyses of the three clay minerals are given instable. Details of the methods used and results of X-ray diffraction anal-yes of the clays were given by Griffin and Shrimp, 1976. The predominantly Ca-saturated, pm fractions of the clays were then used in the column leaching studies.

The leachate used was collected from the Du Page County landfill. The details of the site description and well location were given by Hughes et al. (1971). The leachate was collected by using a tubing pump and large plastic containers that were equipped with valves to allow con-

Tenuous purging with argon gas to maintain anaerobic conditions.

The bentonite used in this study was obtained from Ashaka and Tango deposits, Gombe State and were labeled as GA and GT respectively. The bentonite samples were obtained in milled powder form. The samples were pre-treated with 10% H2O2 to remove or oxidize any colored organic and inorganic matter in the clay (James et al., 2008). The suspension was then agitated and allowed to stand for 2 hr. The clear supernatant liquid was decanted and the clay NaOH solution for a period of 2 hr with moderate agitation using a mechanical stirrer. The supernatant was also decanted and rinsed with deionized water, dried and ground. The physicochemical properties of the bentonite were reported elsewhere (Abdullahi and Audu, 2015.)

The clay component of GCL materials tested in this study consists of regular and polymer-treated bentonite. As mentioned in Chapters One and Two, polymer treatment arguably renders the clay non-reactive to many organic and inorganic chemicals. In municipal solid waste landfills where the inorganic or organic contaminant concentration 31 in the leachate is low, lining systems can rely on natural or untreated bentonites (Egloffstein 1995; Ruhl and Daniel 1997). Such GCL bentonites typically contain natural sodium Montmorillonite, although calcium Montmorillonite is sometimes used. In regions where leachates with high concentrations of contaminant are present, the use of polymer-treated or polymer-coated bentonite is beneficial, as it possibly renders the Montmorillonite non-reactive towards most organic and inorganic chemical compounds. Laboratory test results (El-Hajji et al. 2001) suggest that polymer-treated GCLs maintain their low hydraulic conductivity when hydrated with liquid containing single-species solutions at low concentration. In this chapter, laboratory data are presented for seven untreated and treated GCL bentonites permeated with natural landfill leachate solutions with different concentrations.

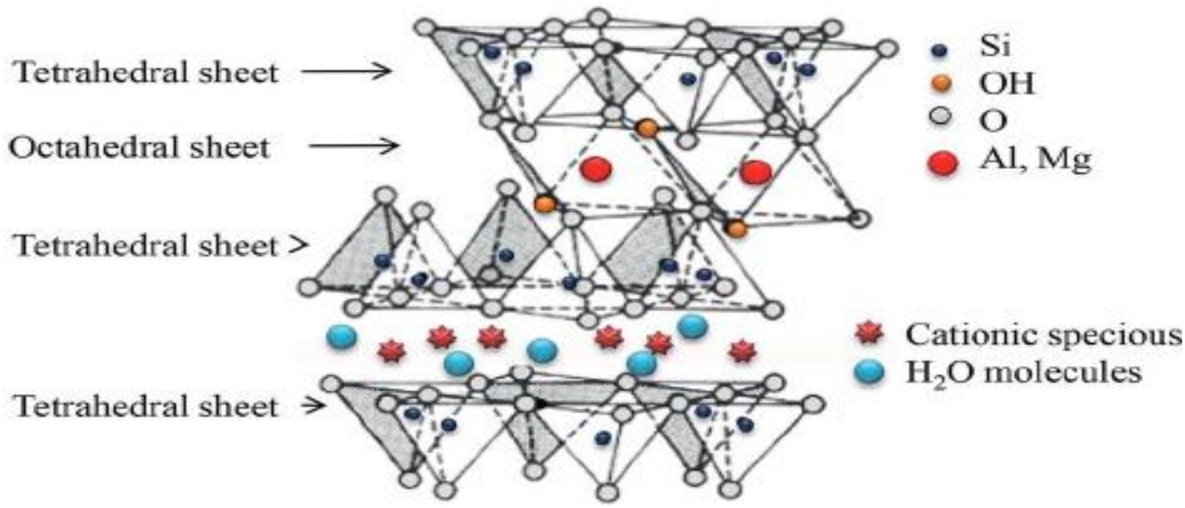

Figure 3.1 source 2-1 Two-to-one (2:1) clay mineral

The soil interlayer's for the smectite group are weakly held together and can have a basal spacing (d-spacing) that varies between 9.6 Angstrom in the dry condition to a complete separation when the soil is treated with Ethylene Glycol(Moore and Reynolds 1989). Because the interlayer is expansible, smectite exhibit high swelling potential. The separation between individual smectite sheets varies and depends on.

1. The interlayer cations type for example monovalent cations like sodium ($Na+$) cause more expansion than do divalent cations like calcium ($Ca2+$),
2. The concentration of ions in the surrounding solution, and
3. The amount of water present in the soil.

3.2.1 Bentonite in GCL

Betonite a key component in commercially-manufactured GCLs, are natural clays formed as a result of mechanical and chemical weathering of volcanic ash that has been deposited in salt or fresh water. Sodium and Calcium Montmorillonite, which constitute the main mineral in bentonite clays, are present in salt and fresh water deposits, respectively. Bentonite exhibits low hydraulic conductivity (up to 10-10 cm/s), high fluid adsorption capacity, and can swell to several times its original volume. Its swelling capacity depends on factors such as mineral composition, grain size, aggregate size, CEC, chemical concentration of the permeating liquid, and chemical composition of the first wetting liquid. Extrinsic factors that affect the hydraulic conductivity of bentonite include, among other things, confining pressure, laboratory pressure-saturation conditions, and hydraulic. Two mechanisms exist by which polymer treatment enhances the resistance of bentonite to Cation exchange, the main cause of flocculation which, in turn, results in an increase in hydraulic conductivity. The first mechanism involves the replacement, during manufacturing, of the adsorbed sodium or calcium ions in the clay by a cationic polymer. This process is irreversible because a single polymer chain contains thousands of captions which would need to be displaced simultaneously if cation exchange is to take place later. The second mechanism relies on a weaker bond (dipole attraction) between the cationic polymer and the sodium ions. In this case, sodium ions are not replaced, but rather the sodium Montmorillonite sheets are “coated” with the polymer.

3.3 Experimental Study:-

Ordinary Clay particles have extremely low Porousness go and further, to relate with the properties of a decent liner, the typical earth was mixed with bentonite at 3%, 5%, 7% extents

Experimentation was modified for finish of following:

i. List properties of clayey soil and Bentonite dirt.

ii. Appropriateness of clayey soil utilized as liner material dependent on water powered conductivity.

iii. Designing properties of Mixed soil (dirt and Bentonite, for example, unconfined compressive quality and

iv. Shrinkage potential.

v. Concoction properties, for example, pH, Feline particle trade limit and so on (mud, Bentonite and mixed soils).

vi. Concoction properties for leachate.

3.3.1 Definition of leachate

Leachate means any liquid percolation through the deposited waste and emitted from or contained within a landfill.

1. The leachate consists of many different organic and inorganic compounds that may be either dissolved or suspended.
2. They will bring potential pollution issues for groundwater and surface waters in nature. The landfill leachate is a secondary contamination related to landfills. At present, leachate from 9/45 most of landfills were treated by municipal wastewater in municipal wastewater treatment plants (MWTPs).

3.3.2 Description of Clays and Leachate.

In the present study, seven bentonite clays, produced by two GCL manufacturers were used. Three were described by the manufacturers as “polymer treated”, although the exact treatment process was not disclosed. Some of the samples were obtained directly in the form of a dry clay powder from the manufacturer while others were extracted for the testing program by cutting a sample of the parent GCL material and extracting the clay component. Contains a description of the seven bentonite with the nominal properties provided by the manufacturers. The principal mineral in all seven clays is sodium Montmorillonite. The leachate was obtained from incinerator ash disposal facilities in three different counties in the State of Florida from Bay County, from Palm Beach County, and from Pasco County. The Pasco County facility is an ash monomial while the other two facilities use landfill co-disposal where both incinerator ash and MSW are disposed.Summarizes the relevant chemical characteristics of the leachate.

3.3.3 Leachate Test For Solidified Hazardous wastes.

Different criteria have been used to evaluate the effectiveness of solidified hazardous wastes. From a regulatory compliance perspective, leachate testing has been most frequently required to determine the adequacy of site cleanup and potential groundwater protection. Since no one leachate test has been consistently used or universally accepted, the major leachate tests and their corresponding applications are reviewed. Ranges for key variables of these tests are presented. Then different models for evaluating effectiveness are examined. Conclusions regarding ideal leachate testing are draw. Leachate generated by water percolating through a hazardous waste disposal site could contain significant concentrations of toxic chemicals. Proper leachate management is essential to avoidance of contamination of surrounding soil, ground water, and surface waters. Consequently, this document has been prepared to provide guidance on available management options for controlling, treating and disposing of hazardous waste leachates. Leachate management options include all of the decision factors throughout the entire hazardous waste management process which have an impact on the nature or generation potential of leachate. Thus, consideration of leachate management options could begin with the manufacturing process and extend through the hazardous waste management chain to leachate treatment/ disposal. This management chain can be divided into four major areas:

1. Waste generation,
2. Hazardous waste treatment prior to disposal,
3. Disposal site management, and
4. Leachate treatment/disposal.

Because companion permit manuals and technical resource documents address many of these aspects in detail, the central focus of this document is on leachate management subsequent to leachate generation. When other aspects of leachate management are mentioned, the reader is referred to an appropriate source for details. Hazardous waste leachate management is an area where little past experience exists. Therefore, in preparing this document, it has been necessary to draw heavily upon experience in related areas. Certain pitfalls are inherent in such an approach and thus, an effort has been made to alert the reader to areas of uncertainty throughout this document.

Figure 3.2.1 soil and hazardous waste.

