IMPACT OF SOLID WASTE DISPOSAL ON SOIL CHARACTERISTICS IN KOLASIB, MIZORAM.

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IMPACT OF SOLID WASTE DISPOSAL ON SOIL CHARACTERISTICS IN KOLASIB, MIZORAM.

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DECLARATION

I, Albert Vanlalliantluanga, hereby declared that the subject matter of this thesis entitled "IMPACT OF SOLID WASTE DISPOSAL ON SOIL CHARACTERISTICS IN KOLASIB, MIZORAM" is the record of work done by me, that the content of the thesis did not form basis of award of any previous degree to me or to the best of my knowledge, to anybody else, and that the thesis has not been submitted by me for any research degree to any other University or Institute.

This thesis is being submitted to the Mizoram University for the award of the degree of Doctor of Philosophy in Environmental Science.

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Dated (ALBERT VANLALLIANTLUANGA)

Dedicted to my parents'

Mr. Liankhuma and Laltluangi

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CHAPTER 1

INTRODUCTION

1.1 Solid Waste

The wastes are the unwanted material, whether liquid, solid, gaseous or radioactive - hazardous or non-hazardous which are discharged, emitted or disposed in the environment in such volume, composition or manner so as to cause nuisance in the environment and resulting into adverse effects on human health. The fast-growing population, urbanization, industrialization and changes in life style have all contributed to an increase in waste generation in the present world (Shaylor *et al.*, 2009).

The solid wastes are the materials which have been excluded for further use and which neither be transported by water nor readily escape into the atmosphere. Solid wastes consist of the highly heterogeneous mass of discarded solid materials from the community as well as the more homogeneous accumulation of agricultural, industrial and mining wastes (Civera *et al*., 2008).

Due to enormous growth in population and accelerated developmental activities, there is a sharp increase in solid waste generation, which has created a catastrophe in cities and towns. Now a day, the generation and disposal of solid waste are documented as a problem of growing importance and significance throughout the world. Many countries are trying to deal not only with greater volume but also more dangerous waste materials. The major sources generating waste materials are household activities, industries, institutions, commercial places, agriculture, construction and demolition activities, trade and industrial operations, etc. In the present world, especially in urban areas, the solid waste has aggravated the environmental pollution problem and also has adverse effects on human health in terms of diseases. As a result, solid waste management has become one of the important challenges for scientists world-wide.

Like other developing countries, in India the urbanization, industrialization, changes in living conditions and fundamental increase in consumer‟s habits have resulted in a rapid and steady rise in solid waste generation. In India, as reported by Dhande *et al.*(2005) the urban population of 240 million generated approximately 29 million tons of refuse annually at an average rate of 0.33 kg/capita/day. Of this, about 43 million tonnes (70%) is collected and 11.7 million tonnes (20%) is treated. It has been argued that about 50% of solid waste is generally dumped in landfill sites (SWM, 2017, Anon 2019). As reported by Kansal (2002), per capita waste generation figure is low (0.33 kg/day) for India as compared to many other developing countries (Pakistan - 0.6 kg/day, Sri Lanka - 0.7 kg/day, Indonesia - 0.55 kg/day) and developed countries (USA - 1.8 kg/day, Germany - 0.85 kg/day, Italy - 0.69 kg/day).

India has witnessed an alarming growth in solid waste generation during last few decades. There is a dearth of precise and reliable data on solid waste generated in India. Further there is no agency which is involved in collection and documentation of solid waste generation data on perpetual basis. In October 1994, the leading magazine `*India Today*` reported that, the total quantum of solid waste generated in India from the metropolitan cities was amounting to 8.3 million metric tonnes per annum. Moreover, in August 1995, the National Environmental Engineering Research Institute (NEERI) published a strategy paper on solid waste management in India, reporting the total solid waste generated in India was 23.86 million tons per annum. The report published by National Plastic Waste Management Task Force, under the Ministry of Environment and Forests, Government of India (1997) stated that a total of 80,000 tons per day (27.2 million tons per annum) of municipal solid waste generated in the country. In 1998, in a brochure on “Launching a clean city campaign in the states in the 50th year of independence published by Ministry of Urban Affairs and Employment, Government of India, it was reported that the total solid waste generated in India in a year amounting to 30 million tonnes. The generation of solid waste in India can be projected to increase at a rate of 1 to 1.33% annually (Shekdar, 1999). In 2002, Toxic Links, an NGO published that about 0.1 million tonnes of municipal solid waste generated every day i.e., approximately

36.5 million tonnes annually. It is estimated that in India the solid waste generation may rise from 40,000 metric tonnes per annum in April 2004 to over 125,000 metric tonnes by the year 2030 (Anonymous, 2004).

In India, solid wastes are disposed or dumped in barren lands and are irresponsibly managed. Unlike the secured or sanitary landfills which are properly designed and are identified to offer a great advantage over the open dumpsites. In addition, when compared to open dumpsite, the sanitary landfill is more efficient system that minimizes environmental issues and reduces health risk. Besides, the factors such as financial constraints, the ignorance with regards to the importance of the state of environment and the lack of political will to protect and improve public health and the environment could extensively worsen the current situation of dump sites. These problems resulted due to unplanned solid waste management. This issue is aggravating especially the amount of solid waste generation and an increasing trend with time, along with the uncontrolled population rate, rapid urbanization and industrialization.

1.2 Classification of solid waste

The solid waste can broadly be classified as,

1.2.1 Waste (garbage) Food

Waste from the preparation, cooking and serving of food, market reuse, waste from the handling storage and sale of meat and vegetables are classified as food waste or garbage. Their sources are usually households, institutions and commercials such as hotel, stores, restaurants, markets, etc.

1.2.2 Rubbish

Rubbish includes combustible (primarily organic) such as paper, cardboard, cartons, wood, boxes, plastics, rags, clothes, bedding, leather, rubber, etc. and also includes non-combustible such as metal, tin cans, metal foil, dirt, stones, bricks, ceramics, crockery.

1.2.3 Ashes and residues

They are the residue from fires used for cooking and for heating building, cinders, clinkers, and thermal power plants.

1.2.3 Bulky waste

Bulky waste includes large auto parts, tyres, stoves, refrigerators and other large appliances, furniture, etc.

1.2.4 Street waste

It includes paper, bottles, dirt, leaves, animal droppings, the content of litter, receptacles, dead animals, their sources and streets, sidewalks, alleys, etc.

1.2.5 Pathological waste

It includes wastes generated from hospitals and clinics.

1.2.6 Construction and demolition waste

They are roofing and sheathing scraps, crop residues, broken concrete, rubble, plaster, conduit, pipe, wire, insulation, etc. Their sources are construction and demolition sites, re-modelling and repairing sites.

1.2.7 Industrial waste

The solid waste resulting from industry processes and manufacturing operations, such as food processing wastes, boiler, house cinders, wood plastics, metal scraps , and shaving etc. effluent treatment plant sludge of industries and sewage treatment plant etc. Their sources are factories, power plants, treatment plants, etc.

1.2.8 Hazardous waste

A hazardous solid waste is injurious to the health. It includes wastes from common manufacturing and industrial processes, specific industries, and can be generated from discarded commercial products.

1.3 Sources of solid waste

The major sources of solid waste are as follows:-

1.3.1 Domestic waste : Domestic waste result from household dwelling and includes kitchen waste, papers and cartons, plastic, glass, textile, leather, metal, ash and garbage.

1.3.2 Institutional waste: Major producer of institutional wastes are schools, colleges, offices, banks, hospitals and religious places and contains paper and cartons, food wastes, plastics, hazardous and pathological wastes.

1.3.3 Commercial waste: Commercial waste producers are stores, markets, tea stalls, restaurants, hotels and motor repair shops. These sources produce waste like paper and cartons, glass waste from food preparation, ashes, spoiled and discover goods etc.

1.3.4 Agricultural waste: Agricultural wastes are from diaries, poultries, farms, livestock and other agricultural activities like vegetables cultivation.

1.3.5 Industrial waste: Industrial waste is generated from various kinds of industries and minimal in the town.

1.3.6 Natural waste: Natural wastes contain leaves, trees, branches and that are collected as a result of road side trees, plants and animals.

1.4 Solid waste Generation and Disposal

In India, the current urban MSW production rate is 109,598 tonnes per day (or 0.34 kg/capita/ day) and is assumed to reach to 376,639 tonnes per day (or 0.7 kg/capita/day) by 2025 (Hoornweg and Bhada-Tada 2012). The survey conducted by the Central Institute of Plastics Engineering and Technology (CIPET) at the instance of CPCB has reported generation of 50,592 TPD of MSW in 2010–2011 in 59 cities of India. As per CPCB, 1,43,449 TPD of MSW was generated for 34 states and union territories during 2013–2014. The average rate of waste generation in India, based on this data, is 0.11 kg/capita/ day. Out of the total waste generated, approximately 1,17,644 TPD (82%) of MSW was collected and 32,871 TPD (22.9%) was processed or treated.

The literature indicates that the waste generation rate is between 200 and 300 gm/capita/day in small towns and cities with a population below 2,00,000. It is usually 300–350 gm/capita/day in cities with a population between 2,00,000 and 5,00,000; 350-400 gm/capita/ day in cities with a population between 5,00,000 and 10,00,000; and 400-600 gm/capita/day in cities with a population above 10,00,000. However, these are only indicative figures which need to be verified while planning city specific MSWM systems. (CPCB report, 2016)

As per report, India produces 52 million tonnes of waste each year, or roughly 0.144 million tonnes per day, of which roughly 23 per cent is processed-taken to landfills or disposed of using other technologies (*ibid*, 2016)

The information pertaining to data on waste generation in India is extrapolated values as reported by the CPCB with the assistance of Nagpur-based National Environmental Engineering Research Institute (NEERI) in 2004–05 from 59 cities (35 metro cities and 24 state capitals). This was the last report having real time data and estimated on waste generation in the country. Since then, data on generation of solid waste is calculated by multiplying the urban population by the amount of waste generated per capita per day. This makes estimates of solid waste generated in the country pretty much a guesstimate which, in turn, confounds management. However, what the estimates do demonstrate is the fact that bigger and richer cities produce more waste than poorer cities. This is not only due to their larger population, but also because their residents are more affluent and bigger generators of waste.

The CPCB–NEERI (2004–05) study on waste generation in India indicated New Delhi, Greater Mumbai and Chennai to be recognised as leading cities as waste generators in the country with waste production amounting to 5,922 TPD, 5,320 TPD and 3,036 TPD respectively. In 2011, inventorisation by CPCB again revealed that metro cities, economic hubs of the country, are the leading waste generators (Delhi: 6,800 TPD, Mumbai: 6,500 TPD, Chennai: 4,500 TPD, Hyderabad: 4,200 TPD, and Kolkata: 3,670 TPD) Down to Earth (2016).

Although the Municipal Solid Wastes (Management and Handling) Rules 2000 of India (Anon. 2000) makes it obligatory for all urban local bodies to upgrade their waste collection, transportation, and processing/disposal systems, very few urban local bodies have made any substantial progress in this regard. Design and implementation of Sustainable Municipal Solid Waste Management Systems (SMSWS) is a real challenge for developing countries. This is particularly so in places with very high urbanization rates and very low public awareness.

The most common method of waste disposal in India is dumping on land, because it is the cheapest and feasible method of waste disposal. However, this requires large area and proper drainage. The land disposal of municipal and industrial solid waste is potential cause of groundwater contamination. Unscientifically managed dumping yards are prone to groundwater contamination because of leachate production. Leachate is the liquid that seeps from solid wastes or other medium and have extracts with dissolved or suspended materials from it (Chapman, 1992). The volume of leachate depends principally on the area of the landfill, the meteorological and hydro-geological factors and effectiveness of capping. It is essential that the volume of leachate generated be kept to a minimum and also ensures that the ingress of groundwater and surface water is minimized and controlled. The volume of leachate generated is therefore expected to be very high in humid regions with high rainfall, or high run off and shallow water table (Jeevan 1992).

1.5 Soil

The upper layer of earth in which plants grow, black or dark brown material typically consisting of a mixture of organic remains, clay and rock particulars.

Soil is a mixture of organic matter, minerals, gases, liquids and organisms that together support life. Soils are composition of Mineral particles 45%, Organic matter 5%, Air 25%, Water 25%.

Brown earth is fertile and very suitable for agriculture. The suitability for agriculture is due to characteristics of good texture, dark colour and pH value. Earths body of soil called Pedosphere has four important functions as a- medium for plant growth, means of water storage, supply and purification, modifier of earth‟s atmosphere.

1.5.1 Types of soil

1.5.1.1 Loamy Soil:

This is one of the nutrient rich soil types because of its composition. It is composed of a mixture of clay, sand, silt and decaying organic materials (humus). The soil has a pH level of 6 with high calcium content and the potential of retaining water makes it one of the riches soils for crop production. The distinguishable composition of loamy soil may vary, but it can be made perfect with the right balance of addictive. For instance, compost manure is usually added to loamy soil to improve the desired qualities which may be lacking. Loamy soil is dark in colour and has a dry, soft and crumby feel on the hands. It has good nutrients and water holding capacity. It also drains will and has pore spaces which enable air to freely move in between the soil particulars down to the plant roots. Essentially, this is the characteristic making loamy soil the most ideal for plant growth and for that reason, the most preferred soil by gardeners.

1.5.1.2 Clay Soil:

Clay is one of the many unique soil types due to its composition of a very fine-grains and plasticity when moist but hard when fired. The clay soil particles are tightly compressed together with no or very little air space. Because of this features clay persists as the heaviest and desert type of soil. Also, it is this characteristic that makes it to hold and retain large quantities of nutrients and water and still making it very difficult for air and moisture to penetrate through it. So, the achieve successful gardening, one has to know the correct state and condition of the soil. Wet clay is ordinarily difficult to garden with since it is heavy but dry clay is smooth and soft and as such, easier to manage.

1.5.1.3. Silty Soil:

It is composed of clay, mud or small rocks deposited by a lake or river. It is made up of much smaller particulars compared to sandy soil and when moistened it forms a soapy slick. For this reason, silty soil is extremely smooth and since it retains a lot of water, it is fairly fertile. Regardless of its good characteristics, silty soil is deficient of nutrients in comparison to other soil types. Because of the characteristics of silty soil, it can be easily compacted by the weight of heavy overlaying materials. For this reason, if it is in garden, one should avoid walking on it which can lead to its compaction, which may require aeration. Silty soil is perfect for crop farming as the particles in silty soil are mini scale.

1.5.1.4. Peaty soil:

It is under normal circumstances dark brown but is can as well be black in colour. Peaty soil has large quantities of organic material and is rich in water, which makes it one of the best soil types for plant growth. However, the soil needs to be drained first due to its high nutrient and water content. Because of its characteristics of high nutrient and water content, peaty soil is able to keep plants healthy even in dry weather and shields the plants from harm during rainy periods. The water content in peaty soil is to a small degree acidic but is ideal for controlling plant diseases and can be utilized to balance the pH level of other soil types.

1.5.1.5. Sandy Soil:

It is pale yellowish brown in colour and are one of the poorest types of soil. Sandy soil is composed of look coral or rock grain materials and has a dry and gritty touch. It is also grouped as one of the soils composed of the largest particles which prevent it from retaining water. As such, sandy soils loose water content very fast which makes it very difficult for plant roots to establish. Thus, plants do not get the opportunity of using the nutrients and water in sandy soil more efficiently as they are speedily carried away by run off. This is what makes sandy soil the poorest for supporting any kind of plant growth.

1.5.1.6. Chalky Soil:

It is a type of soil found in limestone beds with deeply rooted chalk deposits. Chalky soils are extremely dry and are known to impede the germination of plants. They are composed of or containing or resembling calcium carbonate or calcite and characteristically have the colour of chalk. Accordingly, chalky soil is entirely imperfect for crop farming or plant growth as it presents a lot of difficulties to work with. It has high lime content but low water content, which gives it a pH level of 7.5. This means the chalky soil is basic and it normally leads to yellow and stunned plants.

1.5.2 Soil composition

The composition of the soil is placed into four different categories, inorganic material, organic material, water and air. Inorganic material is any compound that is not derived from animal or plant sources. Carbon atoms are not present in inorganic compounds. Organic material is composed of animal and plant sources. Carbon atoms are present in organic compounds. The amount of water and air particles that are present ions the soil will also determine its composition.

1.5.3 Soil Characteristics

1.5.3.1 Soil Moisture Content:

Water content or moisture content is the quantity of water contained in a material, such as soil called soil moisture, Moisture is one of the most important properties of soil. Absorption of the nutrient by soil is largely depends on moisture content of the soil moisture of soil also shows its effect on the texture of soil.

1.5.3.2 Soil bulk Density:

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed as g/cm^3.

1.5.3.3 Soil pH:

The most significant property of soil is its pH level, Its effects on all other parameters of soil. Therefore, pH is considered while analysing any kind of soil. If the pH is less than 6 then it is said to be an acidic soil, the pH range from 6-8.5 it"s a normal soil and greater than 8.5 then it is said to be alkaline soil.

1.5.3.4 Soil Organic Carbon Content:

It is also a valuable property of soil. If the soil is poor in organic matter, then it enhances the process of soil erosion. If the soil organic matter is present in soil, then this soil is useful for the agricultural practices. Organic matter may be added in the soil in the form of animal manures, compost, etc. The presence of the higher content of organic matter in the soil can be another possible reason for lowering of the pH. Soil organic matter content has decreased from surface to subsoil due to levelling.

1.5.3.5 Soil Total Nitrogen Content:

Nitrogen is the most critical element obtained by plants from the soil and is a bottleneck in plant growth. About 80% of the atmosphere is nitrogen gas. Nitrogen gas diffuses into water where it can be “fixed” (converted) by blue-green algae to ammonia for algal use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because nitrogen can enter aquatic systems in many forms, there is an abundant supply of available nitrogen in these systems.

1.5.3.6 Soil Phosphorus Content:

Phosphorus is a most important element present in every living cell. It is one of the most important micronutrient essential for plant growth. Phosphorus most often limits nutrients remains present in plant nuclei and act as energy storage.

1.5.3.7 Soil Exchangeable Potassium Content:

Potassium plays an important role in different physiological processes of plant; it is one of the important elements for the development of the plant. It is involved in many plant metabolism reactions, ranging from lignin and cellulose used for the formation of cellular structural components, for regulation of photosynthesis and production of plant sugars that are used for various plant metabolic needs.

1.6 Implications of solid waste disposal

Solid waste has the potential to degrade air, soil and water. Improper handling of solid waste is also causes damage to the environment and subsequently health hazard. The main risks to human health arise from the breeding of disease vectors, primarily flies and rats. Solid waste helps in inducing health hazards like plague, dengue, cholera etc. A common transmission route of bacillary dysentery, amoebic dysentery and diarrheal disease in India is from human faeces by flies to food or water and hence to human. Use of water polluted by solid waste for bathing, irrigation and drinking can also cause diseases like skin infections. The persistent organic pollutants existing in solid waste cause dangerous effects on human and wild life.

Solid waste disposal causes environmental pollution and health problems and proliferation of disease by viruses and micro-organism and contamination of ground water by untreated medical waste in landfills (Patil and Pokhrel, 2008). Weak and inappropriate management may create serious repercussions on the public health and a significant impact on the environment (Pescod and Saw, 1998). Such amount of waste presents treatment and disposal challenges. Besides preventing cross contamination during the management process, selecting a suitable and environmentally friendly method is a top challenge.

Deteriorating soil quality and decrease in vegetation abundance are grave consequences of open waste dumping which have resulted in growing public concern.

Dumping of solid wastes on land is a common waste disposal method and practiced almost by all the cities around the globe. Precipitation that infiltrates through the municipal solid waste leach the constituent from the decomposed waste mass, while moving down causes the subsurface soil to be contaminated by organic and inorganic solutes.

On the other hand, waste materials, and materials derived from wastes, possess many characteristics that can improve soil fertility and enhance crop performance. These materials can be particularly useful as amendments to severely degraded soils associated with mining activities.

1.7 Scope of the study

Due to urbanization and demographic pressure, generation of solid waste increases enormously. Mizoram is also one of the state in India where a huge amount of garbage is disposed off without proper disposal system, which may cause adverse effects on environment as well as human health. In view of above, the present investigation has been carried out which may be pioneer study for Mizoram in terms of aspects related to solid waste generation and its disposal.

1.8 Objectives

1. To survey solid waste disposal in Kolasib Town.
2. To analyze solid waste generated in Kolasib Town.
3. To assess impact of solid waste disposal on soil characteristics

CHAPTER 2

REVIEW OF LITERATURE

2.1 International:

The menace of environmental pollution has been haunting the human world since early times and is still growing due to excessive growth in developing countries. Municipal solid waste (MSW) normally termed as „„garbage"" or „„trash"" is an inevitable by-product of human activity. Population growth and economic development lead to enormous amounts of solid waste generation by the dwellers of the urban areas (Karishnamurti and Naidu, 2003). Urban MSW is usually generated from human settlements, small industries and commercial activities (Singh *et al.*, 2011).

"An additional source of waste that finds its way to MSW is the waste from hospitals and clinics. In majority of countries most of the smaller units do not have any specific technique of managing these wastes. When these wastes are mixed with MSW, they pose a threat for health and also they may have long term effect on environment" (Pattnaik and Reddy, 2009).In developing countries open dumpsites are common, due to the low budget for waste disposal and non-availability of trained manpower. Open dumping of MSW is a common practice in Pakistan. It also poses serious threat to groundwater re-sources and soil. The contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity (Smith *et al.,* 1996).

Over the last many years, heavy metals have considerably damaged the soil quality and fertility in consequence of increased environmental pollution from industrial, agricultural and municipal sources (Adrian, 1986). Metals cause physiological disorders in soils as absorption through root system consequently retards plant growth and deprives it of vigour (Moustakas *et al.,* 1994). Waste carries different metals which are then transferred to plants by different ways (Voutsa *et al.*, 1996). Depending on the tendency of the contaminants they end up either in water held in the soil or leached to the underground water. Contaminants like Cd, Cu, Ni, Pb and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Shaylor *et al.*, 2009).Diversity of vegetation is directly influenced by soil characteristics.

Several studies show evidence of seriousness of hazards caused by open waste dumping ultimately affecting the plant life on the planet leading towards an irreversible erosion trend unless the present land use pattern is checked (Phil-Eze, 2010).Solid waste pollutants serve as an external force affecting the physico-chemical characteristics of soil ultimately contributing towards the poor production of vegetation (Papageorgiou, 2006). The pollutants, in the first place, hinder the normal metabolism of plants which is an invisible injury and owing to which the visible injury appears in the aftermath (Ahmed *et al.*, 1986). It is depriving our ecosystem of the natural balance and bear result beyond any repair.

