A STUDY ON PLASTIC WASTE MANAGEMENT IN AIZAWL CITY, MIZORAM

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A STUDY ON PLASTIC WASTE MANAGEMENT IN AIZAWL CITY, MIZORAM

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Submitted

in partial fulfillment of the requirement for the Degree of Doctor of Philosophy in Environmental Science of Mizoram university, Aizawl.

CERTIFICATE

This is to certify that the thesis "**A Study on Plastic Waste Management in Aizawl City, Mizoram**" submitted by Mr. **Anil Pratap Singh** for the award of Doctor of Philosophy in **Environmental Science** is carried out under my guidance and incorporates the student's bonafide research and this has not been submitted for award of any degree in this or any other university or institute of learning.

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Declaration

I, Anil Pratap Singh, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else and that the thesis has not been submitted by me for any research degree in any other University/Institute. This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Environmental Science**.**

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Place: (ANIL PRATAP SINGH)

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LIST OF ABBREVATIONS

ICPE :Indian centre for Plastics in Environment

PET :Polyethylene Terephthalate

HDPE: High Density Polyethylene

PVC: Polyvinyl Chloride

LDPE: Low Density Polyethylene

PP: Polypropylene

PS:Polystyrene

PC: Polycarbonate

BPA:BisphenolA

PBDE: Polybrominated diphenylesters

UNEP:United Nations Environment Programme

NAFTA: North American Free Trade Area

CPCB:Central Pollution Control Board

SUP: Single use plastics

EPR: Extended Producer Responsibility

PS:Product Stewardship

ASC: American chemistry council

CIPET: Central Institute of Plastic Engineering and Technology

USEPA:United State Environmental Protection Agency

GHG:Green House Gases

SRP: Self Reinforcing Polymer

PWM:Plastic waste management

AMC:Aizawl Municipal Corporation

ULB:Urban Local Body

SPCB:State Pollution Control Board

PCC:Pollution Control Committee

LAD: Local Administration Department

PHED: Public Health Engineering Department

MSPCB: Mizoram State Pollution Control Board

TPD:Tonnes per day

HSEG: Higher Socioeconomic Group

LSEG :Middle Socioeconomic Group

MSEG: Lower Socioeconomic Group

PE:Polyethylene

GPGP: Great pacific garbage patch

IWM:Integrated waste management

PHA: Polyhydroxyalkanoate

PC:Lolycaprolactone

PBS: Polybutylene succinate

PLA: Poly lactic acid

TQM: Total quality Management

AUA: Aizawl urban area

DTIE: Division of Technology, Industry and Economics, International Environmental Technology

HIPS: High impact polystyrene

PPVC: Plasticized Polyvinyl Chloride

SW:Soild Waste

MSW:Municipal Solid Waste

MPW: Municipal Plastic Waste

SIRDPR: The State Institute for Rural Development and Panchayati Raj

MRF: Material Recovery Facilities

CHAPTER 1:

INTRODUCTION

1. INTRODUCTION

1.1 Problem statement

Plastics are incredible human invention which is versatile and which could be widely used in the field of industrial production and our daily lives. The indiscriminate use and production of plastic waste has become a serious concern.

Plastic waste is generated from variety of sources mainly from industrial, commercial and residential activities. Industrial waste is produced due to processing, manufacturing, and packaging activities. Automotive industries produce plastic waste like spare parts, fan blades, bumpers, seat covers and grill etc. In industries during construction phase pipe and fittings, sheets and waste tiles, electrical switches, cable sheath, screens are generated (Narayan,2001; ICPE,2006). In commercial areas workshops, supermarkets, wholesalers generate reasonable amount of plastic waste mostly comprising of packaging material. Hotels and restaurants produce plastic waste in the form of bottles, straws, wrappers and packaging materials. Residential area like colonies, housing societies, apartments, and park generate plastic waste mainly due to littering and non segregation of waste at source (Thompson et al., 2009). Around 80% of plastic getting in to world's oceans come from land based sources. Important land based sources are water and sewer discharge, tourism, fishing, illegal dumping and industrial activities. Important sea based activities responsible for generating plastic litter are commercial fishing, boating, shipping industry ,oil and gas exploration activities (Barnes et al.,2009).Once dumped openly plastic waste contaminate rivers, streams, oceans, air and soil. Burning leads to release of toxic gases and chemicals like dioxin, recycling if not managed properly leads to several environmental and occupational hazards. During production process of plastics benzenes, xylenes and ethylene oxides are released which are known to cause birth defects, cancer and immune disorders (Galgani et al., 2015).The major items present in plastic waste is represented in table 1.

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Table 1.Major Items present in Plastic waste

Category	Examples
Polyethylene terephthalate (PET)	Water bottles,textile fibre,peanut butter jars, pillow and sleeping bag fillings, food jar
Polyvinyl chloride (PVC)	Plumbing pipes, seat covers, shoe soles,cables
High-density polyethylene (HDPE)	Milk, juice, cream and Shampoo bottles and packaging
Low-density polyethylene (LDPE)	Sheets,garbage,trash, Shopping, grocery bags, packaging materials
Polypropylene (PP)	Medicine bottles, straws, car batteries, bottle caps, disposable syringes, car bumpers and chips packets
Polystyrene (PS)	Pharmaceuticals, disposal cups, cutlery and packaging foam
Polycarbonate (PC)	Electronic items, mobile phone covers, hard disc covers, key boards, mouse and defense tools and equipments
Nylon	Fishing nets, clothing, ropes

Main contributor to soil plastic pollution is illegal dumping of solid waste, sewage sludge and agricultural activities. Plastics is extensively used as mulching and in green houses in agricultural activities.Polyethylene mulching is being replaced by biodegradable alternatives but due to incomplete breakdown small plastic fragments are generated in soil (Molgaard,1995).

Upon replacement of plastic covering in green house, plastic is left loose, is an important source of plastic litter in soil.Sometines plastic residue is burnt leading to contamination of soil. Plastic waste disposal on land severe environmental problems like making soil infertile, release of greenhouse gases, leaching of heavy metals to ground water.Indescriminate littering of plastics on land reduces percolation and aeration in soil (Horn et al.,2004).

Once discarded plastic reach in to soil and water. Very often plastic waste blocks sewage system creating a flood like situation. In aquatic systems plastic block sunlight hence reduces photosynthesis. Composting is also perceived as source of micro plastic litter in soil. A study conducted in Italy found average 4.9% plastics contamination in manure (Novamount,2018). Surface of plastics leads to formation of biofilms (Zbyszewski and Corcoran, 2011).

Microorganism present in biofilms produce foul odor and release toxic chemicals. Water blockage due to plastic debris leads to breeding of mosquitoes and other vectors. Plastic waste generated on land reaches sea through rivers. In oceans plastic remain for long periods and gets accumulated at remote location such as mid ocean gyres, shipping routes, population centers on islands (Morritt et al., 2014.,Hartmann et al.,2017,Carson et al.,2013).

Solid waste containing plastics is very often burnt in open which leads to air pollution. Burning of plastic waste releases toxic chemicals like polychlorinated biphenyls, dioxin, mercury, furans etc (Forrest et al.,1995).Burning of plastic waste increases susceptibility to respiratory ailments heart disease and damage to nervous system. Incomplete combustion of plastic waste containing PE, PP, PS leads to formation of carbon monoxide, dioxins, carbon black, pyrenes etc.Plastics contain various chemical with toxic potential.PVC and PS have been found to release toxic chemicals in environment which causes cancer and hormonal imbalance. These polymers are also broken down by heat, UV rays and mechanical action (Halden,2010).

During polymerization process for manufacturing of plastic products certain chemical known as additives are added to give plastics a desired property. One such additive is Bisphenol-A(BPA) is a endocrine disruptor and mimics oestrogen,increases chances of prostate cancer, breast cancer,obesity,lowers sperm count and increases chances of miscarriage (Melzer et al., 2011). Phthalates (1,2 Dibenzenecarboxylic acid and 2-ethylhexyl phthalate) are used as plasticizers to make plastic more flexible. Phthalates are proven to have anti androgen activity, induce allergies and obesity.Polybrominated diphenylesters (PBDE's) are used as flame retardant (Koelmans et al.,2016).Exposure to PBDE hampers development of nervous and reproductive system.BPA and Phthalates tend to concentrate in body tissues.BPA also leach from landfill and contaminate groundwater, rivers ,streams harming fish and other aquatic life. Heavy metals such as Cadmium (Cd), lead (Pb), Nickel(Ni) present in children toys,mobilephones pose a risk to human health (Mudgal et al., 2011).

Abondoned or lost fishing net commonly known as Ghost fishing, packing loops, rope are chiefly responsible for entanglement of marine creatures (Barnes & Milner,2005). Entanglement can lead to serious injury or wound, drowning, make it more vulnerable to predators and can also loose ability to catch prey. Scientists think decline in population of Hawaiian Monk seal and Northern Fur Seal is due to entanglement (Derraik,2002).Microplastics is being ingested by filter feeders, deposit feeders and detritivores mistaking them for food. Around 400 species have been found to ingest or getting entangled, killed or injured in plastic debris. In a study it was found that 7 turtle species and two third of all sea birds have ingested plastics at some part of time (Duncan et.,2018). According to UNEP (2006) plastic waste causes up to a million sea birds and 100000 marine mammals. Laist (1997) in a study reported around 267 different species which were found to suffer from plastic debris, it includes 86% turtles, 44% sea birds and 43% of all marine mammals. Sedentary creatures like corals are damaged and suffocated by plastic waste and leftover fishing nets plastic debris transfers harmful invasive species to non native environment.

Great pacific garbage patch is a huge assemblage of marine debris covering approximately an area of 1.6 million square kilometers. It is situated between Hawaii and California. The patch comprises of tiny bits of micro plastics very often not visible to naked eye, making a sea water look like cloudy soup. About 80% of debris that have accumulated in these patches comes from land based sources (Leberton et al.,2018).Plastics are major component of debris present in garbage patch. More than 1.8 trillion pieces of plastics afloat weighing more than 80,000 tonnes, which concentration levels ranging from 10 kg/m^3 to more than 100 kg/m^3. Main components of plastic present in the great pacific garbage patch are discarded fishing gear (nets and rope), polyethylene and polypropylene (Eriksen,2014).

Plastics lead to global ecotourism loss worth of 13 billion dollars due to aesthetic and economic loss caused by debris and plastic pollution (Ranaud,2014).Single use plastic bags and Styrofoam are very popular as they are cheap, strong and are hygienic but once used they get discarded and take hundreds of year to degrade, contaminate soil and water. Phthalates and Bisphenol A (BPA) are toxins which get leached from plastics and contaminate soil and water (Hartmann et.al,2017).Pthalates get deposited in fat bearing tissues and act as endocrine disrupters. It can also lead to dysfunctioning of reproductive system, inhibition of secondary sexual characteristics and lead to cancer. BPA act as estrogen disrupter and has deleterious effect of placental tissue growth.It can lead to premature birth,still birth, intrauterine problems and preeclampsia. BPA was found to have carcinogenic effect in rodents especially on prostrate glands and urinary tracts (Halden,2010).

If current trend of plastic production continues then green house emission by plastic sector will account for 15% of global annual carbon budget by 2050.In 2012 alone global plastic production accounted for 390 million tonnes of CO_2 emission to atmosphere. At present around 150 million tonnes of plastic waste is lying in oceans.Since plastics is made up of additives,plasticizers, stablizers and colourants which are toxic in nature.It is estimated that around 23 million tonnes of additives present in plastic waste is in oceans,which is raising a serious concern.Plastics significantly impact maritime economy which includes tourism,fishing and shipping industry (Jang et.al.,2014).Apart from direct economic losses there is adverse impact on human health and livelihood, food chains and other environmental factors (Green et. al.,2017).

Human population and waste generation are closely interlinked. According to an estimate by,the year 2050 the global population is projected to reach 9 billion and at the present consumption rate plastic production is projected to cross 1 billion ton(https://www.statista.com).

Plastic production consumes 6% of the global oil production and approximately 400 million tonnes of greenhouse gas emission.The annual production of plastics in the world reached 335million tonnes by 2016, with an annual growth rate of about4%.Plastic waste production is projected to reach 400 million tonnes by 2025.China is the largest producer of plastic products, accounting to about 29% of worldwide production, followed by North American Free Trade Area (NAFTA)(19%) and Europe (18%). Asia accounts for nearly half of the world's plastic production (www.plasticseurope.org).

According to the reports for year 2017-18, Central Pollution Control Board (CPCB) In India approximately 9.4 million TPA (tonnes per annum) plastic waste is generated in the country, which amounts to 26,000 TPD out of this, about 60% is recycled, most of it by the informal sector. While the recycling rate in India is considerably higher than the global average of 20%, there is still over 9,400 tonnes of plastic waste which is either landfilled or ends up polluting streams or groundwater resources. While some kinds of plastic do not decompose at all, others could take up to 450 years to break down(http://cpcb.nic.in/Plastic_waste.php)

The most common use of plastics is packaging which is discarded after use. Around 50% of plastic is discarded as waste after single use (CPCB,2012). Single use plastics (SUP) like cups, plates, straws, stirrers, bottles, food containers are substantial sources of plastic pollution.

Around 8 million tonnes of plastics enters in ocean every year (Jambeck et al.,2015).Microplastics are rising in oceans and is being ingested by marine creatures. Certain chemical are added to make plastics more flexible, fire resistant and durable. These chemical are Polybrominated Biphenyls, Bisphenols, Phtahalate esters etc. once released from plastic, upon degradation these chemicals can have serious health implications thereby affecting reproductive, endocrine system and central nervous system.

In aquatic ecosystems like oceans, rivers and lakes, plastic waste leads to entanglement,ingestion and suffocation of birds, fish, turtle, mussels and crustaceans.

According to (Woods et al.,2019)15% of species suffering entanglement and ingestion are on IUCN Red list species and three out of ten rivers which carry approximately 90% of plastic waste are present in India which are Ganga, Indus and Brahmaputra. Ganga carries approximately 1, 10,000 tons of plastic waste to Bay of Bengal.

Scientists have even recorded certain chemicals derived from plastics in eggs of birds found in remote areas of arctic and marina trench. Plastics have been proven to cause stress, injuries, bioaccumulation, tumor formation, disruption of immune response and metabolic functions. Apart from that plastics lead to revenue loss in tourism sector of the magnitude of 13 billion US Dollars (Qiang et al.,2019). Burning of plastics produce halogens, dioxins and can cause heart disease, respiratory ailments.

Unmanaged plastic waste gets littered everywhere destroys aesthetics of place. Solution to present problem can be achieved through concerted means of stringent legislations, enhancing collection and recycling, suitably substituting plastics with biodegradable alternatives, raising public awareness and taking up cleanup measures.

Conventional technologies like co-processing in cement kilns, utilization in road construction, disposal techniques like land filling and incineration is being coupled with emerging technologies like Plasma pyrolysis, conversion of plastic waste to fuel, to effectively manage plastic waste.Several state governments have banned use of polythene carry bags. Local governments should try to phase out single use plastic items in a progressive and time bound manner. Dedicated means of disposal and recovery through EPR (Extended Producer Responsibility) and PS (Product Stewardship) should be applied through appropriate policy instrument.

Worldwide several initiatives have been taken like ocean clean effort and theme of World Environment Day-2018 was "Beat the plastic pollution". Although plastics has immense opportunity in health care, transport and energy sector, wise and judicious use of plastics is the need of hour.Awareness,sensitization of all stakeholders should be done to ensure plastic waste doesn't exceed carrying capacity of our ecosystem. Biodegradable and Bio- plastics is seen as an alternatives to plastics but reuse, reduce and recycling is paramount in plastic waste reduction strategy. Recycling is most effective means of tackling plastic waste as it reduces emissions of CO_2, SO_2 and NO_X.Changing consumer behavior through creating awareness and sensitization of community so as to reduce overall volume of plastics consumed and substitution with less harmful alternatives should be promoted. Focus should be on using renewable alternatives to packaging like jute or cotton, providing better waste management services, strict implementation of waste management legislations.

Major waste generating sources identified in Aizawl city are residential, commercial, industrial, institutional, construction& demolition and agriculture sector. Residential waste commonly includes Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes.). Industrial waste includes Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes. Commercial waste includes Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes. Construction& demolition waste includes wood, steel, concrete, dirt, etc. Major sources of plastic waste in Aizawl city were identified to be grocery stores, whole sale shops, private stores, show rooms, hotels and restaurants generating single use plastic items like bottles, straw, stirrers, disposable cups, plates, wrappers, packaging material.

1.2 Aims and objectives

The present study was carried out with main objective of

1. To quantify and characterize the plastic waste in selected residential, commercial areas and Turial dumping site of Aizawl city
2. To document plastic waste management strategies prevalent in Aizawl city and to suggest suitable measures.

1.3 Scope of research

Waste is necessary evil. During the process of economic development, urbanization and modernization the consumption pattern of societies get changed. Several environmental issues regarding plastic waste arise predominately due to the throwaway culture and lack of waste management system, inadequate resources, in-appropriate technologies, management apathy and low efficiency of system are unable to give fruitful results. Undoubtedly, it is the habit of people and lack of infrastructure for management of solid waste. Problems have been identified in the collection, transportation and disposal system along with the quantified plastic waste. The existing policies have not been able to provide any respite for associated problems. The present study undertook an assessment of plastic waste getting generated in Aizawl city and suggested ways to sustainably manage plastic waste.

1.5 Structure of thesis

The present work can be broadly categorized in to four categories namely 1.Assessment of plastic waste in residential area, commercial sites and dumping site. 2. Physical and chemical characterization of plastic waste.3Comparison of the characteristics of plastic waste characteristics among residential area commercial sites and dumping site.4.Documenting waste management strategies prevalent in Aizawl City and suggesting suitable measures.

CHAPTER 2:

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The term Plastics derives its name from a word “Plasticos” which means a substance which can be moulded or reshaped. Plastics are group of polymers having repeating units of carbon(C) and hydrogen(H). Apart from C and H plastics may contain O,N,S,Cl,Si,F(Plastics Europe,2016).Some of the most common polymers present in plastics are Polyethylene, Poly styrene, Polypropylene, Polybutylene, Polyvinyl Chloride, Teflon, Nylon, Polyesters and Polycarbonates. Polymers are abundant in nature. Polymers can be natural or manmade (American chemistry council, 2012). Most common natural polymer is DNA(Deoxy ribonucleic Acid) and RNA (Ribonucleic acid).Cellulose, rubber latex, spider silk, hair, horn are examples of polymers.Some of important natural polymers and their uses is presented in Table 2. In year 1909 first man made plastic was manufactured and it was commonly known as Bakelite. Ryan was the first manmade fibre made from cellulose in 1910.Later on Nylon was manufactured in year 1935(Hans,1993).On the basis of chemical properties plastics can be divided into two broad category; Thermoplastics and Thermosetting Plastics. Thermoplastics can be heated and reshaped again and again while Thermosetting Plastics once formed can’t be reshaped, upon heating thermosetting plastics gets deformed. Almost every sphere of human life is touched by plastics ranging from automobiles, medical science, mobile phone, batteries, clothing, footwear, food,drinks and packaging (Selke,2003).Plastic waste is a serious concern as plastics take hundreds of years to degrade.Several environmental issues have arisen due to indiscriminate use and lack of proper plastic waste management.

Table 2. Natural polymers and their uses

Polymer	Source	Uses
Cellulose	Cell wall of plants and algae	Paper,cellophane,rayo and , fuel
Lignin	Cell wall of plants	Timber,news print and fuel
Chitin	Exoskeleton of crustaceans, insects and cell wall of fungi	Medical and agriculture

Polyesters	Plant cuticle	Clothing
Fibre	Wool,silk	Clothing

2.1Plastic waste Generation

Plastic is present everywhere. It is so ubiquitous that it has become a symbol of anthropogenic era. Nearly half of all plastics produced is Single use plastics. In the year 2015 approximately 381million tonnes of plastic were produced. Since the year 1950 around 8.3 billion tonnes of plastics have been produced out of which around 6.3 billion tonnes of plastic waste was created and around 60% (4.9 billion tonnes) has either been disposed of in landfills or polluted the environment (Geyer et al.,2017.,Mcarthur foundation,2016). Surprisingly only 9% of total plastic waste is recycled in world. If current consumption pattern continues then by year 2050 around 1 billion tonnes of plastics will be produced.China with 8.8 million metric tonnes is largest producer of Plastics in the World (Wilson, 2015).

Plastics and polymer industry in India is growing at a rate of 10%.The production has grown from 8.33 million metric tonnes in 2010 to13.4 million tonnes in 2015.It is being projected that if annual growth rate continues at 10.5% then by 2020 plastics and polymer production in country will reach 22 million tonnes.Plastic production is mainly comprises of polyolefins such as polyethylenes, polypropylenes and polystyrenes.Major Plastic producers in India are Bharat petroleoum,Reliance industries,Indian Oil Corporation,Gas authority of India Ltd etc.The average per capita consumption of plastics in India is approximately 11kg which is very low as compared with developed countire like USA where average per capita consumption is around 109 kg(www.downtoearth.org).According to Central Pollution Control Board(CPCB) approximately 25940 tonnes of plastic waste is being produced per day.Pastic waste comprises around 8-10% of total municipal solid waste. Highest producer of plastic waste in India is Delhi, Kolkata followed by Ahmedabad.In India out of total plastic waste generated around 60% is recycled. Recycling is mainly done by informal sector. India consumes about 13 million tonnes of plastic products each year out of which 9 million tones of plastic waste is produced every year (www.teriin.org).The consumption pattern of plastics in different sectors worldwide are represented in table 3.

Table 3.Plastic consumption in various sectors

Sector	Percentage
Packaging	43%
Infrastructure	21%
Automobile	16%
Agriculture	2%
Others	18%

According to Bhattacharya et al.,2018 India generates close to 62 million tonnes of municipal solid waste (MSW) annually with the organic fraction in the range of 40%–60%. MSW in India has approximately 40–60% compostable, 30–50% inert waste and 10% to 30% recyclable (Joshi and Ahmed, 2016).According to Planning Commission Report (2014) it is projected that by 2031 the urban centers will generate 165 million tons of waste annually and by 2050 it could reach 436 million tonnes.

Plastic waste forms about 8% of the generated solid waste in the country.The per capita waste generation has seen a steady rise from 0.44 kg/day in 2001 to 0.5 kg/day and has been estimated to be growing at a rate of 1.33% per annum (CPCB, 2012).

According to CPCB (2016) India generates about 25940 tons of plastic waste per day. Out of which around 40% of plastic waste remains uncollected. In India Packaging Industry is growing at the rate of 18% and is expected to reach 72.5 billion by year 2020.According to Plastic Infrastructure Report total consumption of plastic in India in the year India in year 2017 was 12.8 million tonnes.In India per capita plastic consumption is 11 Kg/yr.By year 2031 total plastic production in country will be around 31.4million tones/yr (Indian centre for Plastics in Environment,2006).

CPCB has estimated collection efficiency as 80.28% in 2014, out of which 28.4% was treated. A study conducted by the CIPET (Central Institute of Plastic Engineering and Technology)-CPCB on the ‘Assessment and Characterization of Plastic Waste in 60 Major Indian Cities’ observes a 94% of plastic waste generated is recyclable and belonged to the thermoplastics family, while the rest 6% are non-recyclable thermoset plastics. 67% of the plastic waste belonged to the HDPE/LDPE, 10% to PP, and 8.66% to PET amongst others (CPCB,2015).In India large chunk of plastic waste comprise of packaging material, multilayer pouches, sachets, polybags etc. Household plastic waste is major source of plastic waste in India (Narayan,2001).

2.2 Plastic waste management

Waste is a substance which is designated to have less or negligible economic value. Technically waste is material that may lack primary economic value but possess secondary intrinsic value. To ensure environmental sustainability waste prevention, reduction, minimization and treatment is a huge challenge (USEPA,2002).

Waste collection, storage and transportation is a major activity of Municipal authorities. Urban local bodies spend approximately Rs.500-1000 for collection and transport of 1 tonne of municipal waste. Waste collection involves primary and secondary collection (CPCB, 2012). Primary collection includes collection of waste from residential and commercial areas, and taking to storage depot or taking to disposal site. Secondary collection involves collection of waste from community bins, waste storage depots and then transferring it to processing sites for recycling or to disposal facilities.

The steps involved in recycling are sorting, washing, shredding, identification and extruding. Managing and recycling plastic waste is not only environmental friendly but also economically beneficial (CPCB,2015).

The complexity of plastic types and high cost of separating make it difficult to recycle and reprocess the plastic wastes. According to statistics, only 9% of the plastics were recycled and about 12% were sent to waste to energy plant for incineration, while most of the plastics (79%) were disposed as trash and end up in landfill or in the natural environment. Resource recovery from plastic wastes like PE, PP and PET that are sorted out from the waste stream by citizens can be recycled to the primary material(Gent et al.,2001).They can be made into finished products after granulation, or be directly processed by simply cleaning; crushing and plasticizing. The utilization mode without any modification is called direct recycling (Foster.,2008).Direct recycling is characterized with low operating costs, low equipment and technological requirements. It cannot be used in the production of higher quality products. In order to improve the quality of recycled materials, it is often necessary to add a certain proportioned virgin PE, PP, or PET materials, which accordingly increase the manufacturing cost. Modified regeneration refers to the modification of recycled materials by mechanical blending or chemical grafting, which could improve the mechanical properties of the modified regenerated products. Modified regeneration process routes are more complex and some also need specific mechanical equipment (Strapasson et al.,2005).

Mechanical recycling involves melting of old plastic and using it to make new products. It involves collection, sorting, washing, grinding, filtering and extruding. Chemical recycling also called as Feedstock recycling involves depolymerization and complete breakdown. It involves pyrolysis, hydrogenation and gasification (Bernardo et al.,2016).The recycling of plastics is necessary in order to minimize the pressure on additional natural resources. The management of plastic waste is largely determined by the type of plastic materials Plastic waste recycling can provide an opportunity to collect and dispose of plastic waste in the most environmental friendly way and it can be converted into a resource. In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which are in high demand. Plastic waste recycling also has a great potential for resource conservation and GHG emissions reduction, such as producing fuel from plastic waste (Wilson, 2009).