Figure3.2.2 Clay and hazardous waste

Figure 3.2.3 Bentonite soil and hazardous waste

Figure 3.2.4 Bentonite soil Clay and normal soil

Figure 3.2.5 Bentonite soil Clay and soil hazardous waste after 25days

3.4 Leachate Generation

As discussed in subsequent sections, leachate management is highly dependent upon leachate characteristics. Leachate characteristics, in turn, are upon how the leachate is generated. Because hazardous waste management under regulations is in its early stages, there is a dearth of information on leachate generation. Ideally, leachate treatment alternatives should be evaluated using actual leachate in treatability and pilot plant studies. However, at the time of permitting new sites leachate is unavailable. Methods to select appropriate treatment technologies in the absence of actual leachate for treatability studies are described in . The methods described in this section envision projecting leachate compositions using data on the wastes expected to be disposed of, extrapolations from analogous disposal experience, and from theoretical. While a complete discussion of leachate generation from a theoretical point of view is beyond the scope of this manual, this section describes factors that influence leachate generation in general terms. Emphasis in this section is placed upon factors affecting leachate quality. A detailed description of methodologies for estimating leachate volume is provided in a companion document in this EPA hazardous waste series, "Hydrologic Simulation on Solid Waste Disposal Sites", SW-868. Although intended to describe leachate for municipal landfills, a report by Phelps (discussed theoretical aspects of the change of mass in fluid and solid phases with respect to time. Phelps provided leaching curves (concentration vs. time) to describe the effects of four parameters on leachate concentrations:

1. Depth to infiltration rate,
2. Mass transfer rate constant,
3. Equilibrium constant,
4. The initial amount of leachable material per unit volume of Colum.

Manual users are referred to this reference for a detailed discussion of the theoretical principles of leachate generation, albeit for municipal landfill. Freeze and Cherry discussed leachate generated from land disposal-of solid wastes, sewage disposal on land, agricultural activities, etroleum leakage and spills, and radioactive waste disposal. This reference also could be helpful in estimating leachate compositions. He aider of this section is an enumeration of factors which could be important in assessing leachate generation. For details, the reader is again referred to the works by Phelps and Freeze and Cherry.

3.4.1 Factors Affecting Leachate Generation and Characteristics

Leachate will be generated as a result of the movement of liquids by gravity through a disposal site. Similarly, leachate will be generated as liquid contained within a disposal impound entoves through soil beneath the disposal area. Leachate quality is dependent upon numerous factors. It is not the intent to deal with such factors in detail here: rather the reader is given a brief overview for purposes of identifying consideration which should be explored at length elsewhere.

3.4.2 Physical Influences

3.4.3 Liquid Characteristics-

Liquid· moving through the site can be comprised of precipitation falling upon the site, groundwater migrating through the site, and te liquids fraction of disposed materials. The quant it of liquid will be a major determinant of the rate at which he leachate will be generated as well as the leachate composition. Liquid movement can be complicated by variations in density, viscosity, and miscibility. It is possible that the liquid could be multi-phased, e.g., water, oil, and solvents with the 1arious phases moving through· the solid medium at different rates.

3.4.4 Solid Characteristics-

For landfills, solid waste materials could comprise a significant fraction of the medium through which the liquid passes. Thus, it should not be assumed that soil alone is the solid odium. Furthermore, it is unlikely that the solid wastes or soil are homogeneous. Because of the expected solid mixture, porosity and particle sizes are expected to be variable. This will have an influence on liquid velocity and the time in which the liquid is in contact with the solid. Initially, liquid percolating through a landfill will be absorbed by the solid material. When the absorptive (moistureholdig) capacity is reached, i.e., when the solid is saturated, then leachate quality is likely to be influenced by surface reaching. After saturation, the length of the solid column be the major detenlinant of the time required for the liquid reach the leachate collection system.

3.4.5 Physical Transformations-

The principal physical transformation expected in the leaching process is plugging of pore spaces and the resultant influence on chemical processes and leachate flow rates.

If the disposed wastes contain significant amounts of suspended solids, then the place arterial will act as a filtering medium, and percolation flow rates will decrease as the pore spaces become clogged.

3.4.6 Chemical Influences

Solubility Solubility is one of the most important factors which influence leachate quality. Solubility is a function of the chemical composition of the liquid phase, surface area contact between the liquid phase and the solid medium, contact time, pH, temperature, and chemical composition of solid material. Chemical composition of the leachate determines dissolution and reaction rates. For example, if the liquid phase approaches the solubility product for certain compounds, then further leaching will be limited and transfer rates from the solid to the liquid will be low. Conversely, if the liquid phase is dilute, dissolution of the solid medium will be more rapid. If the solubility product is exceeded, then chemical precipitation could occur. Size of solid particles has a direct influence upon leaching. Thus, longer contact times per.nit more complete chemical reactions between the liquid and solid, until eventually equilibrium concentration is reached. pH is considered a significant variable affecting leachate composition because of its effect on solubility and chemical reactions occurring in the disposal site. In general, pH affects solubility in two principal ways:

1. Alteration of simple solution equilibrium, and
2. Direct participation in red reactions.
3. pH generally is a function of the type of waste disposed.

Low molecular weight acids and carbon dioxide which result from an aerobic digestion of organic material reduce the pH. Hazardous wastes can contribute to pH change due to their own specific characteristics or by the dissolution of waste arterials into leaching water. Changes in pH can influence the solubility of the waste materials. For example, easy metals are solubilizing in acidic solution. Normally, the solubility product for metals is lowest in mildly basic solution. Thus, acidic conditions promote the leach ability of metal ions, and markedly increase the potential for appearance in the leachate collection system. Soil admixtures also can influence solubility. Acid ·or alkaline soils can influence solubility either positively or negatively. For example, acid soils tend to promote solubilization of waste constituents, whereas higher pH in alkaline soils likely will retard solubilization. A disposal site has some capacity to tolerate acids or bases before the pH of the system is markedly affected. If this buffer capacity is high, the leachate composition is more stable and predictable.

3.4.7 Chemical Transformation-

Chemical transformations occurring within the disposal site could include adsorption, oxidation and reduction, and precipitation. Most soils are known to have Cation exchange capacity. This capacity is variable dependent upon the type of soils. To a lesser extent, some soils are known to sorb anions. While this may be an important influence during initial stages of disposal operations, it is expected that exchange capacity will be exhausted at about the time the solid medium is saturated by te liquid. Thereafter, exchange capacity will be at equilibrium and will not be a consequential determinant of leachate composition. Chemical reactions could occur in the disposal site depending upon the types of materials disposed. For example, neutralization reactions could be evident, and metals could precipitate in alkaline solution.

3.4.8 Biological Influences-

Microorganisms solubilize and oxidize organic waste constituents. Microbes not lethally affected by the waste product may decompose both the toxic and nontoxic organic compounds organics that can be metabolized further. The microbial population within the disposal site depends upon waste composition, nutrients available, concentration of toxic material, oxygen levels, temperature, pH, percent moisture, and the initial population found in the waste liquid or solids and any admixes such as soil. Aerobic microorganisms will give way to anaerobic species as oxygen is depleted. Anaerobic microorganisms which then predominate may generate significant amounts of gases such as methane, hydrogen sulfide, and ammonia that can cause both odor problems and potential explosion hazards.

3.5 Leachate Management-

Once leachate has been collected, numerous alternatives exist for treatment and disposal. Treatment can be accomplished either off-site or on-site. By using off-site treatment, disposal from the landfill operator's perspective also is accomplished. In the case of on-site treatment, disposal options must be examined in concert with treatment options because of the different degrees of treatment which may be required. Typically, disposal can be accomplished by-

1. Discharge to receiving surface waters,
2. Discharge to publicly owned treatment works,
3. Shipment to a hazardous waste treatment facility,
4. Seep well injection, or
5. Land treatment.

3.5.1 Off-Site Treatment of Disposal Options-

Treatment disposal of leachate for purposes of this manual refers to treatment disposal at a facility not associated with the landfill or surface impoundment operation. Primary off-site treatment/disposal alternatives include:

- Publicly owned treatment works (POTW),
- Hazardous waste treatment disposal facilities, and
- Industrial waste treatment facilities.

Technologies used at an off-site facility can be any of those listed of this manual. Other possible technologies include land treatment and deep well injection. The former technology serves as both a treatment and disposal process while the latter is a disposal mechanism. Primary concerns of the owner of the leachate generating facility need not be with the technologies employed at an approved off-site facility but rather with proper manifesting, on-site storage, transportation, and pretreatment of the leachate and the associated economics. The reader is reminded tat if the leachate is determined to be a hazardous waste, it must be managed the same as any other hazardous waste.

This means that if it is transported to another site for any purpose (treatment/disposal) the hazardous waste manifest requirements (under RCRA) must be satisfied. Additionally, if the leachate generating facility collects hazardous leachate in surface impoundments either for storage prior to transport off the site or as part of the onsite treatment process, the impoundment must comply with pertinent RCRA regulations. Additional information on impoundment design and performance can be found in the following technical resource documents:

• Lining of Waste Impoundment and Disposal Facilities, SW-870,
• Landfill and Surface Performance Evaluation, SW-869, and
• Closure of Hazardous Waste Surface Impoundment, SW-873.

Numerous factors should be evaluated before selecting or approving an off-site treatment/disposal option. Costs and guarantees provided by the off-site facility will be major considerations. However, other important factors (which may or may not influence costs) also should be considered:

• Availability and proximity of an approved off-site facility.
• Technol09ies employed at the off-site facility.
• Need for pretreatment prior to shipment off site.
• Duration of the required service.
• Projected operating life of the off-site facility.

• Regulatory agency limitations on the off-site facility including air, water, and waste permits.

• Capacities of the off-site facility.

• Reliability of service which can be provided by the off-site facility.

• Quantity of hazardous leachate to be transported and methods of transport.

• Public attitudes or other constraints to shipment of the hazardous leachate.

• Capability to establish on-site treatment including capital, land, and qualified personnel.

• Disposal options if on-site treatment is feasible.

• Expected variations in leachate quality during the life of the dispose. Site including post closure period.

• Ability of the off-site facility to accept varying quality leachate or availability of another facility to accept leachate should quality or quantity change due to changes in disposal site practices or aging of the disposal site.