Assessment of soil pollution becomes difficult when contaminants belong to different sources and their products are variably distributed (Partha *et al.*, 2011). Chemical properties of soil serve as main reason of vegetation changes (Neave *et al.*, 1994). In plants accumulation of chemical elements depends not only on their absolute content in a soil but also on the level of fertility, acidic, alkaline and oxidative-reductive conditions and on the presence of organic matter (Subbiah and Asija, 1976).

The disturbances of higher intensity sometimes endanger the survival of some species and yield to low richness (Hussain and Palmer, 2006). In this regard, developing countries are even deeper into the chaos as having poor financial resources to upgrade their disposal facilities and turned out to be more vulnerable to the hazards of dumping for their environment (Hazra and Goel, 2009)

Ali, *et al.* (2004) has developed an estimating system for construction and demolition waste management describes a computerized estimating system that can be used to quantify the generation of wood, gypsum drywall, roof asphalt shingles, and carpet wastes from building-related new construction and demolition projects. The system application requires appropriate housing statistic data which are typically readily available. An interface is created between a GIS system and the estimating tool that allows a recycling program developer to visualize the spatial distribution of construction and demolition waste within the region of interest. In addition, a methodology for estimating the waste generated from renovation/remodelling activities is presented.

Reddy *et al.* (2008) also state that fresh municipal solid waste samples obtained from Orchid hills dumpsite (David junction, Illinois, USA). Land filled municipal waste samples, underwent the process of leachate recirculation under NMC and higher water content for compressibility and shear strength parameters.

Synthetic MSW was prepared and effect of degradation on geotechnical properties was observed. Leachate (with pH 7.5) from orchard hills landfill was added (Reddy *et al.* (2011).

Musa A. (2012) studied the dumpsite under study was located in Jikpa area of Bosso, Nigeria. Soil samples were collected from 3 trial pits, one inside the dumpsite and the other 2 in surrounding areas. They were tested for geotechnical properties in laboratory. Results showed that contaminated soil had lower specific gravity, lower MDD and higher OMC. Cohesion and angle of internal friction was lower for contaminated soil. Contaminated soil had higher NMC, co-efficient of permeability, co-efficient of volume change and co-efficient of consolidation. Naveen et al. (2014) investigate the effect of MSW on engineering properties of soil at Mavallipura site. It was observed that permeability, OMC was very high and MDD was low.

Pandey *et al.* (2015) has collected soil sample near Satna and examined the physical characterization and geotechnical properties of solid waste. It was found that MDD and OMC was very high, permeability decreased as confining pressure increased.

Hernandez *et al.,* (1999) stated that the decline of soil organic matter (SOM), as a consequence of the application of intense soil cultivation practices, has been identified as one of the most important threats to soil quality. Depletion of SOM, is accompanied by a cascade of adverse impacts, including decreases in soil fertility and productivity, decreased biodiversity, lower microbial activity, instability of aggregates, and reduction in infiltration rate followed by increased runoff and erosion, which further stimulate soil degradation.

While the developed countries of the world, such as Germany, have in place effective systems for MSW management (Schwarz-Herion *et al.,* 2008), in many developing countries, such as Nigeria, management of MSW is a major concern, even in major cities of the country. The increasing level of solid waste is a serious problem in the urban areas of the world. This is compounded by the high rate of population growth and increasing per-capita income, which results in the generation of enormous solid waste posing serious threats to quality of soil and water. These threats are even more in the developing countries where large quantities of solid waste are dumped haphazardly, thereby, putting pressure on scarce land and water resources and at the same time affecting the properties of soils (Edward and James, 1987)

Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls, being the major cause of soil and groundwater pollution (Nayak *et al.,* 2007; Amadi *et al.,* 2012). Therefore, MSW management is one of the major environmental problems for Indian cities. When rainfall occurs, rain comes in contact with solid waste and forms leachate which finds its way to percolate into aquifers and soil strata. Leachate may contain a large amount of organic content, heavy metals and inorganic salts (Renou *et al.,* 2008; Aziz *et al.,* 2010; Aziz and Maulood, 2015; Mojiri *et al.,* 2016).

Open dumping has been reported to have serious long-term damaging effect on environmental factors (Phil-Eze, 2010; Yasin and Usman, 2017), especially in the soil environment (Adewumi and Ajibade, 2015; Breza-Boruta *et al*., 2016; Akortia, *et al*., 2017; Kodirov *et al.,* 2018) which is as a result of inappropriate landfill sites and poor management techniques (Adewumi *et al*., 2019; Ajibade *et al*., 2019).

Ali *et al.* (2014) observed significant modifications in soil properties of some dumpsites with high values of pH, total dissolved solids and electrical conductivity as compared to the control sites. Also, Breza-Boruta *et al.*(2016) found that accumulated waste in the dumpsite causes depletion in soil organic matter which inhibits microorganism growth. Alteration in physical and biochemical properties of soil can lead to soil degradation (Civeira and Lavado, 2008).

Groundwater and surface water could also be affected through rainwater infiltration of toxic materials (Ilori *et al.,* 2019) and soil erosion of contaminants from the dumpsites and mining activities to the nearby stream (Ugya *et al*., 2018). Efforts by government to improve on the system of waste collection and disposal has yielded little or no result as open dumpsites can still be found at strategic places in most cities across Nigeria. The consequence of this is damaging to the ecosystem and soil around the dumpsites because we are experiencing more bacteria that are multi-resistant which can pose a severe public health issue (Elbendary *et al*., 2018).

2.2 National:

Rapid growth in industrialization and urbanization in India has led to increasing generation of municipal solid waste (MSW). The amount of MSW is expected to increase significantly in the future due to rapid population explosion and economical potential of cities (CPCB, 2000; Sharma and Shah, 2005; Hazra and Goel, 2009). The waste generation in India is more than 42 million tons annually and the rate of solid waste generation vary from 0.2 kg/d to 0.8 kg/d (Sharholy *et al.,* 2008; Ogwueleka, 2009; Rana *et al.,* 2015). It is reported from the literature study that the increase in MSW generation in India is around 5% annually (Sharholy *et al.,* 2008; Kumar *et al.,* 2009). It was estimated that the MSW generation is 127,486 tonnes per day (TPD) in India in 2011 (Rana *et al.,* 2017). Out of the total waste generated in India, 89,334 TPD of MSW was collected and 15,881 TPD was recycled (TERI, 2015). At present, about 960 million tonnes of solid waste is being generated annually as by-products during municipal, industrial, mining, agricultural and other processes in India. Out of this, 350 million tonnes is organic waste from agricultural sources, 290 million tonnes is inorganic waste of industrial and mining sectors, and 4.5 million tonnes is hazardous in nature (Pappu *et al*., 2007). Metro cities in India generate approximately 30,000 tonnes of solid waste every day, and Class 1 cities generate about 50,000 tones every day (Sujatha *et al.*, 2013). Lack of proper management of solid waste in Indian cities is very common with the absence of appropriate data including volume of generation, collection, transportation and disposal of solid wastes generated (Shekdar, 2009). In India, the current status of MSW management is not very satisfactory. For example, a matrix method of evaluation of Tricity showed the efficiency of less than 40% for the existing system (Rana *et al.,* 2015, 2017). The generation of MSW in Himachal Pradesh, India, was reported to be 360 TPD in 2015 (Sharma *et al.*, 2017). For the hazardous waste in Himachal Pradesh, 84.27% is land-fillable, 5.33% is incinerable, and 10.3% is recyclable (Sharma *et al.,* 2017). The waste generated per capita in Himachal Pradesh is around 0.413 kg/d.

Krishna *et al.* (2016), studied results show that the values of the natural moisture content of the uncontaminated soil generally lower compared to those of the contaminated soil samples. The chloride concentration in contaminated soil is 108.46 mg/l, it indicates that it is higher than uncontaminated soil which is 40mg/l. This indicates that due to disposal of solid waste the quality of the soil is reduced. Lastly the study conclude based on the results obtained, the disposal solid waste, soil quality is gets reduced compared to uncontaminated soil.

Sharma *et al.* (2018) also states that the solid waste of dumpsite contains various complex characteristics with organic fractions of the highest proportions. As leachate percolates into the soil, it migrate contaminants into the soil and affects soil stability and strength.

Unscientific disposal causes an adverse impact on all components of the environment and human health (Jha *et al.,* 2003; Sharholy *et al.,* 2008). The waste disposal sites and landfills that are neither properly designed nor constructed become point sources for pollution of aquifers and soils. MSW disposal is at a critical stage of development in India. There is a dire need to develop facilities for the disposal of drastically increased amount of MSW. More than 90% of the waste in India is believed to be dumped in an unsatisfactory manner. It is reported from the literature study that an area of approximately 1400 km2 was occupied by waste dumps in 1997 and it is expected to increase substantially in the near future (Goswami and Sarma, 2008; Sharholy *et al.,* 2008). In this context, it is suggested to construct properly engineered waste disposal facilities to improve public health and prevent environmental resources including surface water, groundwater, air and soil from being polluted (Nanda *et al.,* 2011; Musa, 2012)

Karthik (2018) stated that there is an effect on both chemical and geotechnical properties of soil because of contamination of soil. There were not many variations in pH, Alkalinity, BOD and COD of uncontaminated soil was less than that of contaminated soil. Chloride concentration in uncontaminated soil was found to be greater than contaminated soil this may be due to seasonal variation also.

Desmukh and Aher, (2017) also mentioned that the disposals of municipal solid waste (MSW) in open dumps are a widespread activity around the vicinity of urban area. When rainwater interacts with dumping yards, generate a leachate and percolates through the soil strata and after particular time they pollute the groundwater and soil in the vicinity. It was observed that, since the waste was disposed, a number of contaminants readily penetrate and deteriorate the soil in the area. Thus, the disposal of waste should be discouraged and waste management and treatment should be put in place for protection of soil fertility around dumping site near the Sangamner city.

The physical compositions of solid waste vary depending on its types and sources. The nature of the deposited waste in a landfill will affect gas, leachate production and composition by virtue of relative proportions of degradable and non-degradable components, moisture content and specific nature of biodegradable element (Sharma *et al.*, 2017).

Due to rapid increased urbanization, industrialization and improper management of solid waste, on one side the world is facing fresh water scarcity, on the other hand whatever the remaining ground water resources are available, is facing critical stress in quality. Other than this, inadequate maintenance of distribution system also pollutes drinking water. Different physicochemical parameters of ground water quality in Erode city, Tamil Nadu, India was compared with Bureau of India standards (BIS) and world health organization standards (WHO) and had observed increased concentration of constituents like total dissolved solid (TDS), total hardness (TH), Total alkalinity (TA), Sodium (Na+), Magnesium (Mg+), Chloride (Cl-), Fluoride (F-) and Nitrate (NO3-) above the upper permissible limit for drinking purpose making the water not potable (Nagarajan *et al*. 2012).

The most common method of waste disposal in India is dumping on land, because it is the cheapest method of waste disposal. However, this requires large area and proper drainage. The land disposal of municipal and industrial solid waste is potential cause of groundwater contamination. Unscientifically managed dumping yards are prone to groundwater contamination because of leachate production. Leachate is the liquid that seeps from solid wastes or other medium and have extracts with dissolved or suspended materials from it (Goswami *et al*., 2007).

Leachate from the solid waste dump has a significant effect on the chemical properties as well as the geotechnical properties of the soil. Leachate can modify the soil properties and significantly alter the behaviour of soil (Roa *et al*,. 1992, Panahpou *et al*., 2011, Sunil *et al*., 2008, Fransisca *et al*., 2010, Ukpong *et al*., 2011). Addition of a chemical may affect the behaviour of soil. Ramakrishne gowda *et al*. (2011) studied the effect of interaction of shedi soil containing alkali on various geotechnical properties such as the index properties, compaction characteristics, volume change behaviour, strength characteristics and hydraulic conductivity. It was seen that though the plasticity index of soil decreases and optimum moisture content increases with increasing concentration of alkali content in the fluid, the shear strength of soil decreases essentially due to decrease in the cohesion of the soil particles.

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of study area

3.1.1 Location and Linkages:

Kolasib town is located at 24º13‟52"N 92º40‟34"E longitude. It is one of the most important towns in the state Mizoram, North East India, and the National Highway NH-54 passes through the town thereby directly linking the town with Silchar in Assam. It lies at an altitude of 650 metre above sea level. It is one of the district capitals of Mizoram. (Fig. 3.1).

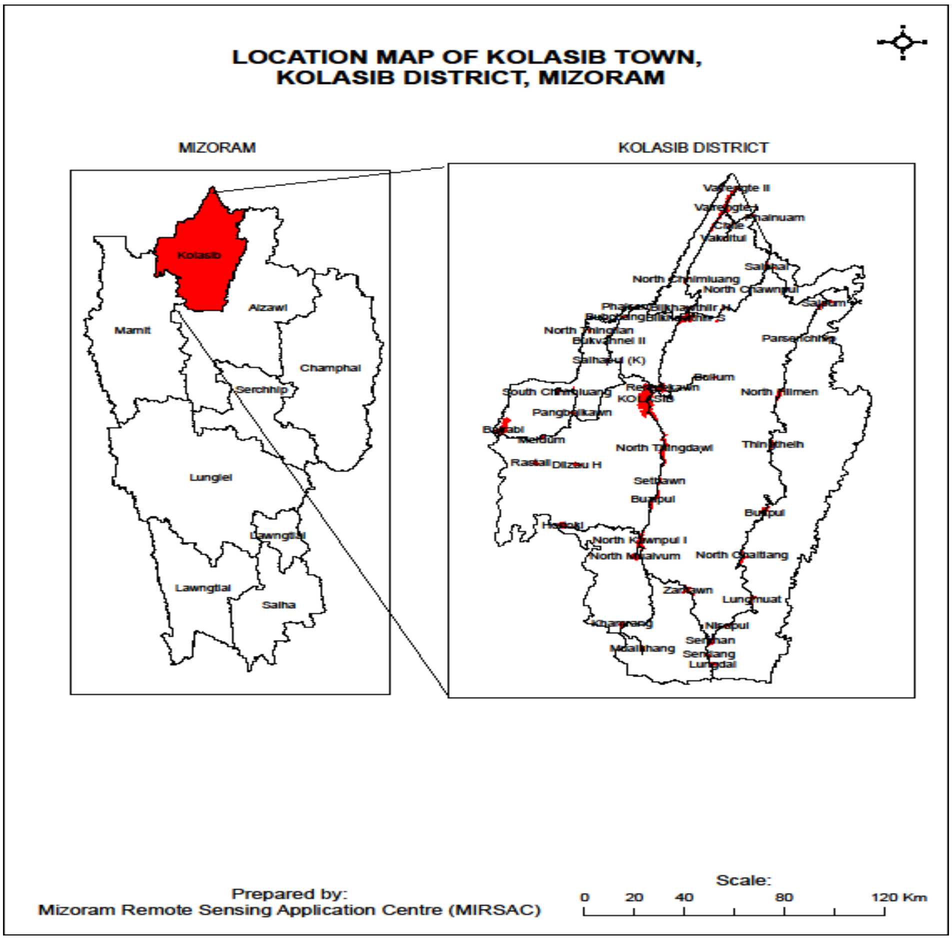

Fig. 3.1 Location map of Kolasib Town

3.1.2 Physiography:

Kolasib town is situated in the hill tract along and above Aizawl-Silchar road. It consists a number of low hills with undulating surface. The low hills are elongated with almost flat top and gentle slope in the east, south west, but they are comparatively steep in the north and in the north-west. The area as a whole is favourable and suitable for development of town and its future expansion.

3.1.3 Drainage System:

Kolasib town being on a hill tract extending from north-south direction mainly drains to the north-east and to the west respectively. There is no single river which controls the drainage system of the town, but numerous small streams and nullahs are running and dissecting the area in different direction. There are four main streams namely Tuilutlui, Mangkhawhlui, Lungdawhlui and Ramtilui all are flowing westward at a little distance in the western side of the town. Other important streams are Khuangphahlui, Zotuilui, Tuidamlui, Bung lui, Bangla lui and Tuikhurlui following in the eastern direction from the heart of the town. These streams are again joined by a number of nullah on both sides.

3.1.4 Geography &Geomorphology:

The hill range consists of thick and hard sandstone and shales of late tertiary age. The rock types are the continuation of the Patkai range which was probably laid down in the delta or estuary of a large river originating from the Himalayas in a tertiary period. The general geology is therefore represented by a respective succession of neo-genearenaceous and argillaceous sediment which belong to the surmaseris. The deep strike direction is more or less horizontal which express the stability of soil and rock for building construction purpose.

3.1.5 Water Resources:

There are two sources of water for Kolasib Town. One is natural water sources like streams which are running in and around the town, namely Bangla lui, Rengtekawn lui, tuilut lui, etc. These streams are perennial while other streams are dried up in dry season. The other resource of water is rain water Kolasib is situated under the direct influence of south west monsoon which receives heavy amount rainfall during monsoon season. The average annual rainfall is 197 cm. This rain water can be harvested by means of construction of gutters and storage for various purposes.

3.1.6 Climate:

The climate of Kolasib town is mild and equable. It is characterize by warm-wet summer and cold dry winter. The range of temperature during summer months and winter months are 20º-30ºC respectively. As the town is under the direct influence of South-West monsoon, it receives heavy amount of rainfall. The average annual rainfall is 197cms. July and August are the wettest months while December and January are the driest and coldest months in the year.

3.1.7 Population growth:

According to 1981 census, the total population of Kolasib Town was 8256. In 1991, Kolasib town was treated as class IV census town for the first time and the total population of the town was 13,482. Prior to that, it was a small town. In 2001, the population increased from 13482 to 19,008 and further the population increased to 24272 in 2011.(Table 3.1).

Table 3.1: Population density of Kolasib, Mizoram.

Year	Town wise population	District wise population	% to District population
1981	8256	38432	21.48
1991	13,482	48769	27.64
2001	19008	65960	28.82
2011	24272	83955	28.91

Source: Census Record of 1981, 1991 , 2001, 2011

3.1.8 Educational Institution:

There are formal educational institutions from Primary School to College level. In addition, there are 9(nine) Anganwadi Centres which are attended by 524 children. The number of Primary Schools amounting to 17, Middle School- 9,High School- 3.

As of 2011, Census of India, Kolasib is a notified town Town having a population of 24272 with an area of 85 Sq km the notified town has 12102 male and 12170 female. Population with children of 0-6 is 3428 which is 14.12% of total population of Kolasib notified Town. Female sex ratio is 1006 against state average of 97.6 literacy of Kolasib Town is 97.75% higher than state average of 91.33%,,male literacy is 98.25%while female literacy is 98.25%. The town has total administration over 5142 houses to which it supplies basic amenities like water and sewerage. It is also authorised to build roads within the town and impose taxes on properties coming under its jurisdiction.

3.2 Survey of solid waste generation

Survey was done using personal observations, questionnaire and interviews with people from different localities. Questionnaire was prepared to study waste management and disposal method (sample given in appendix). 200 questionnaires were distributed using simple random sampling method on 12 localities, all the questionnaires were collected and analysed.

Personal interviewed was also carried out at different waste collection points in 12 localities and the dumping trucks drivers and the attendees to study the frequency and method of waste disposal and their comments were recorded.

3.3 Dumping ground

The dumping ground is located in Rengte Tlang which is 7 Kms from the Kolasib Town, and occupies an area of 2 hectares. The slope of the hill is about 65 degree from the bottom line. The unprocessed solid wastes were dumped over the slope of the hill. The height of the hill is 200 feet approximately. The garbage thickness from the top soil is about 6 inches. (Fig. 3.3).

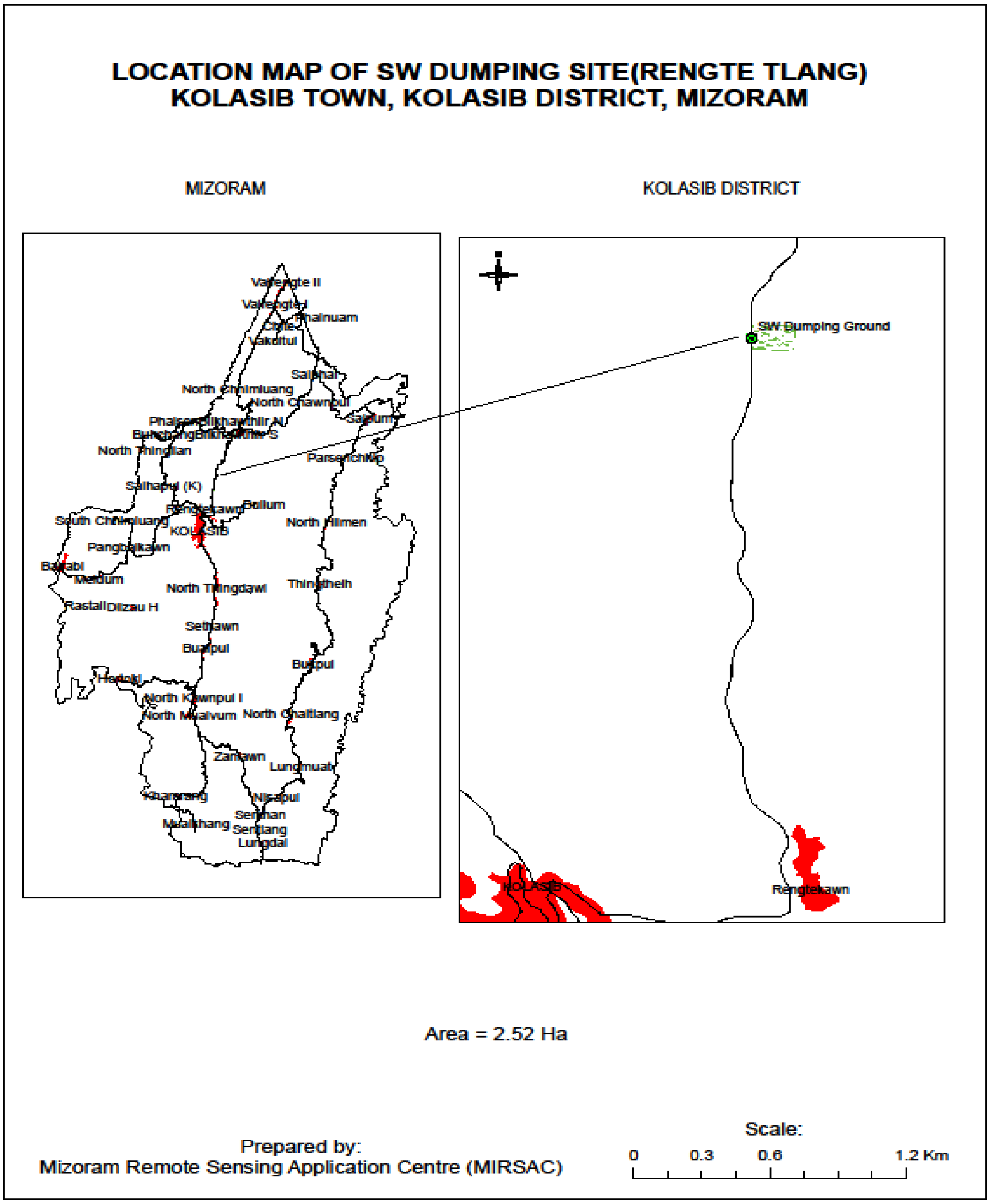

Fig. 3.2 Location Map of Dumping Ground.