Mixed plastic wastes have a calorific value of about 35 MJ/kg which is about 85% that of fuel oil. Therefore it can be used as a fuel in power plants, in place of coal or oil. Combustion is fully controlled, does not require pretreatment of the mixed waste plastics and is a mature technology practiced in over one thousand plants worldwide and is relatively mature. Plastic components containing chlorine, nitrogen and other additives will also release inorganic pollutants such as $NO_x$and HCl during the incineration process, causing secondary pollution. The oil produced by pyrolysis of plastics has a high calorific value comparable to commercial fuels. High volatile content favors the production of liquid oils, while high ash content reduces the amount of liquid oils produced, thereby increasing gaseous yield and coke formation (Ramesh et al.,2010).

Gasification is thermo chemical process and involves partial oxidation of plastic waste.As a result of gasification a gaseous mixture containing CO and H is produced. This gaseous mixture is known as Syngas. Syngas can be utilized for lighting,cooking and heating. A significant advantage of gasification compared to pyrolysis is that it is more flexible. Gasification of waste plastics is mainly for the production of energy-carrying gas (H_2) and synthesis gas (fuel, dimethyl ether, methanol, etc.), wherein the synthesis gas has an average calorific value of about 6–8 MJ/m^3(Al Salem et al.,2009). The composition and application of the gas produced by the gasification process depend on the gasifying agent used .The main problem of plastic gasification is the high tar content in gas products, which is usually higher than the tar content in biomass gasification. Therefore, gasification of waste plastics requires a very efficient gas cleaning system (Cimpan et al.,2016). Direct recycle has advantages of low operating cost, less equipment and processing requirements, but it cannot be used to produce high-quality regenerated products(Faraca et al.,2019).

Land filling is not considered as best suitable option for waste management. It is a carefully designed structure present below and above ground.Landfilling is a strategy to isolate waste from surrounding environment, to keep it dry and slow down its decomposition, prevent contamination of ground water and adverse effect on human health. The waste dumped in landfills are compressed to reduce its volume and covered with soil. Since most of the plastics are non biodegradable, plastic waste remains in landfill without breaking down.Also landfills require a large amount of space (Avasthi,2017).Upon leaching plastic may release Harmful toxins like Bisphenol-A and Phthalates. Plasma Pyrolysis Technology involves combination of pyrolysis technique with thermochemical properties of plasma.Pyrolysis leads to breakdown of plastic waste to its monomers by thermal breakdown at 300-400 C in presence of catalyst such as Aluminium Oxide in absence of oxygen (Mara,2009).Upon pyrolysis, plastic waste produces diesel like substance. In plasma pyrolysis, plastic waste is heated to 850^{0}C in a feeder chamber lacking oxygen and leads to dissociation of plastic waste in to CO, H and CH_4. After first stage in secondary chamber temperature of about 1050 C is maintained, having excess air,burns H,CO and hydrocarbons leading to production of water and CO_2 (USEPA,1990).

Pelletization improves consistency, storage and handling of plastic waste. Calorific value and combustion characteristics improve due to pelletization.The process of pelletiztion involves segregation, crushing, solidification to produce briquettes.Pelletization alters physical properties of waste. Waste plastic pellets are used in cement Klins and coal fired power plants.Coprocessing techniques utilize plastic waste as alternate fuel and raw material (AFR) and as in industrial processes such as Cement kilns, power stations (Rigamonti,2010).

By co processing of plastic waste, cement manufacturers and power plant operators can save fossil fuels and hence can achieve more ecologically efficient production.RDF/Liquid Fuel is produced when plastic waste is converted to fuel by catalytic pyrolysis.In specially designed reactors, in absence of oxygen random depolymerization takes place leading to breakdown of plastic waste in to monomers (Giugliano et al.,2011).

Plastic waste is also utilized in construction of road ,the plastic waste is shredded to a definite size of 2-4 mm.This shredded plastic waste is added to stone aggregate (granite and ceramic) and bitumen and heated to 160-170 C.Bitumen blended roads with plastic are more durable with fewer potholes. At present there is 21000 miles of plastic blended roads in India. Approximately 1 tonne of plastic waste is utilized for constructing 1km of highway (width 3.75m).Utilization of plastic waste in road construction considerably saves plastic waste reaching environment and enhances petrochemical conservation (Ismail and Hashmi,2008).

A group of scientists from United States,United Kingdom, Brazil have engineered a enzyme which can digest PET.This enzyme have been derived from PETase a natural enzyme found in *Ideonella sakaiensis* (http://www.sci-ews.com).A fungus *Aspergillus tubingensis* have been reported at Kew botanical gardens to degrade polyester polyurethane (PU) (https://sdg.iisd.org/) Recently scientists from University of Limerick have developed a technology known as SerPET through which plastic bottles can be converted in to various consumer goods such as luggage,sailing and sports equipments.Thus by converting plastic bottles in to self reinforcing polymer (SRP) through serPET can help reduce volumes of plastic waste and prevent plastic waste load in landfills.Squid protein extracted from teeth present on the arms of Squid can be processed in to eco-friendly biodegradable plastics (Abdon et al.,2019).

It has also been shown that several fungi have the potential to degrade PE in aquatic and soil environments. It was also recently shown that a marine fungus, *Zalerion maritimum*, can degrade PE (Paco et al., 2017). Recently Munir et al. (2018) isolated and identified the LDPE-degrading fungi *Trichoderma viride* and *Aspergillus nomius* in a landfill soil in Medan (Indonesia) and showed them to degrade LDPE film over a 45-day incubation period. Several enzymes have been identified that can hydrolyse ester-containing PET and other polyester plastics such as polyurethane (Wierckx et al., 2018).Caterpillars of wax worm have been found to breakdown polyethylene at Institute of Biomedicine and Biotechnology of Canterbria.Scientists from Beihang University from China isolated bacteria which can degrade PET from plastic eating moth larva(https://industryeurope.com/). Mikael Hedenqvist, Professor at KTH Royal Institute of Technology has developed a process to produce plastics from renewable feedstock such as wheat gluten (https://www.kth.se). Soy, wheat, corn, oat, potato, cotton, oil, milk, feather, wool, silk can provide suitable feed stock to produce protein plastics. Sourcing feed stock from renewable sources rather than non renewable sources can greatly reduce our dependence on fossil fuels and can enhance sustainability.

A study published in Journal of the Science of Food and Agriculture reports that suitable combination of starch, protein, glycerol can form films with same strength and flexibility like (https://www.hindawi.com) that of plastics. Research is going on in to produce liquefied waste plastics as raw material for fossil fuel refining. Researchers of Indian Institute of Technology (IITG) have developed biodegradable plastics for the first time in India (http://www.iitg.ac.in/coesuspol).

A 20 million Dollar ocean clean project has been launched between California and Hawaii to collect trash. The ocean clean up system consists 600 meters long floater above surface of water and 3 meters deep skirts below. Floater helps the system afloat while skirt prevents plastics from escaping.The system is carried passively by currents. Floating system will capture from small pieces to larger debris.The ocean clean-up project targets to capture up to 50% of plastics in the area within 5 years (https://www.theoceancleanup.com).

Single use plastics are generally provided to customers freely which promotes its excessive use. Hence bans and increasing cost of single use items by levy and taxes can deter people and force them to use these items wisely. Items designed and made from fiber like jute and cotton can be promoted as they can be degraded easily.

Table 4.Components of Plastic waste management system

Legislations	Policy,Laws,rules,Act
Institutions	State and central government, Pollution Control Boards Pollution control committees, Municipal authorities
Financial mechanisms	Levies, local taxes, state taxes, grants and subsidies from central government
Technology and Infrastructure	Transport,treatment,recycling and disposal techniques like Incineration, Plasma pyrolysis, RDF,coincineraion and coprocessing
Stakeholders	Waste generators, consumers, producers and waste managers

Table 5.Types of plastic recycling (Matthews, 1993).

Category	Method
Material/ Mechanical recycling	Recycling to make raw materials and plastic products it includes Shredding,molding,sheeting
Chemical/ Feedstock recycling	Monomerization Gasification Liquefaction
Thermal/ Energy recovery	Cement clins power generation RDF(Refuse derived fuel) RPF(Refuse paper and plastic fuel

There are several challenges to recycling of mixed plastic waste is that nearly all polymers are immiscible, polymer contamination leads to materials with poor mechanical properties and potential phase separation. Also, polymeric materials are affected by degradation processes which may occur during manufacturing, usage and mechanical recycling. The polymeric purity of post-consumer plastic waste streams may be further lowered by the inclusion of multipolymer products (two or more plastic polymers assembled together) and by particle and or molecular contamination. While particle contamination originates from presence of non-plastic objects (misplacements, e.g. metal cans) and non-plastic parts attached to the plastic waste items (interfering materials, such as metallic wheels in a plastic toy), molecular contamination can originate from contact materials, product residues and substances intentionally added for the previous use of the plastic waste, e.g.plasticisers, stabilizers, pigments and flame retardants) Recycled plastics are often considered of inferior properties compared to virgin materials, partly because of thermal-mechanical degradation caused by the shear and the increase in temperature occurring during mechanical recycling and partly due to contamination of the targeted polymer because of the incomplete efficiency of sorting machinery (Faraca and Thomas,2019)

Electronic component-derived waste plastics, also known as“e-plastics.” These are problematic because they often contain halogens, especially brominated flame-retardants, along with metals such as silver, lead, and gold. Current sorting and washing processing technologies are not designed to handle the highly variable and often complex products (e.g., laminates) that are intrinsic to our current waste plastic streams. Labels, and metal foil-laminated bags, must be effectively identified with almost 100% accuracy before the waste stream is shredded. Current costs of both mechanical and chemical recycling must be reduced to be competitive with the manufacturing costs of world-scale polyethylene, polypropylene, and polyester plants (Degnana and Shinde,2019)

2.3 Plastic Waste Management (PWM) Rules, 2016

The Government of India notified Plastic Waste Management Rules,(2016) on 18thMarch, 2016, superseding Plastic Waste (Management &Handling) Rules, 2011. These rules were further amended and named as ‘Plastic Waste Management (Amendment) Rules,(2018).These rules shall apply to every waste Generator, Local Body, Gram Panchayat, Manufacturer, Importer, Producer and Brand Owner. Carry bags made of virgin or recycled plastic, shall not be less than fifty microns in thickness. The provision of thickness shall not be applicable to carry bags made up of Compostable plastic, complying IS/ISO: 17088.

Waste Generators including institutional generators, event organizers shall not litter the plastic waste, shall segregate waste and hand over to authorized agency and shall pay user fee as prescribed by urban local bodies (ULB) and spot fine in case of violation. Local Bodies shall encourage use of plastic waste for road construction or energy recovery or waste to oil or co-processing in cement kilns etc. It shall be responsible for development and setting up of infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies or producers.

Gram Panchayat either on its own or by engaging an agency shall set up, operationalize and coordinate for waste management in the rural area under their control and for performing the associated functions, namely, ensuring segregation, collection, storage, transportation, plastic waste and channelization of recyclable plastic waste fraction to recyclers having valid registration; ensuring that no damage is caused to the environment during this process; creating awareness among all stakeholders about their responsibilities; and ensuring that open burning of plastic waste does not take place.

State Pollution Control Board (SPCB)/ Pollution Control Committee (PCC) shall be the authority for enforcement of the provisions of PWM Rules, 2016, relating to registration, manufacture of plastic products and multi-layered packaging, processing and disposal of plastic wastes. Concerned Secretary-in-charge of Urban Development of the State or a Union Territory and concerned Gram Panchayat in the rural area of the State or a Union Territory shall be the authority for enforcement of the provisions of PWM Rules, Rules relating to waste management by waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multilayered packaging.District Magistrate or Deputy Commissioner shall provide the assistance to SPCBs/PCCs, Secretary-in- Charge, Urban Development Department and Gram Panchayat under his jurisdiction, whenever required for enforcement of provisions of PWM Rules, 2016.

Table 6.Status of use of plastics carry bag in different states (CPCB,2016)

s no	state	status
1.	Assam	Complete ban
2.	Chattisgarg	Complete ban
3.	Jammu& Kashmir	Complete Ban
4.	Karnataka	Complete Ban
5.	Nagaland	Banned
6.	Orissa	Complete Ban

7.	Punjab	Complete ban
8.	Uttar Pradesh	Complete ban
9.	Uttarakhand	Complete ban
10.	Maharashtra	Partial Ban
11.	Manipur	Partial Ban
12.	Meghalaya	Partial Ban
13.	AndhraPradesh	Partial Ban
14.	Goa	Partial Ban
15.	Gujrat	Partial Ban
1 6	TamilNadu	Partial Ban
17	Jharkhand	Partial Ban

Common measures to curb menace of plastic waste include partial or complete bans and reduction strategies. Although measures to curb plastic waste exists but there is lack of sincere implementation. Apart from plastics only few countries have done policy intervention to limit microbeads by mostly restricting its use in cosmetics.

Table 7.Alternatives to plastic usage

1.	Replacement of plastic bags with jute bags or paper bags
2.	Avoiding single use items such as bottled water,straw,plastic cups and plates
3.	Purchasing toys made from natural materials such as clay instead of plastics
4.	Avoiding packaged frozen foods instead prefer to buying fresh foods
5.	Promoting biodegradable and biobased plastics
6.	Selecting disposable and recyclable products
7.	Labeling of plastic polymers and imposing heavy taxes
8.	Extended producer responsibility, Deposit return scheme, Green chemistry
9.	Raising public awareness

Table 8.Strategies for effective plastic waste management

1	Creating after use plastic economy
2	Reducing leakage to natural systems
3	Decoupling plastics from fossil feedstock

4	Adopting circular economy approach in plastic management
5	Sourcing plastics from biomass based feedstock
6	Effective recycling,depolymerization to generate feedstock, developing technology to remove additives
7	Development of biobenign material,superpolymers which has excellent recyclability
8	Establishment of global plastics protocol

2.4 Solid waste management in Aizawl City

The Aizawl Municipal Corporation (AMC) is governed by the Mizoram Municipalities Act, (2007) which lays down the legal and administrative framework for day today functioning and governance, jurisdiction and lays down rules and procedure for functioning AMC. The corporation is headed by elected leadership from the wards within the geographic jurisdiction of the corporation boundaries. The solid waste management in Aizawl city is primarily the responsibility of AMC.AMC looks at all aspects of waste management – collection, storage and disposal of waste. Sanitation wing of AMC headed by Sanitation officer takes up the responsibility of management with Engineering Department helps in obtaining the vehicles, gadgets, tools, equipments and building necessary facilities like landfill site, etc.

In the organisational structure of AMC the Sanitation Officer is responsible for waste management and sanitation in the administrative areas of AMC. Under sanitation wing whole area has been divided into 19 wards with each ward having local councils. Local council headed by chairman. Each local council is responsible for management and handling of solid waste. The average solid waste generation rate is 400 gram per capita per day (gpcd). It is estimated that Aizawl produces MSW approximately at the rate of 184.5 T/d. The MSW generated in the city mainly consists of domestic refuses, wastes from commercial areas, vegetable fruit market, slaughter houses, bio-medical waste and wastes from hotels and restaurants. Apart from wastes generated from these areas, wastes are also collected from drains in the form of wet silts, which are dried along road sides. It is reported that the collection of solid waste is 75 T/d indicating a collection efficiency of around 57 %. The expected population of Aizawl in 2031 will be around 8,20,000. At the Present Solid Waste (SW) generation rate of around it is estimated that Aizawl will produce MSW approximately at the rate of 410 T/d during that time.

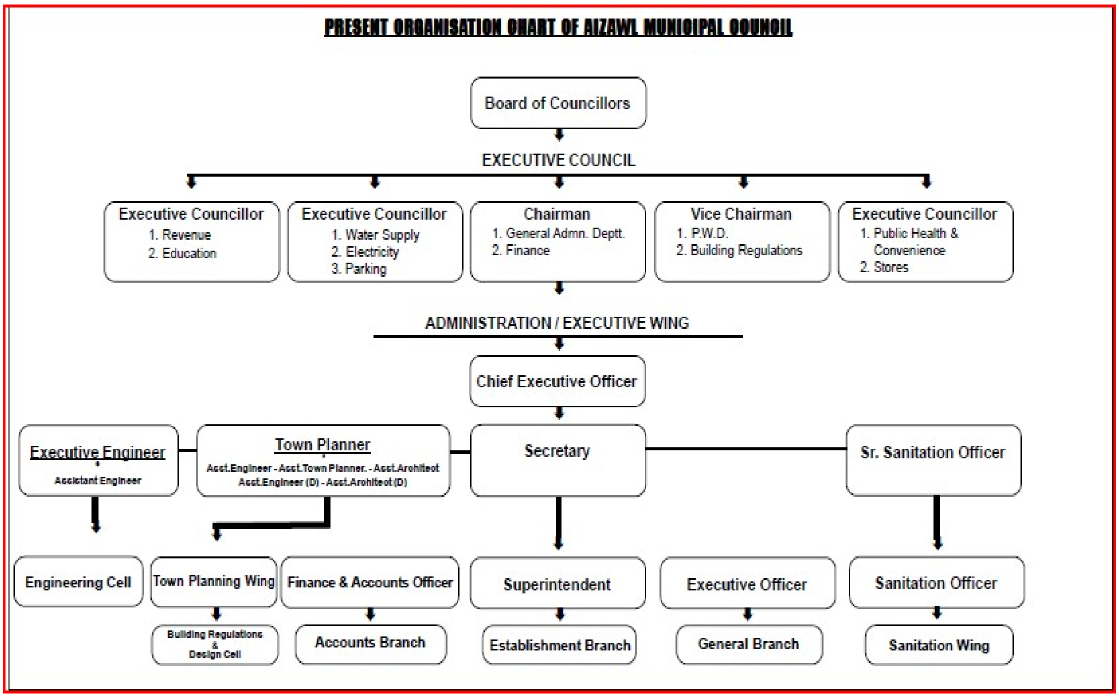


Fig.1Organisation chart of Aizawl Municipal Council (Source: http://amc.mizoram.gov.in/)

The solid waste management system of Aizawl city is handled by Local Administration Department (LAD) of Mizoram. The primary collection system of solid waste in the city is reported to be unsatisfactory and inefficient. Since the city is of undulating terrain, totally motorized vehicles are being used for collection and transportation of waste. The wastes from household are brought by the residents to a fixed point where transport vehicle halts to collect it. No bins are found visible for storing waste, and as a result, residents throw the waste at the road side at some designated locations. Collection of waste from those points are reported and found to be irregular. SW from shops and establishments are also getting dumped on the road sides (sometimes even on roads), open drains,and sloppy hilly areas. The Local Administrative Department has placed 20 mobile garbage trailers of 3.375 m^3 capacity each along the central road of city between raj bhavan to Chanmari as a pilot project. The collection and transportation of waste for this pilot project have been privatized. These containers are serving the commercial area including some residential zones. The physical condition of these trailers is not satisfactory. Every time these containers are found to be overloaded.

Recently, the Clean Mizoram Society placed 50 litter bins at different locations of the city hanging them at light posts and walls. But, it was observed that around 40% of the solid waste, getting dumped into road side, open and sloppy areas, remains unattended. In low income group residential areas, collection and transportation system is found to be totally absent. The collection of SW in Aizawl city is being done by 18 trucks each of 3.0 m^3 capacity. The numbers of these trucks is inadequate and their conditions are poor. Most of the vehicles are found to be old and inefficient, resulting in frequent breakdowns and heavy operational and maintenance costs. Further, most of the roads are narrow; posing difficulties to the movement of trucks. These vehicles are insufficient for collection and transportation. The collected wastes are transported to the disposal site at Tuirial and Durtlang. It was reported that the transportation of MSW to the dumping site from the city is also irregular. There are two sites for disposal of solid waste in the city. It is reported that 90% wastes are disposed at Tuirial site which is located on the western side of Aizawl city at a distance of 27 km from the heart of the city. Remaining 10% wastes are disposed at Durtlang site, which is 20 Km from city, located at Aizawl to Silchar road towards the north side. Both disposal sites are situated outside the city limits.

Fig.2Waste being collected by AMC vehicle from Chanmari locality

In its effort to make Aizawl a clean and smart city, izawl Municipal Corporation (AMC) launched a door-to-door collection of waste (collection at source) as a pilot project at Ramhlun South locality, which falls under Ward- IV. Mizoram Government has established Solid Waste Resource Management Centre at Tuirial in the stateto provide basic infrastructure of proper road access, fence, office, stores, workers rooms, toilet facilities for staffs etc. Also, construction of Vermicompost plant and Mechanical compost plant for recycling decomposable waste is being planned. The Board of Councilors in its Meeting held on dt. 26.3.2019 has resolved banning of Plastic w.e.f. 1st August, 2019.Ban on single-use plastic bags and other plastic products has come into effect from Thursday. August 1, 2019.AMC has Proposed to set up waste recycling plant in various rural areas,to make local Rules, capacity building of Village Council.AMC is planning a new initiative to promoted plastic recycling. In this initiative plastic wastes will be stocked by the residents at plastics collection centre which are constructed at the suitable locations arranged in cluster wise in the village. The plastics wastes will be collected by PHED from each village and transport to Block Headquarters wherein cleaning and compressed will be done by Baling Machine. Thereafter, the proper package of raw plastic wastes will be dispatched to the nearest reliable plastic recycling factory available outside State

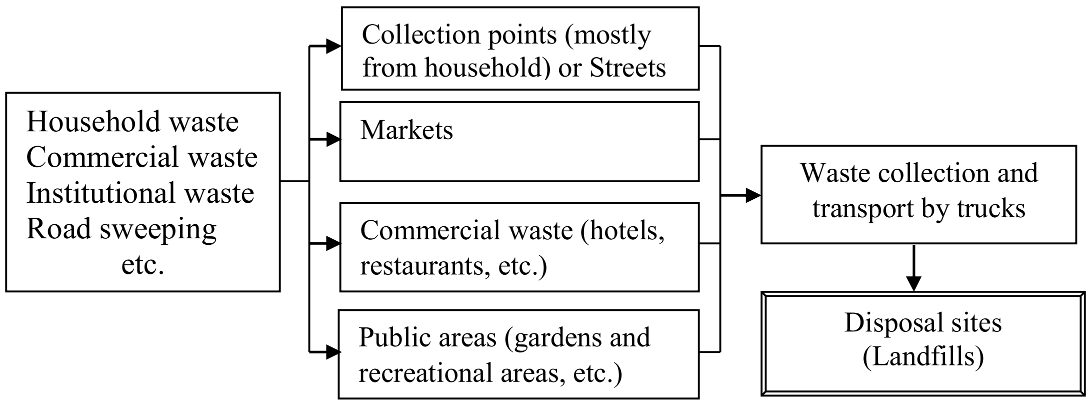


Fig.3Waste collection mechanism in Aizawl city

Table 9.Vital statistics regarding solid waste management in Aizawl city (MSPCB,2018)

Soild waste generation:	266.04MT/day(Mizoram) 182.53MT/day (Aizawl)
Collection:	182.53MT/day
Segregation	68.67% (Practiced in all 19 wards)
Transportation	100%
	1.Material recovery facility:74 TPD

Treatment and processing	2.Composting:50TPD 3.Vermicomposting:22 TPD 4.Landfilling:44 TPD
Plastic waste generation in Aizawl city	Aizawl city 8.5 Tonnes per day (7.95% of SW) as on 2010-11 As on 2020-21 14.51Tonnes per day

2.5 Studies done in India

Very less work has been reported on the quantification and characterization of plastic waste from residential, commercial and dumping site .he available sources are given below.

Hazra and Goel,(2009) overviewed of current solid waste management (SWM) practices in Kolkata, India and found more than 2920 tonnes/day of solid waste was generated in the Kolkata Municipal Corporation (KMC) area. There was no treatment provided to the waste and waste was dumped on open land after collection. Lack of suitable facilities (equipment and infrastructure) and underestimates of waste generation rates, inadequate management and technical skills, improper bin collection, and route planning was found to be responsible for poor collection and transportation of municipal solid wastes.

Srivastava et al.,(2010) studied generation of plastic waste generation in Madhya Pradesh and observed that 4.5% of MSW can be classified into plastic waste. The total quantity of MSW generated from all the 10 regions of M.P. viz., Rewa, Ujjain, Gwalior, Sagar, Satna, Dhar, Indore, Jabalpur, Bhopal & Guna is about 4377.44 MT/day. Out of which about 195.5 MT/day is plastic waste. About 147.55 and 48.45 MT/day classified into recyclable and non recyclable plastic waste respectively. It is thus evident that 75% of the total plastic waste is recyclable and 25% is non recyclable.

Jayashree et al.,(2013) quantified plastic litter on four sandy beaches in Mumbai. The mean abundance of 7.49 g and 68.83 items per square metre was recorded. The abundance of plastics significantly varied among the beaches showing an increasing trend in the southern part. The abundance of plastics by weight in Dadar was significantly higher than that in Aksa. The size fractionation of plastics proved that small particles (1-20 mm) are predominant with 41.85% microplastics (1-5 mm) which emphasizes the high risk to marine organisms due to possible ingestion. The highest quantity of microplastics was seen in Juhu beach (55.33%) followed by Versova, Aksa and Dadar.

Bhattacharya et al.,(2016) studied challenges and opportunities: in plastic waste management in India and found average per capita consumption of plastic in India is about 11 kg, which is considerably low as compared to the global average of 28 kg. Plastic contributes to 8% of the total solid waste, with Delhi producing the maximum quantity followed by Kolkata and Ahmedabad.Majority of the plastic waste generated comprised the HDPE/LDPE materials, such as polybags and multilayer pouches used for food packaging, gutkha, and so on. Further, the study also observes that households are the biggest source of this plastic waste.