For a number of reasons, it is expected that off-site treatment will be feasible only in a limited number of cases. In instances, waste treatment facilities will be available at reasonable distances or will be technically capable of accepting hazardous leachate while still satisfying their permit requirements. It also is unlikely that such facilities will assume the potential liabilities associated with accepting a hazardous leachate which is expected to vary in composition and quantity. Therefore, stringent pretreatment requirements probably would be imposed making on-site treatment a necessity. Leachate treatment at a central hazardous waste treatment facility is likely to be technically feasible. Transportation costs are expected to be a key factor in determining the viability of this option, at least until more approved hazardous waste treatment facilities become available.

3.5.2 On-Site Treatment Disposal-

On-site hazardous leachate treatment can be used to accomplish either pretreatment of the leachate with discharge to another facility for additional treatment before disposal or treatment complete enough to meet direct discharge limitations. Pretreatment processes will be dictated by the capabilities of the subsequent off-site facility. Objectives of pretreatment could be to:

• Equalize leachate quality and quantity fluctuations and provide short term storage.

• Adjust pH to within acceptableimits for discharge to a POTW.

• Reduce concentrations of toxic components to acceptable levels for discharge to a PCTW.

• Remove hazardous constituents so that a portion of the leachate can be judged non-hazardous

Or non-hazardous fraction could be shipped to off-site.

• Reduce the volume of leachate transported of site.

Complete treatment, on the other hand, should produce an effluent suitable for discharge to surface water or groundwater. Thus, the major difference between complete on-site treatment and pretreatment is likely to be the extent of the treatment. That is, the treatment technologies are essentially the same, but the extent of application will differ depending upon effluent objectives. Potential leachate treatment technologies are discussed in unfortunately; there has been very little actual application of these technologies to hazardous waste leachate treatment. However, experience with other applications can be used to guide selection of leachate treatment schemes. Of these annual addresses the various decision factors involved in selection of leachate treatment sequences. Most leachate treatment processes will result in the production of by-products such as sludges, air pollution control residues, spent adsorption or ion exchange materials, other considerations important to design of an effective on-site leachate management program inclucie:

•Sampling and monitoring of raw leachate composition and quality of effluent and product streams, ,

• Manifesting of hazardous leachate and residues shipped off the site.

• Personnel safety and training.

• Routine maintenance.

• Contingency plans and emergency provisions, and

• Equipment redundancies and back-up.

These items are discussed in further detail .One possible approach to on-site leachate management which is not discussed subsequently is leachate recycling. This approach involves the controlled collection and recirculation of leachate through a landfill for the purpose of promoting rapid landfill stabilization. The precise mode of operation of leachate recycling is poorly understood since it has only recently been investigated in sanitary landfill simulations. Therefore, the state of development of this technique is judged to be insufficient for it to merit further consideration as a primary approach to hazardous waste leachate management at this time. However, leachate recycling may have some merit as an interim measure under certain circumstances as discussed.

3.6 Leachate Tests-

Figure 3.2.6 Leachate

Research facility leachate tests are best used to think about the viability. The tests are institutionalized and in this manner will have a few impediments for a given site.

When all is said in done, fast filtering will result in low contaminant focuses in leachate. Trial of this sort supplants draining answer for acquire active data and speak to non-balance conditions. Then again, moderate filtering results in greatest. Contaminant fixations in leachate. In this case draining arrangement isn't recharged and balance (Le. static) conditions are reenacted. Two classifications of leachate tests exist, cluster and section. Clump tests might be directed utilizing a pummeled test what's more, fomentation or a stone monument and no disturbance; the previous generally gives greatest contaminant focuses and does not join substitution of draining arrangement while the later is regularly used to acquire rate information. Section tests are intended for a pounded test and indicated filtering rate; they are increasingly illustrative of genuine field conditions in any case, are not regularly utilized given information reproducibility issues furthermore, longer required trials. Other tests have also been developed but have had fewer applications.

3.6.1 Summary of the Major Leachate Tests

Table 3.1 the major Leachate

1. Extraction Procedure Toxicity (EP TOX)
2. Toxicity Characteristic Leaching Procedure(TCLP)
3. Multiple Extraction Procedure (MEP)
4. California Waste Extraction Test (CAL WET)
5. American Society of Testing Materials (ASTM)
6. American Nuclear Society (ANS) 1
7. MCC-1 Static Leach Test

A brief review of these major leachate tests follows.

The first four tests listed all use pulverized samples. EP TOX has traditionally been used by the Environmental Protection Agency (EPA) to characterize hazardous wastes. This test was intended to simulate landfill leaching and has been used to predict maximum contaminant concentrations. TCLP is now replacing EP TOX in many applications and has been used by EPA as the basis for promulgating some best demonstrated available technology (BDAT) treatment standards. Maximum concentrations in leachate have specified for selected hazardous constituents. Like the EPTOX test, TCLP also simulates maximum contaminant concentrations. Some laboratory comparison studies haves shown the TCLP test to be slightly more precise than EPTOX. The MEP test essentially repeats the EP TOX test nine times and is intended to simulate long-term landfill leaching from acid rain. Long-term in this case is on the order of 1,000 years.CAL WET has primarily been used by the State of California to characterized hazardous wastes in much the same way EPA has used the EP TOX test. However, the results may be more stringent than both EPTOX and TCLP for certain metals. Each of these footrests is considered to be very conservative given sample grinding and acidic leaching solutions. The last three tests listed all use a monolith sample. The key variables encountered in these major leachate tests are summarized in along with the low to high range seen among these tests. Of the variables listed, extraction fluid, the number of extractions and liquid to solids ratio has been found to have the biggest impaction contaminant concentrations in the final leachate.

3.6.2 Collected Leachate

The leachate collection system will be a key monitoring location. Because leachate composition is expected to vary with time in terms of types and concentration of compounds, analyses of collected leachate will serve to define the unit operations used for treatment and their operating ranges. Hence, collected leachate characterizations are expected to be useful in making treatability assessments of process alternatives and in defining specific unit operations and their operating ranges. Collected leachate characterizations also provide a baseline for evaluating treatment effectiveness. Coupled with effluent analyses, this would provide an assessment of removal efficiencies for individual unit operations as well as the overall treatment chain.

3.6.3 Leachate as a potential water contaminant-

Water contamination is of concern when the solid is placed near surface or ground waters, and when unhindered flow occurs from solid waste to the surface or ground waters. Where leachate enters surface waters, visual observations and sample analysis can be used to verify its impact on water quality. Movement of leachate into subsurface formations is most of-ten detected with monitoring well or, if the situation is serious, when a drinking water supply well is contaminated. A typical subsurface migration pattern. The appropriate leachate control method must be selected after the potential for leachate contamination of ground and surface waters has been studied. The extent to which the addition of contaminants to ground or surface water is viewed as detrimental has been debated extensively. Many states have adopted ground water quality standards which specify maximum allowable concentrations of contaminants. The standards specify maximum ground water contaminant concentrations either under the disposal site or at the edge of a buffer zone around the site. The numerical values are often based on the National Drinking Water Standards.

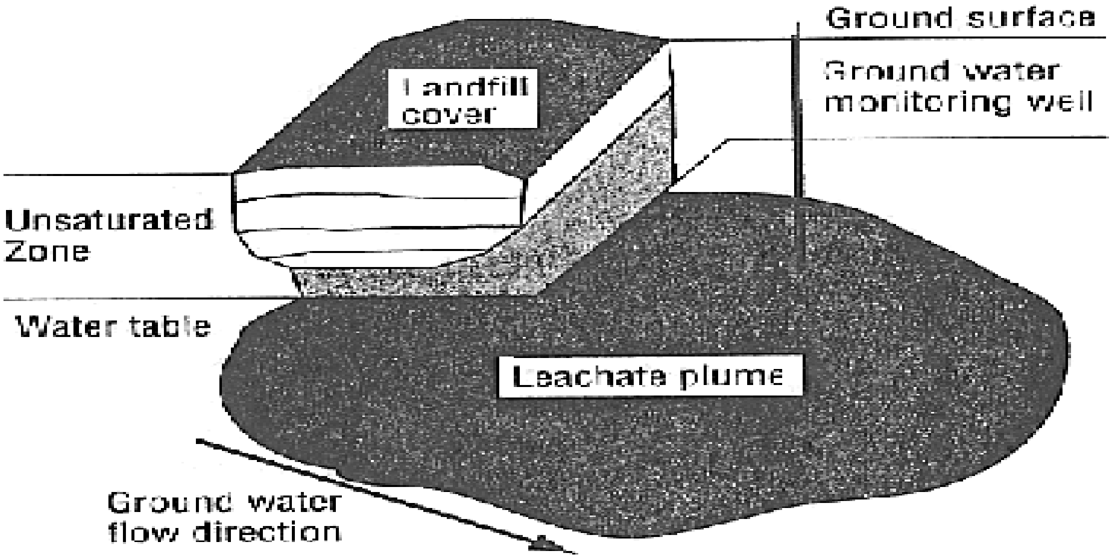

Figure 3.2.7 the potential for leachate contamination of ground and surface waters has been studied

3.6.4 Factors affecting leachate generation-

Factors influencing leachate generation and indirectly the potential for detrimental water resources impacts at a landfill are:

1. Climate
2. Site topography
3. Final landfill covers material
4. Vegetative cover
5. Site phasing and operating procedures
6. Type of waste materialism the fill.

The climate at the site significantly influences the rate of leachate generation All other factors being equal, a site located in an area of high precipitation can be expected to generate more leachate. Vegetation will, by evaporate transpiration; re-direct a portion of the infiltrating precipitation back into the atmosphere. Topography affects the site's runoff pattern and amount of water entering and leaving the site. Landfills should he designed to limit leachate generation from areas peripheral to the site by diverting runoff away from the site, and by constructing the landfill cover area in a way that promotes runoff and reduces infiltration.

Table 3.2 Impact of Soil Surface on Waste Runoff

Surface	**Runoff**	**Coefficient**
Grassy-sandy soil		
Flat	2%	0.05 to 0.10
Average	2-7%	0.10 to 0.15
Steep	7%	0.15 to 0.20
Grass-heavy soil		
Flat	2%	0.13 to 0.1
Average	2-7%	0.18 to 0.22
Steep	7%	0.25 to 0.35

The final vegetative cover plays an integral part in leachate production control. Its basic functions are to limit infiltration by intercepting precipitation directly, thereby improving evaporation from the surface, and to reduce percolation through the cover material by taking up soil moisture and transpiring it back to the atmosphere. A site with a poor vegetative cover may also experience erosion which cuts gullies through the cover soil, allowing precipitation to flow directly into the land filled waste.