Dumping ground at RengteTlang

View from top of the hill

View from bottom of the hill

3.4 Selection sampling sites

A total of 6 (six) sampling sites were selected. Of this, 5 sites in solid waste dumping ground (LA1= Left corner upper side, LA2= Left corner lower side, RA1= Right corner upper side, RA2= Right corner lower side, C= Centre) and one site (CR= control/reference) outside the dumping ground where there is effect of solid waste dumping. The control/reference site was selected in order to assess the impact of solid waste disposal on soil characteristics. (Fig. 3.4).

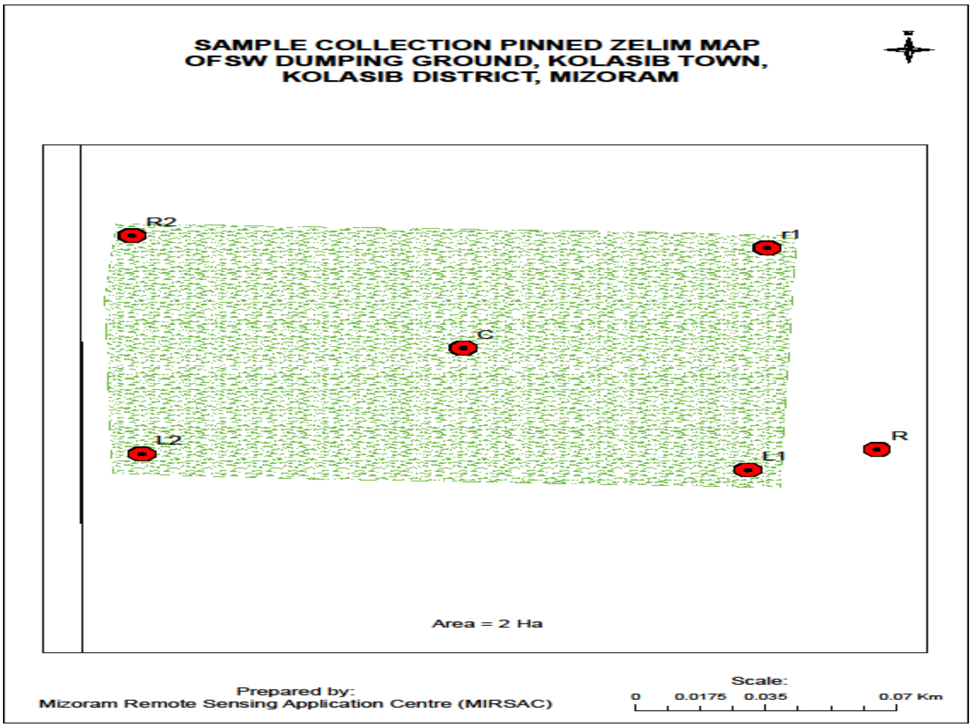

Fig. 3.3 Selection of sampling Site pinned Zelim Map of RengteTlang dumping ground.

3.5Waste collection and Segregation

The waste was collected from the dumping site following random sampling method, and 10kg waste was taken each from ten different sites every month. Different categories of waste (viz., paper, plastic, polythene, plastic bottles, paper pouches, cardboard, polyester, rubber, leather, batteries, concrete, stone, ash, sand, glass, metals, plastic, soft drink cans, carton packs, synthetic textiles, coating chemicals like Latex) were segregated and weighted, using balance and the data were recorded. From each selected dumping site, 5kgs of waste was taken and segregated into different types. After segregation, each type of waste was pooled and weighted. The quantification of each type of waste was performed in light of total waste generated.

3.6 Collection of soil samples

Soil Samples were collected from selected sites for a period of two years (November 2016 to October 2018) at monthly interval for analysis of soil characteristics. The monthly data were computed on seasonal basis i.e., Pre monsoon (January-April), Monsoon (May-August), Post monsoon (September to December) seasons.

3.7 Analytical method for soil

3.7.1 Soil pH

10g of freshly collected soil samples was taken in a beaker containing 50ml of distilled water. The soil was stirred for 20 minutes on a magnetic stirrer. The solution was kept overnight and the pH of the soil solution was taken with the help of electronic pH meter.

3.7.2 Bulk Density

$$\text{Bulk Density} = \frac{weight\ of\ oven - dried\ soil\ (g)}{Volume\ of\ soil\ corer\ (cubic\ cm)}$$

Where,

Volume of soil corer = 3.14*rh*,*r*-inside radius of cylinder (cm) and *h* – height of cylinder (cm).

3.7.3 Soil moisture content

The soil moisture content was calculated by using the method given by Anderson and Ingram (1993).10g of freshly collected soil was kept in a hot air oven at 105˚C for 24 hours. The oven dried soil was weighted. The percentage of the soil moisture content is calculated by the following formula:

$$\text{Moisture content (\%)} = \frac{W1 - W2\ x\ 100}{W2}$$

Where, W1= Initial weigh of soil, W2 = Final weight of the soil

3.7.4 Soil Organic Carbon

The soil organic carbon was determined by the dichromate method (Walkey and Black, 1934).

Organic carbon content was calculated using the following formula:

$$\text{Organic carbon content (\%)} = \frac{10\ (B-T)\ x\ 0.003\ x\ 100}{B\ x\ S}$$

Where, B=volume of ferrous ammonium sulphate for blank titration in ml.

T=volume of ferrous ammonium sulphate for soil sample in ml.

S= weight of soil sample

3.7.5 Soil Total Nitrogen

The soil total nitrogen content of the soil sample determined by Kjeldahl Digestion Method (Anderson and Ingram, 1993).

$$\text{\% of total N 2} = \frac{14\ x\ Normality\ of\ acid\ x\ Titrated\ value}{Sample\ \text{weight}\ x\ 1000}$$

3.7.6 Soil Phosphorous

The soil phosphorous content of the study site will be determined following Olsen method (Olsen *et al.*, 1954).

Olsen"s Phosphorus (Kg/ha) = $$\frac{R(\frac{7}{v})(\frac{1}{S})(2.24\ x\ 10\text{n}}{10\text{n}}$$

Where, V = Total volume of extractant (50 ml)

v = Volume of aliquot taken for analysis (5 ml)

S = Weight of soil (2.5 g)

R = Weight of Pin the aliquot in mg (from standard curve)

n = 6

3.7.7 Soil Exchangeable Potassium

The calculation of soil exchangeable potassium as suggested by Gupta (1999) is given as,

Available potassium (mg of K / g of soil)

$$= \frac{A\ x\ V}{\text{W}\ x\ 100}$$

Where,

A = Potassium content of soil extract from standard curve (mg/L, or, ppm)

V = Volume of the soil extract (ml)

W = Weight of air dry sample taken for extraction (g)

R = ppm of Kin the extract (obtained from standard curve)

3.8 Statistical analysis

All the data were analysed statistically using Microsoft excel and SPSS software to check the validation of the observation on correlation by means of Spearman test and significance level of change between control site and dumping site as well as seasonal variation by Kruskal-Wallis independent variable test.

CHAPTER 4

RESULTS AND DISCUSSION

The present investigation has been carried out for two successive years i.e., November 2016 –October 2017 and November 2017 – October 18, and findings are presented and interpreted as follows.

4.1 Survey on Solid waste generation in Kolasib Town

During the study period, survey was carried out in different localities to observe the solid waste generation, it was found out that every household have their own dustbin, there is no segregation of waste at the sources. Different type of waste was mixed in one bin without proper cover. In some part of the street there were dustbins placed by NGOs which were left unattended, it was sometimes collected by collectors from the concerned department and by nearby people. The waste from different household, institutions and commercial areas were collected by two garbage trucks with ten of truck/lorry attendants. With this, very limited Man power, the department is able to cover up to 40% of the household in the Town. The Trucks can enter around 16 village councils/localities out of total no of 24 (only main road) except on Sundays, the department trucks run every morning, stopping in each point for 10-15 minutes, waiting for the garbage to collection of solid waste in the Town. The approximate amount of waste collected daily is 7 tons, the waste were collected by truck attendants manually and were openly disposed off in Rengte tlang dumping ground owned by Urban Development and Poverty alleviation Department, Kolasib. The waste after being scavenged by waste pickers were usually left in the dumping ground with occasional burning. Run-off from rainfall usually transport this leftover to the adjoining river and annual streams which ultimately gets deposited to river.

4.2 Quantification of solid wastes in Kolasib Town

The information on status of solid waste generated has been procured through questionnaire by using Simple Random Sampling Method (SRSM), taking into account 200 household from 16 different localities of Kolasib town. **(Table 4.1).**

Table 4.1 Quantification of solid waste generated in the study area according to questionaire survey

Family size (Number of person per family)	Number of families out of 200	Percentage	Daily solid waste generated(Approx.) in kg
1-4	58	29%	500g-1kg
5-10	128	64%	1.5kg-2kg
11-15	14	7%	3kg-4kg

Table 4.2 Quantification of solid waste generated in the study area according to Total No of families.

Family size (No. of person per family)	Total Number of families in Kolasib Town	Percent age	Daily solid waste generated (Mean) in kg per family	Daily solid waste generated (Mean) in kg by total family in kg	Total waste generated in a month by total family in kg	Total waste generated in a Year in kg
1-4	1492	29%	0.750kg	1119	33570	402840
5-10	3291	64%	1.75kg	5759.25	172777.5	2073330
11-15	360	7%	3.5kg	1260	37800	453600
Total	5142	100	6kg	30852	925560	11106720

It has been observed that the people use to dump 8% of solid waste in their own compound/ premises, and 92% solid waste disposed off in the dumping ground through garbage trucks. The amount of solid waste increases with increase in family size. In table 4.1b the amount of waste generated daily is 30.85tonnes, 925.56 tonnes in a month and 11.107 million tonnes in a year. The disposal of solid waste largely depends on UD&PA Department dumping ground. The questionnaire reflects that garbage truck plying only twice a week which is not sufficient for collection of solid waste effectively. There is an urgent need to increase the number and frequency of garbage trucks so that 100% solid waste generated in the area should be dumped to dumping ground and cleanliness in the area could be established.

During the study period, different wastes were segregated into eight categories. Different types of waste generated with their quantity and percentage were shown in Table 4.2 and Fig. 4.1.

Table 4.3: Composition of different types of solid wastes generated.

SSl. No.	**Type of solid waste**	**Quantity in kg (Nov 2016 to Oct 2017)**	**% of Total Solid waste**	**Quantity in kg (Nov 2017 to Oct 2018)**	**% of Total Solid waste**
1.	Organic (food waste)	366521.76	33	344308.32	31
2.	Paper and paper product	233241.12	21	222134.4	20
3.	Plastics	122173.92	11	111067.2	10
4.	Glass	44426.88	4	55533.6	5
5.	Metal	22213.44	2	22213.44	2
6.	Textiles (Rubber, leather cardboard, Polyester)	55533.6	5	55533.6	6
7.	Inorganic substance(concrete, stone, ash, carbon parts)	255454.56	23	277668	25
8.	Natural waste	11106.72	1	11106.72	1
	TOTAL	**1110672**	**100**	**1110672**	**100**

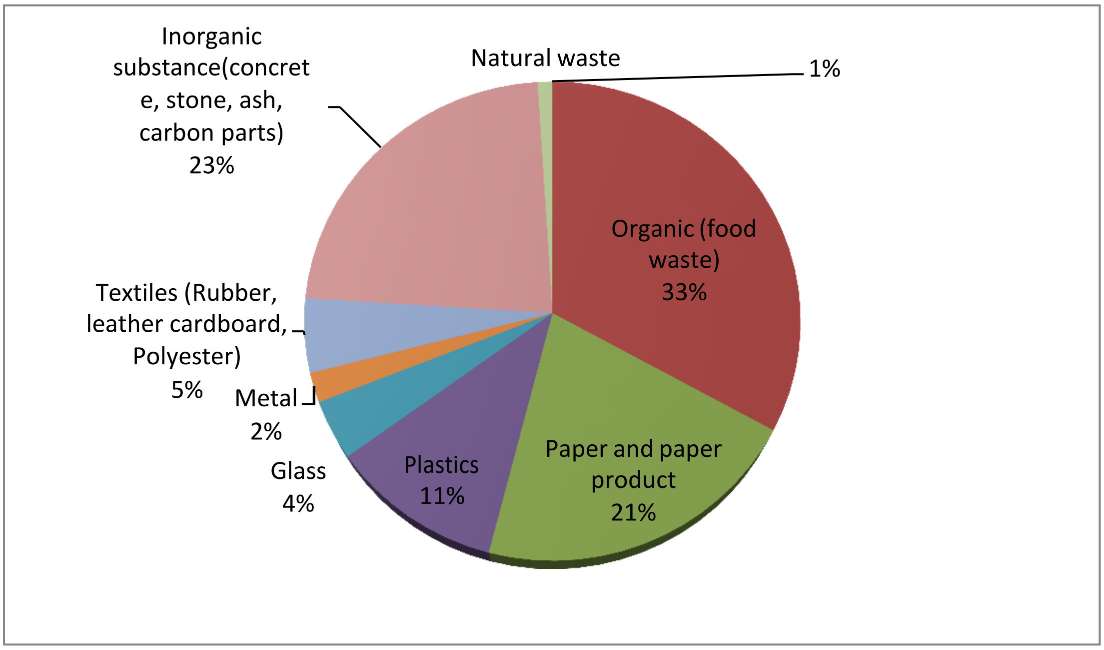

Fig. 4.1. Graphical representation of composition of different types of waste generated during 2016-17

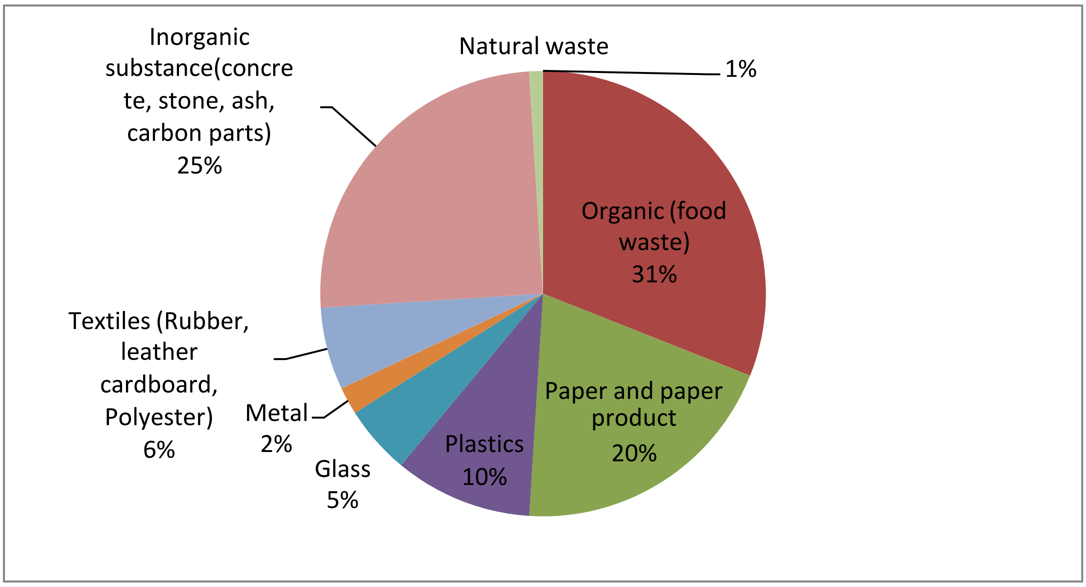

Fig. 4.2. Graphical representation of composition of different types of waste generated in 2017-18

From the observation (**Table 4.2 and fig. 4.1 & Fig 4.2**) it reveals that organic food waste constitutes highest percentage 366521.79 (33%) kg and 344308.32kg (31%) during 2016-17 and 2017-18 respectively, and followed by inorganic substances like concrete cements, stone, ash and carbon parts as 255454.56kg (23%) and 277668kg (25%) during 2016-17 and 2017-18 respectively; paper and paper products as 233241.12 kg (21%) in 2016-17 and 222134.4 kg (20%) in 2017-18; plastics waste as 122173.92kg (11%) in 2016-17 and 111067.2kg (10%)in 55533.6; textiles waste (rubber, leather, cardboard, polyester, etc.) as 55533.6kg (5%) in 2016-17 and 55533.6kg (6%) in 2017-18 ; glasses as 44426.88kg (4%) in 2016-17 and 55533.6kg (5%); metals as 22213.44kg (2%) in both year; natural waste as 11106.72 kg 1% during the study period. The higher amount of organic waste may be due to collection of waste from domestic area. Papers and paper products were mainly disposed off from institutional area and government offices. Of all kinds of solid wastes generated, only metals taken out for recycling.

4.3 Physico-chemical characteristics of soil

The soil samples were analysed for various qualitative parameters on monthly basis and findings are presented on seasonal basis as described in the chapter Materials and Methods.

4.3.1 pH

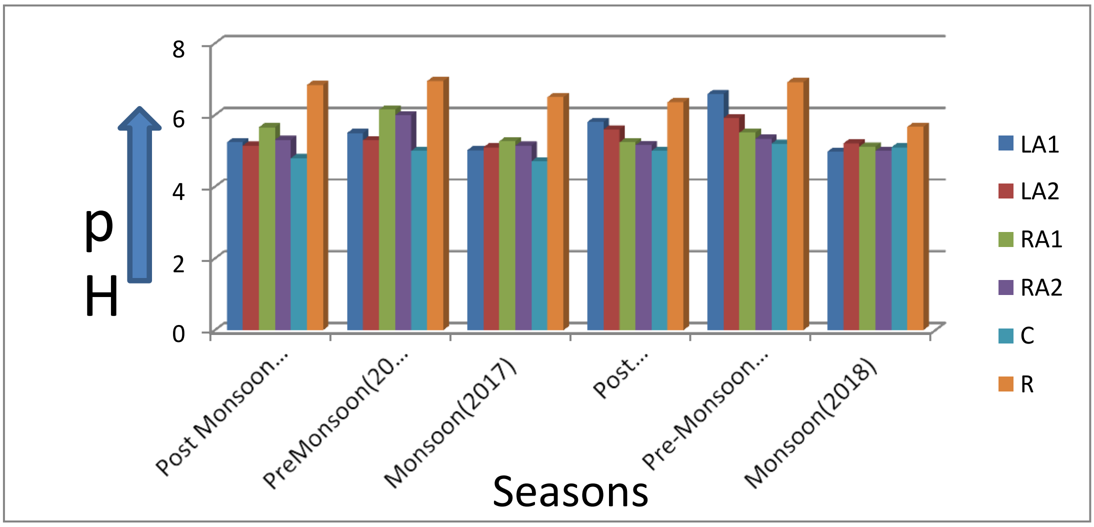

Figure 4.3 Seasonal variations in pH of soil at different sampling sites.

Table 4.4 Seasonal variations in pH of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	**LA_2**	**RA_1**	**RA_2**	**C**	**CR**
Post Monsoon (2016)	5.24	5.15	5.66	5.31	4.8	6.84
Pre Monsoon (2017)	5.5	5.3	6.15	6	5	6.95
Monsoon (2017)	5.02	5.1	5.27	5.15	4.71	6.5
Post Monsoon (2017)	5.81	5.6	5.24	5.16	5	6.36
Pre-Monsoon (2018)	6.59	5.92	5.51	5.34	5.2	6.92
Monsoon (2018)	4.98	5.21	5.12	5	5.1	5.67

During the year 2016-17, minimum pH 4.7 mg/l **(Table 4.4 and Fig. 4.5)** was recorded in monsoon season at centre site and maximum during post monsoon season at control site 6.95 mg/l. Similarly, during the year 2017-18, minimum pH 4.98 mg/l **(Table 4.4 and Fig. 4.5)** was observed in monsoon season at LA1 and maximum during post monsoon season at control site 6.92 mg/l. The pH of the study site has positive and significant correlation with moisture content at ($r=0.269^{**}$ $P\leq0.01$) and available phosphorus ($r=0.334^{**}$ $P\leq0.01$), negative significant correlation with organic carbon ($r=-0.259^{**}$), exchangeable-P ($r=-0.254^{**}$) (**Appendix III)**.

During the study period it was observed that pH value was higher during pre-monsoon and post monsoon season and lower during monsoon season. This could be due to dilution of hydrogen ion concentration by rain water which is acidic in nature. Statistical analysis proved that there is a significant change of pH between different seasons (H=0.00) ($P\leq0.05$) **(Appendix V).** Among different study sites, control site has higher pH value compare to dumping site. This may be due to the development of organic acid as a by-product of decaying organic matter. This can also be due to the acidic nature of the synthetic leachate itself. In the dumping sites, centre part has lowest pH value which is due to concentration of leachate at the central part of the dumping area that enters from different corners.

Soil pH is a degree of acidity and alkalinity in soil pH levels range from 0 to 14, with 7 being neutral, below 7 acidic and above 7 alkaline. The ideal pH range for most plant is between 5.5 and 7.0. However, many plants have thrived best at pH values outside this range. Pillai *et al.* (2014) from their study on soil pollution near a municipal solid waste disposal site in India also found that there is a decline in pH as the concentration of leachate increased.

A pH of 6.5 is just about right for most home gardens, since most plants thrive in 6.0 to 7.0 (slightly acidic to neutral) ranges. Some plants have a preference more strongly acidic soil, while few grow better in soil that is neutral to slightly alkaline. When a plants soil pH is too high, the plants ability to absorb certain nutrients is disturbed. As a result, some nutrients cannot be absorbed properly. For example, if a plants leaves become yellow between the veins, this indicated iron deficiency for most plants, the optimum pH range is from 5.5 to 7.0, but some plants will grow in more acid or may require more alkaline level. The pH is not an indication of fertility, but it does affect availability of fertilizers nutrients. pH is simply a measure of how acid or alkaline substances is, and soil acidity or alkalinity is important because it influenced how easily plants can take up nutrients from the soil. Soil pH is a measure of acidity (sourness) or alkalinity (sweetness) of a soil. In some mineral soils, aluminium can be dissolved at pH levels below 5.0 becoming toxic to plant growth. Soil pH may also affect accessibility of plant nutrients. Nutrients are most obtainable to plants in the ideal level.