Singh and Sharma (2016) studied major sources of plastic waste and found that majority of plastic waste originates from industrial and municipal sectors. According Singh and Sharma (2016) Local Administration Organization is responsible for waste management in the area, provide waste collection services and disposal. Many actors involved in plastic waste collection and recycling like Waste generators such as households, the commercial sector and institutes collect and sell their recyclable plastic waste to waste shops or waste recyclers. The remaining plastic waste is collected by the informal sector. Plastic waste from curbside bins at roadsides and transfer stations is collected by waste pickers transfer station scavengers and is sold to waste shops. Finally, landfill scavengers also collect plastic waste from landfills. Waste pickers and transfer station scavengers do not collect plastic bags or films to recycle because they are contaminated cannot be sold. Manual segregation at sources and dumpsites leads to inefficient segregation and recycling of plastic waste **(Kumar et al.,2011).**

Khan et al.,(2016) studied Impact of socioeconomic status on municipal solid waste generation rate in Dhanbad city,Jharkhand, found that average waste generated in the municipality is 0.41 kg/capita/day in which the maximum waste was found to be generated by lower middle socioeconomic group (LMSEG) with average waste generation of 0.46 kg/capita/day. Plastic waste was maximum (15%) in higher socioeconomic group (HSEG) and minimum (1%) in LSEG. Food waste was major component of generated waste in almost every socioeconomic group with maximum (38%) in case of HSEG and minimum (28%) in LSEG.

Kumar and Sammader,2017 developed a model to establish the relationships between the household solid waste generation rate and the socioeconomic parameters, such as household size, total family income, education, occupation and fuel used in the kitchen. Multiple linear regression technique was applied to develop the two models, one for the prediction of biodegradable MSW generation rate and the other for non-biodegradable MSW generation rate for individual households of the city Dhanbad, India.

Kumar et al.,2018 established a relationship between plastic waste generation rate and the identified socioeconomic groups, higher socioeconomic group (HSEG), middle socioeconomic group (MSEG), and lower socioeconomic group (LSEG) of the study area (Dhanbad, India). For identification of the socioeconomic groups, four different socioeconomic parameters were considered (total family income, education, occupation and type of houses). The plastic waste generated in the study area was 5.7% of the total municipal solid waste. In terms of total plastic waste generation rate, it was found that HSEG had maximum (51 g/c/d) and LSEG had minimum (8 g/c/d) generation rate.

Aryan et al.,(2019) used Life Cycle Assessment technique to assess possible environmental impacts of the existing and proposed plastic waste management scenarios on various impact categories for the study area Dhanbad city, India. This study considered two major plastic wastes, Polyethylene Terephthalate (PET) and Polyethylene (PE). The results showed that the Recycling had the least environmental impacts on most of the impact categories due to use of recycled PET and PE flakes as substitution for virgin PET and PE flakes and also due to less emissions during recycling process of these two plastic wastes.

Krishnakumar et al.,(2020) the plastic debris present in beach sediments at the remote islands of the Andaman and Nicobar Archipelago, India. The maximum number of plastic debris was noticed in the North and Middle Andaman Island sector and the Nicobar Island sector. White, irregular shaped polyethylene and polypropylene debris were the predominant plastic varieties found in the study area. The plastic litter was contributed from tourist, shipping activities and improper handling of solid wastes.

Kumar et al.,(2021) studied plastic waste management during and post COVID-19 pandemic and observed that advent of the COVID-19 pandemic has enhanced the complexities of plastic waste management. Our improved, hyper-hygienic way of life in the fear of transmission has conveniently shifted our behavioral patterns like the use of PPE (Personal protective equipment), increased demand for plastic-packaged food and groceries, and the use of disposable utensils. Incentivizing measures that encourage circularity and sustainable practices, and public-private investments in research, infrastructure and marketing would help in bringing the aforementioned changes. Individual responsibility, corporate action, and government policy are all necessary to keep us from transitioning from one disaster to another.

2.5 Studies done outside India/abroad

Thanh et al.,(2011) assessed the quantity and composition of household solid waste, especially plastic waste to identify opportunities for waste recycling in the capital city of the Mekong Delta region in Southern Vietnam. Household solid waste was collected from each household and classified into ten physical categories. The average household solid waste generation rate was 281.27 g/capita/day. The compostable and recyclable shares respectively accounted for high percentage as 80.74% and 11%. Regarding plastic waste, the average plastic waste generation rate was 17.24 g/capita/day; plastic packaging and plastic containers dominated with the high percentage, 95.64% of plastic waste. Plastic shopping bags were especially identified as the major component, accounting for 45.72% of total plastic waste.

The composition and characteristics of MSW is greatly influenced by the economic status, living standards, food habits, rituals, literacy rate, type of energy source, climatic and topographical conditions **(Jin et al. 2006).** The main composition of waste discarded from households in most developing countries, in order of dominance, is food waste, followed by paper waste followed by plastic waste **(Banarjee et al.,2014., Bernache-Pérez et al., 2016).**Various authors have shown that the amount of waste generated by a country is proportional to its population and the mean living standards of the people **(Wertz 1976; Grossmann et al. 1974). Medina (1997)** related waste generation rates to income levels of people. However, it has been shown that these are not the only governing factors. Amongst other socioeconomic factors that have been said to influence MSW generation are persons per dwelling, cultural patterns, education, and personal attitudes **(Al- Momani 1994; Grossmann et al. 1974, Dennison et al. 1996,Bandara et al. 2007).Hockett et al (1995)** conducted a study to identify and measure the variables which influence per capita MSW generation in the Southeastern USA using information from counties of North Carolina as a data set. They developed a predictive model of the demographic, economic and structural determinants of per capita waste generation.

Gawada et al.,(2019) studied the composition and management of plastic waste discarded by households in Watamu,Kenya. Plastic waste discarded by households was dominated by low density polyethylene (LDPE), polyethylene terephthalate (PET), high density polyethylene (HDPE) and polypropylene (PP).

Wichai and Chavalparit (2019) studied plastic waste management in Thailand and found that HDPE constituted the highest proportion (46%) of plastic waste, followed by LDPE (24%) and PP (14%). Plastic bags and packaging and bottles constituted maximum fraction of plastic waste. Unfortunately most plastic wastes do not have high potential to be recycled as 80% of plastic wastes was found to be contaminated.

Adane and Muleta (2011) studied usage of plastic bags and their environmental impacts in Jimma city of Ethiopia and found low price and easy availability were the main reasons for the widespread utilization of plastic. Some of the major problems due to plastic pollution observed were animal death, blockage of sewage lines, deterioration of natural beauty of an environment and human health problems.

Recently, many studies have focused on plastic waste. **Subramanian (2000)** studied on the recycling and recovery routes of plastic waste and **Chung (2008)** assessed the reliability of self-reported waste disposal data using plastic bag waste. They also pointed out the considerable contribution of plastic fraction and the urgent need for the proper management of waste plastics.Growing environmental concerns associated with the accumulation of plastic waste in the natural environment has incentivized considerable research into renewable alternatives, and more recently,alternative waste management strategies **(Payne et la.,2019).**

Ashiq et al.,(2021) studied Life cycle assessment of plastic grocery bags single-use (HDPE, biodegradable plastic, kraft paper) bags and reusable (cotton, polypropylene non-woven) bags. The usage characteristics (reusability, dimensions, carrying capacity) of bags, the production process (raw materials extraction, production processes), and emissions were determined as the significant factors contributing to the negative environmental impacts. In a model city with confined waste management, the assessment determined that the reusable polypropylene non-woven bag (PNB) caused the least overall negative environmental impacts when there are 50 instances of reuse, followed by single use HDPE plastic bag (HPB).

Eduardo et al.,(2021) analyzed the environmental impacts of nine scenarios for Polyethylene Terephthalate (PET) bottle waste disposal, in the city of Bauru, Brazil and results have shown that recycling is a better option than incineration across all impact categories analyzed. Landfilling had lower net impacts than incineration in all categories.

Putri et al.,(2018) studied plastic waste management in Jakarta, Indonesia and found that municipalities collect plastic mixed with other waste, scavengers recover plastic waste by picking through waste, and some citizens recover plastic at community-based waste management centers called waste banks. In Jakarta, 24% of plastic waste was recycled. Despite this recycling rate, 62% of remaining plastic waste goes to landfills and 14% from recycling activities that goes into the environment. The percentage of plastic waste in Jakarta of total MSW was found to be 14.02%. MSW generation was estimated to be 6717.4 tonns/day while plastic waste generation was 940 tonns/day or 28,211 tonns/month.

Al-Maaded et al.,(2012) studied solid waste management and plastic recycling in and found that Qatar produced around 2,000,000 tonns of MSW annually, corresponding to a daily generation rate per capita of about 2.5 kg. About 60% of MSW is organic material. Landfill and composting is considered the most appropriate waste disposal techniques in Qatar.

Monjur et al.,(2017) plastic waste management in Bangladesh and found that waste collection system in Bangladesh is in the under developing stage and mainly dependent on the informal sector, community based management system and a little portion of the government funding. Around 4–12% of the MSW consists of different kinds of plastic waste from various sources, the per capita plastic consumption rate is 3.5 kg/yr in Bangladesh. Lack of facilities, infrastructure development, and insufficient budget for waste management are some of the prime causes of improper plastic management in Bangladesh.

Olusola et al.,(2020) studied plastic waste generation and management in Sub-Saharan Africa to provide an overview of the plastic lifecycle and problems associated with plastic waste management in sub-Saharan Africa.The study found that population of sub-Saharan Africa is around 1 billion as of the year 2019, the amount of generated waste is 180 million tonnes at the rate of 0.5% per capita/day, the amount that is openly dumped is 70% and the plastic waste generated annually is 17 million tonnes.

Sujauddin et al.,(2009) studied per capita waste generation by residents, its composition, and the households' attitudes towards waste management at Rahman Nagar Residential Area, Chittagong, Bangladesh and fund that generation of HSW was positively correlated with family size, education level and monthly income of the households.

Damghani et al.,(2008) studied the generation, characteristics and management of solid waste in Tehran. MSW comprised more than 97% of Tehran's solid waste, while three other types of solid waste were less than 3% of it, namely hospital waste (1.0%), industrial waste (0.6%) and construction and demolition waste (0.5%). The contribution of household solid waste to total municipal solid waste is about 62.5%.

Bernardo et al.,(2008) studied Solid-waste management practices of households in Manila, Philippines and found that households generated an average of 3.2 kg of solid waste per day, or 0.50 kg/capita/day. The types of wastes commonly generated are food/kitchen wastes, papers, PET bottles, metals, and cans, boxes/cartons, glass bottles, cellophane/plastics, and yard/garden wastes. The respondents segregate their wastes into PET bottles, glass bottles, and other waste (mixed wastes).

Norful et al.,(2020) conducted a study on HSW generation and Composition in Homs City, Syria and found that average of 0.68 kg/per/day solid waste generated was calculated for the entire study area in Homs city. Also, the data analysis presents that organic waste constitutes the largest component in the waste mixture (69.1%) followed by plastic (10.6%), inert materials (8.7%), paper (4.6%), textile (2.5%), metal (1.2%), glass (1.1%), wood (0.6%), and hazardous materials (1.6%), a positive correlation was found between household waste generation and monthly income, household size, and age of the household head, whereas a negative correlation was found between household waste generation and the education level of the household head.

Qu et al.,(2009) studied generation rate of household waste and was found to be 0.23 kg/capita/day. Household waste consisted of kitchen waste, paper/cardboard, plastics, textiles, metals, glass and other wastes, the proportion of each waste was approximately 69.3%, 10.3%, 9.8%, 1.3%, 0.8%, 0.6% and 2.7%, respectively. An evaluation of the relationship between daily per capita generation of household waste and socio-economic factors indicated that household size and income both showed a negative relationship with household waste generation (kg/pers/day).

Dangi et al.,(2011) studied MSW generation in Kathmandu and found that generation rate was 523.8 tonns/day or 0.66 kg capita/day as compared to the 320 tonnes day reported by the city. The coefficient of correlation between the number of people and the amount of waste produced was 0.94. Key household waste constituents included 71% organic wastes, 12% plastics, 7.5% paper and paper products, 5% dirt and construction debris and 1% hazardous wastes.

Saaato et al.,(2007) studied solid waste generation profile in parts of Makurdi, a rapidly growing urban city in North central Nigeria. The quantity of plastic materials from household and non-household sources ranged from 6-10%. There was more paper from commercial and institutional premises (9-12%) than from household or small/medium scale industrial premises (2-4%). Glass (0.1-6.9%), metals (mostly cans and bottle corks, 0.7-3.4%) and textiles (0.3-6%) form only a minor proportion of the waste across generators. Waste generation rates for households was found to be 0.54kg/cap/day.

Al Khatib et al.,(2010) studied waste management in in the Nablus district Palestine and found the majority of waste was organic (65.1% by weight), suggesting a strong resource recovery potential in terms of animal feed or compost. Recyclable waste (plastic, paper and card) made up 16.7% by weight the waste composition suggesting an incentive to introduce source separation. To enhance sustainable waste management, public awareness, funding, expertise, equipment and facilities and other provisions currently lacking or inappropriate must be provided.

Dahlbo et al.,(2018) studied recycling potential of post-consumer plastic packaging waste in Finland and found that the share of monotype plastics in the overall MSW plastics fraction was 80%, hence by volume the recycling potential of MSW plastics is high. Polypropylene (PP) and low density polyethylene (LDPE) were the most common plastic types present in mixed MSW, followed by polyethylene terephthalate (PET), polystyrene (PS) and high density polyethylene (HDPE).

Seng et al.,(2011) MSW management in Phnom Penh and found that per capita household waste generation was 0.487 kg/day. At 63.3%, food waste is the predominant portion of generated waste, followed by plastics (15.5%), grass and wood (6.8%), and paper and cardboard (6.4%). The remaining waste, including metals, glass, rubber/leather, textiles, and ceramic/ stone, accounted for less than 3%. Waste recycling through informal sectors is very active; recycled waste accounted for about 9.3% of all waste generated.

Grazhdani, 2016 did a Comprehensive study of the variables influencing household solid waste production and recycling rate in Albania. The results reveal that households with heterogeneous characteristics, such as education level, mean building age and income, present different challenges of waste reduction goals. Numerically, an increase of 1% in education level of population corresponds to a waste reduction of 3kg on the annual per capita basis. Economic development, urbanization, and improved living standards increase the quantity and complexity of generated solid waste.

Asari et al.,(2019) quantified ocean plastic waste and discussed the effective and needed countermeasures in Pacific island countries. The total amount of mismanaged plastic waste was estimated to be 3,27,000 or 1,56,000Tonnes/yr in Pacific island countries. The regional Pacific island countries contribution to the global total mismanaged plastic waste was estimated to range from 1.3% to 2.7%.

Zhang and Wen,(2014) studied consumption and recycling collection system of PET bottles in Beijing, China and found that consumption of PET bottles in Beijing was nearly 100,000 tonnes in 2012. Age, occupation, gender, and education were identified as significant factors linked to PET-bottled beverage consumption, while income was not a significant factor. 90% Of post-consumed PET bottles were collected by informal collectors (i.e., scavengers and itinerant waste buyers).

Genc et al.,(2019) estimated recycling cost of plastic by using actual data taken from a recycling centre, where plastic solid wastes were collected separately. The total amount of plastic wastes recycled at the centre was approximately 695 tonnes. The operating cost of plastics separation at the recycling centre, the transport of plastic wastes, labouring, maintenance, electricity, insurance and chemical costs were taken into consideration in the cost evaluation. Accordingly, the unit cost of recycling was calculated as US$0.40 kg^{-1} of plastic waste.

Faraca et al.,(2019) studied plastic waste generated from recycling center and results s showed that impurities represented 28% (wet weight) of the plastic waste, and that about 75% of the plastic waste was characterized as Low Quality applications, indicating some legislative recovery restrictions. By accounting for the level/type of impurities, the overall recycling potential was found to be 52% for hard plastics, 59% for plastic films and 79% for PVC waste. The results showed that while varying according to polymer type, the recyclability of "High Quality" plastic waste was 12-35% higher than "Low Quality" applications.

Burnley(2018) conducted life cycle assessment to investigate the environmental benefits of removing dense plastics from household in United Kingdom waste before burning the waste in an energy from waste facility. Such a process was found to improve the climate change impacts of the waste management system by 75% and the non-renewable resource depletion impacts by 18%.

Appiah et al.,(2017) examined the effect of blending waste thermoplastic polymers, namely High density polyethylene (HDPE) and Polypropylene (PP) in Conventional AC-20 graded bitumen, at various plastic compositions. The plastics were shredded and blended with the bitumen 'in-situ', with a shear mixer at a temperature range of 160^{0}C–170^{0}C. Basic It was observed that polypropylene polymer, showed profound effect on homogeneity and compatibility with slight linear increment in the viscosity, softening and penetration values as against relatively high changes for HDPE modified bitumen.The viscosity of unmodified bitumen was enhanced with the addition of the polymers and thixotropic effect was observed for both HDPE and PP at 60 ^{0}C. For all modified binders prepared, the penetration values decrease as polymer- bitumen ratio increases whiles softening temperature generally increases as polymer ratio increases.

Valentina et al.,(2018) identified the multiple-use carrier bag alternative with the best envi-ronmental performance to be provided in Danish supermarkets. Study aimed to assess the environmental impacts associated with production, distribution, use and disposal of the multiple-use carrier bags available for purchase in Danish supermarkets in 2017, for a range of environmental impacts. Three end-of-life options were taken into account for the disposal.It was concluded that carrier bags scoring the lowest climate change impacts were un-bleached paper, biopolymer and LDPE carrier bags. Whether it was reused or incinerated, paper provided a slightly better climate change performance than LDPE carrier bags. Heavier carrier bags provided the highest climate change impacts, with polyester, PP, recycled PET, compo-site and cotton providing increasingly higher climate change impacts.

Nabeel.,(2010) studied management of PET Plastic Bottles Waste through Recycling in Khartoum State,Sudan and found that mechanical recycling of PET bottles is the most preferred recovery route for homogeneous and relatively clean plastic waste stream. It is well suited for developing countries since it is less cost-intensive and currently being employed in Khartoum plastic recycling units.

Anna et al.,(2013) studied existing collection and recycling systems for plastic waste from households and other MSW sources regarding key actors, existing collection systems and financing measures in Nordic countries and identified challenges hampering the collection and recycling of plastic waste are lack of communication and trust for collection and recycling of plastic waste in general, lack of treating and sorting capacity in the Nordic region, costly treatment and logistics, difficulty with obtaining high-quality secondary raw material to enable competition with virgin material, lack of product design to facilitate, weak market demand for recycled plastics and absence of incentives and goals for boosting recycling of plastics. Possible alternative solutions for increased recycling of plastics in the Nordic region could be collection of plastic packaging in mixed waste fractions or in mixed packaging waste fractions followed by central sorting, collection in material streams, the use of weight-based waste fees, and increased Nordic cooperation within collection and recycling of plastic waste.

Lebreton,(2018) analyzed the polymer composition of ocean plastic collected in the Great pacific garbage patch (GPGP) were by Fourier-transform infrared spectroscopy. Polyethylene (PE) and polypropylene (PP) were by far the most common polymer types.

Plastic objects that could be identified included containers, bottles, lids, bottle caps, packaging straps, ropes, and fishing nets.

Martin et al.,(2017) estimated the spatial distribution, types, and characteristics of macro, meso, and microplastic fragments in shoreline sediments of a freshwater Setubal Lake, one of the larger floodplain lakes of the Paraná River.Food wrappers (mainly polypropylene and polystyrene), bags (high- and low-density polyethylene), bottles (polyethylene terephthalate) and disposable Styrofoam food containers (expanded polystyrene) were the dominant macroplastics recorded in this study an average of 25 mesoplastics (mainly expanded polystyrene) and 704 microplastic particles (diverse resins) were recorded per square meter in sandy sediments.

Sadri and Thomson,(2014) studied the quantity and composition of floating plastic debris from surface waters of the Tamar Estuary United Kindom.Plastics were found in a variety of forms and sizes and microplastics (<5 mm) comprised 82% of the debris. The most abundant types of plastic were Polyethylene (40%), Polystyrene (25%) and Polypropylene (19%).

Moritt et al.,(2014) studied plastic in the Thames river, United Kingdom for three month period from September to December 2012, at seven localities in the upper Thames estuary, 8490 submerged plastic items were intercepted, in excess of 20% of the litter items were components of sanitary product.The most contaminated sites were in the vicinity of sewage treatment works. While floating litter is visible, this study also demonstrated that a large unseen volume of submerged plastic is flowing into the marine environment.

Moore et al.,(2011) studied quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. Total number of plastic objects and fragments was 2.3 billion, total weight of plastic objects and fragments 30 tonns). In terms of the number of pieces, the majority, 71% were foams, with miscellaneous fragments at 14%, pre-production resin pellets at 10% and whole items at 1%. In terms of weight, however, whole items were the heaviest, at 37% of the total, followed by fragments at 29%, pellets at 13% and foamed polystyrene at 11%.

Gasperi et al.,(2014) examined the quality and quantity of floating plastic debris in the River Seine through use of an extensive regional network of floating debris-retention booms; it is one of the first attempts to provide reliable information on such debris at a large regional scale. Plastic debris represented between 0.8% and 5.1% of total debris collected by weight. A significant proportion consisted of food wrappers/containers and plastic cutlery, probably originating from voluntary or involuntary dumping, urban discharges and surface runoff. Most plastic items are made of polypropylene, polyethylene and, to a lesser extent, polyethylene terephthalate.

Faure et al.,(2015) assessed plastic abundance in Lakes Geneva, Constance, Maggiore, Zurich and Brienz and identified the nature of the particles, potential ingestion by birds and fishes, and the associated pollutants. Lake surface transects and a few rivers were sampled using a floating manta net, and beach sediments were analysed. Plastics were sorted by type (fragments, pellets, cosmetic beads, lines, fibres, films, foams) and composition (polypropylene, polyethylene, polystyrene, etc.); fish and water birds were dissected to assess their potential exposure, and analyses were conducted on the hydrophobic micropollutants adsorbed to the microplastics as well as some potentially toxic additives they contained.

2.6 Strategies for reducing plastic pollution

2.7.1Integrated waste management It relies on cradle to grave approach. Right from extraction of raw material,production of finished products, generation of waste, storage, collection, transportation, processing, recycling, energy recovery and disposal. It is a holistic approach which focuses on waste prevention, waste reduction, enhance recovery and safe environmental friendly disposal.

2.7.2 Promotion of bioplastics: Bio plastics are plastics made from renewable sources such as biomass.Most common feedstock used to manufacture bioplastics are sugar, starch, cellulose, vegetable oils obtained from corn, potato, sugarcane, wood etc.While synthetic plastics is derived from petroleum based products. New economy bio plastics include Poly lactic acid, Polyhydroxyalkanoate, starch blends,biobased polyesters etc.while old economy bio plastics includes rubber,cellulose,Linoleum.Bioplastics can be broadly classified in to two categories Biodegradable plastics and Biobased plastics.Some common bioplastics include Poly Lactic acid(PLA),Poly hydroxyalkanoate (PHA),aliphatic polyesters and polysaccharides.Polycaprolactone (PCL),Polybutylene succinate(PBS) are derived from petroleum and are biodegradable.Bioplastics are finding its use as compostable bags,mulch,film,rigid packaging and in catering products.Bioplastics generation saves fossil fuel consumption and hence prevents greenhouse gas emissions. Recovery options for bioplastics includes thermal recovery,Mechanical recycling,landfilling and organic recycling.Biopastics are costly as biobased plastics industries are in nascent stage and bioplastic production is low.Bioplastics have potential to impact food supply and recycling options are still not much for bioplastics.In lines with core principles of circular economy, Bio plastics prevents waste generation and enhances recovery from waste.Bioplastics promote resource efficiency and adheres to low carbon economy.

2.7.3 Zero waste concept: It includes reuse, reduce, recycling, waste minimization, ecolabelling, ecodesigning and extended produces responsibility. Zero waste approach is inspired from TQM (Total quality Management) concept used in industrial production. In waste management scenario zero waste concept intends to achieve zero discharge, zero atmospheric damage and zero material waste. Its main objective is to create a smart system which utilizes resources in waste stream to create wealth and employment.

2.7.4 Circular economy approach: The conventional linear approach involves produce, use and dispose. Generally goods are made from raw materials, sold, used and then discarded as waste. On the other hand circular economy approach in waste management involves extraction of maximum use value even after a product becomes a waste and then safely returning to earths system. Circular economy intends to eliminate waste by maximum utilization of resource. So circular economy focuses more on biobased, biodegradable, renewable alternatives, enhanced energy recovery, increasing utilization rate by improving access and ownership and extending products lifespan.Circular economy approach for plastic, where plastic never becomes waste. It offers a root cause solution to plastic pollution with profound economic, environmental and societal benefits. It involves Elimination of problematic or unnecessary plastic packaging through redesign, innovation and new delivery models. Reuse models are applied where relevant, reducing the need for single-use packaging. All plastic packaging should be 100% reusable, recyclable, or compostable by design. All plastic packaging is reused, recycled or composted in practice. The use of plastic is fully decoupled from the consumption of finite resources. All plastic packaging is free of hazardous chemicals, and the health, safety and rights of all people involved are respected.Changes in Product design: Sourcing raw materials from renewable sources like biomass instead of fossil fuels, creating products which requires less packaging, products which are made from recyclable materials and not releasing harmful chemical in environment, products which are reusable can greatly reduce burden of plastic waste in environment.Better management system: Instead of municipal authorities alone being responsible for waste management, public participation and community engagement in decision making, ownership and responsibility for waste management should be encouraged. Latest technological advancements and techniques should be implemented in plastic waste management.

2.7.5 Effective legislations: Central pollution control board and state pollution control boards have already formulated waste management rule but effective implementation is lacking at ground level. There is lack of funds, proper training and motivation among waste management professionals. The legislation on waste management should incentivize recycling reuse, processing and value addition.

2.7.6 Extended Producer's Responsibilities (EPR):In addition to the responsibilities of Producer's, Plastic Waste Management Rules, 2016 defines the Extended Producer's Responsibility (EPR), as responsibility of a producer for the environmentally sound management of the product until the end of its life. Rule 9 of the Plastic Waste Management Rules, 2016 (PWMR, 2016), sets out modalities for implementation of EPR under the ambit of the rules. The producers are required to set out modalities for waste collectionsystem based on Extended Producers Responsibility and involving State Urban Development Departments, either individually or collectively, through their own distribution channel or through the local body concerned.