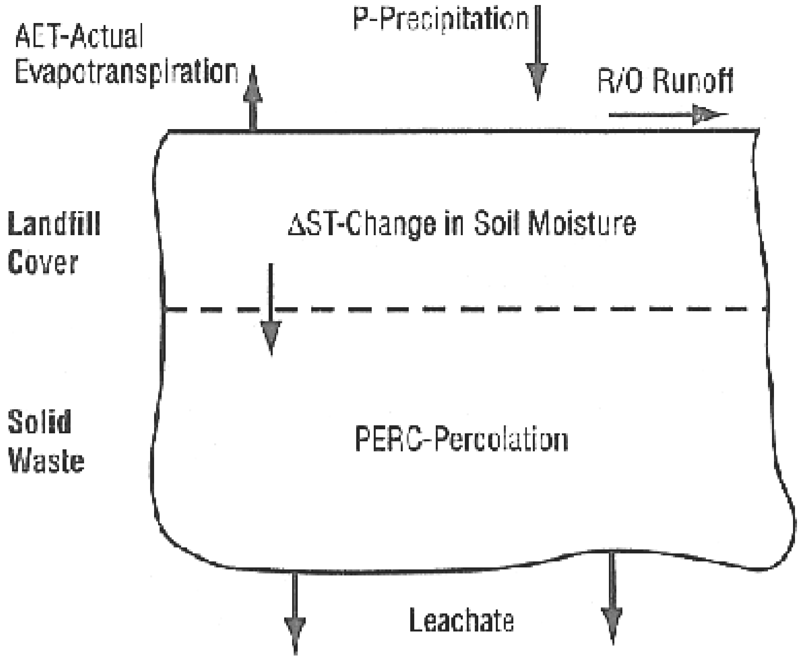

Figure 3.2.8 the permeability of different cover soils

An intermediate or temporary cover is placed over the landfill working face prior to the application of final cover. Leachate generation may be increased by the infiltration of larger quantities of precipitation through the intermediate or temporary cover. Quantity of infiltration will depend upon the soil material, with sandy soils allowing the most infiltration and clay soils the least infiltration. The use of clay soils for intermediate cover will reduce infiltration and consequently leachate generation, but the presence of relatively impermeable layers of soil within the landfill can result in leachate internally pounding upon the intermediate cover as successive lifts are added to the landfill. This internal pending has frequently resulted in leachate moving laterally through the landfill and discharging out the side of the landfill and becoming a source of surface water pollution .The best approach when utilizing clay soil for daily cover is to remove a portion of the clay immediately before placing me next layer of waste. The acceptance of high moisture wastes or liquids is discouraged or prohibited by state laws unless specific management plans are incorporated into the design and operation of the landfill. In recent years the general practice has been to discourage acceptance of wet wastes.

3.6.5 Techniques affect leachate chemistry

The actual leachate composition found at a landfill will depend upon waste composition and conditions within the landfill such as temperature, moisture content, moisture routing, depth of fill, stage of decomposition, ability of intermediate soil Layers to remove contaminates, and quality of water entering the landfill. Ranges of leachate compositions tabulated by Ehrig (1989) . The leachate characteristics were separated in the acetic phase which occurs soon after waste placement and methane organic phase which occurs a period of time after tile waste is land filled. Precipitation events and changes in seasonal temperatures will result in wide fluctuations in actual observations. For example, the COD data collected from a solid waste test lysimeter operated at the University of Wisconsin. The concentration fluctuated considerably for the first three years and then decreased to relatively low values. In contrast, modifying the physical characteristics of the waste by shredding and waiting six months to place an earth cover results in higher initial COD concentrations, but the decline in concentration occurs earlier. It is believed that this is the result, of increased particle surface area, better mixing of the waste, and more uniform movement of moisture.

3.6.6 Plan for leachate control during site development-

The movement of leachate from the land filled solid wastes depends upon site circumstances and landfill design features. It is especially important to plan for leachate control during the development of the landfill rather than after the landfill is constructed, since the control techniques are usually employed beneath the waste. To select a site for maximum natural containment of leachate, interrelations between topographical, hydrological, and geological factors must be considered. These factors will be described in the next lesson on site selection.

When constructing a landfill on a site that does not have a suitable subsurface hydrogeology for natural attenuation, the bottom of the landfill can be lined with compacted clay or silt, betonite, membrane liners, or other rather impermeable materials. Where a high degree of protection is needed, soils such as slow permeability clays are sought for use as a soil liner. Typical permeability’s for soils agencies often require that the soil liner have a permeability of less than 10-7 centimeters per second more information about inspection and quality assurance during construction will be providing later lesson. Leachate retained by the soil liner will accumulate above the liner unless it is removed. To accomplish removal leachate collection pipes are installed over the liner to remove the leachate. The collection system consists of perforated drainpipe which is covered with coarse gravel or stones. A typical layout is shown in . The pipes carry die leachate by gravity to a storage tank from which the leachate is periodically removed for treatment.

When soil conditions are such that naturally occurring or imported soils such as betonite are unavailable or uneconomical, geosynthetic liners can be employed to control leachate movement. A wide variety of geosynthetic is available for use in containing different types of liquid wastes. Considerations when using geosynthetic under landfills include providing a firm base under the liner, construction quality assurance, and protection of die liner after construction. A concern when relying on liners is that chemical interactions may destroy the liner's integrity. Certain waste materials have been known to degrade a particular type of liner. There is concern that properties of certain clays may be changed if attacked by the chemicals present in some leachate. However research has shown that under normal conditions most clay will not undergo significant detrimental changes when subjected to municipal solid waste leachate exposure. In fact, reductions in hydraulic conductivity have been observed. Short duration testing of geosynthetic liners has shown that many materials can resist chemical attack under most conditions. The recommended design procedure for both soil and geosynthetic liners is to consult the results of compatibility tests if available, or to conduct short durations tests with liner samples and leachate generated by the waste. Since leachate production is a long-term concern, liners will need to be tested over a long period of time to determine their ultimate suitability.

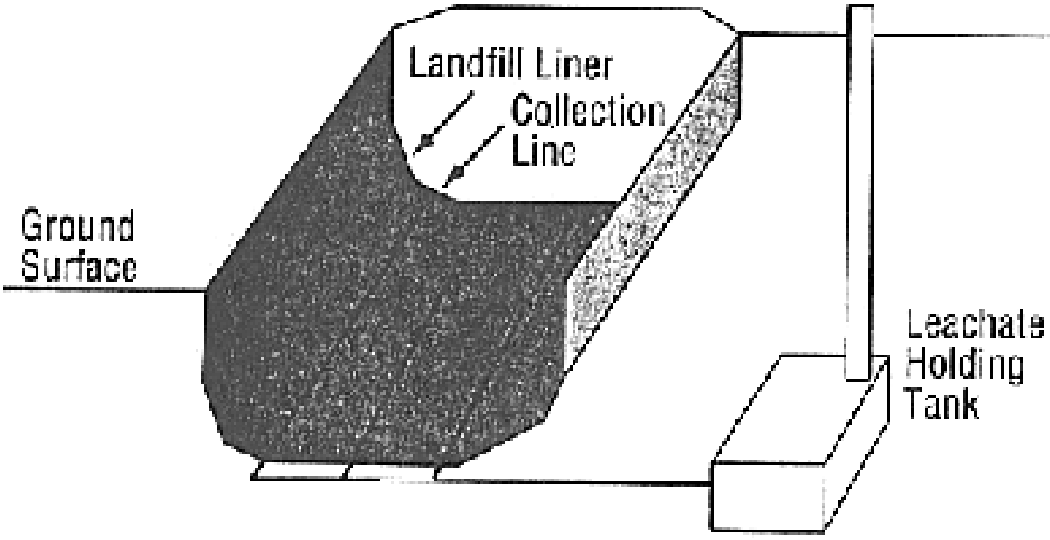

Figure 3.2.9 permeability for soils

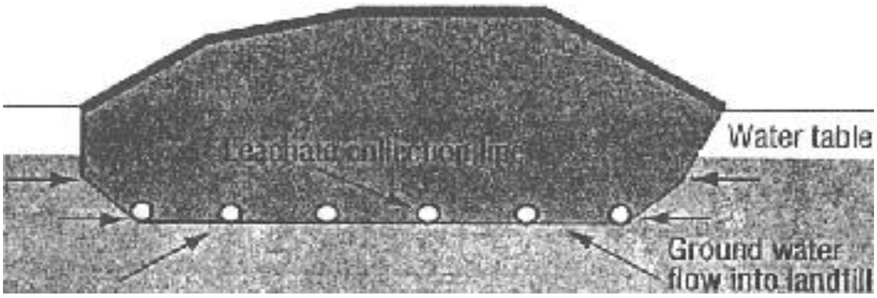

Figure 3.3.1 leachate collection line

Table 3.3 Composition of synthetic Leachate

Chemical Parameters	Concentration (mg/l)			
	A1 (25%)	A2 (50%)	A3 (75%)	A4 (100%)
Chloride	1625	3250	4875	6500
Ammonia	75	150	225	300
Nitrate	14.25	28.5	42.75	57
Iron	2825	5650	8475	11300
Manganese	29.75	59.5	89.25	119
Zinc	9.5	19	28.5	38
Chromium	7.5	15	22.5	30
Cadmium	1.2	2.4	3.6	4.8
Copper	2.75	5.5	8.25	11
Nickel	7	14	21	28
TOC	2790	5580	8370	11160

Landfills are constructed in fine textured soils which have shallow depths to the water. The low permeability of these soils will often allow a landfill operator to excavate below the water table and deposit it the solid wastes before the ground water re-enters the area. State regulations may require the installation of a leachate collection system at the base of the zone of saturation landfill. A typical layout is shown in. This type of collection system will recover leachate mixed with a quantity of ground water.