4.3.2 Bulk density

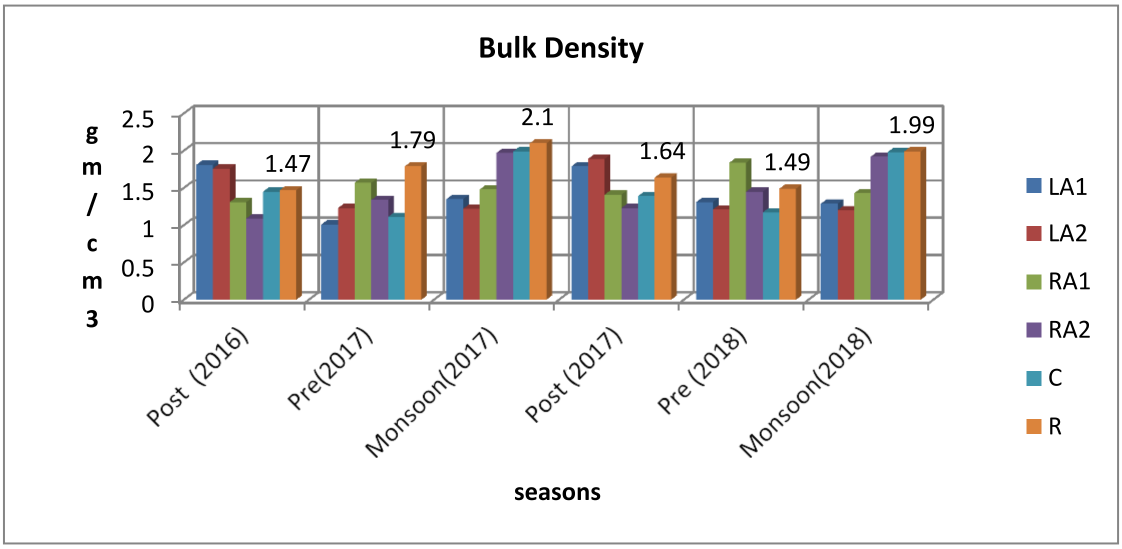

Fig.4.4 Seasonal variations in bulk density (gcm^{-3}) of soil at different sampling sites.

Table 4.5: Seasonal variations in bulk density (gcm^{-3}) of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	**LA_2**	**RA_1**	**RA_2**	**C**	**CR**
Post Monsoon (2016)	1.81	1.76	1.31	1.09	1.45	1.47
Pre-Monsoon(2017)	1.01	1.23	1.57	1.34	1.11	1.79
Monsoon(2017)	1.35	1.22	1.48	1.97	1.99	2.10
Post Monsoon(2017)	1.79	1.89	1.41	1.23	1.39	1.64
Pre-Monsoon (2018)	1.31	1.21	1.84	1.45	1.17	1.49
Monsoon(2018)	1.29	1.20	1.43	1.92	1.98	1.99

During 2016-2017, minimum value of bulk density was found at site LA1 with a value of 1.01gcm^{-3}during pre-monsoon season and maximum at control site with a value of 2.10gcm^{-3} **(Table 4.6 and Fig. 4.5)** during monsoon season and during 2017-2018, minimum value of bulk density was found at site centre with a value of 1.17gcm^{-3}during pre-monsoon season and maximum at control site with a value of 1.99gcm^{-3}during monsoon season **(Table 4.6 and Fig. 4.5)**. Bulk density of the study site has significant positive correlation with available-P ($r=0.430^{**}$ at $P\leq0.01$) and has negative significant correlation was observed with moisture content ($r=-0.232^{**}$) and organic carbon ($r=-0.295^{**}$at $P\leq0.01$) (Appendix III).

Bulk density shows higher value at monsoon season and lowers during post monsoon season which could be due to compaction of soil texture by rainfall. Statistical analysis proved that there was significant change between seasons during the study period ($H=0.001$ at $P<0.05$) **(Appendix V)**. Comparing different study sites control sites have higher bulk density value than dumping area. This shows that bulk density was decrease due to waste disposal. Differences in bulk density between dumping site and control sites may be due to organic and inorganic materials leaching from the municipal wastes help to increase the soil matrix thereby reducing soil bulk density Similar findings were made by Mbagwu (1992), Anikwe and Nwobodo (2002), Wickramarachchi *et al.* (2011).

Bulk density is reliant on soil organic matter, soil texture, the density of soil mineral (sand, silt and clay) and their compaction. As a rule of thumb, most rocks have a density of about 2.65 g/cm^3 so preferably, a silt loam soil has about 50% pore space and a bulk density of 1.33g/cm^3. Specific complications that might be caused by poor function; high bulk density is an indicator of low soil porosity and soil compaction.

4.3.3 Soil Moisture

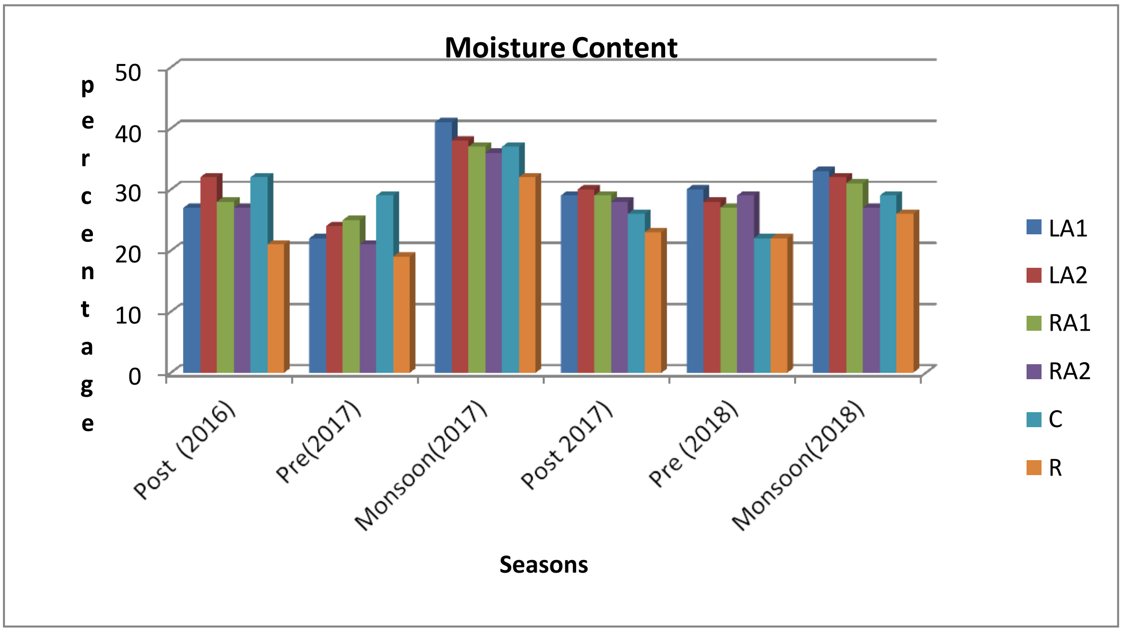

Fig. 4.5 Seasonal variations in Moisture content (%) of soil at different sampling sites.

Table 4.6 Seasonal variations in moisture content (%) of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	LA_2	RA_1	RA_2	C	R
Post Monsoon (2016)	27	32	28	27	32	21
Pre Monsoon(2017)	22	24	25	21	29	19
Monsoon(2017)	41	38	37	36	37	32
Post Monsoon(2017)	29	30	29	28	26	23
Pre-Monsoon (2018)	30	28	27	29	22	22
Monsoon(2018)	33	32	31	27	29	26

In the year 2016-2017, moisture content of the soil was found that minimum at control site with a value of 19% **(Table 4.7 and Fig. 4.6)** during pre-monsoon season and maximum value of 41%**(Table 4.7 and Fig. 4.6)** at site LA1 during monsoon season. During 2017-2018, moisture content of the soil was found that minimum at control site with a value of 22% **(Table 4.7 and Fig. 4.6)** during pre-monsoon season and maximum value of 33% **(Table 4.7 and Fig. 4.6)** at site LA1 during monsoon season. During the study period moisture content has positive significant correlation with total nitrogen ($r=0.397^{**}$ at $P\leq0.01$), pH ($r=0.269^{**}$ at $P\leq0.01$) and negative significant correlation with organic carbon ($r= -0.192^{*}$ at $P\leq0.05$), bulk density ($r=-0.232^{**}$ at $P\leq0.01$), and potassium ($r=-0.223^{**}$ at $P\leq0.01$) **(Appendix III)**.

During the study period it was observed that moisture content of the soil was higher during monsoon period and lower during pre-monsoon period which may be due to increase in humidity of soil by rain water. Statistical analysis shows that there was significant change between different seasons ($H=0.00$ at $P\leq0.05$) **(Appendix V)** during the study period. Comparing dumping site and control site, control site has lower moisture content in all seasons this shows that waste has increase the humidity of soil, it is clear from the observation that the waste component of the study site contain majority of organic waste in which leachate result from decaying of waste matter. This is also due to covering up of soil by waste which decreases the rate of evaporation from soil. Similar observation was found with the work of Krishna *et al.,* (2016), Sharma *et al.,* (2010) they state that the values of the natural moisture content of the uncontaminated soil generally lower compared to those of the contaminated soil samples.

The optimum moisture content is the water content at which maximum dry unit weight can be achieved after given compaction effort. A maximum dry unit weight would have no space in the soil. If the moisture content of soil is ideal for plant growth, plants can easily absorb soil water, much of water resides in the soil as a thin film. Soil water dissolves salt and added up soil solution, which is important as intermediate, and is a very variable in leading the interchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration. As a result, soil moisture plays an important role in the development of weather patterns and the production of precipitation.

4.3.4 Organic Carbon:

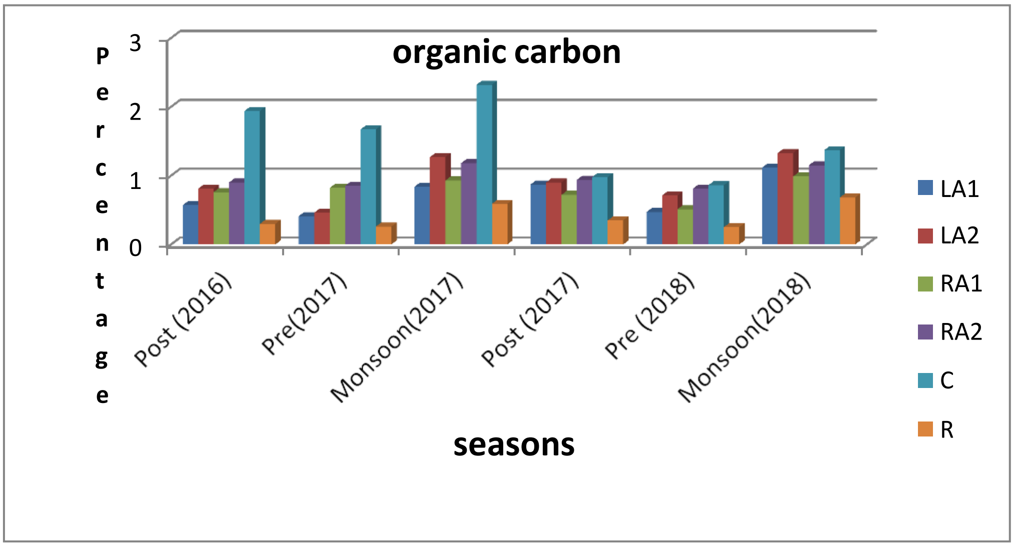

Fig. 4.6 Seasonal variation of Organic Carbon (%)at different sampling sites.

Table 4.7 Seasonal variation in Soil Organic Carbon (%) at different sampling sites.

Seasons	Sampling Sites					
	LA_1	**LA_2**	**RA_1**	**RA_2**	**C**	**CR**
Post Monsoon (2016)	.57	.81	.76	.9	.94	.3
Pre Monsoon(2017)	.41	.46	.82	.85	.67	.26
Monsoon(2017)	.84	.27	.93	.18	.32	.59
Post Monsoon(2017)	.87	.9	.72	.94	.98	.35
Pre-Monsoon (2018)	.47	.71	.51	.81	.86	.25
Monsoon(2018)	.12	.33	.99	.15	.37	.68

During the year 2016-2017 the minimum organic content was observed at control site with a value of 0.26% during pre-monsoon season and maximum at centre site with a value of 2.32% during monsoon season and in the year 2017-2018 **(Table 4.7 and Fig. 4.6)** the minimum organic content was observed at control site with a value of 0.25% during pre-monsoon season and maximum at centre site with a value of 1.37% during monsoon season **(Table 4.7 and Fig. 4.6)**. Organic carbon content of the study site shows positive significant correlation with bulk density ($r=0.190^{*}$at $P\leq0.05$) and negative significant correlation with pH ($r=-0.259^{**}$ at $P\leq0.01$) and moisture content ($r=-0.192^{*}$ at $P\leq0.05$) **(Appendix III).**

During the study period, carbon content was high during monsoon seasons and lowers during pre-monsoon and post monsoon seasons. This significant change was proved statistically H= 0.023 at $P\leq0.05$ **(Appendix V).** From the observation it was found that dumping site has higher amount of organic carbon than control site. Organic Carbon enters the soil through leaching of the decomposition of plant and animal residues, root exudates, living and dead microorganisms and soil biota. Increasing in total organic carbon in soil may reduce atmosphere carbon dioxide and increased soil quality. The amount of organic carbon kept in soil is the sum of contributions of soil (plant and animal residues) and decline from soil (decomposition, erosion and off take in plant and animal production). "Soil organic carbon is mainly constituted by soil organic matter. It is divided between living soil biota and abiotic material. Soil organic carbon tends to be concentrated in the top soil. The Organic matter is widely regarded as a vital component of soil fertility because of its role in physical, chemical and biological processes to supply the plants with the nutrients and also helps soil to keep the moisture" (Joachim .et.al.1989).

4.3.5. Total Nitrogen:

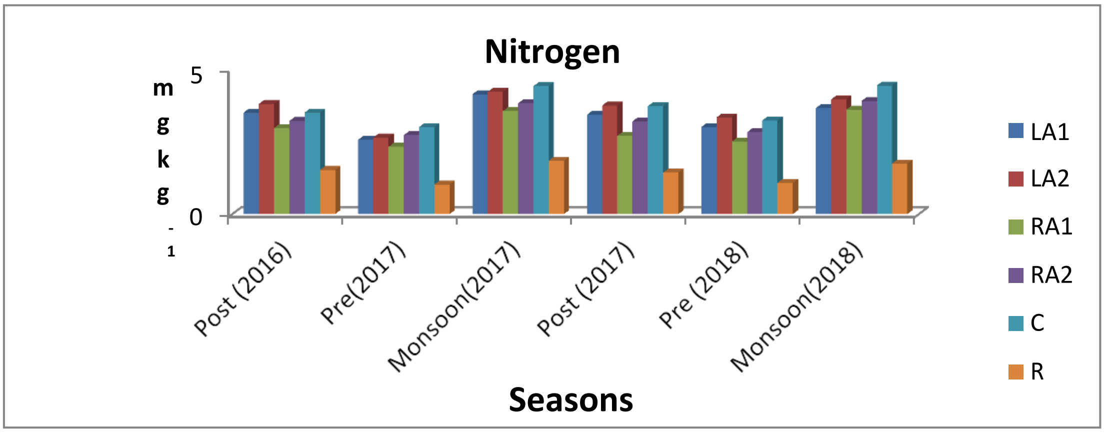

Fig. 4.7. Seasonal variations in Total Nitrogen (mgkg^{-1}) of soil at different sampling sites.

Table 4.8. Seasonal variations in Total Nitrogen (mgkg^{-1}) of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	**LA_2**	**RA_1**	**RA_2**	**C**	**R**
Post Monsoon (2016)	3.5	3.8	2.97	3.21	3.5	1.52
Pre Monsoon(2017)	2.56	2.64	2.32	2.72	3	1.02
Monsoon(2017)	4.13	4.21	3.55	3.82	4.41	1.84
Post Monsoon(2017)	3.42	3.74	2.7	3.2	3.72	1.43
Pre-Monsoon (2018)	3	3.33	2.5	2.82	3.23	1.08
Monsoon(2018)	3.65	3.95	3.6	3.9	4.43	1.74

In 2016-2017, the total nitrogen content was found minimum during pre-monsoon at control site 1.02mgkg^{-1} and maximum during monsoon season at centre site 4.41 mgkg^{-1} of the dumping ground. In 2017-2018 **(Table 4.8 and Fig. 4.7)**, the total nitrogen content was found minimum during pre-monsoon at control site 1.08mgkg^{-1} and maximum during monsoon season at centre site 4.43 mgkg^{-1} **(Table 4.8 and Fig. 4.7)** of the dumping ground. Total nitrogen content of the study site has positive significant correlation with moisture content ($r=0.397^{**}$at $P\leq0.01$) and negative significant correlation with bulk density($r=-0.295^{**}$), available phosphorus ($r=-0.291^{**}$) and exchangeable-P($r=-0.291^{**}$) at $P\leq0.01$ **(Appendix III).**

During the study period, total nitrogen content was found higher during monsoon season and lower during pre-monsoon season this could be due to leachate that enter in the soil through rain water run-off. It has significant change between different seasons at (H=0.00) at $P\leq0.05$ **(Appendix V).** From the observation it was found that control site has lower nitrogen content than dumping site which could be due to composting of nitrogen containing waste in the soil. Similar observation was found from their study by Hossain *et al*. (2017), Bhattacharyya *et al*. (2003), Montemurro *et al.* (2006), Walter *et al.*, (2006), Zhang *et al.* (2006), Hargreaves *et al.*(2008) showed that the addition of municipal solid waste in soil increased total Nitrogen contents.

The higher the value for soil nitrogen quantity the more likely it is that microorganisms in soil will transform more organic nitrogen into mineral nitrogen for plant uptake. However, in coarsed textured soil with where there is high value of nitrogen supply, it is also more likely that nitrate will be leached down the soil profile reach extend of plant roots and possibly into water ways. Intermediate levels of soil nitrogen supply provide a balance between maximizing nitrogen obtainability for plant uptake and minimizing the risk of nitrate leaching. “The level of soil nitrogen supply that best balances the benefits and risks varies depending on clay content of soil. In sand soil, best balance is achieved by “moderate” soil nitrogen supply (25-50 mg-N/kg soil). In contrast, in loam and clay soils “high” soil nitrogen supply is most suitable (50-75 & 75-125 mg-N/kg soil respectively” (*Wang et al.*, 2015).

4.3.6. Available Phosphorus:

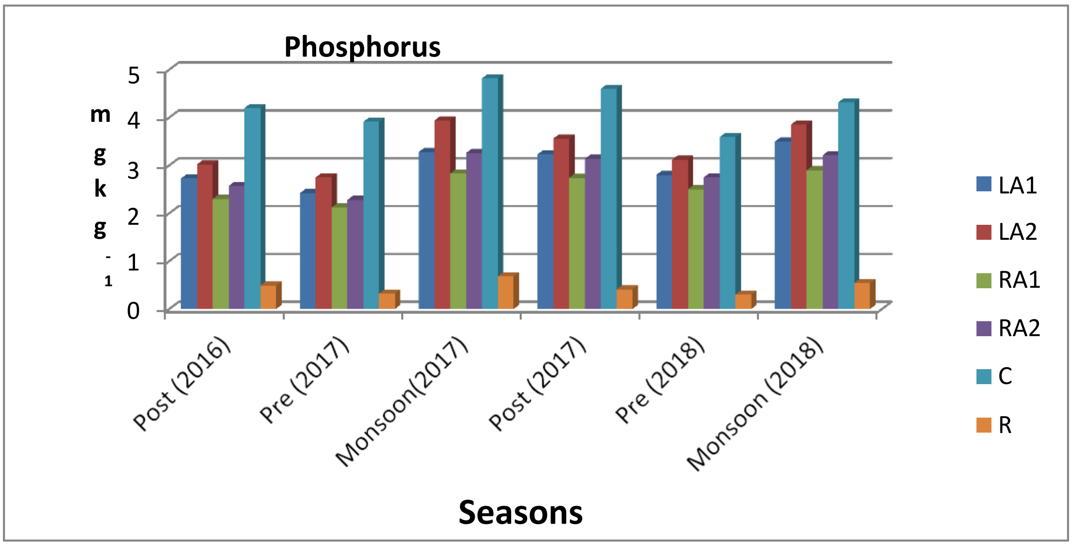

Fig. 4.8: Seasonal variation in available P (mgkg^{-1}) of soil at different sampling sites.

Table 4.9. Seasonal variation in available P (mgkg^{-1}) of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	**LA_2**	**RA_1**	**RA_2**	**C**	**R**
Post Monsoon (2016)	2.73	3.02	2.3	2.57	4.2	0.49
Pre Monsoon(2017)	2.42	2.75	2.12	2.28	3.91	0.32
Monsoon(2017)	3.28	3.94	2.83	3.26	4.82	0.68
Post Monsoon(2017)	3.23	3.56	2.74	3.14	4.6	0.41
Pre-Monsoon (2018)	2.8	3.12	2.5	2.75	3.59	0.3
Monsoon(2018)	3.5	3.85	2.9	3.21	4.32	0.54

During 2016-2017, maximum value of available P was observed at centre site of the dumping ground 4.82mgkg^{-1} during monsoon season and minimum at control site 0.32mgkg^{-1} during pre-monsoon season **(Table 4.9 and Fig. 4.8)**. During 2017-2018, maximum value of available P was observed at centre site of the dumping ground 4.32mgkg^{-1} **(Table 4.9 and Fig. 4.8)** during monsoon season and minimum at control site 0.3mgkg^{-1} during pre-monsoon season. During the study period it has positive significant correlation with pH (r=0.334**) and bulk density (r=0.430**at $P \leq 0.01$), negative significant correlation with Total Nitrogen (r=-0.291**at $P \leq 0.01$) (Appendix III).

During the study period the value of available P was found to be higher during monsoon season and lower during pre-monsoon season. There was seasonal variation at $P \leq 0.05$ (H=0.00) in the study site **(Appendix V).** From the observation it was found that dumping site has higher available-P than control site. This could be due to composting of leachate containing phosphorus elements especially from domestic waste. Other studies Mbarki *et al.* (2008), Lee *et al.* (2004), Yan *et al.*(2016) reported the similar finding that municipal solid waste has increase the content of available-P in soil by enhancing the fertility of soil.

Phosphorus P is essential micro-element, essential for plant nutrition. It participates in metabolic processes such as photosynthesis, energy transfer and synthesis and analysis of carbohydrates, phosphorus is found in the soil in organic compounds and in minerals. However, the amount of readily accessible phosphorous is comparatively low, the total amount of phosphorous in the soil. “The types of phosphorous compounds that exist in the soil are mostly determined by soil pH and by the type and amount of minerals in the soil; mineral compounds of phosphorous usually contain aluminium, iron, manganese and calcium. In acidic soils phosphorous tends to react with aluminium, iron and manganese, while in alkaline soil the dominant fixation is with calcium. The optimal pH range for maximum phosphorous availability is 6.0-7.0” (McGeehan, 2012).