2.7.7 Buy back Depository: Mechanism with a predefined buy back price printed on plastic products, so that consumers receive a specified amount while returning the used products. The manufacturers/ producers of these plastic products need to set up collection centers with reverse vending or crushing machines and recycling units of adequate capacity to collect such used plastic products/packaging and recycle these. This model not only incentivises consumers to not litter plastic products/ packaging post consumption but also encourages retailers/producers to recycle more.

2.7.8 Multiwaste Management Concept:"Multi-Waste Plant" concept proposes the management and valorization of different types of waste, with very different nature, such as industrial waste (plastics), the non-recyclable fraction of waste treatment centers and farm/livestock waste in the same facility. A key aspect of this model is the recovery of energy, for which two complementary technologies are proposed: an anaerobic digester to effectively convert biodegradable organic waste into biogas and, additionally, a thermo-chemical treatment system to transform non recyclable waste into syngas.

CHAPTER 3:

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Description of the Study area

Mizoram is one of the seven sister states of the North East India. It is located within a geographical coordinates of 21^o 58' & 24^o 35' N latitude and 92^o 15' & 93^o 29' E longitude, in the Southern most landlocked state sharing borders with Tripura, Assam and Manipur. The state also shares 722 kilometers border with the neighboring countries of Bangladesh and Myanmar. Aizawl is the capital of Mizoram. With a total area of 457 km^2 it is the largest human habitation in the state. The city is located North of the Tropic of Cancer at 23°30' N and longitude of 92°.15' E. It is situated on a ridge 1,132 m (3715 ft) asl with the Tlawng River to its West and the Tuirial River to its East.

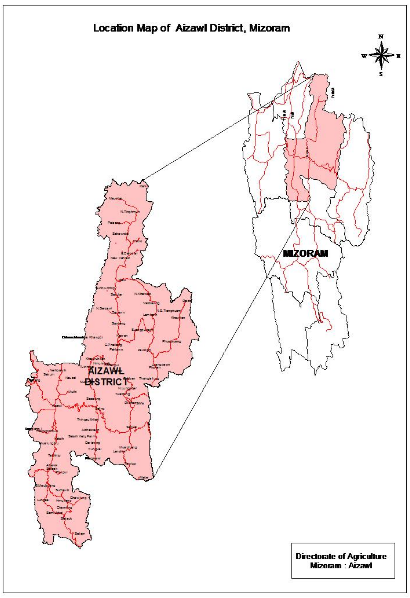


Fig.4 Map of Aizawl city (Directorate of agriculture, 2020)

3.2 Climatic pattern of Aizawl city

Mizoram falls within a region which receives heavy rainfall with an annual average of 2500 mm to 3000 mm. The topography of the land is hilly with rugged terrain with an altitude ranging from 50 to slightly above 2000m asl. Vegetation types of Mizoram based on altitude and rainfall can be broadly classified into Tropical Wet-evergreen forest, Montane Sub-tropical forest and temperate forest. The climate is also pleasant with an average of 11^{o} to $21\ ^{o}C$ during winter and 20^{o} to 30^{o} C during summer. The total geographical area of Mizoram is 21,087 km^{2}which is divided into 8 administrative districts. (Statistical handbook of Mizoram, 2018).Aizawl has a mild, sub tropical climate. The city witnessed rainfall during May to September with an average annual rainfall of 209 cm.Temperature ranges between 20-30 ^{0}C in the summer and 11 to 21 ^{0}C in winter. Total no of households in Aizawl district were 64,753 and average household size was 5 persons. The average gross population density of Aizawl urban area(AUA) is 1708 persons per km^{2}(District census handbook,2011).

The climate of study area is monsoonal with warm moist summer and cool dry winter. Based on weather data it can be stated that April to October contributes wet months December to February as dry and cool months. The wet period can be further divided in to moist summer season (March to May) and rainy season (June to October).There is a consistent increase in rainfall from January onwards till a maximum in August and then it gradually decreases till December. There is a distinct summer (March to May), rainy (June to October) and winter (November to February) seasons. The rainy season is of longest duration than those of summer and winter season. March constitutes the transitional month between winter and summer whereas October is transitional month between rainy and winter season (http://mizenvis.nic.in)

During study period 2017-20, the mean maximum temperature varied from 16 ^{0}C (January) to 24 ^{0}C (August) and mean minimum temperature ranged from $4^{0}C$ (January) to 17 ^{0}C (July).The mean monthly rainfall ranged from 6.16 mm (January) to 417.38 mm (August).The mean annual rainfall was 2187.03 mm.

Seasons

3.2.1 Summer season

The mild moist months of year are March, April and May. This season receives 25.61% of total rainfall of the year. The rainfall varied from 52.58 mm (March) to 346.61% of total rainfall of the year. The mean maximum temperature varied from 19 ^{0}C(May) to 23

^{0}C (April) and the mean minimum temperature varied from 10 ^{0}C (March) to 14 ^{0}C (May).

3.2.2 Rainy season

The rainy seasons the wettest period of the year constituting July, August, September and October with rain fall varying from198.4 mm (October) to 417.38 mm (August).In this season 72.30% of annual rainfall was received. The mean maximum temperature fluctuates very little which ranged from 22 ^{0}C (September) to 24 ^{0}C (August).The mean minimum temperature ranged from 13 ^{0}C (October) to 17 ^{0}C (August).

3.2.3 Winter season

The winter season starts from November to February and this season is characterized by low temperature and low rainfall compared to rainy and summer season. The mean maximum temperature varied from 16 ^{0}C (January) to 21 ^{0}C (November).The mean minimum temperature varied between 4^{0}C(January) to 10^{0}C (November).The mean monthly rain fall varied from 6.07 mm (February) to 23.84 m (November) and received only 2.1% of total annual rain fall.

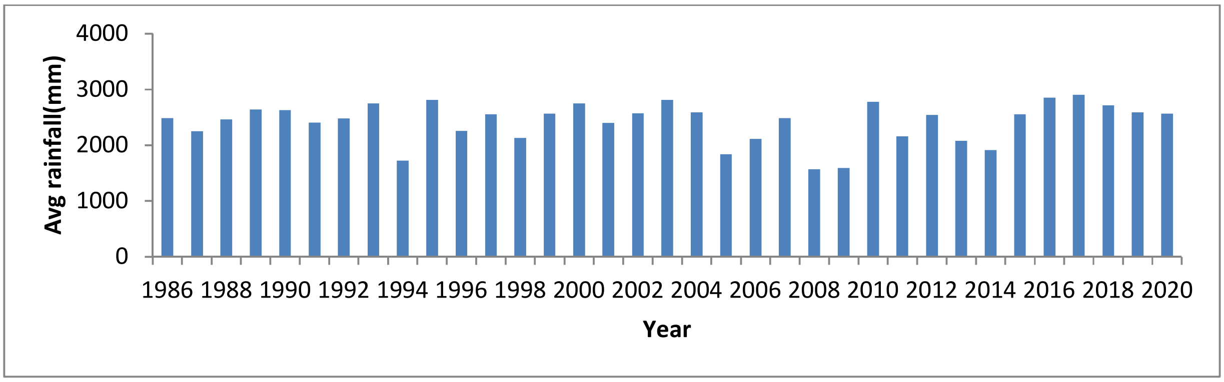


Fig.5 Trend of total Annual Rainfall of Aizawl city in past 30 years (Mizoram State Climate Change cell,2020)

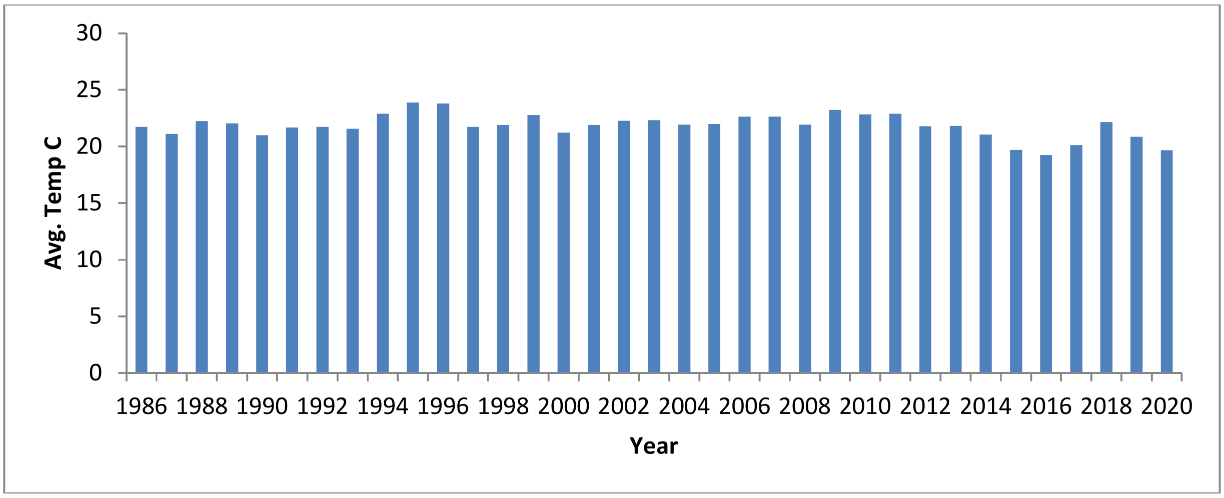


Fig.6 Average temperature of Aizawl city in past 30 years. (Mizoram State Climate Change cell, 2020)

3.3Demographic and socioeconomic profile of Aizawl city

In 2011, Aizawl had population of 400,309 of which male and female were 199,270 and 201,039 respectively. Children (0-6) years were 36012 of which 18159 male children while 17853 were female child.Aizawl District population constituted 36.48 percent of total State population. Total no of households were 82524 on average, households in Mizoram are comprised of 4.5 members. Twenty percent of households are headed by women, with 18 percent of the population living in female-headed households. In terms of literacy ,Aizawl district with a literacy rate of 98.50 against 91.3 % of the states .The density of population of Aizawl District is 112/Km^2 Against the average density of 52/Km^2 .(Census,2011). The estimated per capita income across the north-eastern state of Mizoram in India stood at around 147 thousand Indian rupees in the financial year 2019. Average Monthly Per capita expenditure 1,346.35.The economy of Aizawl is basically sustained by government services as it is capital of Mizoram (Economic

Survey 2019-20Government of Mizoram Planning & Programme Implementation Department)

Table10. Details of Demography of Aizawl city

Area	3,576 Sq. Km
Populations	400,309
No. of Males	199,270
No. of Females	201,039
No. of Towns	7
Villages	96
No. of Assembly Constituencies	14
Population Density	112 Sq.Km
Literates	340,595
Literacy Rate	97.89

3.4 Study sites

The study was conducted in 5 residential areas, 3commercial sites and at dumping area. The study sites for ach residential, commercial and dumping area are described below.

The commercial activities take place mainly at core area of Bara Bazaar-New Market, Bawngkawn, Vaivakawn Sihhmui. Sairang, Sihhmui, Neihbawih, Durtlang, Muanna Veng, Tanhril, Lawipu Veng, Tlangnuam, Saikhamakawn, Samtlang and Lungleng along the main roads. To cater to the retail and wholesale demand for future, 187 hectares have been earmarked for commercial use. Out of total urbanized use, share of commercial use is 2.66%. Wholesale trade centre are located at Bara Bazaar Rangvamual and Zemabawk truck terminal. In order to encourage local arts and crafts, and to introduce food processing, packaging industries and other eco-friendly small scale industries, an area of 103 hectares has been earmarked for industrial use. Small scale cottage industries are located at Luangmual and Zuangtui Industrial Estate. Industrial growth center is identified at Tanhril-Sakawrtuichhun. New Industrial hubs are proposed at Sihphir Vengthar, Zemabawk and Melriat. Out of total urbanized use, share of industrial use work out to be 1.47%.

There are two sites for disposal of solid waste in the Aizawl city. It is reported that 90% wastes are disposed at Tuirial site which is located on the western side of Aizawl city at a distance of 27 km from the heart of the city. Remaining 10% wastes are disposed at Durtlang site, which is 20 Km from city, located at Aizawl to Silchar road towards the north side. Both disposal sites are situated outside the city limits. Average solid waste generation in Mizoram is 266.04 Metric Tonnes per day(MT/Day) and in Aizawl city it is 182.53 MT/Day.Tuirial dump site has a capacity to dispose 44 Tonnes of Soild waste every day.

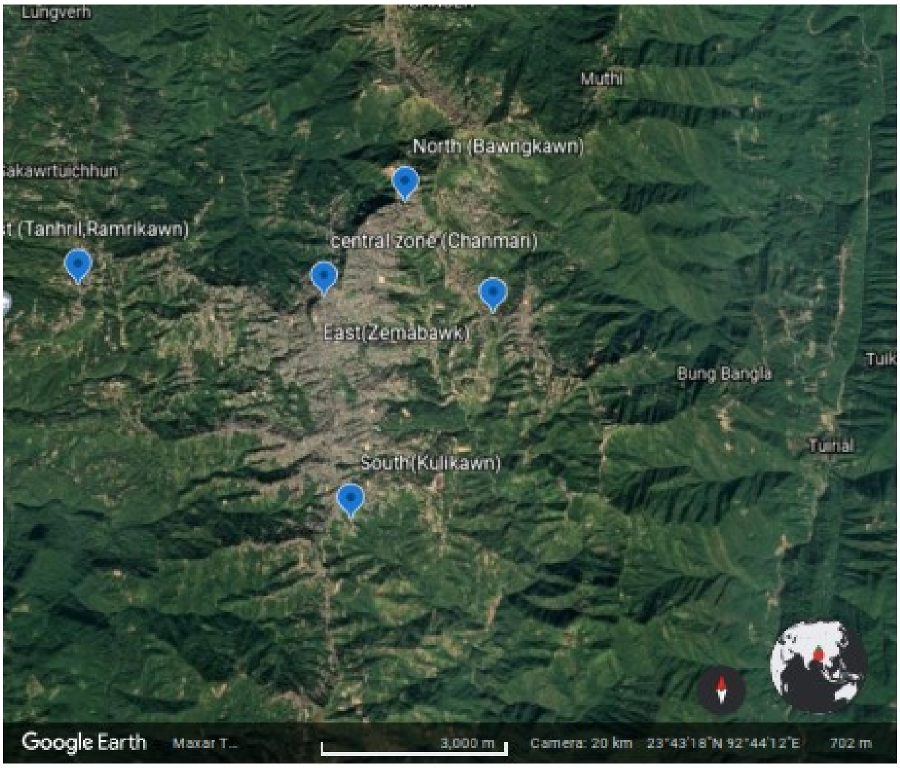


Fig.7 Sampling zones in Aizawl city with localities

Table 11.Distribution of Sample Households among Zones

S no	Zone	Locality	Total household	Total population	Sample household	Sample population	% (H)	% (P)
1	North	Bawngkawn	13,992	70,849	77	432	.55	.60
2	South	Kulikawn	11,910	59,558	77	414	.64	.69
3	East	Zemabawk	10,102	52,313	77	445	.76	.85
4	West	Tanhril	12,298	66,493	77	396	.62	.59
5	Central	Chanmari	11,298	50841	77	443	.68	.87

H=household, P=population

3.4.1 a Aizawl North

Total population of Aizawl North Area was 70,849 which is 24.18 % of the total population of Aizawl District.It comprised of total 13,992 households.In Aizawl North Area Bawngkawn was chosen as study site (Directorate of census operations,Mizoram). Bawngkawn locality comprises of Bawngkawn and Bawngkawn South.Bawngkawn locality falls under Ward no 2 under Tlangnuam Block.Total population of Bawngkawn locality was 10,354 which comprised of 2065 households. Out of total 2065 households 77 households were selected for plastic waste survey during 2017-2020.

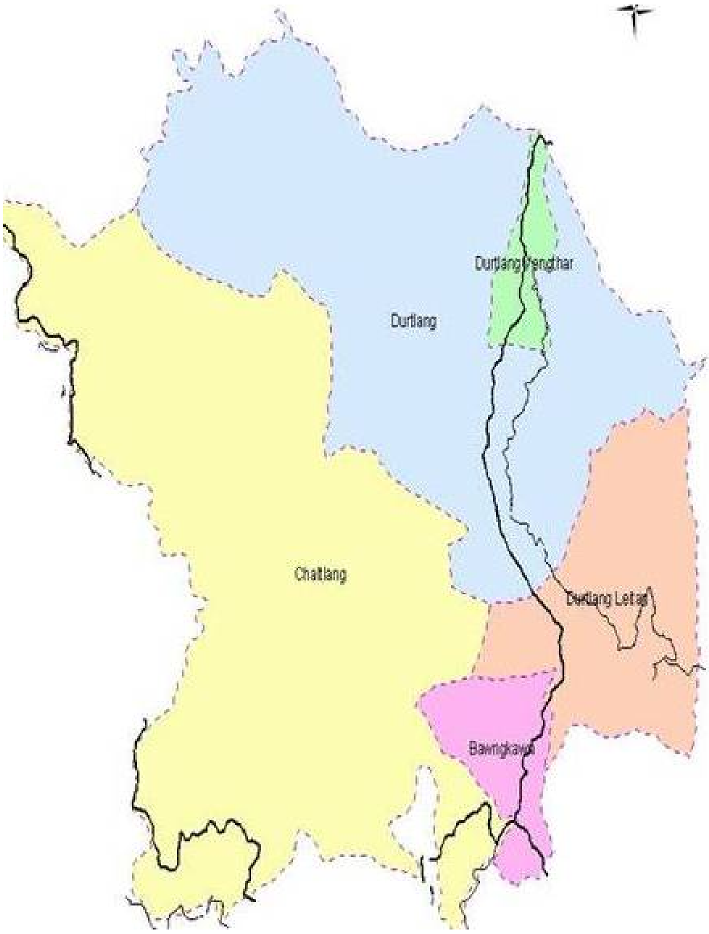


Fig. 8 Map of Aizawl North study site

3.4.1 b East Aizawl

Total population of Aizawl East Area was 52,313which is 17.85% of the total population of Aizawl distict.It comprised of total 10,102 households. In Aizawl East Area Zemabawk was chosen as study site (Directorate of census operations,Mizoram). Zemabawk locality comprises of Zemabawk and Zemabawk North.Zemabawk locality falls under Ward no 7 under Tlangnuam Block.Total population of Zemabawk locality was 11,671 which comprised of 2329 households. Out of total 2329 households 77 households were selected for plastic waste survey during 2017-2020.

Fig.9 Map of Aizawl East study site

3.4.1 c West Aizawl

Total population of Aizawl West Area was 66,493 which is 22.69% of the total population of Aizawl distict.It comprised of total 12,298 households. In Aizawl West Area Tanhril was chosen as study site (Directorate of census operations, Mizoram).Tanhril locality falls under Ward no 11 under Tlangnuam Block.Total population of Tanhril locality was 10,169 which comprised of 2030 households. Out of total 2030 households 77 households were selected for plastic waste survey during 2017-2020.

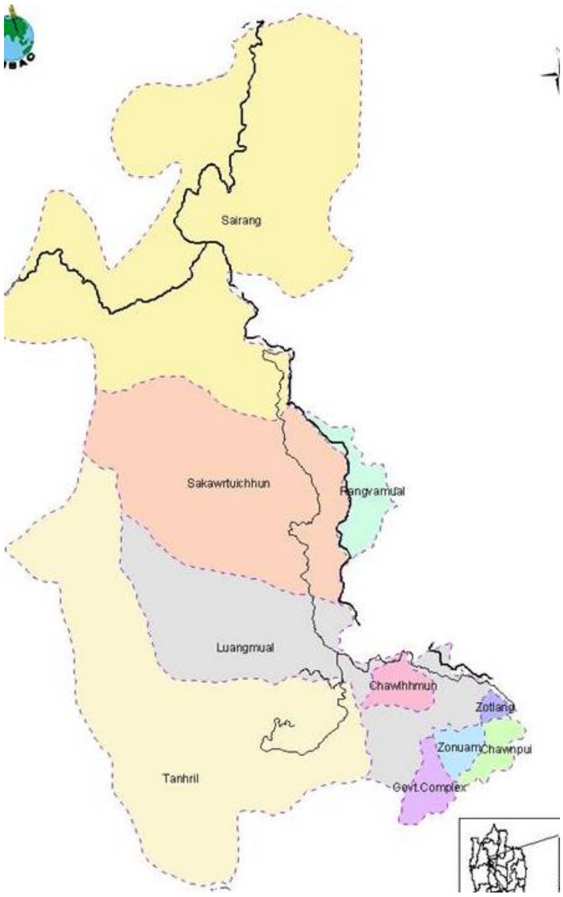


Fig.10 Map of Aizawl West study site

3.4.1 d South Aizawl

Total population of Aizawl South Area was 59,558 which is 20.32% of the total population of Aizawl distict.It comprised of total 11,910 households. In Aizawl South Area Kulikawn was chosen as study site (Directorate of census operations,Mizoram).Kulikawn locality falls under Ward no 19 under Tlangnuam Block.Total population of Kulikawn locality was 11,075 which comprised of 2215 households. Out of Total 2215 households 77 households were selected for plastic waste survey during 2017-2020.

Fig.11 Map of Aizawl South study site

3.4.1 e Central Aizawl

Total population of Aizawl Central Area was 50841 which is 17.35% of the total population of Aizawl distict. It comprised of total 11298 households. In Aizawl Central Area Chanmari was chosen as study site (Directorate of census operations,Mizoram).Chanmari locality falls under Ward no 19 under Tlangnuam Block.Total population of Chanmari locality was 8,680 which comprised of 1730 households. Out of Total 1730 households 77 households were selected for plastic waste survey during 2017-2020.

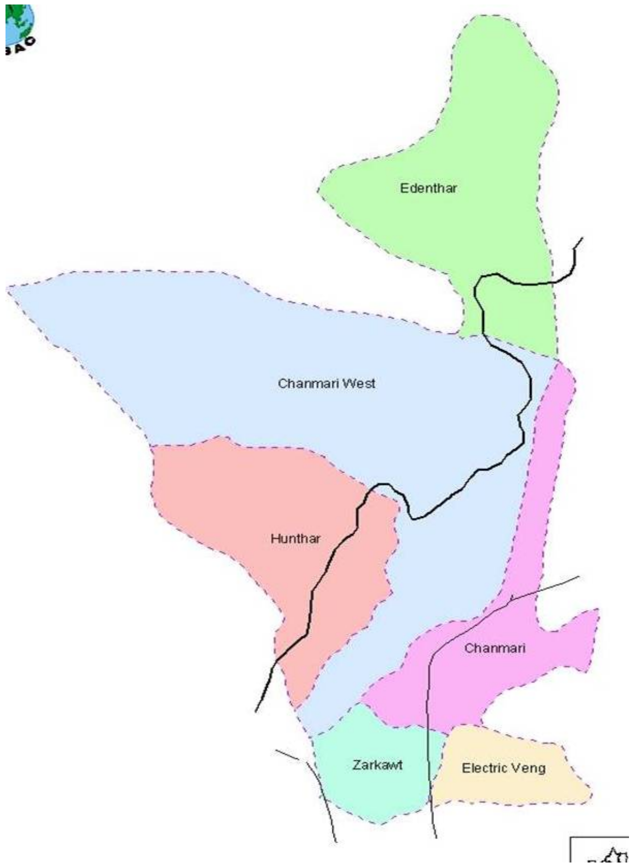


Fig.12 Map of Aizawl Central study site

3.4.2 Commercial area

The commercial sites namely Bara Bazar,Millenium center and Zarkawt was selected for plastic waste assessment during 2017-20

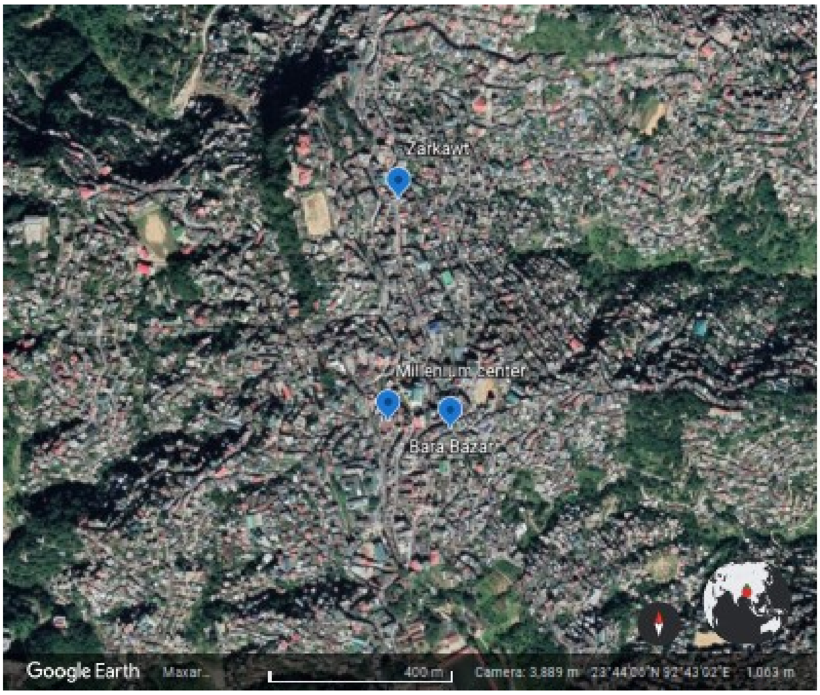


Fig.13 Map showing commercial site studied in Aizawl city

3.4.2 a Barabazar

Bara Bazar area is situated in heart of Aizawl buzzing with business activities.It has plenty of shops catering to daily need of people like shops for consumer goods, garments,house hold items,vegetable,meat shops and transport hub.It is very popular spot for general public and it gets very crowded during weekends and during festival season.Bara Bazar.Bara bazaar was selected to capturedata on waste plastics getting generated mainly from day to day activities.

Fig.14Bara bazaar area

3.4.2 bMillenium center

Millennium center is main shopping mall with many show rooms, restaurents, salons.Also it is main center for organizing various social events, music and dance shows, promotional activities. It is very popular among younger generation mainly school and college students.Millenium center was selected as it gives a chance to capture data on waste plastics getting generated mainly from shopping activities.