Table 3.4 Ionic Concentration in the Synthetic Leachate

Parameters	Concentration (mg/l)			
	A1	A2	A3	A4
Captions	2957.7	5915.4	8873.1	11830.8
Anions	1639.25	3278.5	4917.75	6557

3.6.7 Leachate treatment processes

Leachate treatment options include recycling, on-site treatment, discharge to a municipal sewage treatment plant, or a combination of these approaches. Leachate recycling is accomplished by collecting leachate at die base of the landfill and redistributing it over the top of the waste. Research both supporting and discouraging this approach can be cited. Recent experience, however, has shown that recycling can significantly reduce leachate chemical concentrations, even out the flow of leachate that must be removed from die landfill for further treatment, and possibly enhance die stabilization of die landfill. Several states have modified regulations to encourage research on leachate recycling. The principal objective of these efforts is to discover procedures which will result in the land filled waste being decomposed more quickly, thereby releasing gas for energy recovery and shortening the duration of long-term monitoring and maintenance. Onsite treatment has been attempted with pond systems, conventional treatment plants, anaerobic treatment processes, and physical-chemical units. When compared to either municipal or most industrial wastewaters, leachate is a very high strength waste. Consequently die treatment process must he carefully developed to guarantee a successful system. The most commonly used leachate treatment option is discharge to municipal sewage treatment plants. Since leachate strengths are significantly greater than normal municipal wastewaters, care must be taken to avoid 'overloading the plant. Studies have shown that a 5 percent loading of a sewage treatment plant with leachate will not disrupt its operation, but greater loadings may be detrimental.

3.7 Effect of Leachate Environmental impact

The risks from waste leachate are due to its high organic contaminant concentrations and high concentration of ammonia. Pathogenic microorganisms that might be present in it are often cited as the most important, but pathogenic organism counts reduce rapidly with time in the landfill, so this only applies to the freshest leachate. Toxic substances may, however, be present in variable concentrations, and their presence is related to the nature of the waste deposited. Most landfills containing organic material will produce methane, some of which dissolves in the leachate. This could, in theory, be released in poorly ventilated areas in the treatment plant. All plants in Europe must now be assessed under the Directive and zoned where explosion risks are identified to prevent future accidents. The most important requirement is the prevention of the discharge of dissolved methane from untreated leachate into public sewers, and most sewage treatment authorities limit the permissible discharge concentration of dissolved methane to 0.14 mg/l, or 1/10 of the lower explosive limit. This entails methane stripping from the leachate. The greatest environmental risks occur in the discharges from older sites constructed before modern engineering standards became mandatory and also from sites in the developing world where modern standards have not been applied. There are also substantial risks from illegal sites and ad-hoc sites used by organizations outside the law to dispose of waste materials. Leachate streams running directly into the aquatic environment have both an acute and chronic impact on the environment, which may be very severe and can severely diminish bio-diversity and greatly reduce populations of sensitive species. Where toxic metals and organics are present this can lead to chronic toxin accumulation in both local and far distant populations. Rivers impacted by leachate are often yellow in appearance and often support severe overgrowths of fungus. The contemporary research in the field of assessment techniques and remedial technology of environmental issues originating from landfill leachate has been reviewed in an article published in Critical Reviews in Environmental Science and Technology journal.

3.7.1 Problems and failures with collection systems-

Leachate collection systems can experience many problems including clogging with mud or silt. Bioclogging can be exacerbated by the growth of micro-organisms in the conduit. The conditions in leachate collection systems are ideal for micro-organisms to multiply. Chemical reactions in the leachate may also cause clogging through generation of solid residues. The chemical composition of leachate can weaken pipe walls, which may then fail.

3.7.2 Fact and Finding of Leachate:-

The following facts and findings can be inferred from this Study:

1. Leachate that derives from the deposited waste released from or contained within a landfill is generated from the rainfall that enters a landfill as well as moisture that already exists inside the waste material.
2. The composition of leachate depends on various factors which consist of the kind of waste that’s deposited, quantities of rainfall, surface water infiltration and the way lengthy the waste has been contained within the landfill.
3. Substances going on in leachate can encompass chemical oxygen call for (COD) pH, ammonia nitrogen, and heavy metals.
4. Leachate often outcomes in a robust, offensive smell.
5. Leachate may be managed in lined landfills with leachate series and storage systems. These systems commonly encompass provisions for the drainage of leachate inside the landfill and pumping the leachate to storage tanks. The stored leachate can then be trucked or pumped to a wastewater remedy plant.
6. Most more modern landfills are designed to manage leachate. However, a few older centers do no longer have liners and leachate collection/garage systems in location. Since leachate is not amassed in these older centers, management is restrained to methods that lessen leachate technology via floor drainage manage, limits on open landfill regions, and effective landfill.

CHAPTER 4

RESULTS AND DISCUSSION

Results of the tests carried out after maturing periods of 7 days, 50 days, 100 days and 150 days for analyzing the effect of chemicals on particle size distribution, shear strength, After berg limits and hydraulic conductivity of test soils are as discussed.

4.1 Particle Size Distribution

The results of the particle size distribution of test Bentonite soil-I and ordinary clay soil II treated with leachate at different concentrations namely A1, A2, A3 and A4 along with the control soil are presented in Table 3.3 to figure 4.8.