4.3.7. Exchangeable Potassium:

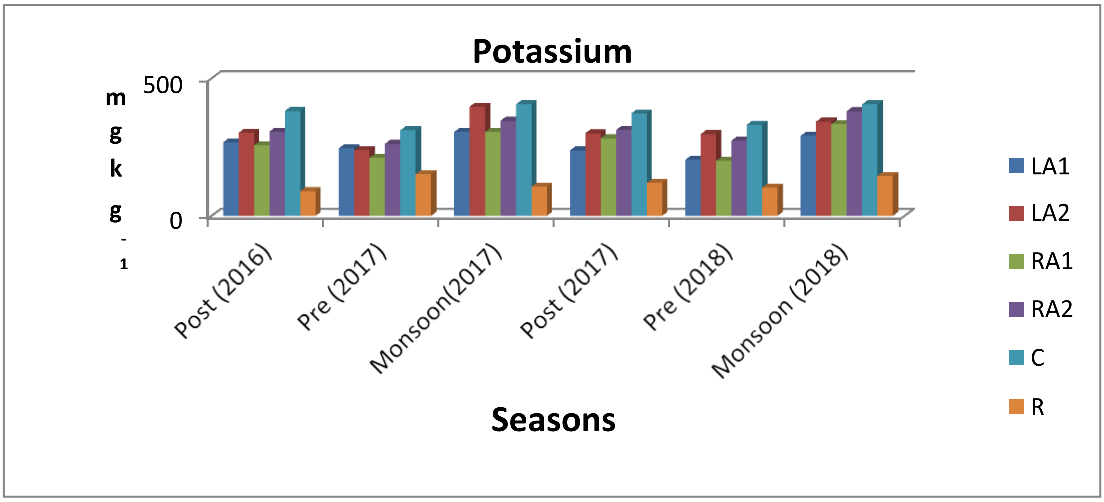

Fig. 4.9. Seasonal variations in Exchangeable K of soil at different sampling sites.

Table 4.10. Seasonal variations in Exchangeable K of soil at different sampling sites.

Seasons	Sampling Sites					
	LA_1	LA_2	RA_1	RA_2	C	R
Post Monsoon (2016)	267.11	301.98	255.93	306.41	381.11	90.36
Pre Monsoon (2017)	245.37	239.22	211.01	261.81	311.37	152.12
Monsoon(2017)	305.4	397.33	305.36	345.9	405.78	105.99
Post Monsoon(2017)	237.74	300.36	282.45	312.14	372.78	119.24
Pre-Monsoon (2018)	203.74	297.06	199.42	273.44	331.36	103.27
Monsoon(2018)	290.98	342.5	332.91	380.8	405.69	145.5

During 2016-2017 maximum value of exchangeable K was observed at centre site 405.78mgkg^{-1}in monsoon season and minimum at control site 90.36mgkg^{-1}during post monsoon season **(Table 4.10 and Fig 4.9).** In 2017-2018 maximum value was found at centre site 405.69mgkg^{-1}during monsoon season and minimum at control site 103.27mgkg^{-1}during pre-monsoon season **(Table 4.10 and Fig 4.9).** During the study period it has negative significant correlation with pH (r=-0.208*at

P≤0.05), moisture content(r=0-.223**) and total nitrogen (r=0-.274** at P≤0.01) **(Appendix III).**

From the observation it was found that exchangeable P was lower during pre-monsoon and post monsoon season and higher during monsoon season. Significant change was observed between different season (H=0.00) at P≤0.05 (Appendix V) during the study period. This could be due to increase in rate of decomposition by rain water which increase humidity and leachate can easily enter to soil from run-off. From the study it was also observed that control site has lower potassium content compare to dumping site. Aktar *et al.* (2018), Chinyere *et al.* (2013), Giannakis *et al.* (2014) also found that there was significant increase of exchangeable Potassium ion (P=0.5) compared to waste dumping site and control site.

"Depending on soil type, from 90% to 98% of soil potassium is in relatively unobtainable forms minerals. Unlike nitrogen and phosphorous, is not associated to great degree with organic matter. Readily available potassium is composed of exchangeable potassium is absorbed on the soil colloid surfaces and is available for plants. However, higher plants obtain most of the potassium from the soil solution phase. The equilibrium between these different forms of potassium is „dynamic""" (Karthikayan *et al.*2002).

4.4 Impact of solid waste disposal on Soil characteristics:

The impact of solid waste on soil characteristics was studied by comparing soil physico-chemical parameters between dumping sites and control sites. Mean value was taken from five sampling sites of dumping ground and was compared to control site for each and every parameters. One way Anova test was run to check the validation of significant change between dumping site and control site. The Anova table was given in the appendix.

pH:

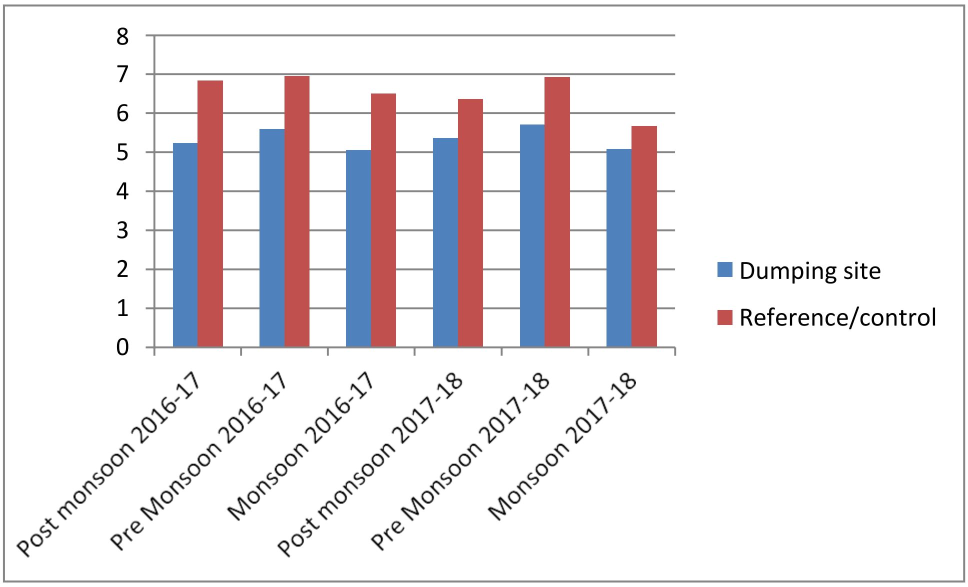

Fig 4.10 comparison of dumping site and control sites pH of soil

Table 4.11: comparison of dumping site and control sites pH of soil

Season	Dumping site	Reference/control
Post monsoon 2016-17	5.23	6.84
Pre Monsoon 2016-17	5.59	6.95
Monsoon 2016-17	5.05	6.5
Post monsoon 2017-18	5.36	6.36
Pre Monsoon 2017-18	5.71	6.92
Monsoon 2017-18	5.08	5.67

“pH or Hydrogen ion concentration is an important quality of natural soil. The pH of natural soil lays between7-8.5 and the variation is due to biological activity, temperature, disposal of municipal waste etc.” (Oyedele *et.al.,* 2008). The life and growth of plant is directly affects by the soil pH as it affects the obtainability of all nutrients in the soil. “A pH range of 6.5-7.5 is considered as the range in which the most of the soil nutrients are available to plant” (Raman *et al.,* 2009). During the study period pH of the soil were lower in dumping site then the reference site, from the result it is clear that the waste material was acidic and percolation of this waste material to the soil lower the pH of the soil in dumping site. Significant change was not observed from statistical analysis between dumping site and control site (H=0.355) at P>0.05 **(Appendix IV).**

Bulk density:

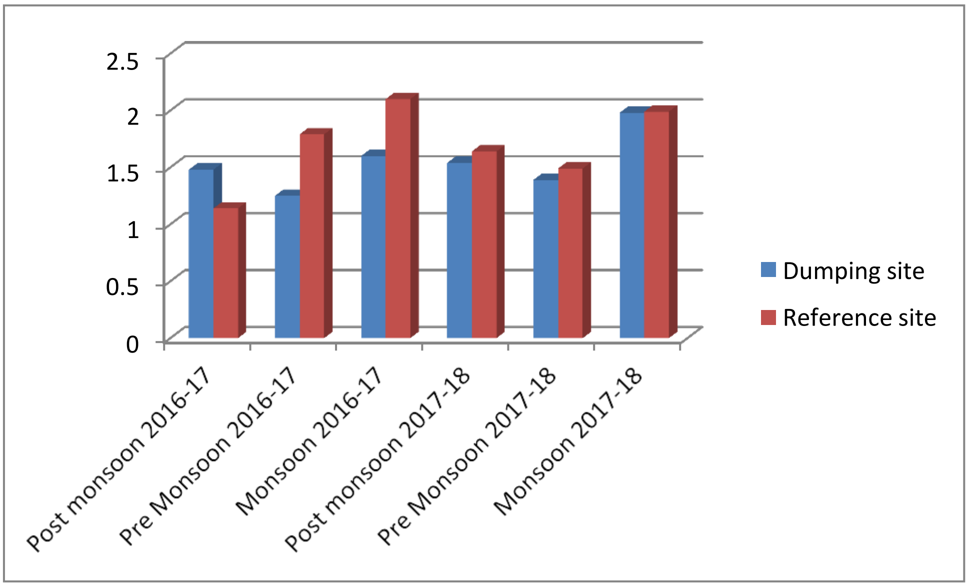

Fig. 4.10 comparison of dumping site and control sites bulk density

Table 4.12: comparison of dumping site and control sites bulk density (gcm^{-3}) of soil

Season	Dumping site	Reference site
Post monsoon 2016-17	1.48	1.14
Pre Monsoon 2016-17	1.25	1.79
Monsoon 2016-17	1.6	2.1
Post monsoon 2017-18	1.54	1.64
Pre Monsoon 2017-18	1.39	1.49
Monsoon 2017-18	1.98	1.99

Bulk densities of the study site were higher in the reference site except post monsoon season of the first year during the study period which shows that dumping of waste increases bulk density of the soil by retaining moisture content and increasing its water holding capacity **(Table 4.12 and Fig 4.11)**. It may be due to changes of soil texture. . From the statistical analysis it was found that bulk density has significant change between dumping site and control site ($H=0.042$ at $P<0.05$) **(Appendix IV).**

Moisture content (%)

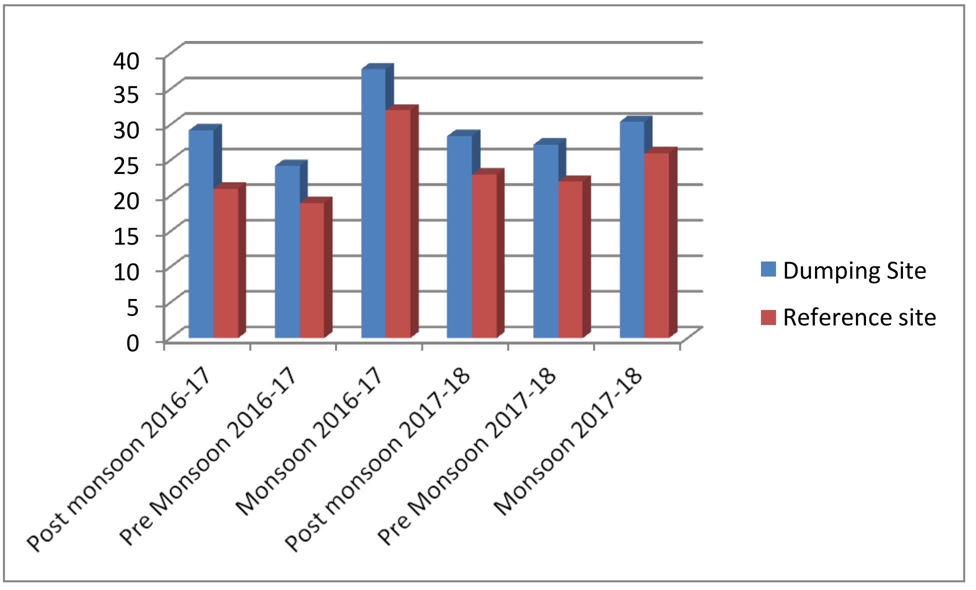

Fig.4.11 comparison of dumping site and control site moisture content

Table 4.13: comparison of dumping site and control site moisture content (%) of soil

Season	Dumping Site	Reference site
Post monsoon 2016-17	29.2	21
Pre Monsoon 2016-17	24.2	19
Monsoon 2016-17	37.8	32
Post monsoon 2017-18	28.4	23
Pre Monsoon 2017-18	27.2	22
Monsoon 2017-18	30.4	26

Average Moisture content of the study site ranges from 19% to 37.8% during the study period. Maximum value was at dumping site during Monsoon season and minimum at reference site during pre-Monsoon season **(Table 4.13 and Fig.4.12).** From the observation, it is found that dumping of solid waste increases the moisture content of the soil. There was significant change (H= 0.022 at $P \leq 0.05$) **(Appendix V)** between dumping site and control site. "The moisture content of soil sample simply the presence of leachate those likely to generate from the discarded solid waste. Insufficient generation of leachate tends to evaporate moisture during summer meanwhile the residues remain in the soil, which contaminates the properties of soil" (Eddy *et al.*, 2006).

Organic Carbon content (%):

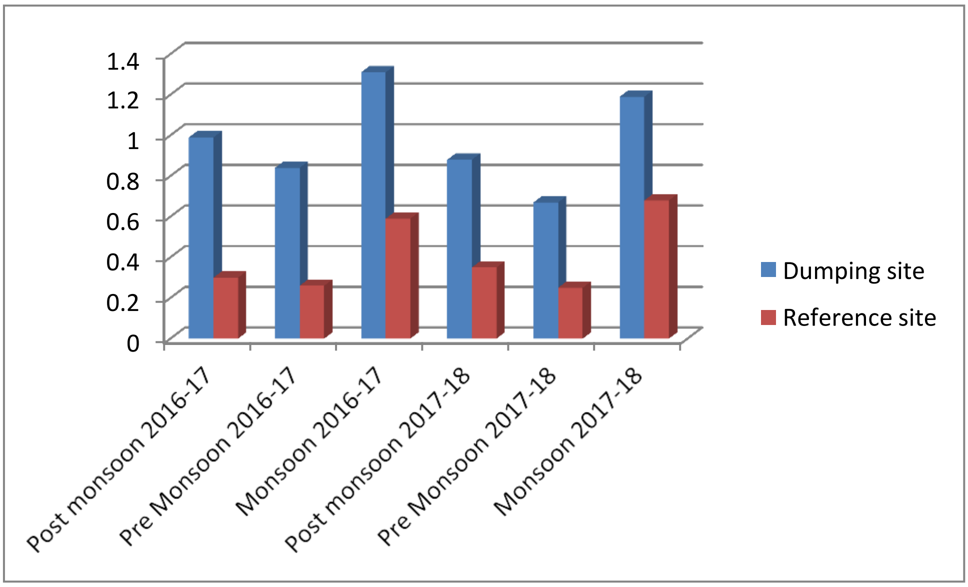

Fig. 1.12 comparison of dumping site and control sites organic carbon

Table 4.14 comparison of dumping site and control sites organic carbon content (%) of soil

Season	Dumping site	Reference site
Post monsoon 2016-17	0.99	0.3
Pre Monsoon 2016-17	0.84	0.26
Monsoon 2016-17	1.31	0.59
Post monsoon 2017-18	0.88	0.35
Pre Monsoon 2017-18	0.67	0.25
Monsoon 2017-18	1.19	0.68

The concentration of organic carbon ranges from 0.25 at reference site during pre-monsoon season of the second year and 1.31 at dumping site during monsoon season of the second year during the study period **(Table 4.13 and Fig.4.12)**. Organic carbon concentrations tend to increase at the dumping site. It was also observed that there is significant change in organic carbon content between control site and dumping site (H=0.009 at P≤0.05) **(Appendix IV).** Chouaki *et al.*, (2019), Zhou *et al*., (2012), also found that high values of organic carbon in duping site compare to non-dumping site and state that it could be explained by the build-up of the municipal solid waste, which is a source of large amounts of organic matters resulting from the decomposition process and the composting of organic waste.

Total Nitrogen Content:

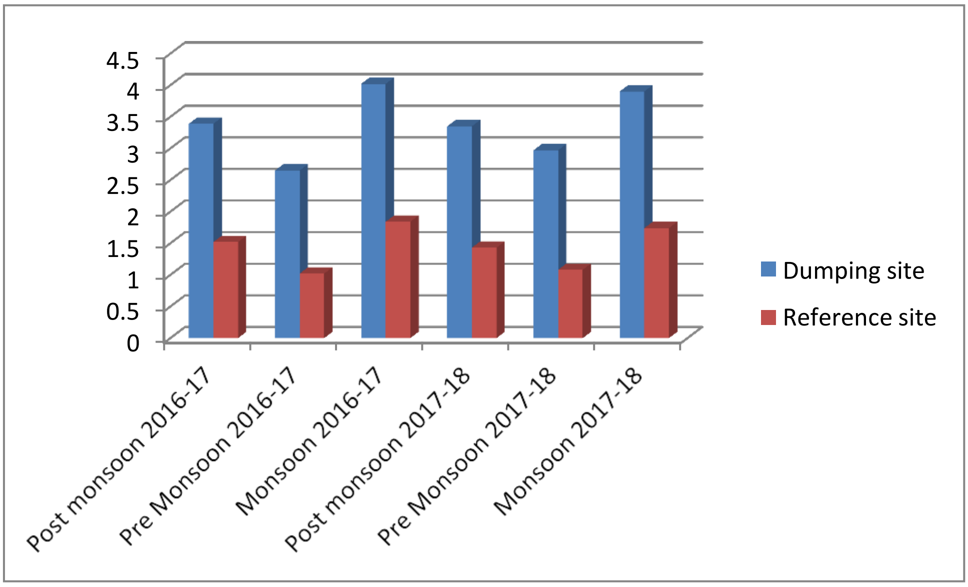

Fig.4.13 comparison of dumping site and control sites Total Nitrogen

Table 4.15 comparison of dumping site and control sites Total Nitrogen content (Mgkg^{-1}) of soil

Season	Dumping site	Reference site
Post monsoon 2016-17	3.39	1.52
Pre Monsoon 2016-17	2.65	1.02
Monsoon 2016-17	4.02	1.84
Post monsoon 2017-18	3.35	1.43
Pre Monsoon 2017-18	2.97	1.08
Monsoon 2017-18	3.9	1.74

During the study period nitrogen value ranges from 1.02 to 4.02 at reference site in pre monsoon and maximum at dumping site in Monsoon season respectively **(Table 4.15 and Fig.4.14)**. From the results, it is found that nitrogen content was higher in dumping site than the reference site as a result of decomposition of organic matter containing nitrogen. But statistical analysis do not show significant change between dumping site and control site($H=0.764$ at $P\leq0.05$) **(Appendix IV).** And also the nitrogen content tends to increase with an increase in moisture content of the soil. Nitrogen is a significant macro nutrient of the soil. It is repeatedly cycled among plants, soil organisms, soil organic matter, water and atmosphere.

Available Phosphorus

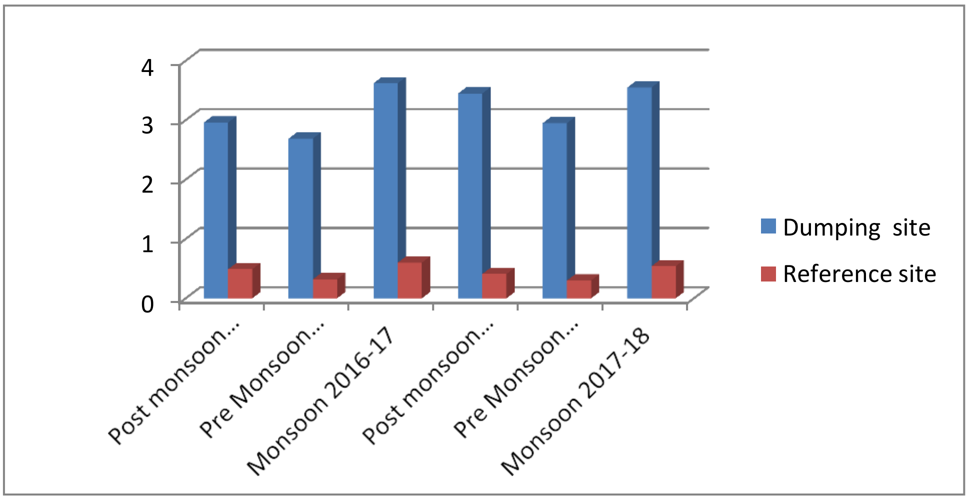

Fig 4.14 comparison of dumping site and control sites Available Phosphorus

Table 4.16 comparison of dumping site and control sites Available Phosphorus

Season	Dumping site	Reference site
Post monsoon 2016-17	2.96	0.49
Pre Monsoon 2016-17	2.69	0.32
Monsoon 2016-17	3.62	0.6
Post monsoon 2017-18	345	0.41
Pre Monsoon 2017-18	2.95	0.3
Monsoon 2017-18	3.55	0.54

During the study period, phosphorus content was higher during monsoon seas and lower during Pre-monsoon season. The value of Phosphorus was found much higher in dumping site than reference site **(Table 4.15 and Fig.4.14)**. This could be due to decomposition of bone and ash from organic waste which contain high amount of phosphorus. Statistical analysis also proved significant change between dumping site and control site (H=0.034 at $P \leq 0.05$) **(Appendix IV).**The maximum and minimum value ranges from 0.32-3.62 during the study period. Phosphorus is an essential element for plant growth. Lack of phosphorus has negative impact on agriculture land.