Fig.15 Millenium center

3.4.2 c Zarkawt

Zarkawt area is main business hub for Aizawl city it has many Banks,offices,travel agencies,automobile show rooms,hotels,high end eateries like KFC,Dominos Pizza,Marts,Shops for computer and electronics items.Zarkawt area was selected as it gives a chance to capture data on waste plastics getting generated from take away joints and leisure and pleasure activities mostly.

Fig.16 Zarkawt area

3.4.3 aDumping site

Tuirial Dumping Site is located on the road side of the National Highway-54, about 20 kms from Aizawl city. Site falls roughly within the geographical coordinates 23°44’27” North and 92°47’41”. Dumping site lies within the Tuirial Airfield locality.

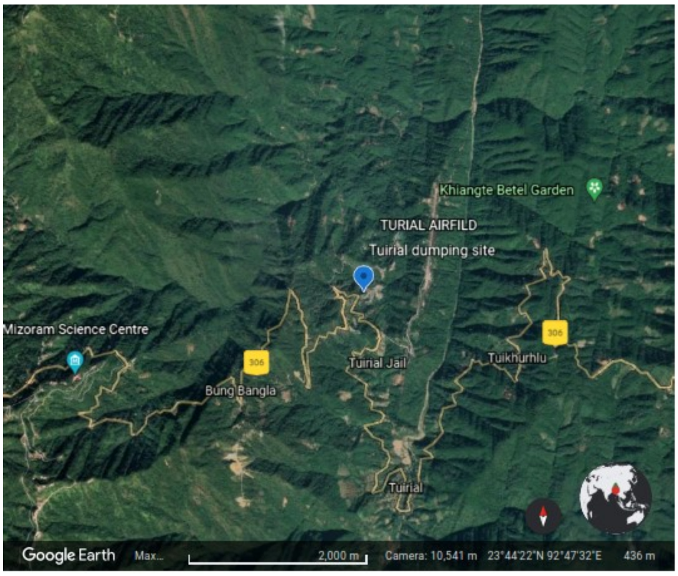


Fig.17 Tuirial dumping site situated in Aizawl city

Turial dumping site is one of the two dumping sites operated by Aizawl Municipal Corporation. It is main dumping site where about 90% of all solid waste collected is dumped. Plastic waste assessment is carried out at dumping sites to get a holistic view of waste situation as dumping site receives waste from all streams like residential, commercial, institutional construction and demolition sectors.

Fig.18 Dumping site at Turial

3.5 Research Design

Descriptive research has been used in present study. Descriptive survey enables to obtain the current information. Descriptive survey method focused on investigating the current status, practice, the problem of institutional arrangement and capacity in assessment of plastic waste management practices in Aizawl city. Descriptive research design involves collecting quantitative and qualitative information regarding plastic waste generation and assessment under present situation.

3.6 Sources of Data

In this study, both primary and secondary data sources were utilized. Primary data for this study were collected from household survey, interviews, discussion and field observations and field measurement. In addition to these secondary data were also collected from different sources like election commission data, census report, reports available at block and local council office, Aizawl Municipal Corporation and Mizoram government department websites.

3.7 Sample Size and Sampling Techniques

In the study both probability and non-probability sampling methods were employed. From among the probability sampling, stratified and simple random techniques were used to identify the respondents. In simple random sampling of a given size all members of a frame are given an equal probability of selection. From among non-probability sampling technique, purposive sampling technique was used for the for selection of sites in commercial area and waste assessment at dumping site. Before conducting waste survey a pilot study was done to collect data regarding average household size,yearly income, education level. The relevant information was collected through face to face discussion with participants, consulting local council, block level officers and Election commission data. The population was stratified in to various clusters on basis of household size and economic status and within each cluster random sampling was done. The households within each cluster were selected through lottery method. Probability sampling technique was adopted for selection of households randomly in each locality from a population. Election commission date was used for random selection of households in each residential area. All the households had an equal opportunity to be a part of the sample. For studying relationship of economic status and plastic waste generation stratified random sampling method was used. The whole population of each locality was divided into sub groups on the basis of net yearly income /year, and then households were randomly selected from each economic stratum.

3.8 Sample size

Sample size for household survey for conducting plastic waste assessment was determined according Designing Household Survey Samples: Practical Guidelines (2005) and Gwada et al., 2019.

$$n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2}$$

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384.16$$

where
z is the z score
ε is the margin of error
N is population size
p̂ is the population proportion
z for a 95% confidence level is 1.96.
Population size: 2,93,416

Margin of error: 5%

Sampling confidence level: 95%

Sample size thus obtained was dispersed across five localities North,South,East,West and Central locality in Aizawl city. Thus in each locality 77 households were surveyed.

3.9 Data collection and data analysis

3.9.1 Quantification

3.9.1 a Plastic waste quantification in residential area

In residential area MSW was assessed from each household twice a week on Tuesday and Saturday in early morning hours from6.00 am to 10.00 am. The MSW was collected and spread on a plastic sheet and segregated in to biodegradable and non biodegradable fraction. From non biodegradable fraction plastic waste was segregated and weighed. The plastic fraction was further sorted in to various physical forms, weighed and recorded.

3.9.1 b Plastic waste quantification at commercial sites

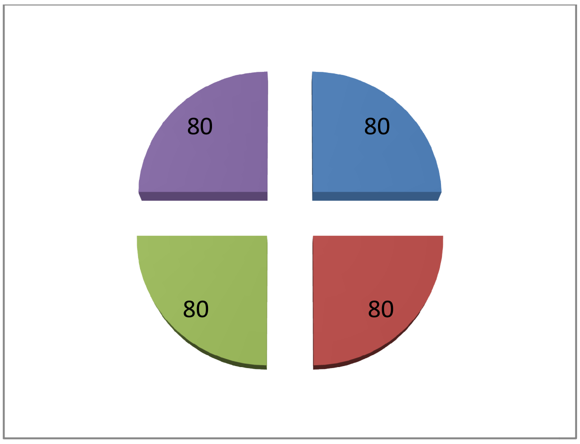
In each commercial area, 5 collection points were selected and from each collection point 10kg of MSW obtained by quartering technique was collected twice a week on

Tuesday and Saturday. MSW thus collected was segregated in to biodegradable and non biodegradable fraction. From non biodegradable fraction plastic fraction plastic waste was segregated, sorted and weighed.

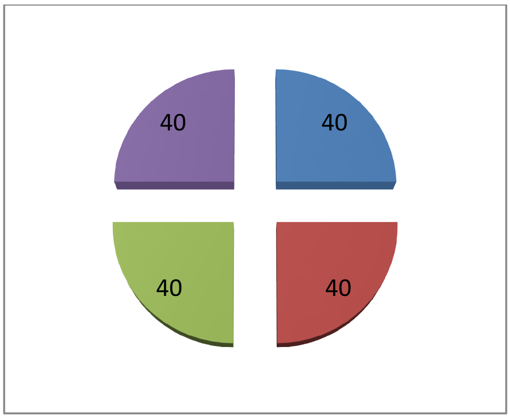
3.9.1 c Plastic waste quantification at dumping site

At dumping site plastic waste assessment was carried out during 2017-18, 2018-19, 2019-20.Every year survey was conducted bi weekly for total nine months covering three months each for winter (November ,December, January), Summer (March, April, May) and rainy (July,August,September) season. The methodology prescribed by ASTM (Standard Test Methods for determination of composition of unprocessed Municipal waste) D5231-92 (2016) was fallowed. Likewise ASTM method was adopted to access 320 Kg of mixed solid which was collected bi weekly and finally reduced to 20 kg by quartering technique.320 Kg of solid waste was mixed thoroughly divided in to four parts of 80 kg each.The opposite 2 parts were discarded and remaining two parts was collected further 160 kg was again divided four sections having 40 kg each. Again two opposite sections were discarded and two remaining sections were collected and 80 Kg was further were divided in to 20 kg each. From finally achieved 20 kg solid waste fraction plastic waste was separated and segregated in to various physical and chemical categories. Weight of each category was taken in grams.

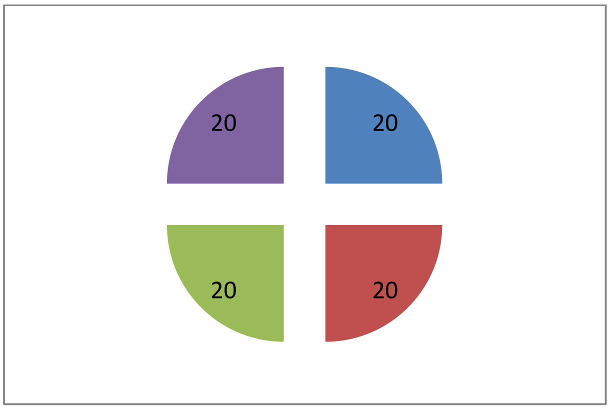
Step 1.Waste sampling by quartering technique from selected 320 Kg mixed solid waste



Step 2.Waste sampling by quartering technique from selected 160 Kg mixed solid waste



Step3.Waste sampling by quartering technique from selected 80Kg mixed solid waste



3.9.2 Characterization

Hand sorting and visual characterization technique was used to segregate plastic waste from mixed soild waste. As plastic waste is visibly different from other components of solid waste plastic was identified by texture, material, colour, various forms, utility, size,shape, weight.This method doesn't need any special machinery for the separation of substances except basic equipments like electonic weighting balance and safety equipments like pairs of gloves, safety glasses with splash shields, a dust mask, and disposable protective kit.

3.9.2 a Physical characterization

In residential area from selected households, plastic wastes was collected biweekly across three seasons namely summer (March-May), Rainy season (July-September), winter season (November-January).All the households in locality were selected randomly as per election commission data. Once household were selected their consent was taken for conducting waste survey. All households were given big plastic bag and they were asked to put MSW produced in the bag provided. All bags were marked with house no, locality, collection date and time. The waste was analyzed and plastic fraction was sorted out. The weight of plastic waste was taken. The plastic waste thus obtained was be categorized in to physical categories depending upon its usage (Table 12). Every year during assessment period (2017-20)100 kg of plastic waste was collected from each locality in residential area and each site in commercial area and sorted into various categories depending upon use like bottles, containers, tubes, packaging, rope, tray, durable plastic products, consumable plastic products and other categories.Further packaging items were sorted in to plastic shopping bags, packaging for food, packaging for non food, Plastic packaging for unspecified purpose and buffer material (Table 13). The plastic waste was spread on large sheet and all the fractions were segregated and weights of all individual categories were taken. The weight of each category was recorded with the help of digital balance and % composition of the total plastic waste was thus achieved.

Table 12 Physical categories of Plastic waste

S no	Category	Weight %
1	Bottles	
2	Containers	
3	Tubes	
4	Packaging	

5	Plastic rope	
6	Tray	
7	Durable products	
8	Consumable products	
9	Other plastics	

Table 13.Physical categories of packaging material

Category	Wt %
Plastic packaging for food	
Plastic packaging for non-food	
Plastic packaging for unspecified purpose	
Plastic shopping bags	
Buffer materials	

3.9.2 b Chemical characterization

Plastic waste was categorized on the basis of its resin type and the type of monomers it is made up of (Table 14**)**. The plastic waste was categorized in to following seven categories and % composition was be calculated. Each year durning assessment period (2017-20) 100 kg of plastic waste was collected from each locality in residential area and each site in commercial area and spread on a sheet and plastic waste sorted depending upon its chemical characteristics (Polymer type) in to seven categories PET(Polyethylene Terephthalate), HDPE(High Density Polyethylene), PVC(Polyvinyl Chloride),LDPE (Low Density Polyethylene), PP(Polypropylene), PS(Polystyrene) and other category (Oth).

After collection,segregation,weighing of plastic waste from residential,commercial and dumping site characterization of waste in to Polyethylene Terephthalate (PET), High

Density Poly Ethylene (HDPE), Poly Vinyl Chloride(PVC), Low Density Poly Ethylene (LDPE), Polypropylene (PP) and Polystyrene (PS) and others ws done.It was done by fallowing the methods obtained by United Nations Environment Programme, Division of Technology, Industry and Economics, International Environmental Technology UNEP DTIE (2009) guidelines for assessment and characterization of plastics.

Fig.19 Plastic Identification Code

Polyethylene Terephthalate (PET) PET exists as an amorphous (transparent) and as asemi-crystalline (opaque and white) thermoplastic material. Generally, it has good resistanceto mineral oils, solvents and acids but not to bases. The semi-crystalline PET has goodstrength, ductility, stiffness and hardness while the amorphous type has better ductility butless stiffness and hardness. PET has good barrier properties against oxygen and carbondioxide. Therefore, it is utilized in bottles for mineral water. Other applications include food trays for oven use, roasting bags, audio/video tapes as well as mechanical components and synthetic fibers.

Polyethylene (PE) The two main types of polyethylene are low-density polyethylene(LDPE) and high density polyethylene (HDPE). LDPE is soft, flexible and easy to cut, with the feel of candle wax. When it is very thin it is transparent; when thick it is milky white,unless a pigment is added. LDPE is used in the manufacture of film bags, sacks and sheeting, blow-moulded bottles, food boxes, flexible piping and hosepipes, household articles such as buckets and bowls, toys, telephone cable sheaths, etc. HDPE is tougher and stiffer than LDPE, and is always milky white in color, even when very thin. It is used forbags and industrial wrappings, soft drinks bottles, detergents and cosmetics containers, toys,crates, jerry cans, dustbins and other household articles.

Polyvinyl chloride (PVC) Polyvinyl chloride is a hard, rigid material, unless plasticizers are added. Common applications for PVC include bottles, thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels,etc. If plasticizers are added, the product is known as plasticized polyvinyl chloride (PPVC),which is soft, flexible and rather weak, and is used to make inflatable articles such as footballs, as well as hosepipes and cable coverings, shoes, flooring, raincoats, shower curtains, furniture coverings, automobile linings, bottles, etc.

Polystyrene (PS) In its unprocessed form, polystyrene is brittle and usually transparent. Itis often blended (copolymerized) with other materials to obtain the desired properties. High impact polystyrene (HIPS) is made by adding rubber. Polystyrene foam is often produced by incorporating a blowing agent during the polymerization process. PS is used for cheap, transparent kitchen ware, light fittings, bottles, toys, food containers, etc.

Polypropylene (PP) Polypropylene is more rigid than PE, and can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong moldings such ascar battery housings and other parts, domestic appliances, suitcases, wine barrels, crates,pipes, fittings, rope, woven sacking, carpet backing, netting, surgical instruments, nursingbottles, food containers,

Table 14.Common name and chemical name of common polymers constituting plastics

Common name	**Abbreviation**	**Chemical name for polymer**
Polystyrene)	PS	Poly(phenylethene)
Low density polythene	LDPE	Poly(ethene)
High density polythene	HDPE	Poly(ethene)
Polyvinyl chloride	PVC	Poly(chloroethene)
Polypropylene	PP	Poly(propene)
Polyethylene terephthalate	PET	Poly(ethenediyl-14-benzenedicarboxylate)

3.9.2 c Identification of plastic typology

The Society of the Plastics Industries (SPI) developed in 1988 the resin identification codeto facilitate the recycling of post-consumer plastics by providing manufacturers a consistent and uniform system to identify the resin content of plastic bottles and containers. The SPI coding, by which a number is recorded within the plastic item to specify the type of polymer used in its manufacture process, focused on the plastic packaging commonly found in the residential waste stream. The majority of plastic packaging is made of six type of polymers such as polyethylene terephthalate (PET or PETE); high density polyethylene (HDPE); polyvinyl chloride (PVC); low density polyethylene (LDPE); polypropylene (PP); or polystyrene (PS). Therefore SPI resin identification code assigned each of these resins a number from 1 to 6. Additionally this system included a seventh code, identified as "other" indicating that the product in question is made with a resin other than the six listed above, or is made of more than one resin used in combination. Identification of plastic polymer type was done according to procedure established by Harris and Walker ,2010.

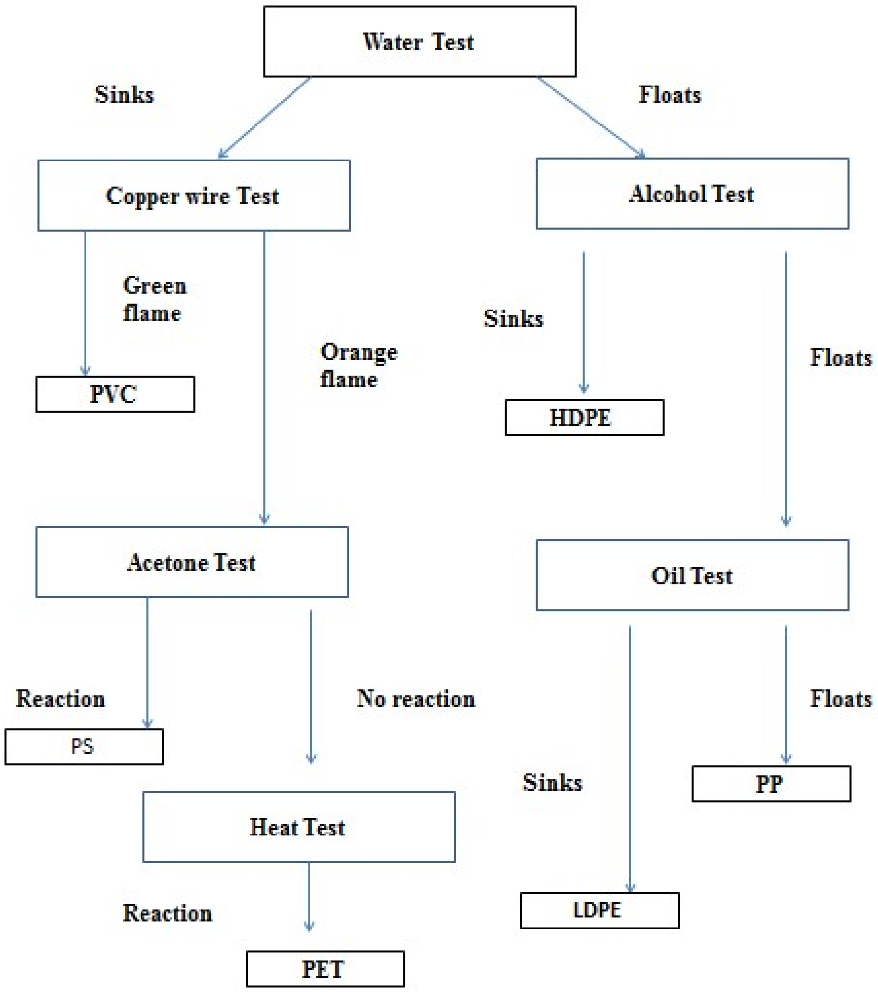


Fig.20 Simplified Scheme for Plastics Identification (Harris and Walker,2010).

Table 15.Categorization of plastic waste on basis of its chemical composition

Plastic Identity Code	Name of plastic
1 PETE	Polyethylene Terephthalate PET
2 HDPE	High Density Polyethylene HDPE
3 V	Polyvinyl Chloride PVC
4 LDPE	Low Density Polyethylene LDPE
5 PP	Polypropylene PP
6 PS	Polystyrene PS
7 OTHER	Includes All Other Plastics, Including Acrylic And Nylon. These Cannot Be Recycled

CHAPTER: 4

RESULTS AND DISCUSSION

4. Characteristics of households

4.1 a Distribution of the respondents by age category and sex

The survey report revealed that in South locality out of total 414 respondents male respondents were 50.48% while female respondent was found to be 49.52%.The percentage of respondents in age group 0-6yrs was 10.87%, 6-18 yrs 10.87% ,age group18-35 yrs 23.43% ,age group 35-60 yrs 27.54% and those in age group above 60 yrs was 17.39% (Table 16).

Table 16. Distribution of the respondents in South locality (n=414)

Age group (Years)	Sex				Total	
	Male		Female			
	Count	%	Count	%	count	%
0-6	22	5.31	23	5.56	45	10.87
6-18	45	10.87	41	9.90	86	20.77
18-35	49	11.84	48	11.59	97	23.43
35-60	59	14.25	55	13.29	114	27.54
Above 60	34	8.21	38	9.18	72	17.39
Total	209	50.48	205	49.52	414	100

The survey report revealed that in North locality out of total 432 respondents male respondents were 50.46% while female respondent was found to be49.53% .The percentage of respondents in age group 0-6 yrs was 10.42%, 6-18 yrs 19.44%,age group,18-35 yrs 23.15% ,age group 35-60 28.47% and those in age group above 60 yrs was 18.52% (Table 17).

Table 17. Distribution of the respondents in North Locality (n=432)

Age group (Years)	Sex				Total	
	Male		Female			
	Count	%	Count	%	count	%
0-6	23	5.32	22	5.09	45	10.42
6-18	42	9.72	42	9.72	84	19.44
18-35	52	12.04	48	11.11	100	23.15

35-60	63	14.58	60	13.89	123	28.47
Above 60	38	8.80	42	9.72	80	18.52
Total	218	50.46	214	49.53	432	100

The survey report revealed that in East locality out of total 445 respondents male respondents were 51.24% while female respondent was found to be 48.76%.The percentage of respondents in age group 0-6 yrs was 10.79%, 6-18 yrs 19.55%, age group,18-35 yrs 23.15%,age group 35-60 28.09%and those in age group above 60 yrs was 18.43% (Table 18).

Table 18. Distribution of the respondents in East Locality (n=445)

Age group (Years)	**Sex**				**Total**	
	Male		**Female**			
	Count	**%**	**Count**	**%**	**count**	**%**
0-6	25	5.62	23	5.17	48	10.79
6-18	44	9.89	43	9.66	87	19.55
18-35	54	12.13	49	11.01	103	23.15
35-60	65	14.61	60	13.48	125	28.09
Above 60	40	8.99	42	9.44	82	18.43
Total	228	51.24	217	48.76	445	100

The survey report revealed that in West locality out of total 396 respondents male respondents were 51.77% while female respondent was found to be 46.34% .The percentage of respondents in age group0-6 yrs was 9.34%, 6-18 yrs 19.44%,age group,18-35 yrs 22.73%, age group 35-60 30.30% and those in age group above 60 yrs was 18.18% (Table 19).

Table 19.Distribution of the respondents in West Locality (n=396)

Age group (Years)	**Sex**				**Total**	
	Male		**Female**			
	Count	**%**	**Count**	**%**	**count**	**%**
0-6	19	4.80	18	4.55	37	9.34
6-18	40	10.10	37	8.94	77	19.44

18-35	48	12.12	42	10.14	90	22.73
35-60	63	15.91	57	13.77	120	30.30
Above 60	35	8.84	37	8.94	72	18.18
Total	205	51.77	191	46.34	396	100

The survey report revealed that in Central locality out of total 443 respondents male respondents were 51.25% while female respondent was found to be 48.77%.The percentage of respondents in age group 0-6 yrs was 9.93%,6-18 yrs 19.64%,age group,18-35 yrs 22.57%,age group 35-60 29.12% and those in age group above 60 yrs was18.74% (Table 20).

Table 20. Distribution of the respondents in Central Locality (n=443)

Age group (Years)	**Sex**				**Total**	
	Male		**Female**			
	Count	**%**	**Count**	**%**	**count**	**%**
0-6	22	4.97	22	4.97	44	9.93
6-18	44	9.93	43	9.71	87	19.64
18-35	55	12.42	45	10.16	100	22.57
35-60	66	14.90	63	14.22	129	29.12
Above 60	40	9.03	43	9.71	83	18.74
Total	227	51.25	216	48.77	443	100

4.1 b Distribution of households according to household size

The pilot survey revealed that in South zone household size varied from with 1-3 members 19.66%, 4-6 members 54.03%, 7-9 members 23.69% and above 10 members 2.62%. Hence sample of 77 household having same size characteristics was randomly selected which had 1-3 members 19.48%,4-6 members 53.25%,7-9 members 24.68% and above 10 members 2.60% (Table 21).

Table 21 Respondents by their household size South Zone

Population(N=11910)			**Sample(=77)**		
Household size	**Frequency**	**%**	**Household size**	**Frequency**	**%**
1-3	2341	19.66	1-3	15	19.48
4-6	6435	54.03	4-6	41	53.25
7-9	2822	23.69	7-9	19	24.68
Above 10	312	2.62	Above 10	2	2.60
Total	11910	100.00		77	100

The pilot survey revealed that in North zone household size varied from with 1-3 members 18.93%, 4-6 members 42.77%, 7-9 members 32.31% and above 10 members 5.99%. Hence sample of 77 household having same size characteristics was randomly selected which had 1-3 members 18.18%,4-6 members 42.86%,7-9 members 32.47% and above 10 members 6.49% (Table 22).

Table 22. Respondents by their household size North zone

Population (N=13992)			**Sample(n=77)**		
Household size	Frequency	%	Household size	Frequency	%
1-3	2648	18.93	1-3	14	18.18
4-6	5985	42.77	4-6	33	42.86
7-9	4521	32.31	7-9	25	32.47
Above 10	838	5.99	Above 10	5	6.49
Total	13992	100.00		77	100

The pilot survey revealed that in East zone household size varied from with 1-3 members 14.33%, 4-6 members 40.44%, 7-9 members 37.92% and above 10 members 7.31%. Hence sample of 77 household having same size characteristics was randomly selected which had 1-3 members 14.29%,4-6 members 40.26%,7-9 members 38.96% and above 10 members 6.49%(Table 23).

Table23. Respondents by their household size East Zone

Population(N=10102)			**Sample(n=77)**		
Household size	Frequency	%	Household size	Frequency	%
1-3	1448	14.33	1-3	11	14.29
4-6	4085	40.44	4-6	31	40.26
7-9	3831	37.92	7-9	30	38.96
Above 10	738	7.31	Above 10	5	6.49
Total	10102	100.00			100

The pilot survey revealed that in West zone household size varied from with 1-3 members 18.08%, 4-6 members 44.193%, 7-9 members 35.05% and above 10 members 2.67%. Hence sample of 77 household having same size characteristics was randomly selected which had 1-3 members 18.18%,4-6 members 44.16%,7-9 members 35.06% and above 10 members 2.60%(Table 24).