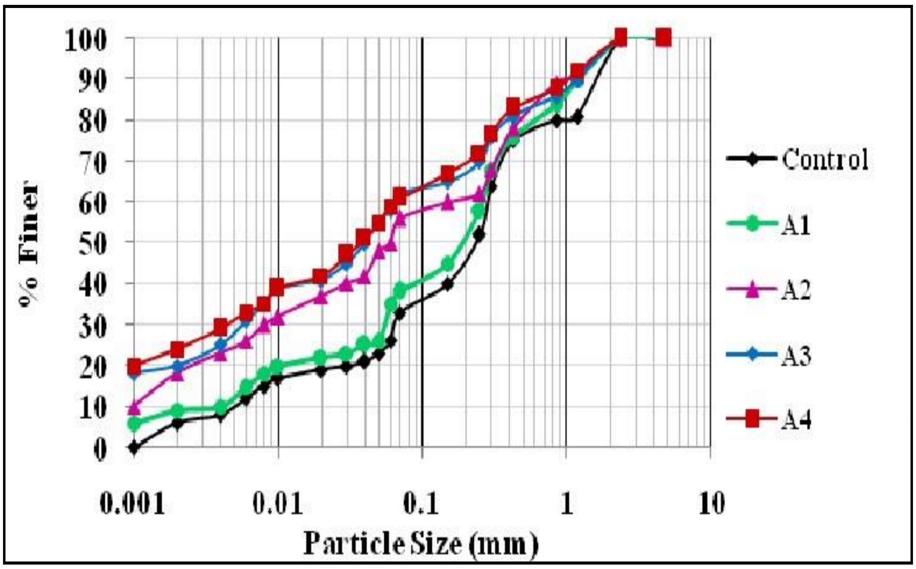

Figure 4.1 Particle Size Distribution of Test Bentonite Soil-I after 7 Days

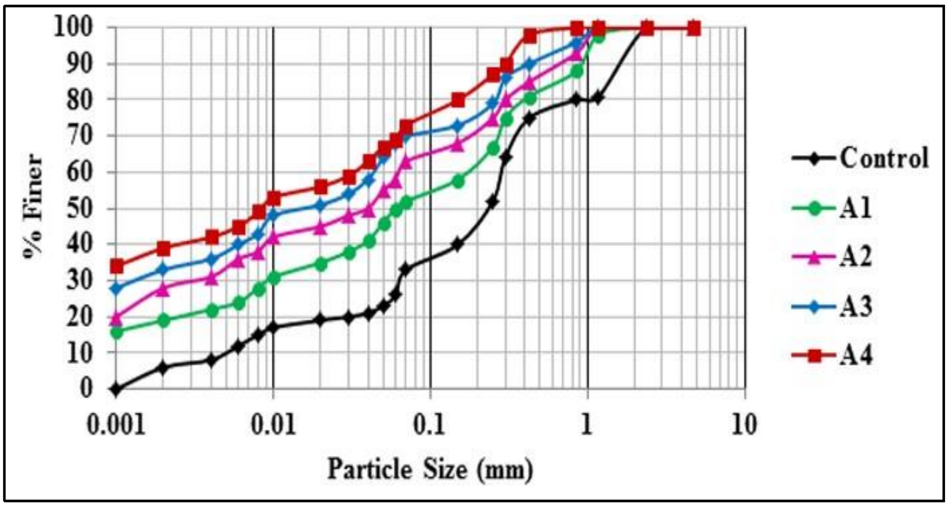

Figure 4.2 Particle Size Distribution of Test Bentonite Soil-I after 50 Days

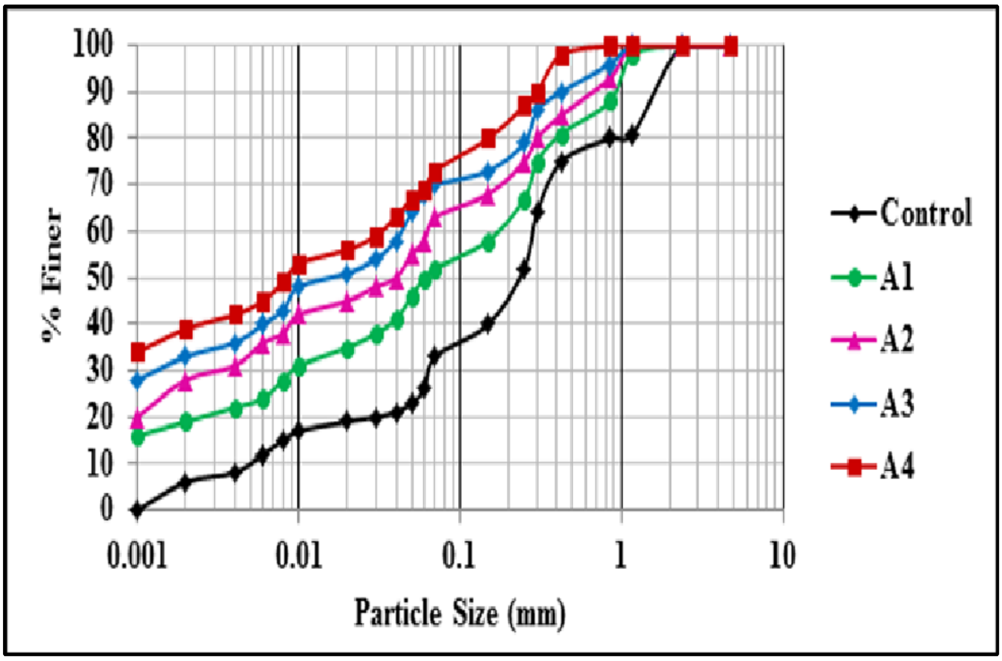

Figure 4.3 Particle Size Distribution of Test Bentonite Soil-I after 100 Day

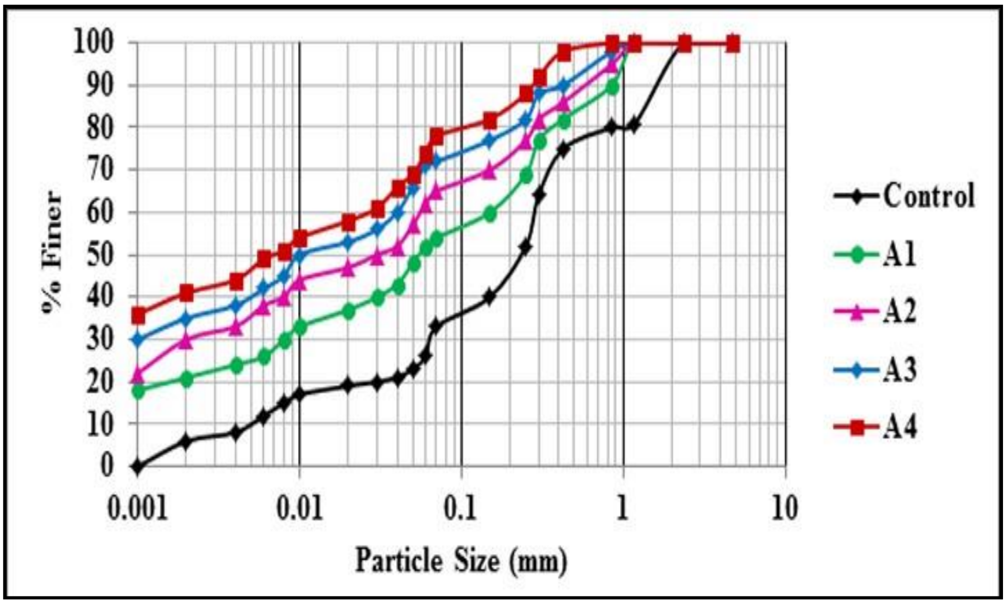

Figure 4.4 Particle Size Distribution of Test Bentonite Soil-I after 150 Days

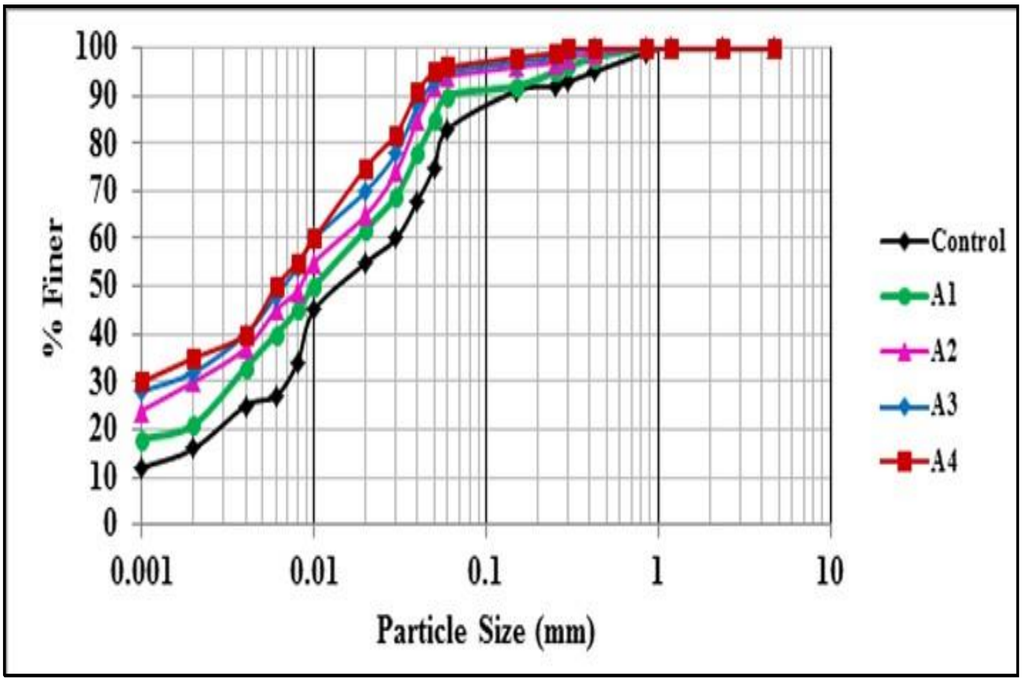

Figure 4.5 Particle Size Distribution of Test ordinary Clay Soil-II after 7 Days

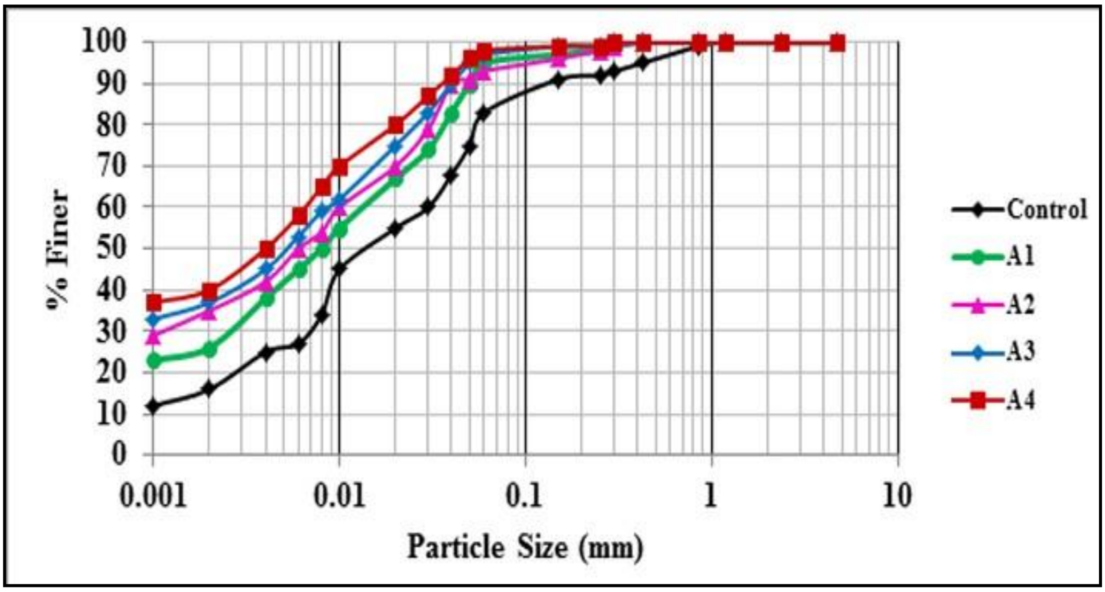

Figure 4.6 Particle Size Distribution of Test ordinary Clay Soil-II after 50 Days

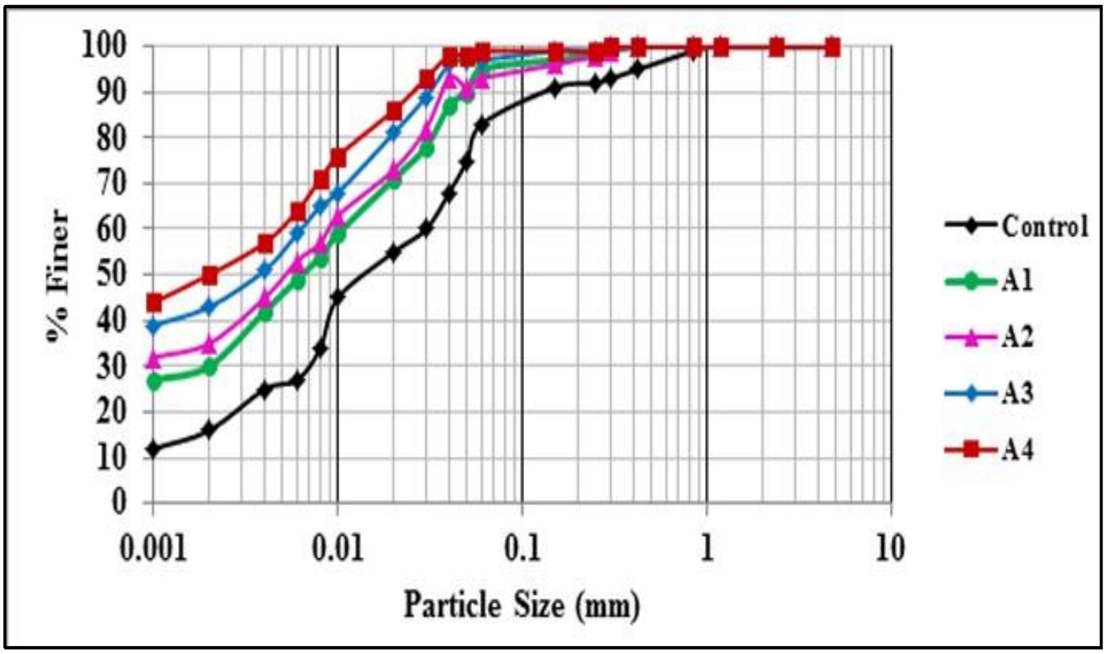

Figure 4.7 Particle Size Distribution of Test ordinary Clay Soil-II after 100 Days