Exchangeable Potassium

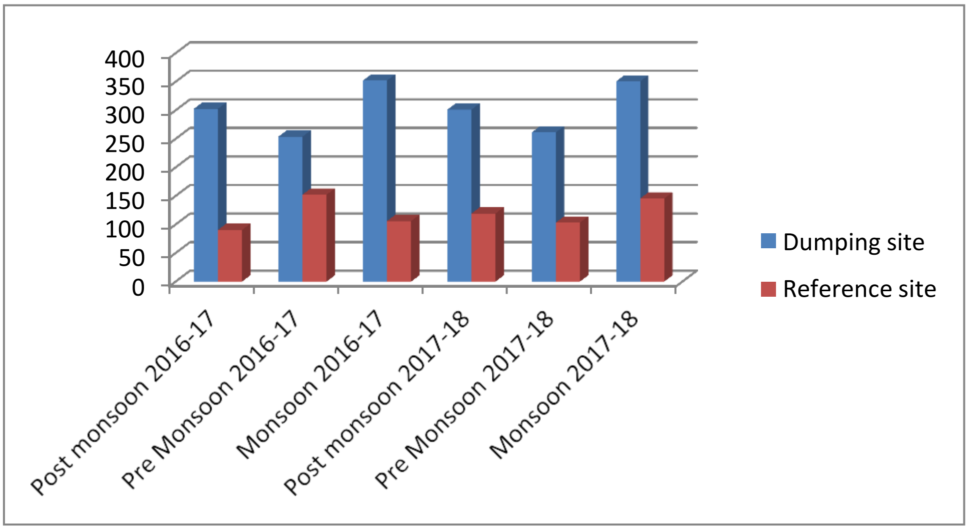

Fig4.15 comparison of dumping site and control sites Exchangeable Potassium

Table 4.17 comparison of dumping site and control sites Exchangeable Potassium (Mgkg^{-1}) of soil

Season	Dumping site	Reference site
Post monsoon 2016-17	302.5	90.36
Pre Monsoon 2016-17	253.7	152.12
Monsoon 2016-17	351.9	105.99
Post monsoon 2017-18	301.1	119.24
Pre Monsoon 2017-18	261.1	103.27
Monsoon 2017-18	350.5	145.5

Potassium content was higher during monsoon season and lower during pre-monsoon season. The value ranges from 90.36 at reference site in post monsoon season and 351.9 at dumping site in monsoon season of the first year during the study period **(Table 4.16 and Fig.4.15)**. From the result, it is found that dumping of solid waste increases the value of exchangeable potassium concentration in the soil. Statistical analysis also proved significant change between dumping site and control site ($H=0.00$ at $P\leq 0.05$) **(Appendix IV).** "Potassium is considered the second important macro element for soil and crop productivity. Hence excess of potassium is not harmful" (Utpal *et al,.* 2008). Potassium contents in soil are due to degradation of solid waste, and it is one of the important elements for healthy growth" (Effiong and Lbia 2003, Eddy *et al.,* 2006). Nitrogen and water cannot be utilized competently if potassium is lacking in soil (Raman *et al.,* 2012). Potassium content was higher during monsoon season and lower during pre-monsoon season. The value ranges from 90.36 at reference site in post monsoon season and 351.9 at dumping site in monsoon season of the first year during the study period. From the result, it is found that dumping of solid waste increases the value of exchangeable potassium concentration in the soil.

From the observation, it is clear that dumping of solid waste can change soil characteristics. We can say that, waste disposal can increases soil productivity somehow by increasing soil moisture content, organic carbon and important nutrients for plant growth. However, microbial analysis is needed to check the health of soil as waste can contain many harmful micro-organisms.

CHAPTER 5

SUMMARY AND CONCLUSIONS

SUMMARY

The present study was conducted during November 2016 to October 2018, the study period was divided into three season viz., Pre-monsoon (January to April), Monsoon (May to August) and Post-monsoon (September to December). It was carried out in Kolasib town, Mizoram. Solid waste management of Kolasib town was studied by using field observation, interviews and site survey. Waste generation was analysed by taking random sample from the study site and the sample were segregated and weighted manually. The objectives of this study were (i) survey of solid waste disposal in Kolasib Town (ii) solid waste generated in Kolasib Town (iii) assessment of impact of solid waste disposal on soil characteristics.

The study area was specifically localised in Kolasib Town solid waste dumping ground which is located at Rengte tlang about 7km from Kolasib Town. The waste after being scavenged by waste collectors are usually left in the dumping ground with occasional burning. Run-off from rainfall usually transport this leftover to the adjoining river and annual streams which ultimately gets deposited to River. The slope of the hill is about 65 degree from the bottom line. The unprocessed solid wastes were dumped over the slope of the hill. The height of the hill is 200 feet approximately. The garbage thickness from the top soil is about 6 inches. For waste generation study personal interviews, questionnaire was engaged. For soil physic-chemical analysis „Handbook of soil and water analysis‟ Maiti, 2004 was referred.

The findings of present investigation can be summarized as follows:

- The approximate amount of waste collected daily is 7 tons, wastes were not segregated at the source and dumping ground. Solid waste management was carried out by Urban Development and Poverty Alleviation Department, Government of

Mizoram, in which there was no safety measure for the garbage collectors. There were only two trucks which ply around the town for garbage collection and can cover only 40% of the town area. All the wastes were burnt occasionally whenever it was needed. The solid waste management in Kolasib Town does not meet the existing Solid Waste Management Rules, 2016 in different manner.

- The wastes generated were segregated into eight categories i.e., Organic (food waste), Paper and paper product, Plastics, Glass, Metal, Textiles (Rubber, leather cardboard, Polyester), Inorganic substance (concrete, stone, ash, carbon parts), others. organic (food waste) constitute highest percentage 32.5% which was followed by Inorganic substances like concrete cements, stone, ash and carbon parts 24%, paper and paper products contribute 21%, plastics waste 11% was the third highest contributor of waste, textiles waste (rubber, leather, cardboard, polyester etc.) accounts 5% followed by glass 4% and metals 2%. Apart from metal wastes, no others were not processed or collected for recycled.

- The physico-chemical characteristics of the soil were studied by examining seven parameters viz., pH, Bulk Density, moisture content, organic carbon, total nitrogen, available phosphorus and exchangeable potassium were analysed. Soil sample were analysed monthly and the data observed were presented seasonally. For impact assessment, the findings at control site were with values at sampling sites within dumping area. The major finding on physico-chemical parameters of the soil can be summarized as follows:

- The pH of the soil varied from 4.7 – 6.95mg/l control site has higher pH value compare to dumping site. pH value was higher during pre-monsoon and post monsoon season and lower during monsoon season. This could be due to dilution of hydrogen ion concentration by rain water which is acidic in nature. Soil pH is a measure of acidity and alkalinity in soil pH levels range from 0 to 14, with 7 being neutral, below 7 acidic and above 7 alkaline. The optimal pH range for most plant is between 5.5 and 7.0. However, many plants have adopted to thrive at pH values outside this range.

- The bulk density of the soil ranges from 1.01gcm^{-3}to 2.10gcm^{-3}during the study period. Bulk density shows higher value at monsoon season and lowers during post monsoon season which could be due to compaction of soil texture by rainfall. Control sites have higher bulk density value than dumping area. Soil with a bulk density higher than 1.6g/cm^{3} tends to restrain the growth of root. It indicate the compaction of soil. It is calculated as the dry weight of soil divided by its volume. This volume includes volume of soil particles and volume of pores among soil particles.

- The moisture content of the soil varied from 19% to 41%. It was higher during monsoon period and lower during pre-monsoon period which is due to increase in humidity of soil by rain water. Control site has lower moisture content than dumping site. The optimum moisture content is the water content at which maximum dry unit weight can be achieved after given compaction effort. A maximum dry unit weight would have no holes in the soil. If the moisture content of soil is desirable for plant growth, plants can easily absorb soil water, in which much of water remains in the soil as a thin film.

- The organic carbon content ranges from 0.25% to 1.37%. It was high during monsoon seasons and lowers during pre-monsoon and post monsoon seasons. Dumping site has higher amount of organic carbon than control site. Organic Carbon enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms and soil biota. Soil organic matter (SOM) is the organic segment of soil limited on non-decomposed plant and animal residues. Increase in total organic carbon in soil may lead to decrease in atmosphere carbon dioxide and increased soil quality.

- The Total Nitrogen content of the soil varied from 1.02mgkg^{-1}- 4.43mgkg^{-1}during the study period. It was found higher during monsoon season and lower during pre-monsoon season this could be due to leachate that enter in the soil through rain water run-off. Control site has lower nitrogen content than dumping site. The higher the value for soil nitrogen supply the more likely it is that microorganisms in soil will convert more organic nitrogen into mineral nitrogen for plant uptake. However, in granular textured soil where there is high soil nitrogen supply, it is also more likely that nitrate will be leached down the soil profile out of reach of plant roots and possibly into water ways.

- The available Phosphorus content ranges from 0.3mgkg^{-1}to 4.32mgkg^{-1}. It was found to be higher during monsoon season and lower during pre-monsoon season. Dumping site has higher available-P than control site. It is vital micro-element, required for plant nutrition. The types of phosphorous compounds that exists in the soil are mostly determined by soil pH and by the type and amount of minerals in the soil, mineral compounds of phosphorous usually contain aluminium, iron, manganese and calcium

- The exchangeable K varied from 90.36mgkg^{-1}to 405.78mgkg^{-1}. It was lower during pre-monsoon and post monsoon season and higher during monsoon season. Control site has lower potassium content compare to dumping site. Potassium, unlike nitrogen and phosphorous, is not associated to any great extent with organic matter. Total amount of potassium in soil will vary from 0.3% to more than 2.5% while total content of potassium is significant. It is of little value in defining low were a given soil can supply potassium to growing plants.

- Dumping of solid waste has great impact on soil characteristic in which it changes the concentration of different physico-chemical parameters. Statistical analysis also proved this change except for pH and Total Nitrogen content at 95% level confidence. From the observation we can say that dumping of waste enhances soil productivity by increasing soil nutrient and soil moisture content but there is possibility of accumulation of harmful micro-organisms detailed investigations is needed to check the health of the soil.

CONCLUSION AND RECOMMENDATION

Based on findings of present investigation it can be concluded that the existing solid waste management practices does not meet the requirements of Municipal solid Waste Management rules, 2016. The number of garbage trucks is not sufficient to collect every waste in the Town area. Most of the wastes generated were not processed for re-use and recycle. The study of physico-chemical parameters show that there is significant change between dumping site and control site which indicates that the solid waste has great impact on the soil quality. It signifies that if the waste was properly managed in the dumping area, it can be used to enhance the soil quality in some manner. On the other hand, as this study does not include soil micro-organisms and pathogenic microbes, dumping of waste in an open area may affect the health of the soil as well as human beings and other living organisms. Also, as the solid waste were not segregated and dumped in one place, all the dumping area was covered by waste material and did not support plant growth. Burning of waste in open air may seriously affect health. Detail investigation on soil micro-organism and pathogenic microbes needs to be addressed to study the impact of solid waste on soil quality. For the better management of solid waste in the study area, it is suggested/ recommended that-

1. Segregation of waste at the source is of utmost importance for better management. For this, public awareness needs to be strengthened.
2. Health and safety measures were needed for garbage collector to check their health impact due to solid waste.
3. Garbage trucks need to be construct with hood as open truck were not recommended for carrying solid waste.
4. Burning of waste at dumping area needs to be avoided as it creates a lot of air pollution.
5. Organic and inorganic wastes need to be dumped separately.
6. Different waste which can be recycled should be collected for recycle which will reduce the amount of solid waste and also will generate economic income to the people.
7. Open dumping of solid waste on ground should be minimized especially for inorganic was as leachate can affect the soil as well as ground water.

<u>Appendix-I</u>

Monthly variation in solid waste generation.

(i) Solid Waste generated during 2016-17 in kg.

Types of solid waste	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**
Organic (food waste)	34	33	32	37	32	35	36	37	40	39	41	36
Paper and paper product	21	20	21	20	19	16	14	20	24	23	18	19
Plastics	15	12	13	06	12	08	11	06	06	12	13	09
Glass	04	04	08	02	03	03	05	03	08	07	09	06
Metal	03	02	04	03	05	07	06	03	07	07	08	07
Textiles (Rubber, leather cardboard, Polyster)	05	05	06	04	07	05	05	07	05	04	04	08
Inorganic substance (concrete, stone, ash, carbon parts)	17	23	19	27	21	25	22	23	09	07	06	14
Others	01	01	01	01	01	01	01	01	01	01	01	01

(ii)Solid Waste generated during 2017-18 in kg.

Types of solid waste	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Organic (food waste)	41	40	42	39	38	34	42	39	34	39	35	36
Paper and paper product	12	13	11	08	13	21	13	12	16	23	12	17
Plastics	02	09	08	07	07	06	06	11	14	12	13	10
Glass	09	08	06	09	05	04	07	03	11	07	09	09
Metal	07	05	06	04	05	02	02	06	05	07	07	04
Textiles (Rubber, leather cardboard, Polyster)	08	06	07	12	08	07	08	10	12	04	09	07
Inorganic substance (concrete, stone, ash, carbon parts)	20	18	19	20	23	25	21	18	07	07	14	16
Other	01	01	01	01	01	01	01	01	01	01	01	01

Appendix-II

Monthly variation inSoil Characteristics.

pH:

Months	**LA_1**	**LA_2**	**RA_1**	**RA_2**	**C**	**R**
NOV.,2016	4.24	4.89	5.66	5.71	5.75	6.01
DEC.,2016	3.52	3.11	3.01	3.26	4.01	4.90
JAN.,2017	3.91	3.12	4.32	4.36	5.71	5.99
FEB.,2017	4.20	4.51	4.90	5.51	5.21	6.05
MARCH,2017	4.50	4.70	5.15	5.01	5.11	5.61
APRIL,2017	5.60	5.90	6.13	6.02	7.03	7.38
MAY,2017	5.21	5.78	5.27	5.05	5.01	4.96
JUNE,2017	6.76	6.71	6.51	6.27	6.66	6.03
JULY,2017	7.02	7.13	7.27	7.56	7.91	8.10
AUG.,2017	6.94	6.85	7.10	7.10	7.15	7.27
SEPT.,2017	5.10	4.97	4.51	4.49	4.25	4.10
OCT.,2017	4.91	4.52	4.45	4.12	4.10	3.97
NOV.,2017	4.81	4.72	5.24	5.36	5.82	6.36
DEC.,2017	4.23	4.15	4.83	4.12	5.21	5.84
JAN.,2018	3.75	3.33	4.57	4.74	4.57	4.91
FEB.,2018	3.96	3.76	4.59	5.79	4.93	6.15
MARCH,2018	4.59	4.89	5.51	5.84	5.14	6.02
APRIL,2018	5.23	4.95	5.74	6.63	5.27	5.91
MAY,2018	5.10	5.42	5.22	4.86	4.91	4.92
JUNE,2018	6.52	6.49	6.45	6.25	6.52	6.12
JULY,2018	6.98	6.91	7.12	7.49	7.59	7.67
AUGUST,2018	6.87	6.72	6.51	6.45	6.39	6.31
SEPT., 2018	4.75	4.63	4.42	4.35	4.37	4.45
OCT.,2018	4.66	4.58	4.10	4.12	4.18	3.93

Bulk Density (gcm^{-3}) :

Months	**LA_1**	**LA_2**	**RA_1**	**RA_2**	**C**	**R**
NOV.,2016	1.81	1.76	1.31	1.09	1.45	1.47
DEC.,2016	1.56	1.29	1.01	1.35	1.37	1.81
JAN.,2017	1.36	1.11	1.24	1.81	1.23	1.61
FEB.,2017	1.23	1.41	1.92	1.23	1.11	1.19
MARCH,2017	1.01	1.23	1.57	1.34	1.11	1.79
APRIL,2017	0.88	0.89	0.94	1.35	1.12	1.17
MAY,2017	4.26	4.01	3.93	3.15	3.10	3.53
JUNE,2017	0.81	0.94	0.97	1.01	1.10	1.23
JULY,2017	1.35	1.22	1.48	1.97	1.99	2.10
AUG.,2017	1.29	1.31	1.45	1.37	1.42	1.51
SEPT.,2017	0.31	0.34	0.45	1.12	1.14	1.190
OCT.,2017	0.15	0.17	0.43	1.11	1.02	1.09
NOV.,2017	1.79	1.89	1.41	1.23	1.39	1.64
DEC.,2017	1.63	1.46	1.36	1.39	1.35	1.98
JAN.,2018	1.52	1.32	1.38	1.94	1.30	1.76
FEB.,2018	1.49	1.24	1.93	1.36	1.24	1.21
MARCH,2018	1.31	1.21	1.84	1.45	1.17	1.49
APRIL, 2018	1.00	0.99	0.98	1.46	1.10	1.27
MAY,2018	4.21	3.98	2.96	2.94	2.91	2.99
JUNE,2018	0.78	0.89	0.93	0.95	0.97	1.21
JULY,2018	1.29	1.20	1.43	1.92	1.98	1.99
AUGUST,2018	1.25	1.29	1.38	1.28	1.37	1.42
SEPT., 2018	0.27	0.31	0.43	0.91	0.94	0.98
OCT.,2018	0.12	0.15	0.40	0.76	0.82	0.88

Soil Moisture content (%) :

Months	LA_1	LA_2	RA_1	RA_2	C	R
NOV.,2016	37.11	42.21	38.91	37.16	42.07	28.00
DEC.,2016	62.90	75.61	63.41	61.71	37.22	41.30
JAN.,2017	42.37	57.91	47.36	47.11	22.93	29.50
FEB.,2017	61.21	59.36	51.29	49.55	45.21	39.79
MARCH,2017	51.21	61.70	53.22	51.57	26.12	38.29
APRIL,2017	43.05	54.45	43.10	40.80	24.75	32.90
MAY,2017	53.21	50.37	48.12	41.77	41.11	43.24
JUNE,2017	87.22	85.31	80.27	80.01	80.97	78.33
JULY,2017	90.75	87.21	85.22	84.00	87.95	80.12
AUG.,2017	85.21	85.12	84.57	83.99	83.13	87.90
SEPT.,2017	72.41	71.43	69.91	67.12	67.10	69.12
OCT.,2017	69.52	65.31	60.91	59.27	59.15	58.70
NOV.,2017	42.91	53.41	49.12	41.26	45.12	30.41
DEC.,2017	53.48	71.78	54.28	54.87	41.91	42.73
JAN.,2018	61.12	63.91	51.17	46.33	38.94	40.94
FEB.,2018	67.35	61.98	54.26	47.41	32.74	29.13
MARCH,2018	62.74	58.43	47.98	53.72	29.78	35.91
APRIL, 2018	53.81	51.21	41.99	47.92	24.66	31.77
MAY, 2018	50.94	48.45	45.34	37.95	38.37	39.95
JUNE, 2018	85.36	83.25	76.43	77.47	77.41	75.27
JULY,2018	88.29	85.70	81.24	79.31	85.52	77.36
AUG.,2018	82.48	81.65	79.36	80.62	79.61	83.42
SEPT.,2018	68.32	68.20	65.74	65.34	63.25	65.81
OCT., 2018	66.74	61.85	57.44	56.69	56.63	54.35

Organic Carbon content (%) :

Months	LA_1	LA_2	RA_1	RA_2	C	R
NOV.,2016	0.81	0.57	0.81	0.76	0.14	0.10
DEC.,2016	0.55	0.31	0.22	0.97	0.34	0.06
JAN.,2017	0.37	0.55	0.43	0.96	0.41	0.15
FEB.,2017	1.93	1.81	1.21	2.31	2.45	2.13
MARCH,2017	0.26	0.41	0.31	0.85	0.27	0.01
APRIL,2017	0.18	0.27	0.22	0.74	0.33	0.03
MAY,2017	0.98	0.92	0.75	0.61	0.59	0.72
JUNE,2017	0.21	0.27	0.84	0.91	0.93	0.98
JULY,2017	0.27	0.28	0.18	0.33	0.19	0.12
AUG.,2017	0.21	0.20	0.25	0.22	0.31	0.19
SEPT.,2017	0.21	0.27	0.33	0.34	0.51	0.55
OCT.,2017	0.13	0.21	0.28	0.29	0.35	0.47
NOV.,2017	0.87	0.46	0.96	0.72	0.21	0.15
DEC.,2017	0.81	0.42	0.36	0.84	0.36	0.21
JAN.,2018	0.63	0.59	0.52	0.87	0.39	0.21
FEB.,2018	0.89	1.74	1.41	2.01	2.13	2.56
MARCH,2018	0.47	0.71	0.81	0.91	0.45	0.05
APRIL, 2018	0.14	0.41	0.42	0.89	0.37	0.01
MAY,2018	0.95	0.85	0.72	0.58	0.56	0.67
JUNE,2018	0.36	0.22	0.81	0.87	0.89	0.88
JULY,2018	0.38	0.25	0.15	0.29	0.17	0.19
AUGUST,2018	0.33	0.16	0.21	0.18	0.28	0.51
SEPT., 2018	0.31	0.23	0.31	0.29	0.49	0.42
OCT.,2018	0.12	0.19	0.25	0.26	0.31	0.13

Nitrogen (Mgkg^{-1}):

Months	**LA$_1$**	**LA$_2$**	**RA$_1$**	**RA$_2$**	**C**	**R**
NOV.,2016	35.02	31.93	21.66	22.11	25.00	29.18
DEC.,2016	25.20	26.98	31.28	37.13	38.94	41.12
JAN.,2017	27.17	29.35	35.33	39.92	42.33	44.29
FEB.,2017	41.21	43.45	49.61	50.31	44.72	39.85
MARCH,2017	25.61	26.42	29.20	31.24	35.09	30.20
APRIL,2017	38.50	39.50	40.50	45.50	37.60	35.00
MAY,2017	55.29	57.26	59.33	53.78	50.24	49.91
JUNE,2017	66.71	62.11	61.61	59.23	59.89	48.14
JULY,2017	41.25	42.12	43.24	43.56	44.11	44.78
AUG.,2017	43.51	43.81	44.91	44.45	47.13	46.12
SEPT.,2017	61.20	60.91	57.81	55.24	49.37	48.71
OCT.,2017	59.61	59.15	57.02	55.19	53.24	48.35
NOV.,2017	36.21	37.43	27.35	25.37	27.22	27.36
DEC.,2017	31.75	25.61	35.71	32.49	29.91	39.41
JAN.,2018	27.36	27.12	34.39	37.24	40.36	41.38
FEB.,2018	25.49	42.80	45.76	48.36	38.17	49.22
MARCH,2018	31.06	38.25	31.29	38.21	32.28	37.16
APRIL, 2018	37.11	41.37	39.74	41.72	39.36	31.74
MAY,2018	55.12	57.18	59.26	53.52	50.55	49.95
JUNE,2018	66.54	62.10	61.41	59.14	59.76	48.10
JULY,2018	41.92	42.36	43.51	43.65	44.28	44.72
AUGUST,2018	43.27	43.75	44.85	44.35	47.26	46.22
SEPT., 2018	61.15	60.84	57.29	55.35	49.21	48.53
OCT.,2018	59.13	60.80	57.80	55.18	49.25	48.33

Phosphorus ($Mgkg^{-1}$):

Months	LA_1	LA_2	RA_1	RA_2	C	R
NOV.,2016	30.17	27.36	25.78	25/14	24.00	23.99
DEC.,2016	25.37	24.91	24.37	23.95	21.97	21.23
JAN.,2017	26.21	25.72	25.23	24.75	23.41	23.11
FEB.,2017	38.12	37.36	35.41	31.82	31.51	30.33
MARCH,2017	35.91	32.31	31.23	30.81	29.13	28.22
APRIL,2017	41.98	39.61	37.37	34.89	34.41	33.22
MAY,2017	35.25	35.91	33.77	31.27	30.00	31.96
JUNE,2017	18.21	18.00	17.55	17.21	17.67	17.12
JULY,2017	32.15	30.24	29.26	28.37	28.12	28.01
AUG.,2017	40.37	40.11	39.97	39.50	41.95	39.91
SEPT.,2017	17.91	17.67	17.61	17.59	16.92	16.81
OCT.,2017	16.83	16.24	17.62	17.61	17.57	17.50
NOV.,2017	32.31	32.63	31.41	27.47	29.41	25.41
DEC.,2017	27.84	27.11	29.26	24.36	27.63	24.78
JAN.,2018	29.23	26.94	25.17	25.73	21.24	21.34
FEB.,2018	35.75	32.48	38.00	35.24	38.71	36.75
MARCH,2018	31.26	37.25	35.93	32.88	35.92	31.92
APRIL, 2018	39.11	39.63	31.74	29.73	31.64	32.79
MAY,2018	35.15	35.87	33.27	31.15	29.94	30.91
JUNE,2018	17.91	17.74	17.18	17.17	17.26	17.10
JULY,2018	31.86	30.12	29.12	28.14	27.79	27.97
AUGUST,2018	40.22	40.10	39.55	39.26	41.23	39.71
SEPT., 2018	17.73	17.27	17.21	17.41	16.47	16.59
OCT.,2018	16.54	16.15	17.44	17.42	17.35	17.26