Table 24. Respondents by their household size West zone

Population(N=12298)			**Sample(n=77)**		
Household size	**Frequency**	**%**	**Household size**	**Frequency**	**%**
1-3	2224	18.08	1-3	14	18.18
4-6	5435	44.19	4-6	34	44.16
7-9	4311	35.05	7-9	27	35.06
Above 10	328	2.67	Above 10	2	2.60
Total	12298	100.00		77	100

The pilot survey revealed that in Central zone household size varied from with 1-3 members 23.31%, 4-6 members 31.73%, 7-9 members 41.08% and above 10 members 3.88%. Hence sample of 77 household having same size characteristics was randomly selected which had 1-3 members 23.38%,4-6 members 31.17%,7-9 members 41.56% and above 10 members 3.90% (Table 25).

Table 25. Respondents by their household size Central zone

Population(N=11298)			**Sample(n=77)**		
Household size	Frequency	%	Household size	Frequency	%
1-3	2634	23.31	1-3	18	23.38
4-6	3585	31.73	4-6	24	31.17
7-9	4641	41.08	7-9	32	41.56
Above 10	438	3.88	Above 10	3	3.90
Total	11298	100.00		77	100

4.1 c Distribution of households according to yearly Income

Ministry of housing and poverty classification was fallowed for assigning various income categories according to household income/yr waste suvey.These category were Lower class (<1.0L), Lower middle class (1.0-3.5L), Middle class (3.5L-9.0L),Upper middle class (10-25 L),Upper class (>25 L).

The pilot survey revealed that in South zone, household income/yr varied from Lower class (<1.0L) with 19.43%, Lower middle class (1.0-3.5L) 41.41%, Middle class (3.5L-9.0L) 19.45%, Upper middle class (10-25 L) 13.29% and Upper class (>25 L) 6.42%. Hence sample of 77 household having same income characteristics was randomly selected which had Lower class (<1.0L) with 19.48%, Lower middle class (1.0-3.5L) 41.56%, Middle class (3.5L-9.0L) 19.48 %, Upper middle class (10-25 L) 12.99% and Upper class (>25 L) 6.49% (Table 26).

Table 26. Respondents by yearly income in South Locality

Population(N=11910)			Sample(n=77)		
Household Income/yr	Frequency	%	Household Income/yr	Frequency	%
<1.0L	2314	19.43	<1.0L	15	19.48
1.0-3.5L	4932	41.41	1.0-3.5L	32	41.56
3.5-9.0	2316	19.45	3.5-9.0	15	19.48
10-25L	1583	13.29	10-25L	10	12.99
>25L	765	6.42	>25L	5	6.49
Total	11910	100.00	Total	77	100

The pilot survey revealed that in North zone, household income/yr varied from Lower class (<1.0L) with 15.54%,Lower middle class (1.0-3.5L) 32.39%, Middle class (3.5L-9.0L) 35.28%, Upper middle class (10-25 L) 14.20 % and Upper class (>25 L) 2.59%. Hence sample of 77 household having same income characteristics was randomly selected which had Lower class (<1.0L) with 15.58% , Lower middle class (1.0-3.5L) 32.47%, Middle class (3.5L-9.0L) 35.06%, Upper middle class (10-25 L) 14.29% and Upper class (>25 L) 2.60% (Table 27).

Table 27 Respondents by yearly income in North Locality

Population(N=13992)			Sample(n=77)		
Household Income/yr	Frequency	%	Household Income/yr	Frequency	%
<1.0L	2174	15.54	<1.0L	12	15.58
1.0-3.5L	4532	32.39	1.0-3.5L	25	32.47
3.5-9.0	4936	35.28	3.5-9.0	27	35.06
10-25L	1987	14.20	10-25L	11	14.29
>25L	363	2.59	>25L	2	2.60
Total	13992	100	Total	77	100

The pilot survey revealed that in East zone household income/yr varied from Lower class (<1.0L) with 14.59%, Lower middle class (1.0-3.5L) 36.94%, Middle class (3.5L-9.0L) 28.67%,Upper middle class (10-25 L) 16.70% and Upper class (>25 L) 3.10%.

Hence sample of 77 household having same income characteristics was randomly selected which had Lower class (<1.0L) with 14.29%, Lower middle class (1.0-3.5L) 36.36%, Middle class (3.5L-9.0L) 28.57%, Upper middle class (10-25 L) 16.88% and Upper class (>25 L) 3.90% (Table 28).

Table 28.Respondents by yearly income in East Locality

Population(N=10102)			**Sample(n=77)**		
Household Income/yr	Frequency	%	Household Income/yr	Frequency	%
<1.0L	1474	14.59	<1.0L	11	14.29
1.0-3.5L	3732	36.94	1.0-3.5L	28	36.36
3.5-9.0	2896	28.67	3.5-9.0	22	28.57
10-25L	1687	16.70	10-25L	13	16.88
>25L	313	3.10	>25L	3	3.90
Total	10102	100.00	Total	77	100

The pilot survey revealed that in zone household income/yr varied from Lower class (<1.0L) with 24.73%,Lower middle class (1.0-3.5L) 33.56%,Middle class (3.5L-9.0L) 27.51%,Upper middle class (10-25 L) 12.93% and Upper class (>25 L) 1.27 %. Hence sample of 77 household having same income characteristics was randomly selected which had Lower class (<1.0L) with 24.68%,Lower middle class (1.0-3.5L) 33.77%, Middle class (3.5L-9.0L) 27.27%, Upper middle class (10-25 L) 12.99% and Upper class (>25 L) 1.30% (Table 29).

Table 29. Respondents by yearly income in West Locality

Population(N=12298)			**Sample(n=77)**		
Household Income/yr	Frequency	%	Household Income/yr	Frequency	%
<1.0L	3214	24.73	<1.0L	19	24.68
1.0-3.5L	4362	33.56	1.0-3.5L	26	33.77
3.5-9.0	3576	27.51	3.5-9.0	21	27.27
10-25L	1681	12.93	10-25L	10	12.99

>25L	165	1.27	>25L	1	1.30
Total	12998	100.00	Total	77	100

The pilot survey revealed that in Central zone household income/yr varied from Lower class (<1.0L) with 14.91%, Lower middle class (1.0-3.5L) 40.38%, Middle class (3.5L-9.0L) 32.71%, Upper middle class (10-25 L) 5.14% and Upper class (>25 L) 6.86 %. Hence sample of 77 household having same income characteristics was randomly selected which had Lower class (<1.0L) with 14.29%, Lower middle class (1.0-3.5L) 40.26 %, Middle class (3.5L-9.0L) 32.47%, Upper middle class (10-25 L) 5.19% and Upper class (>25 L) 7.79% (Table 30).

Table 30. Respondents by yearly income in Central Locality

Population(N=11298)			**Sample(n=77)**		
Household Income/yr	Frequency	%	Household Income/yr	Frequency	%
<1.0L	1684	14.91	<1.0L	11	14.29
1.0-3.5L	4562	40.38	1.0-3.5L	31	40.26
3.5-9.0	3696	32.71	3.5-9.0	25	32.47
10-25L	581	5.14	10-25L	4	5.19
>25L	775	6.86	>25L	6	7.79
Total	11298	100.00	Total	77	100

4.1 d Distribution of the respondents according to education level

Knowledge and understanding about various aspects of waste management can contribute positively towards plastic waste management. The data regarding education level of participants was collected in fallowing categories Can't read and write, Primary(1-5), Middle(6-8), SSC(9-10), HSC(11-12), Graduation/Diploma and Higher level

In south locality participants belonged to 2.90% to Primary (1-5), 15.22% Middle(6-8), 20.05% SSC(9-10), 36.96%HSC(11-12), 20.29% Graduation/Diploma and 4.59% Higher level. (Table 31).

Table 31. Respondents by Education level in South Locality (n=414)

Education level	**Frequency**	**%**
Can't read and write	0	0
Primary(1-5)	12	2.90
Middle(6-8)	63	15.22
SSC(9-10)	83	20.05
HSC(11-12)	153	36.96
Graduation/Diploma	84	20.29
Higher	19	4.59
Total	414	100

In North locality participants belonged to 6.25% to Primary (1-5), 12.04%Middle(6-8), 20.60% SSC(9-10),34.49% HSC(11-12), 21.06% Graduation/Diploma and 5.56% to Higher level (Table32).

Table 32. Respondents by Education level in North Locality (n=432)

Education level	Frequency	%
Can't read and write	0	0
Primary(1-5)	27	6.25
Middle(6-8)	52	12.04
SSC(9-10)	89	20.60
HSC(11-12)	149	34.49

Graduation/Diploma	91	21.06
Higher	24	5.56
Total	432	100

In East locality participants belonged to 10.56% to Primary(1-5), 15.96% Middle(6-8), 17.53% SSC (9-10), 31.01% HSC(11-12), 20.90% Graduation/Diploma and 4.04% Higher level (Table 33).

Table 33. Respondents by Education level in East Locality (445)

Education level	Frequency	%
Can't read and write	0	0
Primary(1-5)	47	10.56
Middle(6-8)	71	15.96
SSC(9-10)	78	17.53
HSC(11-12)	138	31.01
Graduation/Diploma	93	20.90
Higher	18	4.04
Total	445	100.00

In West locality participants belonged to 7.07% Primary (1-5), 14/65% Middle (6-8), 22.22% SSC(9-10), 34.34% HSC(11-12), 18.89% Graduation/Diploma and 3.03% to Higher level (Table 34).

Table 34.Respondents by Education level in West Locality (n=396)

Education level	Frequency	%
Can't read and write	0	0
Primary(1-5)	28	7.07
Middle(6-8)	58	14.65
SSC(9-10)	88	22.22
HSC(11-12)	136	34.34
Graduation/Diploma	74	18.69
Higher	12	3.03
Total	396	100

In Central Locality participants belonged to 9.48% to Primary(1-5),10.16% Middle(6-8),25.51% SSC(9-10),31.15% HSC(11-12),19.64% Graduation/Diploma and 4.06% to Higher level(Table 35).

Table 35. Respondents by Education level in Central Locality (n=443)

Education level	Frequency	%
Can't read and write	0	0
Primary(1-5)	42	9.48
Middle(6-8)	45	10.16
SSC(9-10)	113	25.51
HSC(11-12)	138	31.15
Graduation/Diploma	87	19.64
Higher	18	4.06
Total	443	100

4.2 Questionnaire survey

4.2.1. Do you know about Reuse, Reduce and Recycle?

68.83% respondents in North locality, 79.22% in South Locality, 81.82% in East Locality, 89.61% in West locality and 70.13% in Central locality knew about concept of reduce, reuse and recycling (Fig.21).

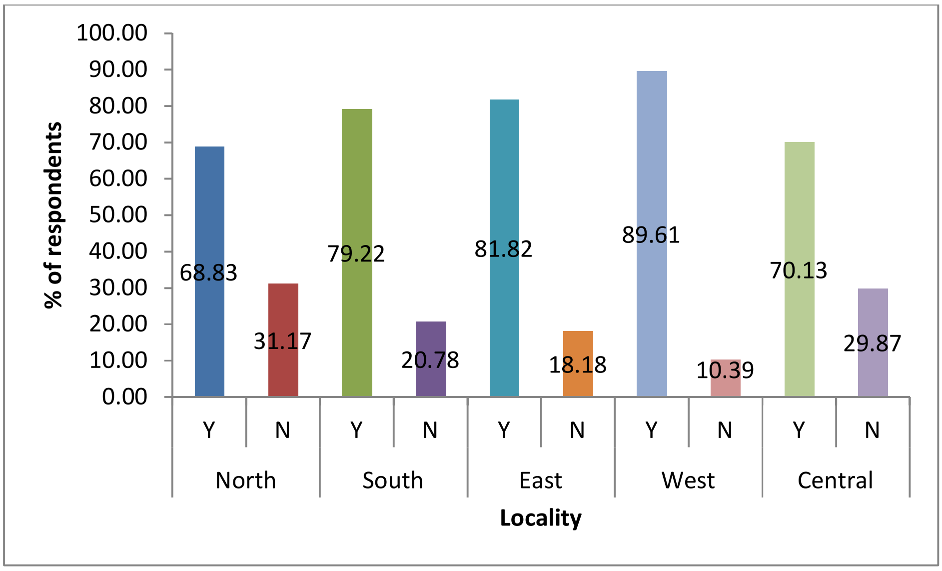


Fig.21Respondents by % for question 1

4.2.2. Do you carry your own bag while going for shopping?

81.82 % respondents in North locality, 79.22% in South Locality,75.32% in East Locality, 80.52% in West locality and 79.22% in Central locality said that they never carry their own bag while going for shopping (Fig.22).

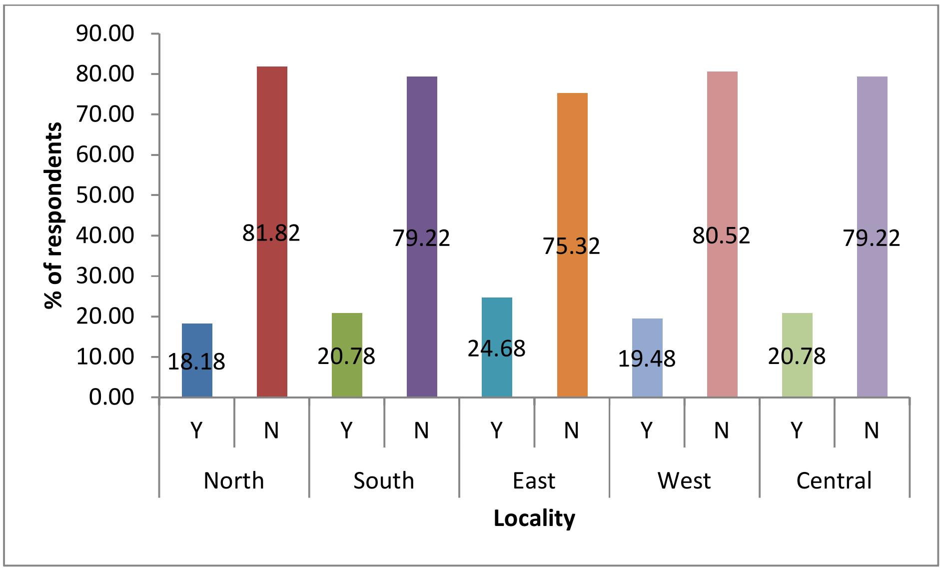


Fig.22Respondents by % for question 2

4.2.3. Do you segregate the waste at your home before disposal?

92.21 % in North locality, 93.51% in South Locality,94.81% in East Locality, 96.10% in West locality, 96.10% in Central locality said that they always segregated their waste in to degradable and non biodegradable fraction before disposal (Fig.23).

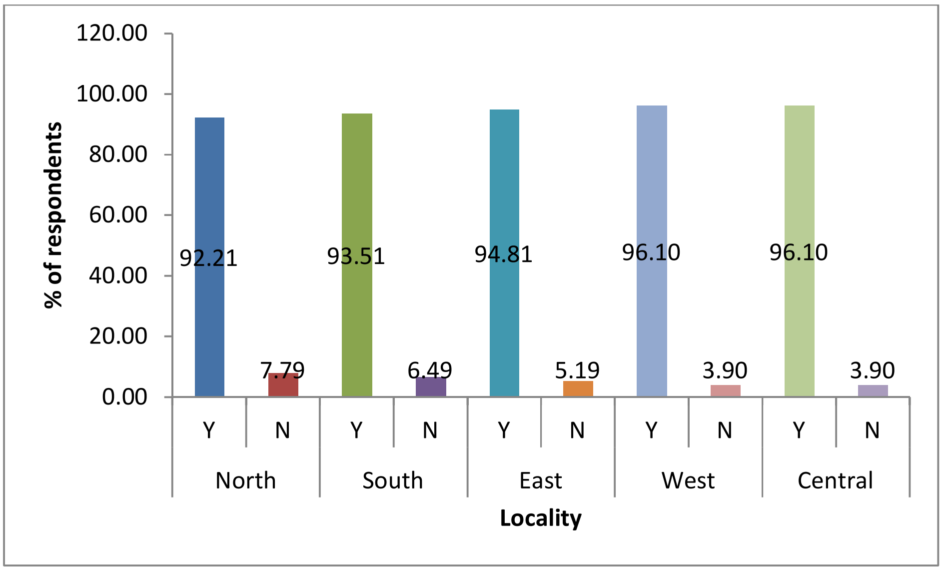


Fig.23 Respondents by % for question 3

4.2.4. Is there door to door waste collection facility in your locality?

Only 25.97 % in North locality, 16.88% in South Locality, 20.78% in East Locality, 11.69% in West locality, and 23.38% respondents in Central locality had facility of door to door collection of waste (Fig.24).

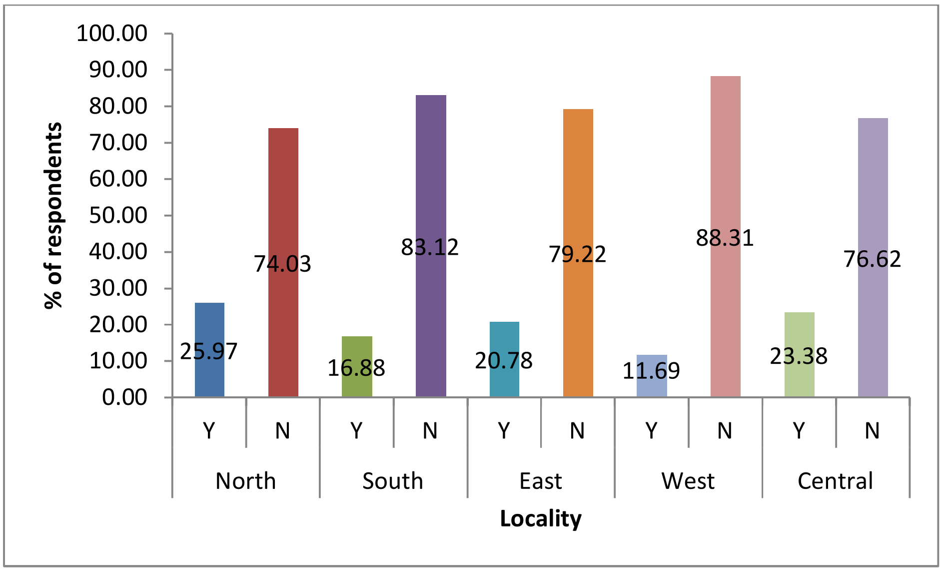


Fig.24Respondents by % for question 4

4.2.5. Is waste is being collected by Municipality every week

All Respondents North locality, South Locality, East Locality, West locality and in Central locality claimed that there is bi weekly collection of solid waste from designated collection points in each locality (Fig 5).

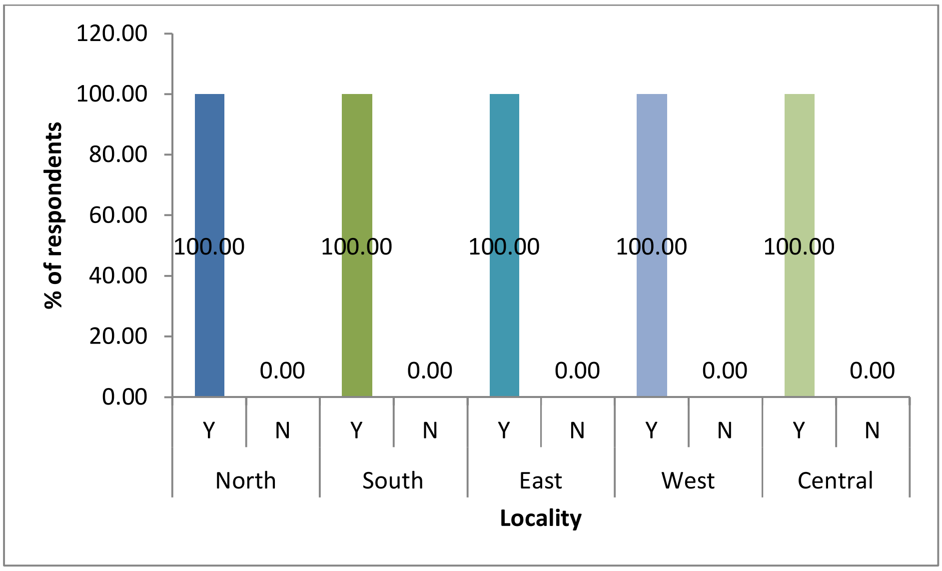


Fig.25 Respondents by % for question 5

4.2.6. Public awareness can greatly reduce plastic waste generation

93.51% respondents in North locality, 94.81% in South Locality, 89.61% in East Locality, 96.10% in West locality and 93.51% in Central locality believe that greater public awareness and sensitization can help reduce menace of plastic waste(Fig 26).

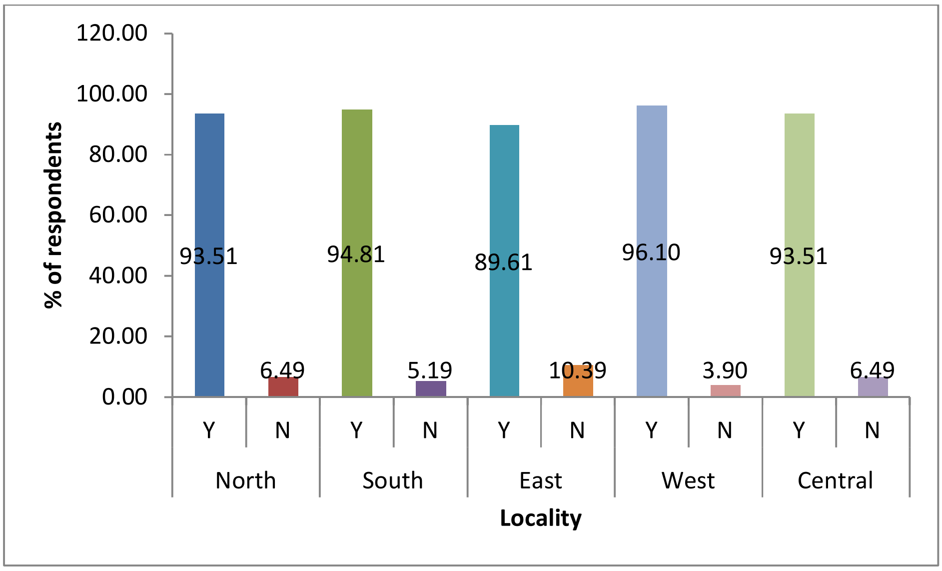


Fig.26 Respondents by % for question 6

4.2.7. Present legislations are enough to curb the menace of plastic waste
87.01 % respondents in North locality, 94.81% in South Locality, 81.82% in East Locality, 81.82% in West locality, 89.61% in Central locality are not satisfied with present legislations and feel laws to handle plastic waste are inadequate (Fig 27).

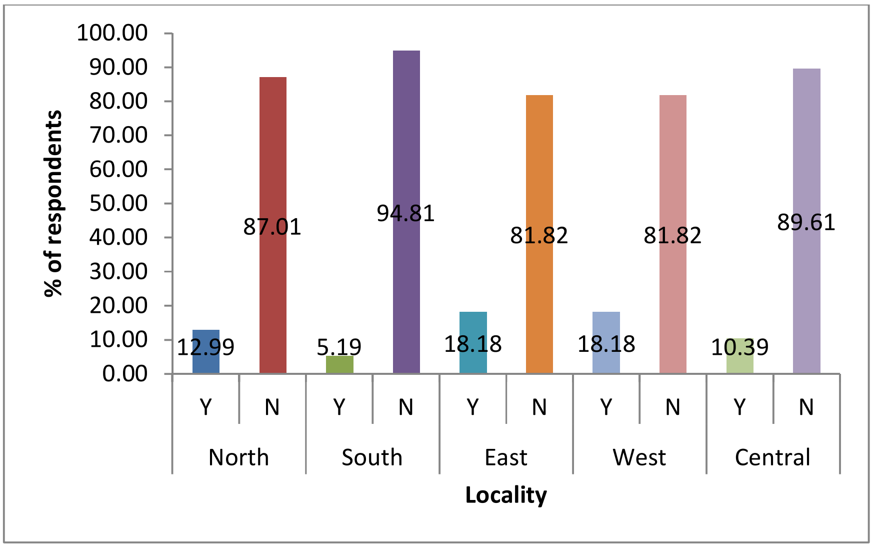


Fig.27 Respondents by % for question 7

4.2.8. Plastic waste management (PWM) should be part of course curriculum in elementary studies

70.13% respondents in North locality, 81.82% in South Locality,81.82% in East Locality, 93.51% in West locality, 83.12% in Central locality feel that school syllabi should include lessons on waste management particularly plastic waste management (Fig 28).

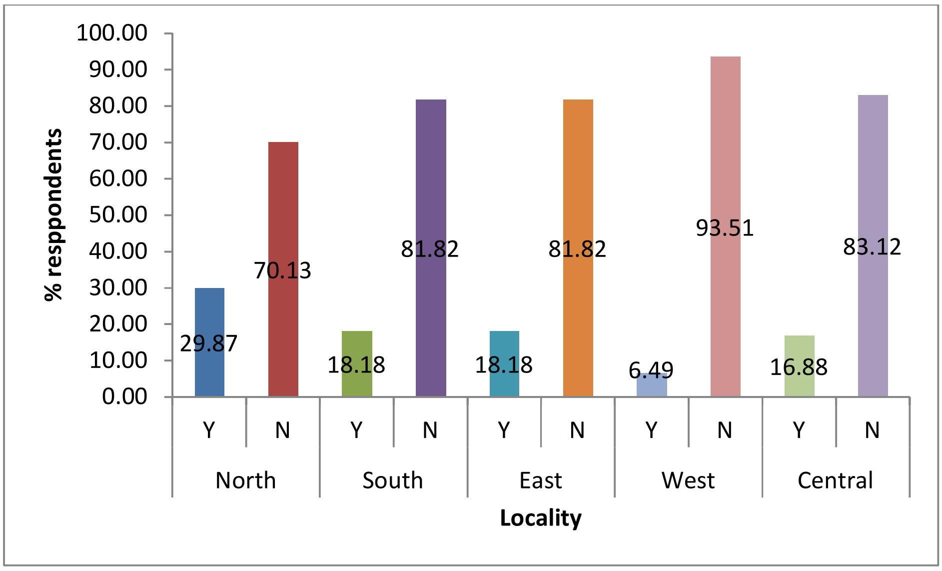


Fig.28Respondents by % for question 8

4.2.9 Municipalities are fulfilling their duty efficiently with regard to PWM

94.81% respondents in North locality, 83.12% in South Locality, 93.51% in East Locality, 83.12% in West locality, 94.81% in Central locality are satisfied with plastic waste management activities performed by municipality (Fig 29).