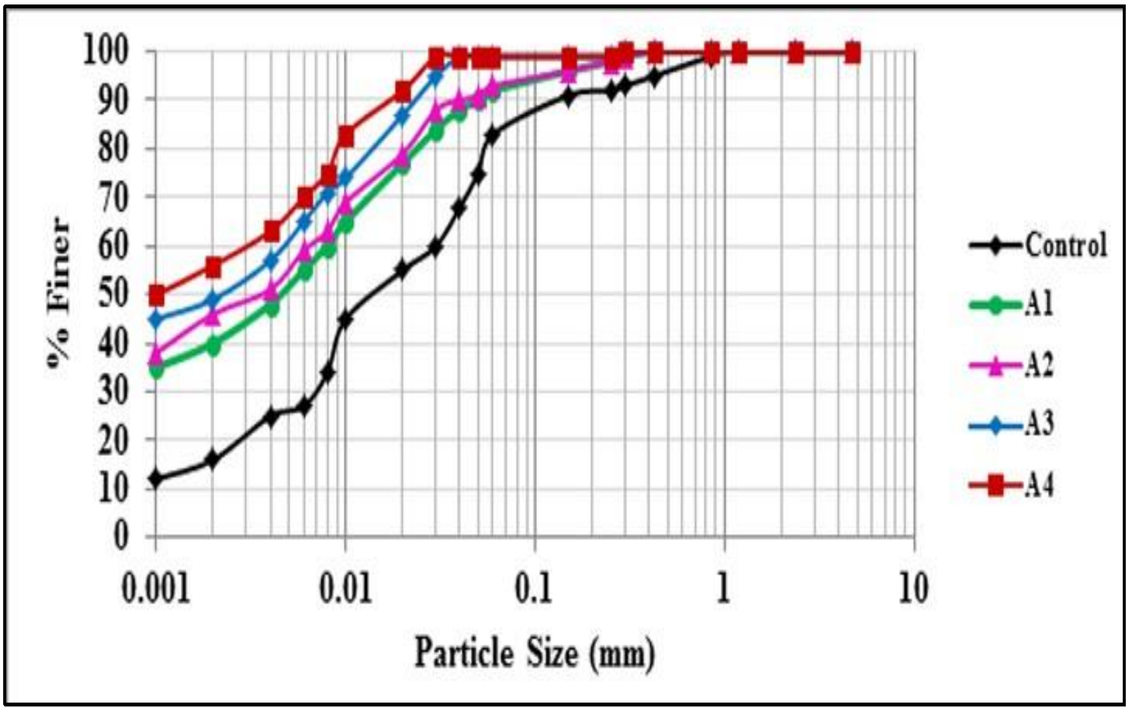

Figure 4.8 Particle Size Distribution of Test ordinary Clay Soil-II after 150 Days

The Figs. 4.1 to 4.8 shows that the chemical treated Test soil-I and Test soil-II has more fines than the untreated control soil. The percentage of fines increases as the concentration of leachate increases.

As the maturing period increases percentage finer increases corresponding to clay size particles. For the Test soil-I treated with 25% concentration of leachate (A1), the percentage of soil finer than 0.002 mm size increases from 6% to 9% in 7 days of maturing period. Further it increases to 14%, 19% and 21% corresponding to 50 days, 100 days and 150 days of maturity period. The corresponding values for Test soil-I treated with 50% concentration of leachate (A2), 75% concentration of leachate (A3) and 100% concentration of leachate (A4) are (18%, 24%, 28%, 30%),(20%, 28%, 33%, 35%) and (24%, 33%, 39%, 41%) respectively.

In Test soil-II treated with 25% concentration of leachate (A1), the percentage finer than 0.002 mm size increases from 16% to 21%, 26%, 30%and 40% corresponding to 7 days, 50 days, 100 days and 150 days of maturing period. The corresponding values for Test soil-II treated with 50% concentration of leachate (A2), 75% concentration of leachate (A3) and 100% concentration of leachate (A4) are (30%, 35%, 36%, 46%),(32%, 37%, 43%, 49%) and (35%, 40%, 50% , 56%) respectively.

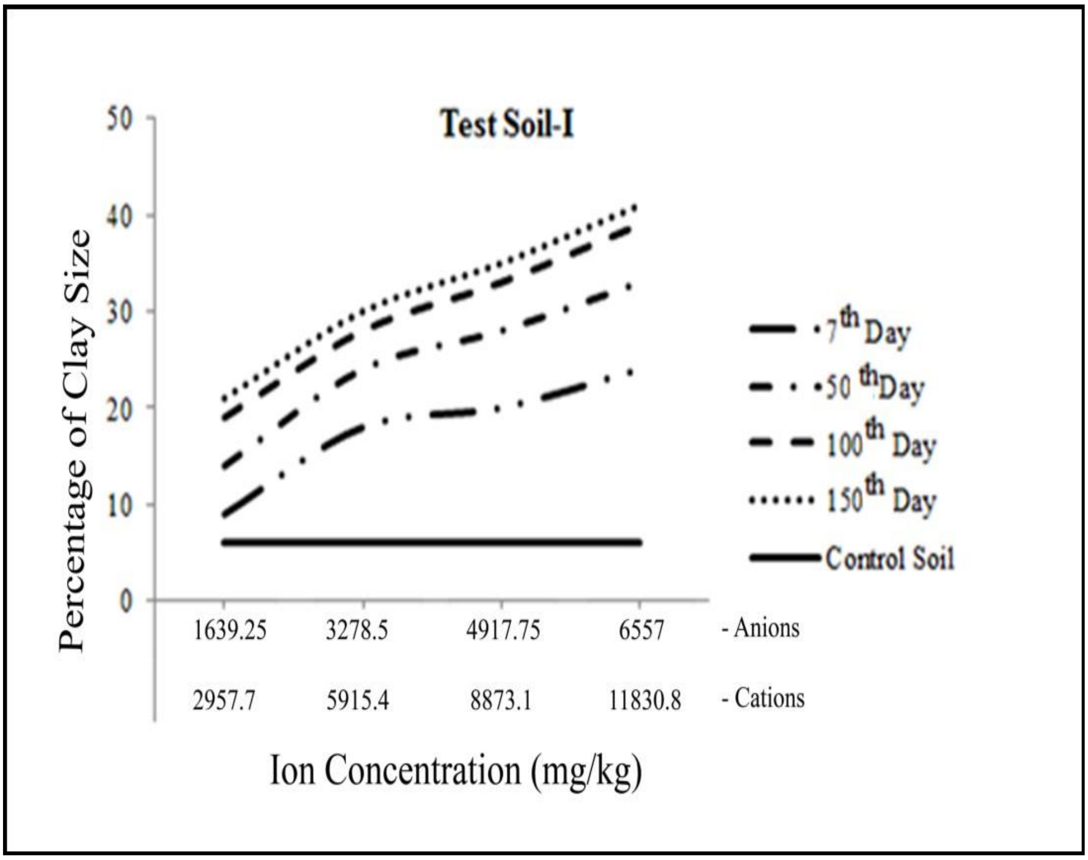

Figure 4.9 Ion Concentration Vs. Clay Size Particles of Test Soil-I

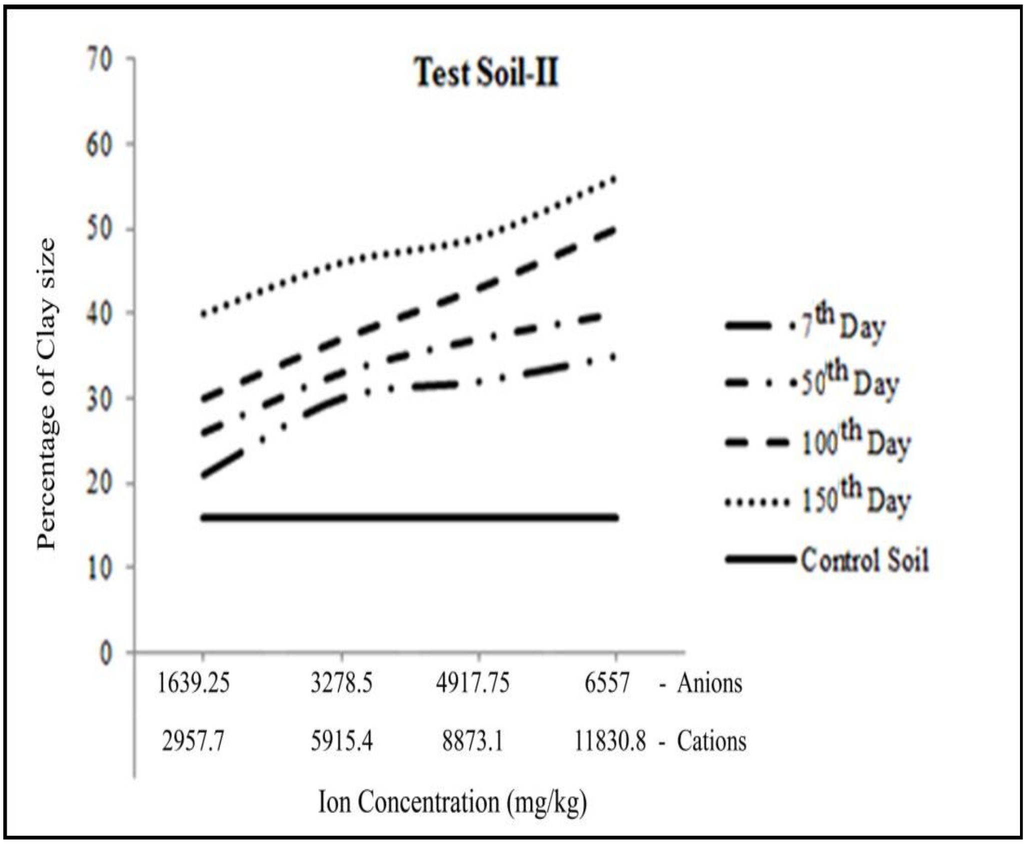

Figure 4.10 Ion Concentrations vs. Clay Size Particles of Test Soil-II

It is found that the chemical concentration has a major influence on the degradation of soil. To understand this, the percentage of clay size particles is plotted against the ion concentration. Fig. 4.9 and 4.10 shows an increase in the clay size particles in Test soil-I and Test soil-II as the ion concentration increases. The results of the study show that the clay size particles are increased due to the influence of chemicals in the landfill leachate. The change in the particle size of the soil can be explained by chemical weathering. Chemical weathering involves the transformation of primary minerals into secondary minerals. Secondary minerals serve as the basic building blocks of the small particles with the soil. As a result, new materials may be synthesized. According to Mitchell, 2005, the clay grain content in heavily polluted soil samples is higher than that of light polluted soil. When a soil mass is influenced by pollutants, the colloids in the soil, such as organic and inorganic composite colloids and soluble salts, gets dissolved and it results in the weakening of strong link between soil grains. Thus most of the soil grains will disperse easily and clay grain content get increased in heavily polluted soil (Jia et al., 2009).