Exchangeable - K (Mgkg^{-1}) :

Months	LA_1	LA_2	RA_1	RA_2	C	R
NOV.,2016	167.11	401.98	376.41	355.93	381.11	590.36
DEC.,2016	162.38	421.89	391.36	348.11	390.18	45.55
JAN.,2017	181.11	497.81	411.26	301.95	400.10	49.93
FEB.,2017	315.12	772.35	621.78	511.23	491.92	61.13
MARCH,2017	193.71	539.22	461.81	311.01	411.37	52.12
APRIL,2017	220.68	649.90	552.90	320.10	426.80	50.44
MAY,2017	234.17	237.89	220.61	219.84	211.25	201.70
JUNE,2017	280.60	271.22	271.14	271.00	271.81	269.83
JULY,2017	291.22	297.33	305.12	305.36	305.78	305.99
AUG.,2017	189.23	194.71	202.40	210.00	215.59	230.18
SEPT.,2017	271.82	269.88	267.72	266.98	265.12	261.91
OCT.,2017	194.23	425.12	412.31	331.26	354.26	554.37
NOV.,2017	191.74	400.36	382.45	312.14	372.78	519.24
DEC.,2017	201.44	484.15	399.56	296.58	429.63	536.78
JAN.,2018	258.67	612.38	423.81	499.36	454.15	429.81
FEB.,2018	295.91	412.99	497.35	481.72	450.98	371.24
MARCH,2018	273.74	497.06	499.42	368.44	431.36	324.27
APRIL, 2018	210.56	529.74	528.63	341.92	412.77	302.40
MAY,2018	234.22	237.86	219.77	218.56	210.67	201.33
JUNE,2018	280.59	271.12	269.83	267.82	271.23	269.25
JULY,2018	290.98	297.26	305.24	304.91	305.69	239.84
AUGUST,2018	188.65	194.68	209.74	209.76	215.23	261.72
SEPT., 2018	270.72	269.77	266.65	266.73	264.73	554.15
OCT.,2018	194.15	424.93	331.19	330.85	353.89	554.17

Appendix-III

Correlation Coefficient analysis between different soil characteristics

		pH	BulkDensity	MoistureContent	OrganicCarbon	Nitrogen	Phosphorus	Potassium
pH	Correlation Coefficient	1	0.153	.269**	-.259**	0.154	.334**	-.208*
	Sig. (2-tailed)	.	0.068	0.001	0.002	0.065	0	0.012
	N	144	144	144	144	144	144	144
BulkDensity	Correlation Coefficient	0.153	1	-.232**	.190*	-.295**	.430**	-0.139
	Sig. (2-tailed)	0.068	.	0.005	0.023	0	0	0.096
	N	144	144	144	144	144	144	144
MoistureContent	Correlation Coefficient	.269**	-.232**	1	-.192*	.397**	-0.105	-.223**
	Sig. (2-tailed)	0.001	0.005	.	0.021	0	0.21	0.007
	N	144	144	144	144	144	144	144
OrganicCarbon	Correlation Coefficient	-.259**	.190*	-.192*	1	0.012	0.097	0.145
	Sig. (2-tailed)	0.002	0.023	0.021	.	0.886	0.248	0.084
	N	144	144	144	144	144	144	144
Nitrogen	Correlation Coefficient	0.154	-.295**	.397**	0.012	1	-.291**	-.274**
	Sig. (2-tailed)	0.065	0	0	0.886	.	0	0.001
	N	144	144	144	144	144	144	144
Phosphorus	Correlation Coefficient	.334**	.430**	-0.105	0.097	-.291**	1	-0.088
	Sig. (2-tailed)	0	0	0.21	0.248	0	.	0.293
	N	144	144	144	144	144	144	144
Potassium	Correlation Coefficient	-.208*	-0.139	-.223**	0.145	-.274**	-0.088	1
	Sig. (2-tailed)	0.012	0.096	0.007	0.084	0.001	0.293	.
	N	144	144	144	144	144	144	144

Appendix-IV

ANOVA analysis between different soil characteristics

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	7.731	5	1.546	1.190	.317
	Within Groups	179.308	138	1.299		
	Total	187.039	143			
BulkDensity	Between Groups	1.277	5	.255	.431	.042
	Within Groups	81.812	138	.593		
	Total	83.090	143			
MoistureContent	Between Groups	4617.223	5	923.445	3.101	.022
	Within Groups	41094.431	138	297.786		
	Total	45711.655	143			
OrganicCarbon	Between Groups	1.144	5	.229	.920	.009
	Within Groups	34.301	138	.249		
	Total	35.445	143			
Nitrogen	Between Groups	103.460	5	20.692	.165	.764
	Within Groups	17277.946	138	125.203		
	Total	17381.406	143			
Phosphorus	Between Groups	273.042	5	54.608	.824	.034
	Within Groups	9142.940	138	66.253		
	Total	9415.981	143			
Potassium	Between Groups	407029.871	5	81405.974	5.650	.000
	Within Groups	1988162.104	138	14406.972		
	Total	2395191.974	143			

APPENDIX V

Non- Parametric one way Anova test for seasonal change

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of pH is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of BulkDensity is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.001	Reject the null hypothesis.
3	The distribution of MoistureContent is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
4	The distribution of OrganicCarbon is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.023	Reject the null hypothesis.
5	The distribution of Nitrogen is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
6	The distribution of Phosphorus is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
7	The distribution of Potassium is the same across categories of Sampling seasons.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Appendix - VI

Questionnaire

1. Name of head of the family ____________________________

2. Locality_______________________

3. Size of the family (Number of family members)

4 ( ) 5 - 10 ( ) 11 - 15 ( ) 16 and above ( )

4. Amount of waste generated per day (kg)

   1 - Organic ( ) 2 - Paper ( )

   3 - Plastic ( ) 4 – Glass ( )

5 – Metal ( )6 – Leather, rubber ( )

   7 – Cement, ash, construction waste( ) 8 – Others ( )

5. Methods/Pattern of waste dumping (put tick mark)

   i) At own compound

   ii) Common local dustbin.

   iii) Garbage truck.

   iv) Others (please specify)__________________________

6. Are you segregating waste in separate dustbin ?

   No ( )

   Yes ( ) If yes how many bins ?

   1 ( ) 2 ( ) 3( )

7. Amount of waste generated per day ?

   i) 200g - 500g ( )

   ii) 600g - 1000g ( )

   iii)1000gabove( )

8. How frequent garbage truck ply in your locality ?

   i) Daily ( )

   ii) One day interval ( )

   iii) Once a week ( )

iv) Twice a week (   )

9. Do you feel sufficient the interval of garbage truck in a week ?

i) Not sufficient (   )

ii) Acceptable (   )

iii) Sufficient (   )

10. What kinds of problems did you face in waste disposal method ?

____

11. Comments, if any ?

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PHOTO PLATES

Collection of waste at different locality

PHOTO PLATE IV

Collection of waste from Market

Dumping of waste by garbage truck at Rengte tlang dumping ground

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TITLE OF THESIS	**:**	**Impact of Solid Waste Disposal on Soil Characteristics in Kolasib Town, Mizoram.**
DATE OF ADMISSION	**:**	12.08.2015

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Changes In Soil Characteristics As Influenced By Solid Waste Disposal In Kolasib, Mizoram.

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Abstract : Disposal of solid waste became more and more complex problem in global scale. It creates huge degradation in the environment. Dumping of solid waste in an open area has results in changes of soil physic-chemical properties. As leachate percolates into the soil, it migrates contaminants into the soil and affects soil stability and strength. This study was conducted during November 2016 to October 2018 at waste dumping site located at Rengtetlang, Kolasib, Mizoram during. Soil samples were collected at seasonal interval. Four samples are taken from each corner and one sample from the centre and another one sample outside the dumping site as reference point. Different parameters viz., pH, Bulk Density, moisture content, organic carbon, total Nitrogen N, phosphorus P, exchangeable potassium were analyzed to study changes in soil characteristics as influenced by solid waste disposal. All the data were compared with the references site, from the observation; it is found that dumping of solid in an open area leads to changes in soil chemical properties.

Keywords: ***solid waste, soil, physico-chemical properties*.**

I. INTRODUCTION

Soil is an essential component for the survival of organisms. Soil is one of the important natural resource which provides the main mineral elements for plant growth and crop production. Formation of 1cm top soil layer requires 100-400 years (Deshmukh 2012). Soil pollution arises due to the leaching of solid waste from landfills. Accumulated municipal solid wastes in landfills decompose by a combination of physical, chemical, and biological processes (Asadi Huat et al. 2011). Leachate is generated when water penetrates through the waste in the landfill. The water can be from all forms of water that fall from the air or flow from the surrounding land into the landfill or from the waste itself. Leachates are reflected one of the types of wastewater with the utmost environmental influence. A large volume of leachate is produced in the process of converting solid waste refuse into compost. This is due to the high moisture content of garbage. Garbage leachate has been reported to affect soil physical and chemical properties. It promotes soil aggregation, reduces surface crusting, reduces pH in calcareous soils, and increases soil organic matter (Khoshgoftarmanesh and Kalbasi 2001). Leachate from municipal solid waste landfills include a variable mixture of solutes, including inorganic ions like Cl-, SO42-, Ca, Mg, Na and K, heavy metals and volatile/semi-volatile organic compounds. It has been suggested leachate should be used as fertilizers (Hernandez et al. 1999). Making use of any organic matter sources, containing municipal waste leachate (MWL) produced in process of converting solid waste refuses into compost in arid and semi-arid regions is very important. In arid and semi-arid regions, the distinct feature of most cultivated soils is relatively low organic matter content and, generally, these soils have poor physical characteristics. Consequently, soil application of organic wastes to supply at least a part of the plant nutrient requirement and improve the physical properties of soil is highly important (Maftoun and Moshiri 2008). Besides considerable organic matter content in leachate causing structure improvement and infiltration increase, they include a lot of macro and micro elements such as N, P, K, Fe, Zn, Cu, Mn and Mo that effects on soil fertility and also they involve infrequent elements causing environmental pollution so waste usage needs to be assessed (Panahpour et al. 2011).

STUDY SITE:

Kolasib Town has an area of 85 Sqkm, it is located at 24°13'52" N 92°40'34" E. It has an average elevation of 662 m. Kolasib is one of the prominent Districts of Mizoram with population of 24272. The District of Kolasib is bound on the north by Assam and on the west by Assam and Mamit District, south by Aizawl district and east by Aizawl district.

The study site is the solid waste dumping ground which is located at Rengtekawn tlang, about 7km away from Kolasib town. The waste after being scavenged by waste collectors are usually left in the dumping ground with occasional burning.

METHODOLOGY

Solid waste and soil Samples were collected for a period of two years at a seasonal interval. A total of 6 (six) sites were selected. Of this, 5 sites in solid waste dumping ground(4 in the corners and 1 in the centre of the dumping ground), and one site (control/reference) near the dumping ground where there is no adverse effect of solid waste dumping on soil characteristics.

The soil sample from each selected site wrer analysed for various soil attributes, and results obtained at control/reference site were compared with other sites to assess impact of solid waste dumping on soil characteristics.

The soil samples for various attributes were analysed by following the methods as outlined in Anderson and Ingram (1993).

Analytical method for soil.

i. Moisture content : Dry weight method.
ii. Bulk density : Dry weight - Volume method.
iii. PH- Electronic PH meter
iv. Organic carbon : Walkley and black method.

v. Total Nitrogen : Kjeldahl method.
vi. Phosphorus P: Olsen method.
vii. Exchangeable K : Spectrophotometric method.

RESULTS AND DISCUSSION

pH or Hydrogen ion concentration is an important quality of natural soil. The pH of natural soil lies between 7-8.5 and the variation is due to biological activity, temperature, disposal of municipal waste etc. (Oyedele .et.al.2008). Soil pH directly affects the life and growth of plants as it affects the availability of all nutrients in the soil. A pH range of 6.5-7.5 is considered as the range in which the most of the soil nutrients are available to plant (Raman et.al.2009).During the study period pH of the soil were lower in dumping site then the reference site, from the result it is clear that the waste material were acidic and percolation of this waste material to the soil lower the pH of the soil in dumping site.(Table 1. & Fig.1.) pH was highest during pre monsoon season and lowest during monsoon season this could be due to rain water which is acidic in nature and diluted the hydrogen ion concentration of the soil.

Bulk densities of the study site were higher in the reference site except post monsoon season of the first year during the study period (Table 2 & Fig.2). Bulk density of the soil was highest in monsoon season for both the site due to increase level of humidity of the soil during rainy season. Maximum bulk density reading was found during monsoon period of the first year and lowest during post monsoon season of the first year.

Moisture content of the study site ranges from 19% to 37.8% during the study period. Maximum value was at dumping site during Monsoon season and minimum at reference site during pre Monsoon season(Table 3 & Fig.3). From the observation, it is found that dumping of solid waste increases the moisture content of the soil. The moisture content of soil sample imply the presence of leachate those likely to genetrate from the discarded solid waste. Insufficient generation of leachate tends to evaporate moisture during summer meanwhile the residues remain in the soil, which contaminates the properties of soil (Eddy.et.al 2006).

Soil organic carbon is mainly constituted by soil organic matter. It is divided between living soil biota and non living biotic material. Soil organic carbon tends to be concentrated in the top soil. The Organic matter is widely regarded as a vital component of soil fertility because of its role in physical, chemical and biological processes to supply the plants with the nutrients and also helps soil to keep the moisture (Joachim .et.al.1989). The concentration of organic carbon ranges from 0.25 at reference site during pre monsoon season of the second year and 1.31 at dumping site during monsoon season of the second year during the study period(Table 4 & Fig.4). Organic carbon concentrations lean to increase at the dumping site

Nitrogen is an important macro nutrient of the soil. It is continually cycled among plants, soil organisms, soil organic matter, water and atmosphere. During the study period nitrogen value ranges from 1.02 to 4.02 at reference site in pre monsoon and maximum at dumping site in Monsoon season respectively(Table 5& Fig.5). From the results, it is found that nitrogen content was higher in dumping site than the reference site as a results of decomposition of organic matter containing nitrogen. And also the nitrogen content tends to increase with an increase in moisture content of the soil.

Phosphorus is an important element for plant growth. Absence of phosphorus has negative impact on agriculture land. During the study period, phosphorus content was higher during monsoon season and lower during Pre-monsoon season(Table 6 & Fig.6). The value of Phosphorus was found much higher in dumping site than reference site. The maximum and minimum value ranges from 0.32-3.62 during the study period.

Potassium is considered the second important macro element for soil and crop productivity. Hence excess of potassium is not harmful (Utpal et.al. 2008). Potassium content in the Soil is due to degradation of solidwaste and it is one of the essential elements for healthy growth (Effiong and Lbia 2003. Eddy et.al 2006). Nitrogen and water cannot be utilized efficiently if potassium is deficient in soil (Raman et. al. 2012). Potassium content was higher during monsoon season and lower during pre monsoon season(Table 7 & Fig.7). The value ranges from 90.36 at reference site in post monsoon season and 351.9 at dumping site in monsoon season of the first year during the study period. From the result, it is found that dumping of solid waste increases the value of exchangeable potassium concentration in the soil.

Figures and Tables

Table 1: Seasonal variation in pH of soil

Season	Dumping site	Reference site
Post monsoon	5.23	6.84
Pre Monsoon	5.59	6.95
Monsoon	5.05	6.5
Post monsoon	5.36	6.36
Pre Monsoon	5.71	6.92
Monsoon	5.08	5.67

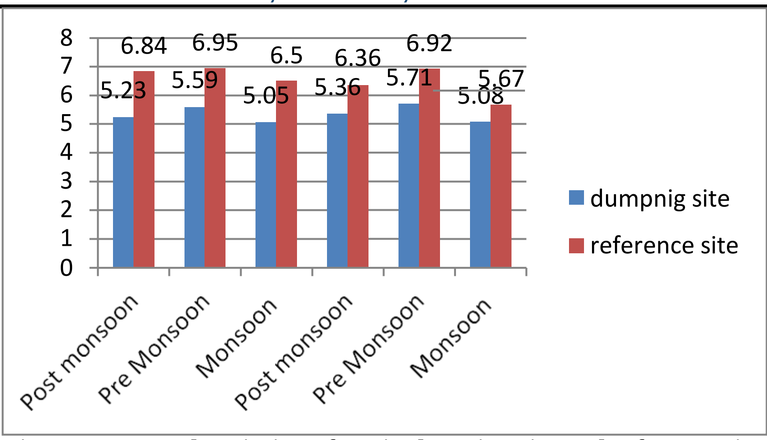

Figure 1 seasonal variation of pH in dumping site and reference site

Table 2: Seasonal variation in bulk density (gcm^{-3}) of soil

Season	Dumping site	Reference site
Post monsoon	1.48	1.14
Pre Monsoon	1.25	1.79
Monsoon	1.6	2.1
Post monsoon	1.54	1.64
Pre Monsoon	1.39	1.49
Monsoon	1.98	1.99

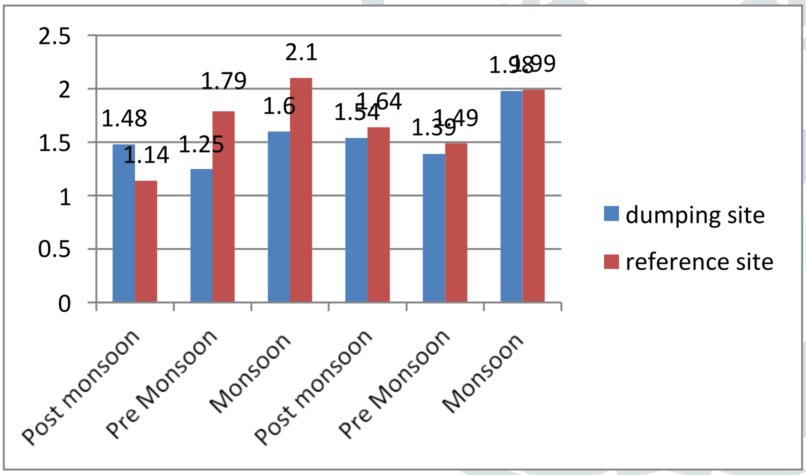

Figure 2 Seasonal variation of bulk density in dumping site and reference site

Table 3:Seasonal variation in Moisture content (%) of soil

Season	Dumping Site	Reference site
Post monsoon	29.2	21
Pre Monsoon	24.2	19
Monsoon	37.8	32
Post monsoon	28.4	23
Pre Monsoon	27.2	22
Monsoon	30.4	26

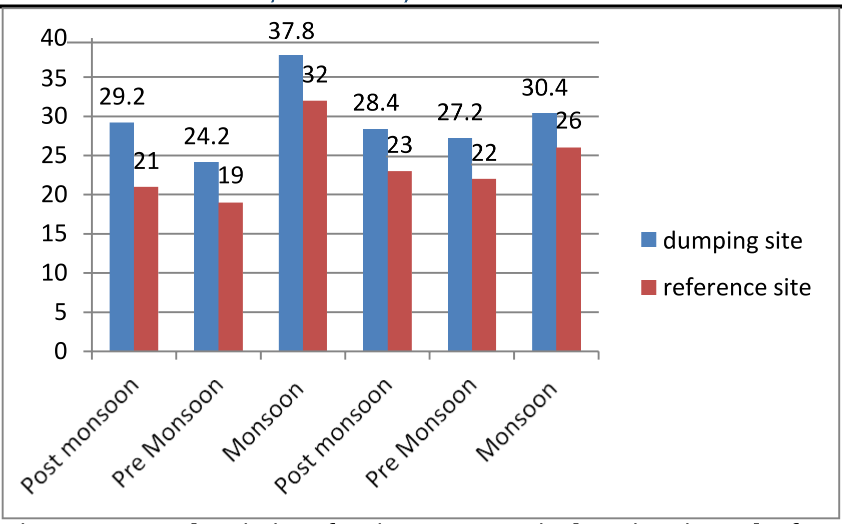

Figure 3 seasonal variation of moisture content in dumping site and reference site

Table 4: Seasonal variation in organic carbon content (%) of soil

Season	Dumping site	Reference site
Post monsoon	0.99	0.3
Pre Monsoon	0.84	0.26
Monsoon	1.31	0.59
Post monsoon	0.88	0.35
Pre Monsoon	0.67	0.25
Monsoon	1.19	0.68

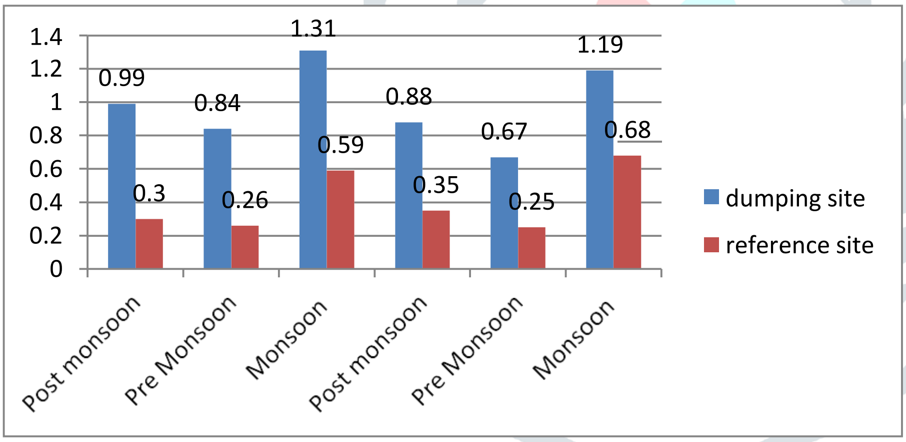

Figure 4 Seasonal variation of organic carbon content in dumping site and reference site

Table 5: Seasonal variation in Nitrogen content ($Mgkg^{-1}$) of soil

Season	Dumping site	Reference site
Post monsoon	3.39	1.52
Pre Monsoon	2.65	1.02
Monsoon	4.02	1.84
Post monsoon	3.35	1.43
Pre Monsoon	2.97	1.08
Monsoon	3.9	1.74