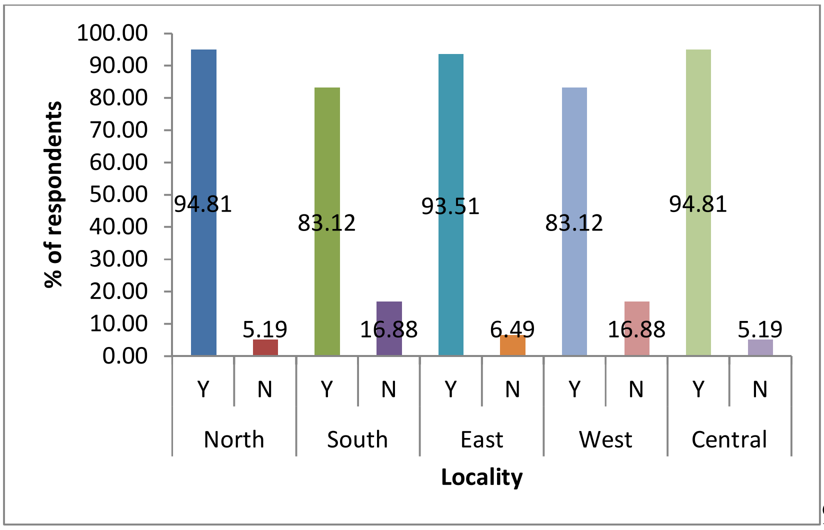


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Fig.29 **Respondents by % for question 9**

4.2.10. Plastic waste can be sustainably managed with community participation

94.81% respondents in North locality, 98.70% in South Locality, 92.21% in East Locality, 88.31% in West locality, 97.40% in Central locality believe plastic waste can be sustainably managed with community participation (Fig30).

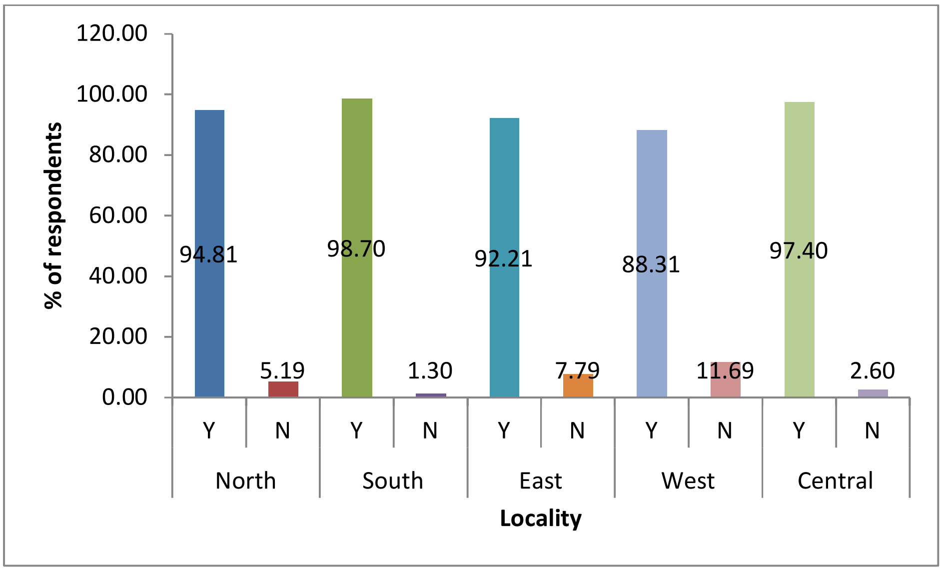

Fig.30 **Respondents by % for question 10**

4.3 Household Plastic waste generation

4.3.A. South Locality

Maximum amount of plastic waste/household generated during winter season was 10.30 kg/household (Table 36).Minimum amount of plastic waste/household was generated during rainy season with 8.13Kg/household. The result of ANOVA test reveals that there was significant monthly variation in household generation of plastic waste during year 2017-18 ($F_{8,664}$=3.41,P<.005;Table 38.a.),2018-19($F_{8,664}$=3.43,P<.005;Table 38.b.),2019-20 ($F_{8,664}$=3.42,P<.005;Table 38.c.).However within the three years significant variation in household generation of plastic waste was not observed ($F_{2,228}$=.28,P>.005; Table 38.d.). By comparing between nine months (Table 37and Fig.31) maximum generation was observed in December (3.66±2.26 kg) and minimum in August (2.61±1.26 kg) .The gross generation of plastic waste by 77 families during 2017-18 was 2059.60kg (Appendix 1);in 2018-19 it was 2157.93kg (Appendix 2);and during 2019-20 it was 2132.23kg (Appendix 3).Between three years plastic waste generation was maximum during 2018-19 and least during 2018-19.

Average household plastic waste generation in South locality during year 2017-18 in month of November was 3.09±1.29kg likewise December 3.57±2.15kg,January 3.39±2.14kg,March 3.01±1.57kg, April 2.97±1.43kg, May 2.84±1.54kg, July 2.60±1.24kg, August 2.53±1.35kg , September 2.75±1.25kg.

During year 2018-19 in month of November was 3.24±1.21kg likewise December 3.72±2.41kg, January3.53±2.25 kg, March 3.15±1.16kg, April 3.10±1.13kg, May 2.98±1.36kg, July 2.74±1.35kg, August 2.66±1.16kg , September 2.91±1.44kg.

During year 2019-20 in month of November was 3.20±1.15kg likewise December 3.68±2.24kg, January 3.49±2.19kg, March 3.11±1.36kg, April 3.08±1.23kg, May 2.95±1.25kg, July2.71±1.29 kg, August2.63±1.27 kg , September 2.86±1.15kg.

Total plastic waste generated/household during 3 years in south locality in month of month of November was 9.53kg likewise December 10.97kg,January 10.41Kg,March 9.27kg,April 9.15kg, May 8.77kg, July 8.05kg, August 7.82kg , September 8.52kg while average plastic waste generation/household during 3 years in month of month of November was 3.18±1.21kg likewise December 3.66±2.26kg,January 3.47±2.19kg,March 3.09±1.36kg,April 3.05±1.26kg, May 2.92±1.38kg, July 2.68±1.29kg, August 2.61±1.26kg , September 2.84±1.28kg (Table 37; Fig.31)

Table 36: Seasonal plastic waste generation (kg)/household

	Winters	Summer	Rainy
2017-18	10.05	8.82	7.88
2018-19	10.49	9.23	8.31
2019-20	10.37	9.14	8.2
Total	30.91	27.19	24.39
Avg	10.30	9.06	8.13

Average household plastic waste generation in South locality during year 2017-18 in winter was 10.05kg, summer 8.82kg and during rainy season was 7.88kg.

Average household plastic waste generation in South locality during year 2018-19 in winter was 10.49kg, summer 9.23kg during rainy season was 8.31kg.

Average household plastic waste generation in South locality during year 2019-20 in winter was 10.37kg, summer 9.14kg during rainy season was 8.2kg.

During 2017-20 three year assessment total plastic waste/household produced during winter was 30.91kg, summer 27.19kg rainy season was 24.39kg, while average plastic waste /household produced during winter was 10.30kg,summer 9.06kg and rainy season was 8.13kg (Table 36).

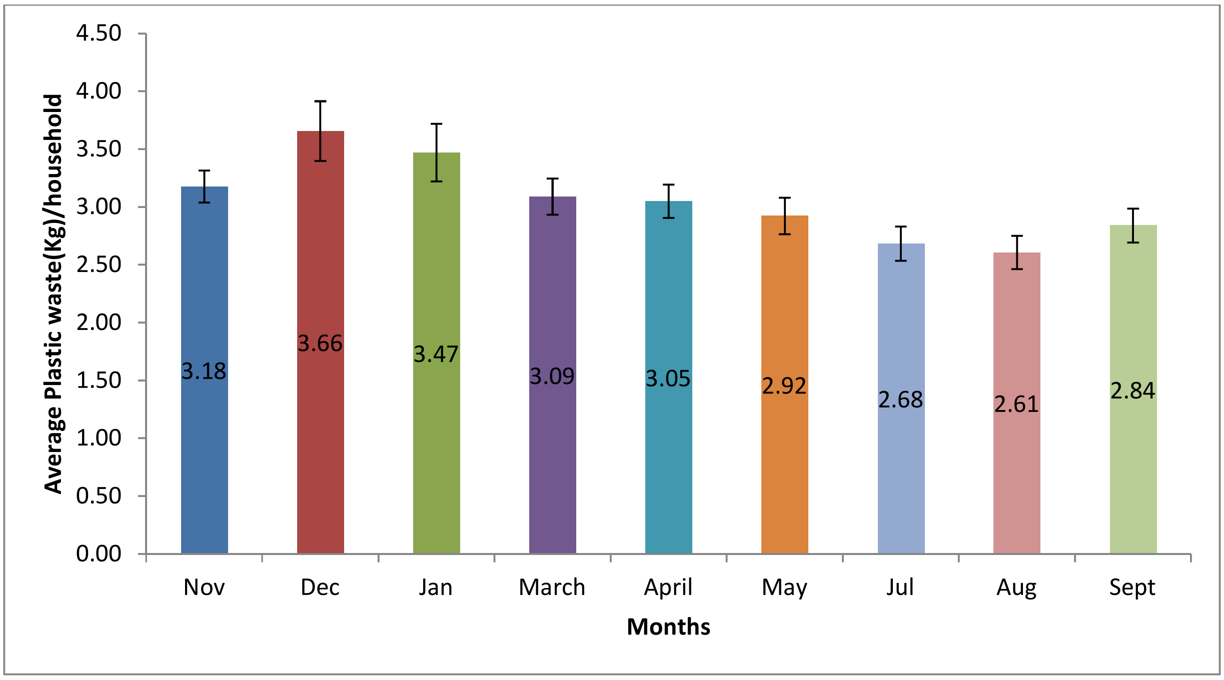

Fig.31: Average plastic waste generation/household in South locality in the three years

Table 37:Plastic waste (kg) generation /household in South locality

Year	Nov	Dec	Jan	March	April	May	Jul	Aug	Sept
2017-18	3.09±1.29	3.57±2.15	3.39±2.14	3.01±1.57	2.97±1.43	2.84±1.54	2.60±1.24	2.53±1.35	2.75±1.25
2018-19	3.24±1.21	3.72±2.41	3.53±2.25	3.15±1.16	3.10±1.13	2.98±1.36	2.74±1.35	2.66±1.16	2.91±1.44
2019-20	3.20±1.15	3.68±2.24	3.49±2.19	3.11±1.36	3.08±1.23	2.95±1.25	2.71±1.29	2.63±1.27	2.86±1.15
Total	9.53	10.97	10.41	9.27	9.15	8.77	8.05	7.82	8.52
Avg	3.18±1.21	3.66±2.26	3.47±2.19	3.09±1.36	3.05±1.26	2.92±1.38	2.68±1.29	2.61±1.26	2.84±1.28

Table 38.a.:ANOVA for monthly variation in Gross plastic waste generation in South locality during 2017-18

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	73.26036	8	9.157545	3.412901	0.000739	1.951923
Within Groups	1835.319	684	2.683214			
Total	1908.579	692				

Table 38.b.:ANOVA for monthly variation in gross plastic waste generation in South locality during 2018-19

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.07922	8	9.259902	3.439207	0.000681	1.951923
Within Groups	1841.638	684	2.692453			
Total	1915.717	692				

Table 38.c.:ANOVA for monthly variation in gross plastic waste generation in South locality during year 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	73.63201	8	9.204001	3.427926	0.000705	1.951923
Within Groups	1836.544	684	2.685005			
Total	1910.176	692				

Table 38.d..:ANOVA for yearly variation (2017-20) in gross plastic waste generation in South Locality

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	67.55742	2	33.77871	0.287485	0.75042	3.035441
Within Groups	26789.42	228	117.4975			
Total	26856.98	230				

4.3.B.North Locality

Maximum amount of plastic waste/household generated during winter season was 9.93kg/household (Table 39).Minimum amount of plastic waste/household was generated during rainy season with 7.72Kg/household. The result of ANOVA test reveals that there was significant monthly variation in household generation of plastic waste during year 2017-18 ($F_{8,664}$=3.47,P<.005;Table 41.a),2018-19($F_{8,664}$=3.47,P<.005;Table 41.b),2019-20 ($F_{8,664}$=3.37,P<.005;Table 41.c).However within the three years significant variation in household generation of plastic waste was not observed ($F_{2,228}$=.8,P>.005; Table 41.d). By comparing between nine months (Table 40. and Fig.32) maximum generation was observed in December (3.53±2.26 kg) and minimum in August (2.47±1.37 kg).The gross generation of plastic waste by 77 families during 2017-18 was 2045.94kg (Appendix 4);in 2018-19 it was 1994.18kg (Appendix

5);and during 2019-20 it was 2040.34kg (Appendix 6).Between three years plastic waste generation was maximum during 2017-18 and least during 2018-19.

Average household plastic waste generation in North locality during year 2017-18 in month of November was 3.08±1.30kg likewise December 3.55±2.14kg,January 3.38±1.74kg,March 2.99±1.56kg,April 2.94±1.43kg, May 2.82±1.55kg, July 2.58±1.24kg, August 2.50±1.56kg , September 2.73±1.54kg .

During year 2018-19 in month of November was 3.01±1.26kg likewise December 3.48±2.34kg,January 3.30±1.97kg,March 2.92±1.24kg,April 2.87±1.25kg, May 2.75±1.34kg, July 2.50±1.19kg, August 2.42±1.39kg , September 2.66±1.23kg.

During year 2019-20 in month of November was 3.07±1.27Kg likewise December 3.55±2.32kg,January 3.36±2.17kg,March 2.99±1.28kg,April 2.93±1.37kg, May 2.82±1.26kg, July 2.56±1.33kg, August 2.49±1.17kg , September 2.73±1.24kg.

Total plastic waste generated/household during 3 years in North locality in month of month of November was 9.16kg likewise December 10.58kg,January 10.04kg,March 8.90kg,April 8.74kg, May 8.74kg, July 7.64kg, August 7.41kg , September 8.12kg while average plastic waste generation/household during 3 years in month of November was 3.05±1.27kg likewise December 3.53±2.26kg,January 3.35±1.96kg,March 2.97±1.36kg,April 2.91±1.35kg, May 2.80±1.38kg, July 2.55±1.25kg, August 2.47±1.37kg , September 2.71±1.33kg (Table 40; Fig.32)

Table 39: Seasonal plastic waste generation (kg)/household in North Locality

Year	Winters	Summer	Rainy
2017-18	10.01	8.75	7.81
2018-19	9.79	8.54	7.58
2019-20	9.98	8.74	7.78
Total	29.78	26.03	23.17
Avg	9.93	8.68	7.72

Average household plastic waste generation in North locality during year 2017-18 in winter was 10.01kg, summer 8.75kg, and during rainy season was 7.81kg.

Average household plastic waste generation in North locality during year 2018-19 in winter was 9.79kg, summer 8.54kg, and during rainy season was 7.58kg.

Average household plastic waste generation in North locality during year 2019-20 in winter was 9.98kg, summer 8.74kg, and during rainy season was 7.78kg. During 2017-20 three year assessment total plastic waste/household produced during winter was 29.78kg, summer 26.03kg., rainy season was 23.17kg,while average plastic waste /household produced during winter was 9.93kg,summer 8.68kg and rainy season was 7.72kg (Table39).

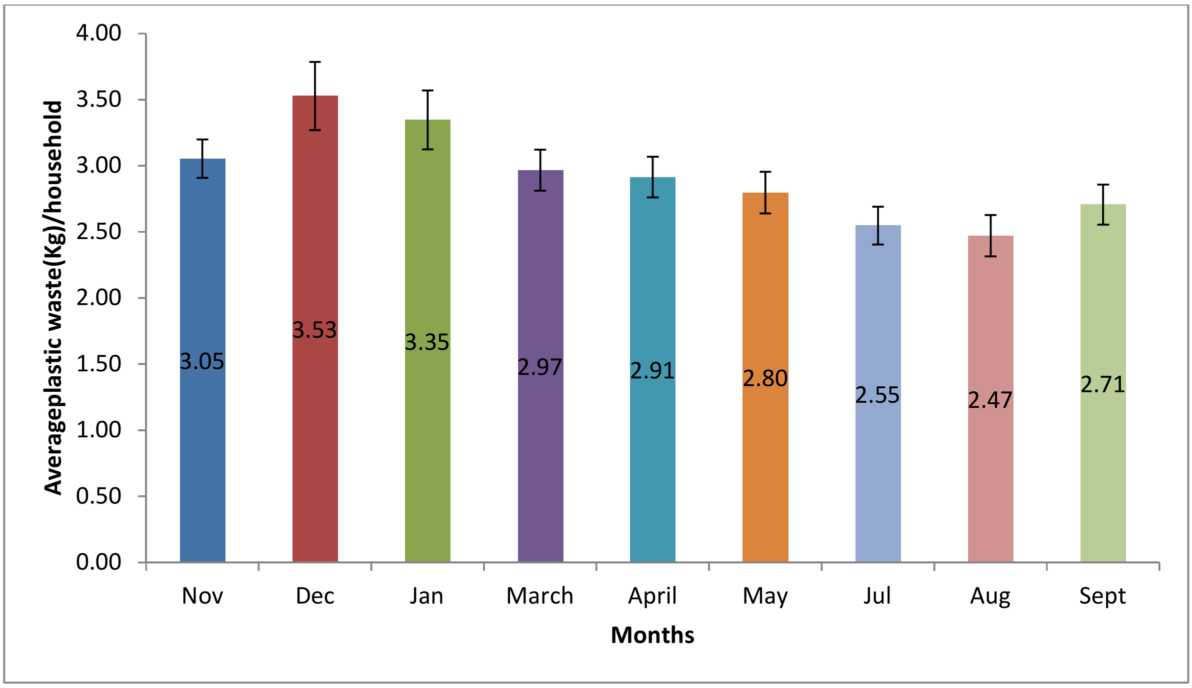

Fig.32: Average plastic waste generation/household in North locality in the three years

Table 40: Plastic waste (kg) generation /household in North locality

Year	Nov	Dec	Jan	March	April	May	Jul	Aug	Sept
2017-18	3.08±1.30	3.55±2.14	3.38±1.74	2.99±1.56	2.94±1.43	2.82±1.55	2.58±1.24	2.50±1.56	2.73±1.54
2018-19	3.01±1.26	3.48±2.34	3.30±1.97	2.92±1.24	2.87±1.25	2.75±1.34	2.50±1.19	2.42±1.39	2.66±1.23
2019-20	3.07±1.27	3.55±2.32	3.36±2.17	2.99±1.28	2.93±1.37	2.82±1.26	2.56±1.33	2.49±1.17	2.73±1.24
Total	9.16	10.58	10.04	8.90	8.74	8.74	7.64	7.41	8.12
Avg	3.05±1.27	3.53±2.26	3.35±1.96	2.97±1.36	2.91±1.35	2.80±1.38	2.55±1.25	2.47±1.37	2.71±1.33

Table 41.a.: ANOVA Table for monthly variation in gross plastic waste generation in North locality during 2017-18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.39761	8	9.299701	3.472702	0.000615	1.951923
Within Groups	1831.713	684	2.677944			
Total	1906.111	692				

Table41.b.: ANOVA Table for monthly variations in Gross plastic waste generation in North locality during year 2018-19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.54329	8	9.317911	3.474421	0.000611	1.951923
Within Groups	1834.392	684	2.68186			
Total	1908.936	692				

Table41.c.: ANOVA Table for monthly variation in gross plastic waste generation in North locality during 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	73.63201	8	9.204001	3.427926	0.000705	1.951923
Within Groups	1836.544	684	2.685005			
Total	1910.176	692				

Table41.d.: ANOVA Table for yearly (2017-20) variation in gross plastic waste generation in North locality

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.95575	2	10.47787	0.089234	0.914664	3.035441
Within Groups	26771.85	228	117.4204			
Total	26792.8	230				

4.3.C.East Locality

Maximum amount of plastic waste/household generated during winter season was 10.22kg/household (Table 42).Minimum amount of plastic waste/household was generated during rainy season with 8.03kg/household. The result of ANOVA test reveals that there was significant monthly variation in household generation of plastic waste during year 2017-18 ($F_{8,664}$=3.44,P<.005;Table 44.a),2018-19($F_{8,664}$=3.50,P<.005;Table 44.b),2019-20 ($F_{8,664}$=3.46,P<.005;Table 44.c.).However within the three years significant variation in household generation of plastic waste was not observed ($F_{2,228}$=.27,P>.005; Table 44.d.). By comparing between nine months (Table 43 and Fig.33) maximum generation was observed in December (3.63±2.29kg) and minimum in August (2.57±1.29kg) .The gross generation of plastic waste by 77 families during 2017-18 was 2057.86kg (Appendix 7);in 2018-19 it was 2079.37kg (Appendix 8);and during

2019-20 it was 2153.59kg (Appendix 9).Between three years plastic waste generation was maximum during 2019-20 and least during 2017-18.

Average household plastic waste generation in East locality during year 2017-18 in month of November was 3.09±1.27kg likewise December 3.57±2.32Kg,January 3.39±2.36kg,March 3.01±1.23kg,April 2.96±1.34kg, May 2.84±1.23kg, July 2.60±1.24kg, August 2.51±1.19kg , September 2.75±1.21kg.

During year 2018-19 in month of November was 3.12±1.21kg likewise December 3.61±2.23kg,January 3.42±2.27kg,March 3.04±1.29kg,April 3.00±1.22kg, May 2.88±1.29kg, July 2.63±1.34kg, 2.54±1.37August kg , September 2.78±1.23kg.

During year 2019-20 in month of November was 3.24±1.28kg likewise December 3.71±2.34kg,January 3.53±2.25kg,March 3.14±1.43kg,April 3.10±1.26kg,May 2.97±1.33kg, July 2.74±1.23kg, August 2.65±1.31kg , September 2.89±1.33kg.

Total plastic waste generated/household during 3 years in East locality in month of month of November was 9.45kg likewise December 10.89kg,January 10.34kg,March 9.19kg,April 9.06kg, May 8.69kg, July 7.97kg, August 7.7kg , September 8.42kg while average plastic waste generation/household during 3 years in month of month of November was 3.15±1.25kg likewise December 3.63±2.29kg,January 3.45±2.29kg,March 3.06±1.31kg,April 3.02±1.27kg, May 2.90±1.28kg, July 2.66±1.27kg, August 2.57±1.29kg , September 2.81±1.20kg (Table43; Fig.33).

Table 42: Seasonal plastic waste generation (kg)/household in East Locality

Year	Winters	Summer	Rainy
2017-18	10.05	8.81	7.86
2018-19	10.15	8.92	7.95
2019-20	10.48	9.21	8.28
Total	30.68	26.94	24.09
Avg	10.22	8.98	8.03

Average household plastic waste generation in East locality during year 2017-18 in winter was 10.05kg, summer 8.81kg, and during rainy season was 7.86kg.

Average household plastic waste generation in East locality during year 2018-19 in winter was 10.15kg, summer 8.92kg, and during rainy season was 7.95kg.Average household plastic waste generation in East locality during year 2019-20 in winter was 10.48kg, summer 9.21kg and during rainy season was 8.28kg.