CHAPTER 5

CONCLUSION

Over the years, various sustainable landfill leachate treatment techniques have been proposed and tested for treating highly polluted leachate. At this point, here are some of the key points from the extensive discussions regarding sustainable landfill leachate treatment:

- Refractory compounds in leachate always change over times due to overwhelmed mankind activities. Therefore, modification of existing treatment technique may be viable to ensure that the treatment efficiency is consistent and in accordance to the regulatory standards.

- There has been a steady progress of new and advanced sustainable landfill leachate treatment which proven to be a promising alternative.

- If Bentonite and ordinary clay mixed then leachate does not pass in landfill.

- Though there are still uncertainties whether these techniques could enhance environmental sustainability and safety of human being, more efforts should be carried out to ensure a livelihood of human being and earth coexistence.

- If dumping is continued, the metal contaminants such as iron, zinc, copper and lead will be hazardous to the general public in and around the study area. Increase in contaminant concentration with time will be more pronounced on the eastern side of the dumping yard.
- Soil leachate interactions studies indicated a change in the mineralogy without significant change in the hydraulic conductivity values.

- The interaction between soil and leachate is found to cause mineral dissolution and transformation. New minerals calcium hydroxyl apatite, ferrihydrate, pyromorphite, stringier and vermiculite are formed as a result of bentonite soil- leachate interaction.

- Liquid limit, plasticity index, free swell and percentage swelling of all types of bentonite reduced due to the effect of acetic acid and calcium chloride solutions.

- Calcium bentonite would be more resistant than sodium bentonite to chemical constituents in the permeating fluids. Percentage swell is seems to be the most suitable independent variable for the better prediction of hydraulic conductivity for most of the bentonite types.

- TSS and TDS of MSW leachate were increasing with increasing MSW depth and decreasing with increasing volume of water added.
- The concentration of element in the leachate that out from the dumpsite soil was very huge, this reason to the huge quantity of solid waste that put on it through the time.
- Removal of pollutants from MSW leachate by passage through a soil was good. Therefore, soil irrigation with MSW leachate may be an effective purification technique provided that it is practiced with caution, and consideration is given to soil and leachate properties.

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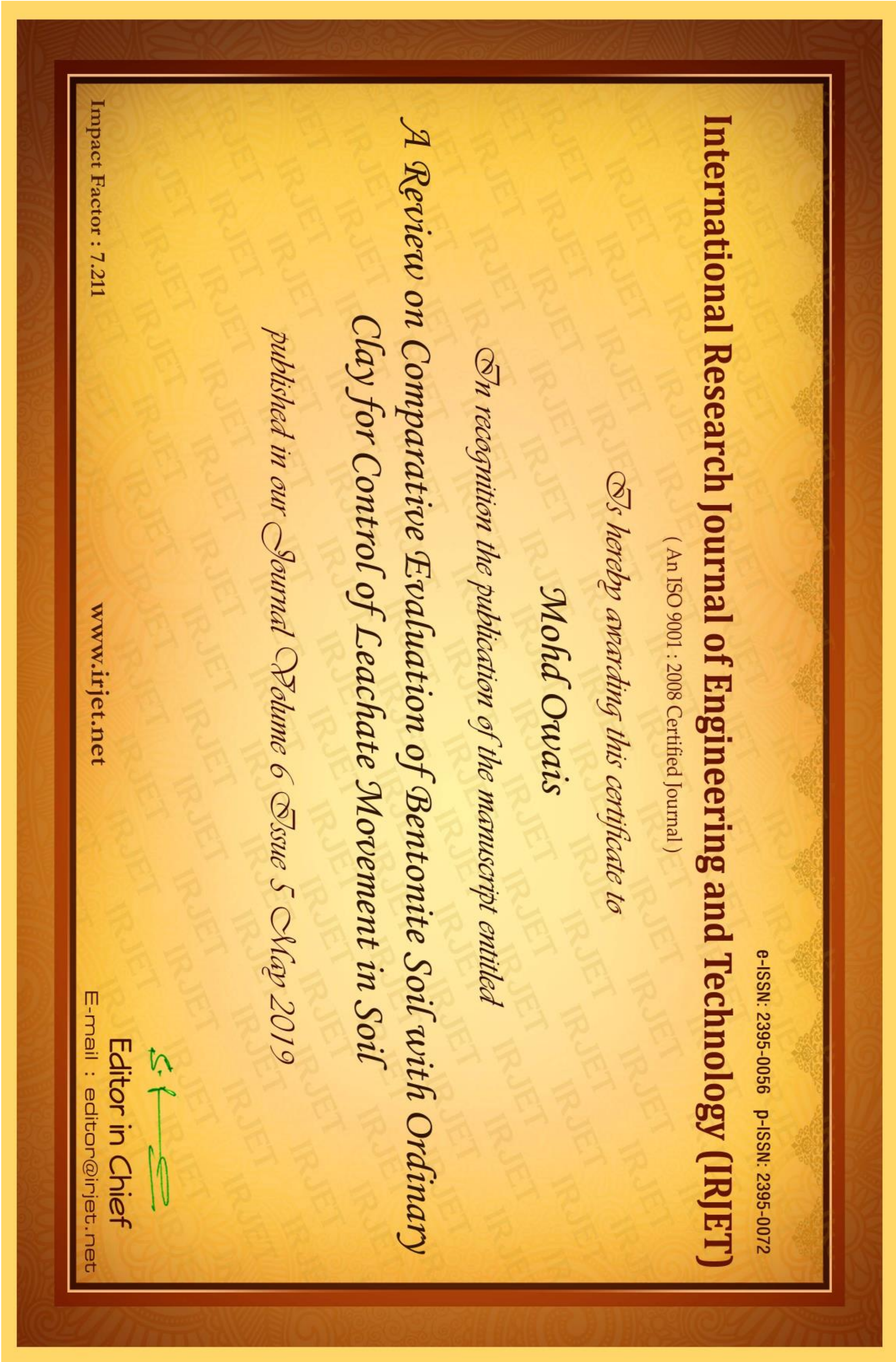

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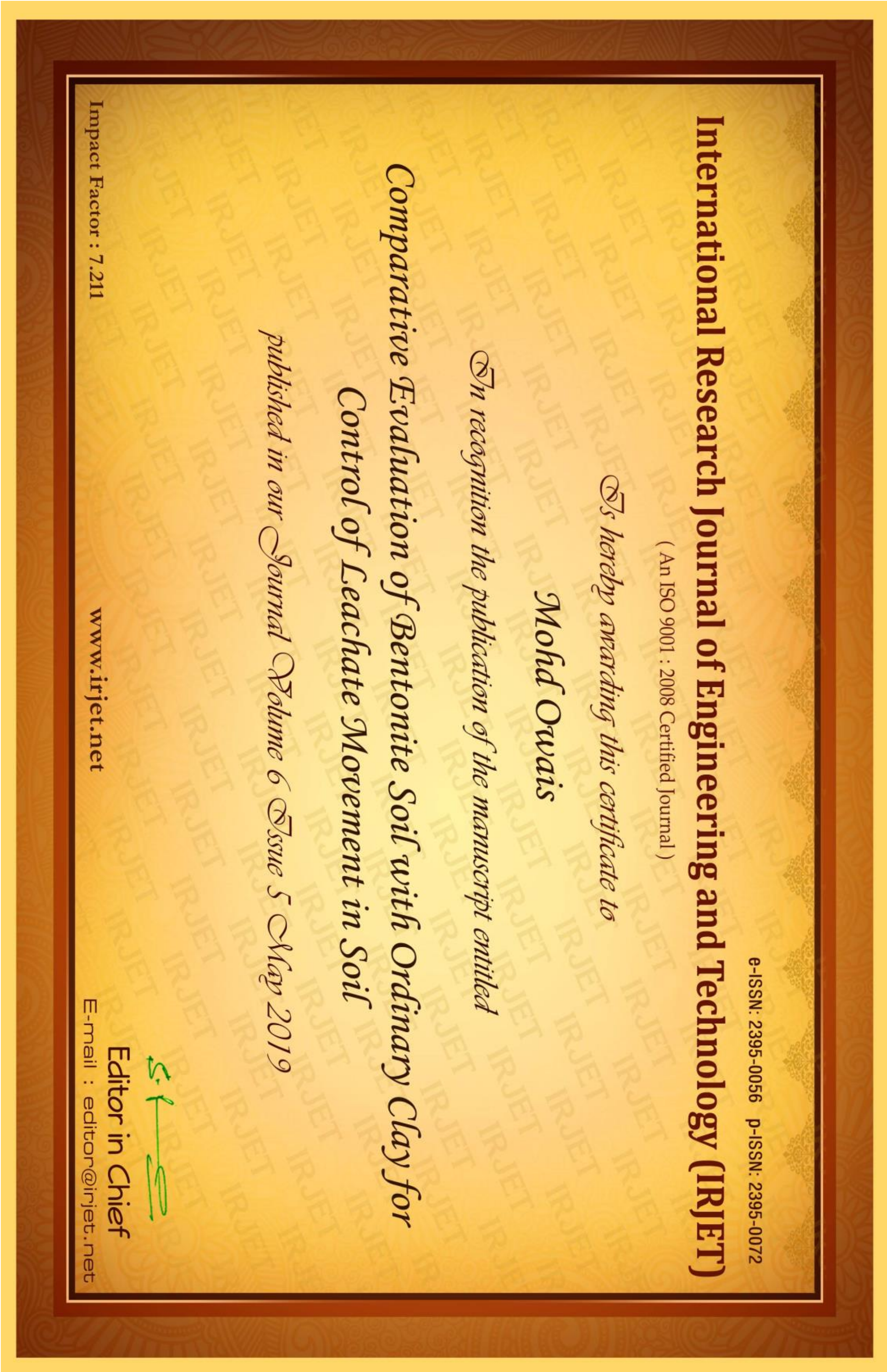

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