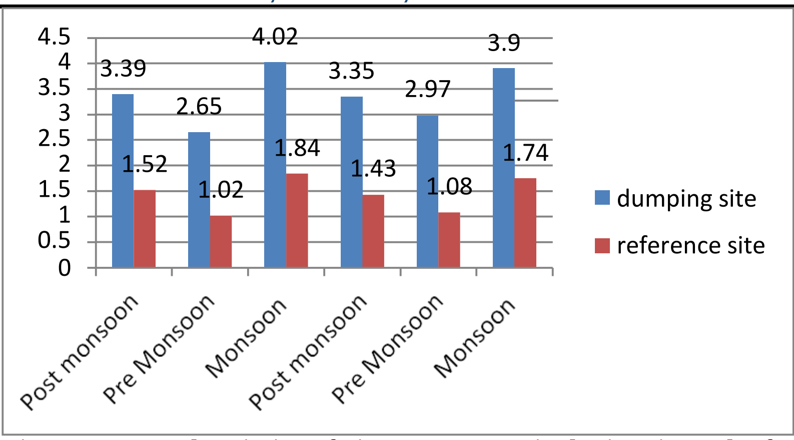

Figure 5 seasonal variation of nitrogen content in duping site and reference site

Table 6: Seasonal variation in available P ($Mgkg^{-1}$) of soil

Season	Dumping site	Reference site
Post monsoon	2.96	0.49
Pre Monsoon	2.69	0.32
Monsoon	3.62	0.6
Post monsoon	3.45	0.41
Pre Monsoon	2.95	0.3
Monsoon	3.55	0.54

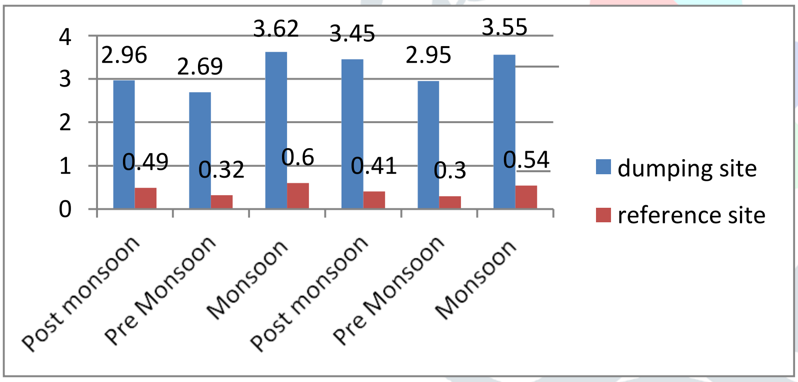

Figure 6 Seasonal variation of Phosphorus content in dumping site and reference site

Table 7: Seasonal variation in exchangeable K ($Mgkg^{-1}$) of soil

Season	Dumping site	Reference site
Post monsoon	302.5	90.36
Pre Monsoon	253.7	152.12
Monsoon	351.9	105.99
Post monsoon	301.1	119.24
Pre Monsoon	261.1	103.27
Monsoon	350.5	145.5

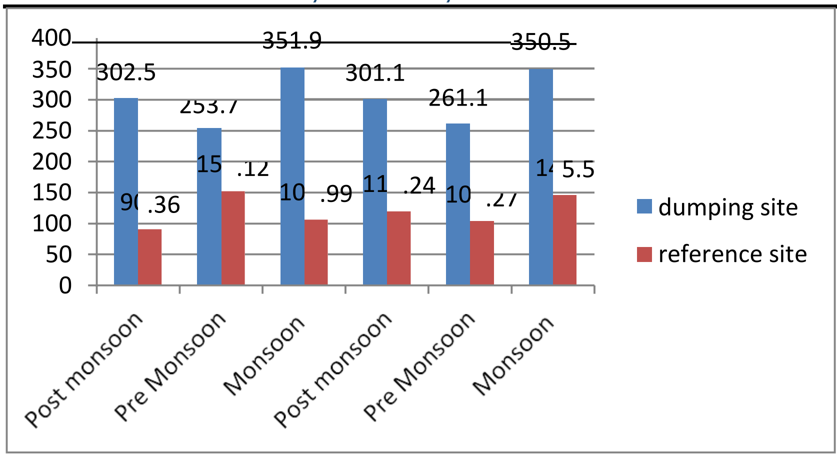

Figure 7 Seasonal variation of exchangable Potassium in dumping site and reference site

CONCLUSION:

From the observation, we can concluded dumping of municipal solid waste has influence on the physico-chemical properties of the soil. The impact may be somehow positive in some ways as it increase the concentration of soil nutrients but there is no test on soil micro-organism and pathogenic microbes, open dumping of solid waste can adversely effect the health of the soil as well as human being and other organisms. Although, there may be an increase in nutrient concentration in the soil, as the soil is covered by waste material, it does not support the growth of plants for the time being.

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Status of Solid Waste Management in Kolasib, Mizoram: An Overview

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ABSTRACT

Solid Waste is the unwanted materials generated from combined residential, industrial and commercial activities in a given area. Management of municipal solid waste is one of the major problems for most of the urban areas. Development of an integrated Solid waste Management is essential for the restoration of the environment. The main aim of this study is to identify different solid wastes and problem of its management practices as well as to formulate better management strategies. Kolasib is one of the capital Towns in Mizoram. During the study period, the solid waste are categorized into the following Organic (food waste), Paper and paper product, Plastics, Glass, Metal, Textiles (Rubber, leather cardboard, Polyester), Inorganic substance(concrete, stone, ash, carbon parts), Others. In kolasib Town, collection and disposal is undertaken by Urban Development and Poverty Alleviation Department, Government of Mizoram. In this paper, ongoing management practices is compared to Municipal Solid Waste (MSW) rules, (2000). The collection, storage, transportation, safe and lawful disposal of solid waste is very important aspect which requires immediate and careful attention. The efficient management of solid waste has become an immense challenge in the study area.

1. Introduction

Management of municipal solid waste is one of the major problems for most of the urban areas in India due to growing population and per capital waste generation rate, inadequate public participation and the deplorable organizational and financial capacities of urban local bodies (Ali and cotton , 1999). The contemporary approach to municipal solid waste management with the primary objective being merely the collection and disposal of the wastes for reasons of public health and hygiene, is increasingly proving to be ineffective and inappropriate (Singhal and Pandey, 2001). Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of solid waste daily. The amount of solid waste is expected to increase significantly in the near future as the country strives to attain an industrialize nation status by the year 2020 (Shekdar et al., 1992; CPCB, 2004; Sharma and Shah, 2005). The management of solid waste is going through a critical phase, due to the unavailable of suitable facilities to treat and dispose of the larger amount of solid waste generated daily in the metropolitan cities. Unscientific disposal causes an adverse impact on all components of the environment and human health (kansal et al., 1998,2002).

2. Study Area

Kolasib is situated at 24°13’52”N 92°40’34”E. It is one of the capital towns in Mizoram, located 83km west of Aizawl, the capital city. The District of Kolasib is bounded on the North by Assam, on the west by Assam and Mamit District, on the south by Aizawl District on the East by Aizawl District. It is linked with the rest of India through National Highway 54.

As of 2011, Census of India, Kolasib is a notified town having a population of 24272 with an area of 85 Sqkm. The notified town has 12102 males and 12170 females population of children with of 0-6 is 3428 which is 14.12% of total population of Kolasib notified town. Female sex ratio is of 1006 against state average of 97.6 literacy of Kolasib town is 97.75% higher than state average of 91.33%,male literacy is 98.25%while female literacy is 98.25%. The town has total administration over 5142 houses to which it supplies basic amenities like water and sewerage. It is also authorised to build roads within the town and impose taxes on properties coming under its jurisdiction .

3. Methodology

Survey was conducted for data collection. Data were collected from the local people through random sampling of personal interview at different localities as well as at the concerning department how the solid waste is collected and processed. This data were analysed and compared with the existing Municipal Solid Waste (MSW) rules, (2000).

4. Results and discussion

The major sources of solid waste in Kolasib town are Domestic waste, institutional wastes, Commercial waste, Agricultural wastes, Industrial waste and others.

- **Domestic waste** : Domestic waste result from household dwelling and includes kitchen waste, papers and cartons, plastic, glass, textile, leather, metal, ash and garbage.

- **Institutional waste**: Major producers of institutional wastes are schools, colleges, offices, banks, hospitals and religious places and contain paper and cartons, food wastes, plastics, hazardous and pathological wastes.

- **Commercial wastes**: Commercial waste producers are stores, markets, tea stalls, restaurants, hotels and motor repair shops. These sources produce waste like paper and cartons, glass waste from food preparation, ashes, spoiled and discover goods etc.

- **Agricultural waste**: Agricultural wastes from diaries, poultries, farms, livestock and other agricultural activities like vegetables cultivation.

- **Industrial wastes**: Industrial waste is minimal in the town.

- **Others:** Others like natural wastes contain leaves, trees, branches and car casses of animals that are collected as a result of road side threes, plants and animals.

Composition and percentage of waste generated at the study site was as follows:

TABLE: The composition of waste generated in Kolasib Town is summarized as:

Sl. No.	Name of solid waste	Quantity in kg Nov.,2016-Oct.,2017	In %
1.	Organic (food waste)	33	33
2.	Paper and paper product	22	22
3.	Plastics	12	12
4.	Glass	4	4
5.	Metal	2	2
6.	Textiles (Rubber, leather cardboard, Polyester)	5	5
7.	Inorganic substance(concrete, stone, ash, carbon parts)	23	23
8.	Other	1	1
	TOTAL	**100**	**100**

4.1 Waste Collection and Transportation on Kolasib Town

In Kolasib Town, Solid Wastes collected manually are openly disposed off in Rengtetlang dumping ground owned by Urban Development & Poverty alleviation Department, Kolasib, which is 7 Km from the Town.It occupied an area of 2 hectares.

The waste after being scavenged by waste collectors are usually left in the dumping ground with occasional burning. Kolasib is at present taking care of the Solid waste management in the Town. The Department has two garbage trucks. There are two trucks drivers, ten Truck/lorry attendants. With this, very limited Man power, the department is able to cover up to 40% of the household in the Town. The Trucks went around ten localities out of Total no of 15 (only main road) except on Sundays, the Department trucks went every morning, stopping it each point for 20-30minutes, waiting for the garbage to be dumped into the trucks, by ringing bells. The approximate amount of waste collected daily is 7 tons (UD&PA Deptt, Kolasib, 2015).This fact discusses common problem in solid waste collection in the Town.

4.2 Comparison of solid waste management practices in Kolasib town with Municipal Solid waste management rules 2000:

Various practices of soild waste management practices in Kolasib Town were not according to Municipal solid Waste management Rules, 2000. The following points mention below are the practices carried out which do not follow the rules.

1. Disposal of Solid Waste entrusted to UD&PA Department, through the fund provided by the State Government. There is no public contribution so far. The state Government contributed the whole fund while the MSW 2000 aims for public contribution and participation.

2. No Segregation practiced at source: The wastes are not segregated at source at present which should be merely practiced in MSW 2000. It should be segregate at source by providing separated bin recyclable and non-recyclable.

3. 3.Solid waste is transported in open trucks in which the rules mentioned the garbage trucks should be covered. Due to this, the wastes which are light in weight could get flown out and get littered on the roads. The loading and unloading of waste is being done manually in the activity: SafaiKaramchar involved in the activity does not use any Personal Protection Equipment (PPE).

4. Collection and disposal of construction and demolition waste is not appropriate. The construction/ Demolition waste generated by local residents is being transported in open vehicles and disposal off in open/low lying area in the vicinity, privately.

5. Disposal of Solid Waste is not appropriate waste collected from the Town is dumped in RengteTlang Dumping ground. There is no engineered Sanitary landfill site for safe disposal of Solid Waste. Open burning of waste is still a common practice.

6. Manual Handling of Solid Wastes:SafaiKaramcharis involved in primary collection of MSW do not use any PPE's such as face masks, disposable glove, boots, hats and proper safety clothing to avoid direct contact with waste reduce likelihood of on-job injury. Manual handling of Solid Waste can be seen everywhere.

7. Lack of awareness among Town residents and civic authorities. Urban Development & Poverty Alleviation Department, Kolasib is responsible for managing MSW in Town. This Department is still ignorant of MSW (Management and Handling) Rules 2000, which indicate that proper awareness is necessary among the Department Staff.

8. Lack of public participation. Public participation is very essential in successful implementation of the MSW management plan is any Town. Thus, a planned and concerted effort is required to bring about awareness among the public and make them realize their responsibilities as individual and a community as a whole.

5. Conclusion

The majority of solid waste produced in study area is from residential sources and consists of the majority of organic waste. The waste management technique in a majority of Kolasib are also not systematic and the majority of them practices roadside picking and disposing of in an open areas which causes the major health problem. Thus, proper characteristics of the solid waste produced should be recognized and systematic solid waste management technique should be practice according to solid waste management rules 2000.

It had been proposed that one village Council ie. collegeveng village Council be selected for pilot project to carry out proper collection and collection and giving proper treatment in the dumping site. The department and the village council members met frequently in order to discuss step of implementation of the Swachh Bharat Mission pilot project with the help of the fund to be given by the Central Government under Swachh Bharat Mission. To materialize the project, a lot of submission was already brought up among the pilot project members. It had been suggested to link between the UD&PA Department and the community. The Department Staff in the initial stage would be responsible for collecting the garbage and wastes from the community. Some of the families still deposited the waste and garbage from their respective houses, in places found convenient to roadside, drain and open spot as the incharge department could not collect them daily.

Recently, in 2015 centrally sponsored scheme- Swachh Bharat Mission (URBAN) is launched by the Prime Minister of India, MrModi, to celebrate the 150^{th} Birth Anniversary of Mr Mahatma Gandhi which is to be celebrated on 19/10/2019. The theme of this session is to have Clean India. One of its Component is to have properly treated Solid Wasted in each town and City in India by 2019.The construction of Treatment Plant is already initiated by the state Government funded by this central scheme. Therefore, the solid waste in the Town may be managed properly in the near future.

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ABSTRACT

IMPACT OF SOLID WASTE DISPOSAL ON SOIL CHARACTERISTICS IN KOLASIB, MIZORAM.

A THESIS

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ABSTRACT

The solid wastes are the materials which have been excluded for further use and which neither be transported by water nor readily escape into the atmosphere. Solid wastes consist of the highly heterogeneous mass of discarded solid materials from the community as well as the more homogeneous accumulation of agricultural, industrial and mining wastes

Dumping of solid wastes on land is a common waste disposal method and practiced almost by all the cities around the globe. Rainfall that penetrates through the municipal solid waste leach the constituent from the decomposed waste mass, while moving down causes the subsurface soil to be contaminated by organic and inorganic solutes.

On the other hand, waste materials, and materials derived from wastes, possess many characteristics that can improve soil fertility and enhance crop performance. These materials can be particularly useful as amendments to severely degraded soils associated with mining activities.

Due to urbanization and demographic pressure, generation of solid waste increases enormously. Mizoram is also one of the state in India where a huge amount of garbage is disposed off without proper disposal system, which may cause adverse effects on environment as well as human health. In view of above, the present investigation has

been carried out which may be pioneer study for Mizoram in terms of aspects related to solid waste generation and its disposal.

The present study was conducted during November 2016 to October 2018, the study period was divided into three season viz., Pre-monsoon (January to April), Monsoon (May to August) and Post-monsoon (September to December). It was carried out in Kolasib town, Mizoram. Solid waste management of Kolasib town was studied by using field observation, interviews and site survey. Waste generation was analyzed by taking random sample from the study site and the sample were segregated and weighted manually. The objectives of this study were (i) survey of solid waste disposal in Kolasib Town (ii) solid waste generated in Kolasib Town (iii) assessment of impact of solid waste disposal on soil characteristics.

The study area was specifically localised in Kolasib Town solid waste dumping ground which is located at Rengtetlang about 7km from Kolasib Town. The waste after being scavenged by waste collectors are usually left in the dumping ground with occasional burning. Run-off from rainfall usually transport this leftover to the adjoining river and annual streams which ultimately gets deposited to River. The slope of the hill is about 65 degree from the bottom line. The unprocessed solid wastes were dumped over the slope of the hill. The height of the hill is 200 feetapproximately. The garbage thickness from the top soil is about 6 inches. For waste generation study personal interviews, questionnaire was engaged. For soil physic-chemical analysis ‘Handbook of soil and water analysis’ Maiti, 2004 was referred.

The findings of present investigation can be summarized as follows:

- The approximate amount of waste collected daily is 7 tons, wastes were not segregated at the source and dumping ground. Solid waste management was carried out by Urban Development and Poverty Alleviation Department, Government of Mizoram, in which there was no safety measure for the garbage collectors. There were only two trucks which ply around the town for garbage collection and can cover only 40% of the town area. All the wastes were burnt occasionally whenever it was needed. The solid waste management in Kolasib Town does not meet the existing Solid Waste Management Rules, 2016 in different manner.

- The wastes generated were segregated into eight categories i.e., Organic (food waste), Paper and paper product, Plastics, Glass, Metal, Textiles (Rubber, leather cardboard, Polyster), Inorganic substance(concrete, stone, ash, carbon parts), others. organic (food waste) constitute highest percentage 32.5% which was followed by Inorganic substances like concrete cements, stone, ash and carbon parts 24%, paper and paper productscontribute 21%, plastics waste 11% was the third highest contributor of waste, textiles waste (rubber, leather, cardboard, polyester etc.) accounts 5% followed by glass 4% and metals 2%. Apart from metal wastes, no others were not processed or collected for recycled.

- The physico-chemical characteristics of the soil were studied by examining seven parameters viz., pH, Bulk Density, moisture content, organic carbon, total nitrogen, available phosphorus and exchangeable potassium were analyzed. Soil sample were analyzed monthly and the data observed were presented seasonally. For impact assessment, the findings at control site were with values at sampling sites within dumping area.The major finding on physico-chemical parameters of the soil can be summarized as follows:

- The pH of the soil varied from 4.7 – 6.95mg/l,control site has higher pH value compare to dumping site. pH value was higher during pre-monsoon and post monsoon season and lower during monsoon season. This could be due to dilution of hydrogen ion concentration by rain water which is acidic in nature. Soil pH is the amount of acidity and alkalinity in soil pH levels range from 0 to 14, with 7 being neutral, below 7 acidic and above 7 alkaline. The ideal pH range for most plant is between 5.5 and 7.0. However, many plants have adopted to grow best at pH values outside this range.

- The bulk density of the soil ranges from 1.01$gcm^{-3}$to 2.10gcm^{-3}during the study period. Bulk density shows higher value at monsoon season and lowers during post monsoon season which could be due to compaction of soil texture by rainfall. Control sites have higher bulk density value than dumping area. Soil with a bulk density higher than 1.6g/cm^3tends to decrese root growth. It is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes volume of soil particles and volume of pores among soil particles.

- The moisture content of the soil varied from 19% to 41%. It was higher during monsoon period and lower during pre-monsoon period which is due to increase in humidity of soil by rain water. Control site has lower moisture content than dumping site. The optimum moisture content is the water content at which maximum dry unit weight can be achieved after given compaction effort. A maximum dry unit weight would have no space in the soil. If the moisture content of soil is optimum for plant growth, plants can readily absorb soil water, much of water remains in the soil as a thin film.

- The organic carbon content ranges from 0.25% to 1.37%. It was high during monsoon seasons and lowers during pre-monsoon and post monsoon seasons. Dumping site has higher amount of organic carbon than control site. Organic Carbon enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms and soil biota. Soil organic matter (SOM) is the organic fraction of soil exclusive of non-decomposed plant and animal residues. Increase in total organic carbon in soil may lead to decrease in atmosphere carbon dioxide and increased soil quality.

- The Total Nitrogen content of the soil varied from 1.02mgkg^{-1}- 4.43mgkg^{-1}during the study period. It was found higher during monsoon season and lower during pre-monsoon season this could be due to leachate that enter in the soil through rain water run-off. Control site has lower nitrogen content than dumping site. The increase in the value for soil nitrogen supply the more likely it is that microorganisms in soil will transform more organic nitrogen into mineral nitrogen for plant uptake. However, in coarsed textured soil with higher values of soil nitrogen supply, it is also more likely that nitrate will be leached down the soil profile out of reach of plant roots and possibly into water ways.

- The available Phosphorus content ranges from 0.3mgkg^{-1}to 4.32mgkg^{-1}. It was found to be higher during monsoon season and lower during pre-monsoon season. Dumping site has higher available-P than control site. It is essential micro-element, required for plant nutrition. The types of phosphorous compounds that occurs in the soil are mostly determined by soil pH and by the type and amount of minerals in the soil, mineral compounds of phosphorous usually contain aluminium, iron, manganese and calcium

- The exchangeable K varied from 90.36mgkg^{-1}to 405.78mgkg^{-1}. It was lower during pre-monsoon and post monsoon season and higher during monsoon season. Control site has lower potassium content compare to dumping site. Potassium, unlike nitrogen and phosphorous, is not associated to any great extent with organic matter. Total amount of potassium in soil will vary from 0.3% to more than 2.5%. While total content of potassium is important. It is of little value in determining low were a given soil can supply potassium to growing plants.

- Dumping of solid waste has great impact on soil characteristic in which it changes the concentration of different physico-chemical parameters. Statistical analysis also proved this change except for pH and Total Nitrogen content at 95% level confidence. From the observation we can say that dumping of waste improves soil productivity by increasing soil nutrient and soil moisture content but there is possibility of build-up of harmful micro-organisms detailed investigations is needed to check the health of the soil.

Based on findings of present investigation it can be concluded that the existing solid waste management practices does not meet the requirements of Municipal solid Waste Management rules, 2016. The number of garbage trucks is not sufficient to collect every waste in the Town area. Most of the wastes generated were not processed for re-use and recycle. The Studied physico-chemical parameters show that there is significant change between dumping site and control site which indicates that the solid waste has great impact on the soil quality. It signifies that if the waste was properly managed in the dumping area, it can be used to enhance the soil quality in some manner. On the other hand, as this study does not include soil micro-organisms and pathogenic microbes, dumping of waste in an open area may affect the health of the soil as well as human beings and other living organisms. Also, as the solid waste were not segregated and dumped in one place, all the dumping area was covered by waste material and did not support plant growth. Burning of waste in open air may seriously affect health. Detail investigation on soil micro-organism and pathogenic microbes needs to be addressed to study the impact of solid waste on soil quality. For the better management of solid waste in the study area, it is suggested/ recommended that-

1. Segregation of waste at the source is of utmost importance for better management. For this, public awareness needs to be strengthened.

2. Health and safety measures were needed for garbage collector to check their health impact due to solid waste.

3. Garbage trucks need to be construct with hood as open truck were not recommended for carrying solid waste.

4. Burning of waste at dumping area needs to be avoided as it creates a lot of air pollution.

5. Organic and inorganic wastes need to be dumped separately.

6. Different waste which can be recycled should be collected for recycle which will reduce the amount of solid waste and also will generate economic income to the people.

7. Open dumping of solid waste on ground should be minimized especially for inorganic was as leachate can affect the soil as well as ground water.

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