During 2017-20 three year assessment total plastic waste/household produced during winter was 30.68kg,summer 26.94kg,rainy season was 24.09kg,while average plastic waste /household produced during winter was 10.22kg,summer 8.98kg and rainy season was 8.03kg (**Table 42).**

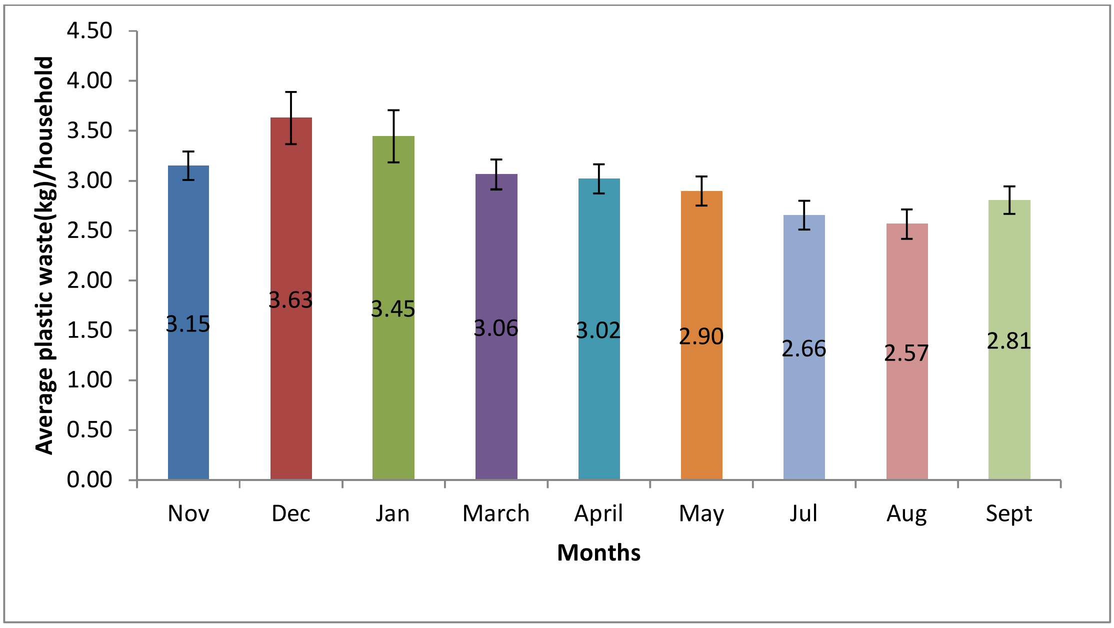

Fig.33: Average plastic waste generation/household in East locality in the three years

Table 43: Plastic waste (kg) generation /household in East locality

Year	Nov	Dec	Jan	March	April	May	Jul	Aug	Sept
2017-18	3.09±1.27	3.57±2.32	3.39±2.36	3.01±1.23	2.96±1.34	2.84±1.23	2.60±1.24	2.51±1.19	2.75±1.21
2018-19	3.12±1.21	3.61±2.23	3.42±2.27	3.04±1.29	3.00±1.22	2.88±1.29	2.63±1.34	2.54±1.37	2.78±1.23
2019-20	3.24±1.28	3.71±2.34	3.53±2.25	3.14±1.43	3.10±1.26	2.97±1.33	2.74±1.23	2.65±1.31	2.89±1.33
Total	9.45	10.89	10.34	9.19	9.06	8.69	7.97	7.7	8.42
avg	3.15±1.25	3.63±2.29	3.45±2.29	3.06±1.31	3.02±1.27	2.90±1.28	2.66±1.27	2.57±1.29	2.81±1.20

Table44.a.: ANOVA for monthly variation in gross plastic waste generation in East locality during 2017-18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.22437	8	9.278046	3.446774	0.000666	1.951923
Within Groups	1841.195	684	2.691806			
Total	1915.419	692				

Table44.b.: ANOVA for Monthly variations in Gross plastic waste generation in East locality during year 2018-19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	75.38409	8	9.423011	3.507588	0.000552	1.951923
Within Groups	1837.542	684	2.686464			
Total	1912.926	692				

Table44.c.: ANOVA for monthly variation in gross plastic waste generation in East locality during 2019-20

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.5759	8	9.321987	3.469589	0.000621	1.951923
Within Groups	1837.751	684	2.68677			
Total	1912.327	692				

Table44.d.: ANOVA for yearly (2017-20) variation in gross plastic waste generation in East locality

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	65.5223	2	32.76115	0.278434	0.757226	3.035441
Within Groups	26827.02	228	117.6624			
Total	26892.54	230				

4.3.D.Central Locality

Maximum amount of plastic waste/household generated during winter season was 10.11kg/household (Table 45).Minimum amount of plastic waste/household was generated during rainy season with 7.90kg/household. The result of ANOVA test reveals that there was significant monthly variation in household generation of plastic waste during year 2017-18 ($F_{8,664}$=3.43,P<.005;Table47.a.), 2018-19($F_{8,664}$=3.47,P<.005;Table47.b.),2019-20($F_{8,664}$=3.44,P<.005;Table47.c.). However within the three years significant variation in household generation of plastic waste was not observed ($F_{2,228}$=.03,P>.005; Table 47.d.). By comparing between nine months (Table 46 and Fig.34) maximum generation was observed in December (3.60±2.16kg) and minimum in August (2.54±1.30kg) .The gross generation of plastic waste by 77 families during 2017-18 was 2080.62Kg (Appendix 10);in 2018-

19 it was 2091.71kg (Appendix 11);and during 2019-20 it was 2056.84kg (Appendix 12).Between three years plastic waste generation was maximum during 2018-19 and least during 2019-20.

Average household plastic waste generation in Central locality during year 2017-18 in month of November was 3.11±1.32kg likewise December 3.61±2.25kg,January 3.40±2.30kg,March 3.05±1.23kg,April 2.98±1.37kg, May 2.83±1.31kg, July 2.61±1.38kg, August 2.54±1.36kg , September 2.74±1.34kg.

During year 2018-19 in month of November was 3.12±1.46kg likewise December 3.62±1.95kg,January 3.44±2.18kg,March 3.06±1.19kg,April 2.98±1.28kg, May 2.85±1.54kg, July 2.62±1.23kg, August 2.56±1.24kg , September 2.76±1.26kg.

During year 2019-20 in month of November was 3.09±1.33kg likewise December 3.58±2.30kg,January 3.38±2.27kg,March 3.00±1.37kg,April 2.95±1.24kg, May 2.83±1.23kg, July 2.60±1.31kg, August 2.52±1.31kg , September 2.76±1.25kg.

Total plastic waste generated/household during 3 years in Central locality in month of month of November was 9.32kg likewise December 10.81kg,January 10.22kg,March 9.11kg,April 8.91kg, May 8.51kg, July 7.83kg, August 7.62kg , September 8.26kg. while average plastic waste generation/household during 3 years in month of month of November was 3.11±1.37kg likewise December 3.60±2.16kg,January 3.41±2.25kg,March 3.04±1.26kg,April 2.97±1.63kg, May 2.84±1.36kg, July 2.61±1.30kg, August 2.54±1.30kg, September 2.75±1.28kg(Table 46; Fig.34).

Table 45: Seasonal plastic waste generation (kg)/household in Central Locality

	Winters	Summer	Rainy
2017-18	10.12	8.86	7.89

2018-19	10.18	8.89	7.94
2019-20	10.05	8.78	7.88
Total	30.35	26.53	23.71
Avg	10.11	8.84	7.90

Average household plastic waste generation in Central locality during year 2017-18 in winter was 10.12kg, summer 8.86kg and during rainy season was 7.89kg.

Average household plastic waste generation in Central locality during year 2018-19 in winter was 10.18kg, summer 8.89kg, and during rainy season was 7.94kg.

Average household plastic waste generation in Central locality during year 2019-20 in winter was 10.05kg, summer 8.78kg and during rainy season was 7.88kg. During 2017-20 three year assessment total plastic waste/household produced during winter was 30.35kg, summer 26.53kg, rainy season was 23.71kg,while average plastic waste /household produced during winter was 10.11kg,summer 8.84kg and rainy season was 7.90kg (Table 45).

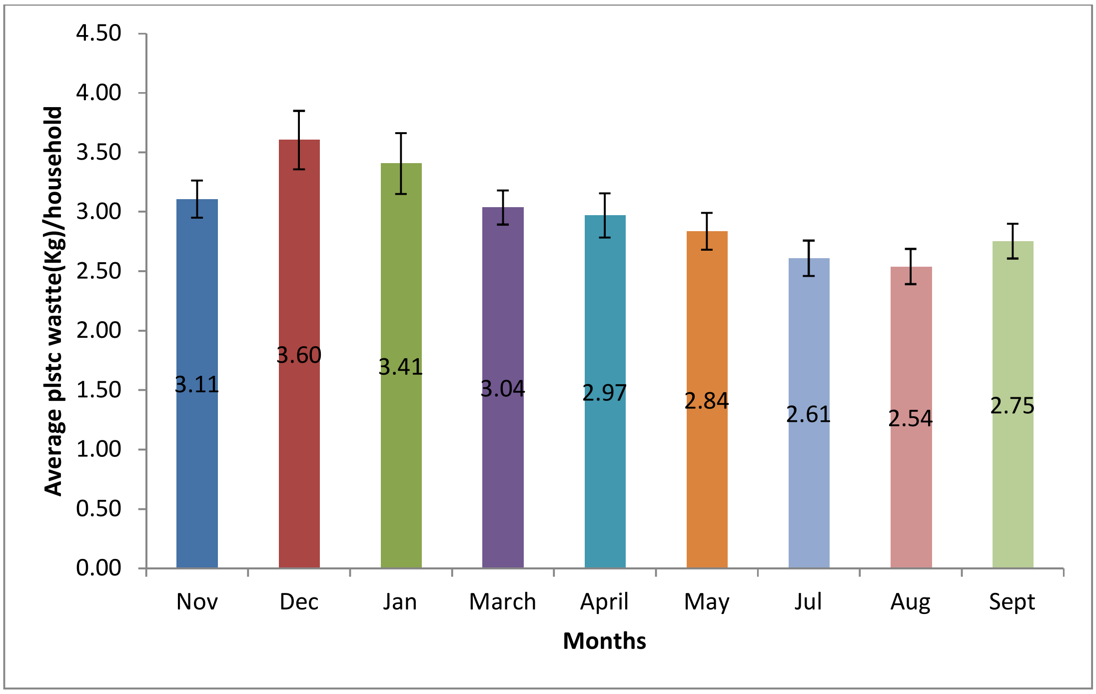

Fig.34: Average plastic waste generation/household in Central locality in the three years

Table 46: Plastic waste (kg) generation /household in Central locality

Year	Nov	Dec	Jan	March	April	May	Jul	Aug	Sept
2017-18	3.11±1.32	3.61±2.25	3.40±2.30	3.05±1.23	2.98±1.37	2.83±1.31	2.61±1.38	2.54±1.36	2.74±1.34
2018-19	3.12±1.46	3.62±1.95	3.44±2.18	3.06±1.19	2.98±1.28	2.85±1.54	2.62±1.23	2.56±1.24	2.76±1.26
2019-20	3.09±1.33	3.58±2.30	3.38±2.27	3.00±1.37	2.95±1.24	2.83±1.23	2.60±1.31	2.52±1.31	2.76±1.25
Total	9.32	10.81	10.22	9.11	8.91	8.51	7.83	7.62	8.26
avg	3.11±1.37	3.60±2.16	3.41±2.25	3.04±1.26	2.97±1.63	2.84±1.36	2.61±1.30	2.54±1.30	2.75±1.28

Table 47.a.: ANOVA for monthly variation in Gross plastic waste generation in Central locality during year 2017-18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	73.57827	8	9.197283	3.43905	0.000682	1.951923
Within Groups	1829.268	684	2.674368			
Total	1902.846	692				

Table 47.b.: ANOVA for monthly variations in Gross plastic waste generation in Central locality during year 2018-19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.51587	8	9.314483	3.472347	0.000615	1.951923
Within Groups	1834.813	684	2.682475			
Total	1909.329	692				

Table 47.c.: ANOVA for monthly variation in Gross plastic waste generation in Central Locality during year 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.05545	8	9.256932	3.448127	0.000663	1.951923
Within Groups	1836.284	684	2.684626			
Total	1910.339	692				

Table 47.d.: ANOVA for yearly (2017-20) variation in gross plastic waste generation in Central locality

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.241191	2	4.120595	0.035173	0.965443	3.035441
Within Groups	26710.41	228	117.1509			
Total	26718.65	230				

4.3.E. West Locality

Maximum amount of plastic waste/household generated during winter season was 10.39kg/household (Table 48).Minimum amount of plastic waste/household was generated during rainy season with 8.18kg/household. The result of ANOVA test reveals that there was significant monthly variation in household generation of plastic waste during year 2017-18 ($F_{8,664}$=3.48,P<.005;Table50.a.),2018-19($F_{8,664}$=3.45,P<.005;Table50.b.),2019-20 ($F_{8,664}$=3.47,P<.005;Table50.c.).However within the three years significant variation in household generation of plastic waste was not observed ($F_{2,228}$=.10,P>.005; Table50.d.). By comparing between nine months (Table 49 and Fig.35) maximum generation was observed in December (3.67±2.31kg) and minimum in August (2.63±1.23kg).The gross generation of plastic waste by 77 families during 2017-18 was 2134.38kg (Appendix 13);in 2018-19 it was 2102.66kg (Appendix

14);and during 2019-20 it was 2164.70kg (Appendix 15).Between three years plastic waste generation was maximum during 2019-20 and least during 2018-19.

Average household plastic waste generation in West locality during year 2017-18 in month of November was 3.18±1.27kg likewise December 3.68±2.14kg,January 3.49±2.17kg,March 3.12±1.14kg,April 3.05±1.13kg, May 2.91±1.23kg, July 2.68±1.27kg, August 2.62±1.16kg , September 2.82±1.24kg.

During year 2018-19 in month of November was 3.2±1.32Kg likewise December 3.6±2.54kg,January 3.5±2.32kg,March 3.1±1.11kg,April 3.0±1.23kg, May 2.9±1.34kg, July 2.7±1.18kg, August 2.6±1.25kg , September 2.8±1.34kg

During year 2019-20 in month of November was 3.25±1.35kg likewise December 3.73±2.25kg,January 3.54±2.23kg,March 3.17±1.22kg,April 3.11±1.25kg, May 2.99±1.17kg, July 2.75±1.14kg, August 2.67±1.29kg, September 2.91±1.21kg.

Total plastic waste generated/household during 3 years in West locality in month of month of November was 9.63kg likewise December 11.01kg,January 10.53kg,March 9.39kg,April 9.16kg, May 8.8kg, July 8.13kg, August 7.89kg , September 8.53kg. while average plastic waste generation/household during 3 years in month of month of November was 3.21±1.31kg likewise December 3.67±2.31kg,January 3.51±2.24kg,March 3.13±1.15kg,April 3.05±1.20kg, May 2.93±1.24kg, July 2.71±1.19kg, August 2.63±1.23kg , September 2.84±1.26kg (Table 49;Fig.35)

Table 48: Seasonal plastic waste generation (kg)/household in West Locality

	Winters	Summer	Rainy
2017-18	10.35	9.08	8.12
2018-19	10.3	9.00	8.10
2019-20	10.52	9.27	8.33
Total	31.17	27.35	24.55
Avg	10.39	9.11	8.18

Average household plastic waste generation in West locality during year 2017-18 in winter was 10.35kg, summer 9.08kg, and during rainy season was 8.12kg.

Average household plastic waste generation in West locality during year 2018-19 in winter was 10.3kg, summer 9.00kg, and during rainy season was 8.10kg.Average household plastic waste generation in West locality during year 2019-20 in winter was 10.52kg, summer 9.27kg and during rainy season was 8.33kg.

During 2017-20 three year assessment total plastic waste/household produced during winter was 31.17kg, summer 27.35kg, rainy season was 24.55kg,while average plastic waste /household produced during winter was 10.39kg, summer 9.11kg and rainy season was 8.18kg (Table 48).

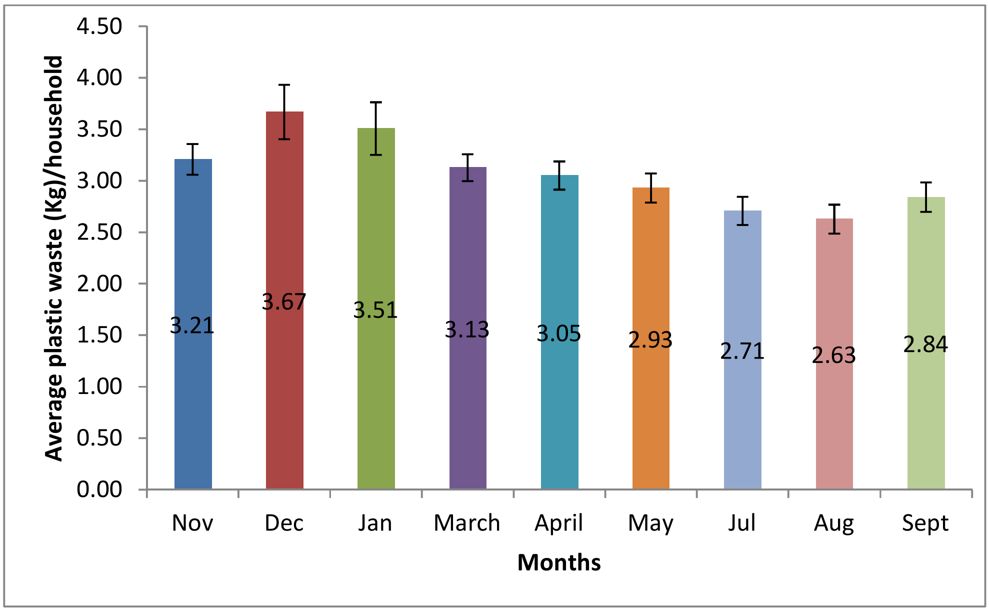

Fig.35: Average plastic waste generation/household in West locality in the three years

Table 49: Plastic waste (kg) generation /household in West locality

Year	Nov	Dec	Jan	March	April	May	Jul	Aug	Sept
2017-18	3.18±1.27	3.68±2.14	3.49±2.17	3.12±1.14	3.05±1.13	2.91±1.23	2.68±1.27	2.62±1.16	2.82±1.24
2018-19	3.2±1.32	3.6±2.54	3.5±2.32	3.1±1.11	3.0±1.23	2.9±1.34	2.7±1.18	2.6±1.25	2.8±1.34
2019-20	3.25±1.35	3.73±2.25	3.54±2.23	3.17±1.22	3.11±1.25	2.99±1.17	2.75±1.14	2.67±1.29	2.91±1.21
Total	9.63	11.01	10.53	9.39	9.16	8.8	8.13	7.89	8.53
Avg	3.21±1.31	3.67±2.31	3.51±2.24	3.13±1.15	3.05±1.20	2.93±1.24	2.71±1.19	2.63±1.23	2.84±1.26

Table 50.a.: ANOVA for monthly variation in gross plastic waste generation in West locality during year 2017-18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.71362	8	9.339202	3.483011	0.000596	1.951923
Within Groups	1834.05	684	2.681359			
Total	1908.763	692				

Table 50.b.: ANOVA for monthly variation in gross plastic waste generation in West locality during 2018-19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.3341	8	9.291762	3.458287	0.000643	1.951923
Within Groups	1837.779	684	2.686811			
Total	1912.113	692				

Table 50.c.: ANOVA for monthly variation in gross plastic waste generation in West locality during 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.78288	8	9.34786	3.479393	0.000602	1.951923
Within Groups	1837.658	684	2.686635			
Total	1912.441	692				

Table 50.d.: ANOVA for yearly (2017-20) variation in gross plastic waste generation in West locality

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	25.00229	2	12.50114	0.106235	0.899258	3.035441
Within Groups	26829.77	228	117.6744			
Total	26854.78	230				

4.4.Comparison of Plastic waste generation among localities

By comparing between the five localities it was observed that during year 2017-18 maximum plastic waste was generated in West locality (2134.68kg) and minimum in North locality (2045.94 kg), during year 2018-19 maximum plastic waste was generated in South locality (2157.93kg) and minimum in North locality (1994.18kg), during year 2019-20 maximum plastic waste was generated in West locality (2164.70kg) and minimum in North locality (2040.34 kg). Gross plastic waste generation among households of various localities was not found statistically significant for year 2017-18($F_{4,380}$=.13,P>0.05;Table 51.a;Appendix:16), 2018-19($F_{4,380}$=.38,P>0.05;Table 51.b.;Appendix:17), 2019-20($F_{4,380}$=.36, P>0.05; Table51.c.;Appendix:18).

Table 51.a: ANOVA for variation in gross plastic waste generation among different localities (South, North, East, Central and West) for year 2017-18

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	64.06511	4	16.01628	0.13659	0.968725	2.39543
Within Groups	44558.18	380	117.2584			
Total	44622.25	384				

Table51.b: ANOVA for Variations in Gross plastic waste generation among different localities (South, North, East, Central and West) for year 2018-19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	181.2579	4	45.31449	0.385346	0.819122	2.39543
Within Groups	44685.81	380	117.5942			
Total	44867.06	384				

Table51.c: ANOVA for variation in gross plastic waste generation among different localities (South, North, East, Central and West) for year 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	169.7242	4	42.43104	0.360832	0.836446	2.39543
Within Groups	44685.06	380	117.5923			
Total	44854.78	384				

Several factors influence the quantity, physical and chemical characteristics of waste generated at various sources. Factors such as employment status, household size, seasons, income level and population influence the variation in the composition of MSW waste streams (Agarwal et al.,2013).One of the major factors leading to variation in the quantity and morphological composition of municipal solid waste is the season. Changes in weather conditions at different seasons in a year affect consumption pattern and human activities and influences the fractions of the waste stream such as plastics, paper, metal, textile and organic waste (Denafas et al., 2014).Seasonal variations in generation of waste have been observed in various studies done previously by Kamran et al.,2015;Gomez et al.,2009;Jadoon et al.,2014;Al Khatib et al.,2010;Zeng.,2005., Gidarakos et al.,2006., Aslani and Taghipou,2018., Denafas et al.,2014). Possible reason for maximum plastic waste/household generation in winter season could be winters being festival season in Aizawl city, it is a time when people tend to consume more evidenced by crowded markets, ongoing sales and online shopping at its peak and least plastic waste/household was generated during Rainy season. It has been observed people’s consumption pattern didn’t change considerably during survey period (2017-20) as family size, yearly income and attitude and perception remained unchanged. Hence yearly variation in a particular locality was not observed. The difference in plastic waste generation observed in various localities which may be due to different demography of various localities(S,N,E,C,W) as waste generation have been found to depend upon economic status, family size, cultural factors and level of awareness among members different households Buenrostro (2003);Ashley et al.,2006;Agarwal et al.,2013,Rhyner (1992).

4.5. Plastic waste generation per capita per year and per day

Maximum plastic waste generation per capita per year was observed in Central locality with 5.56±.99 kg and least in South locality with 4.34±1.14 kg (Table 52). Maximum plastic waste generation per capita per day was found in Central Locality 20.03±1.76 g and least in South locality 15.71±1.61g(Table 54). Result of ANOVA analysis shows significant difference among various localities in terms of plastic waste generation per capita per year ($F_{4,10}$=20.07,P<.005;Table 53;Fig.36), and plastic waste generation per capita per day ($F_{4,10}$=18.33,P<.005;Table 55; Fig.37).

Table 52: Plastic waste generated per capita per year in different localities during three years

Locality	Plastic Waste/Capita/Yr 2017-18	Plastic Waste/Capita/Yr 2018-19	Plastic Waste/Capita/Yr 2019-20	Average
South	4.34±1.20	4.00±.94	4.66±1.30	4.34±1.14
Central	5.56±.86	5.47±.82	5.66±1.30	5.56±.99
West	4.56±1.30	4.61±1.4	4.85±.83	4.67±1.17
North	4.30±.73	4.26±.98	4.59±.95	4.38±.88
East	4.82±1.2	4.75±1.4	4.94±.94	4.84±1.18

During 2017-18 South locality generated 4.34±1.20kg plastic waste/capita/yr, Central locality generated5.56±.86 kg plastic waste/capita/yr, West locality generated 4.56±1.30kg plastic waste /capita/yr, North locality generated 4.30±.73kg plastic waste /capita/yr while East locality generated 4.82±1.2kg plastic waste/ capita/yr.

During 2018-19 South locality generated 4.00±.94kg plastic/capita/yr, Central locality generated 5.47±.82kg plastic waste/capita/yr, West locality generated 4.61±1.4kg plastic waste /capita/yr, North locality generated 4.26±.98kg plastic waste /capita/yr, East locality generated 4.75±1.4kg plastic waste/ capita/yr.

During 2019-20 South locality generated 4.66±1.30kg plastic/capita/yr, Central locality generated 5.66±1.30kg plastic waste/capita/yr, West locality generated 4.85±.83kg plastic waste /capita/yr, North locality generated 4.59±.95kg plastic waste /capita/yr, East locality generated 4.94±.94kg plastic waste/ capita/yr (Table 52; Fig. 36).

Table 53:ANOVA for variation in Plastic waste generated per capita per year in various localities during 2017-18, 2018-19 and 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.939277	4	0.734819	20.07405	9.07E-05	3.47805
Within Groups	0.366054	10	0.036605			
Total	3.305332	14				

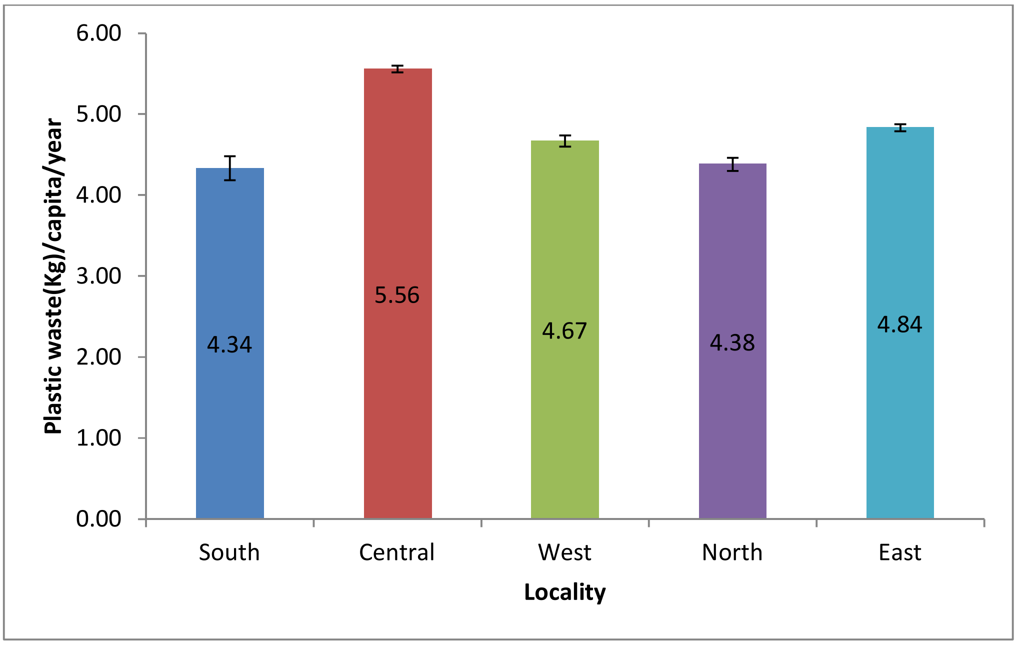

Fig.36: Plastic waste generated per capita per year in different localities during three years

Table 54:Plastic waste (g) generated per capita per day in different localities during three years

Locality	Plastic Waste/Capita/Day	Plastic Waste/Capita/Day	Plastic Waste/Capita/Day	Avg
	2017-18	2018-19	2019-20	
South	15.72±2.2	14.51±1.8	16.89±.83	15.71±1.61
Central	20.14±1.4	19.82±1.7	20.14±2.2	20.03±1.76
West	17.24±.83	16.69±1.3	17.56±1.1	17.16±1.07

North	19.21±1.9	19.42±2.5	20.99±.92	19.87±1.77
East	19.63±1.3	19.74±2.4	18.63±1.3	19.33±1.66

During 2017-18 South locality generated 15.72±2.2g plastic waste/capita/yr, Central locality generated 20.14±1.4g plastic waste/capita/yr, West locality generated 17.24±.83g plastic waste /capita/yr, North Locality generated 19.21±1.9g plastic waste /capita/yr while East locality generated 19.63±1.3g plastic waste/ capita/yr.

During 2018-19 South locality generated 14.51±1.8g plastic waste/capita/yr, Central locality generated 19.82±1.7g plastic waste/capita/yr, West locality generated 16.69±1.3g plastic waste /capita/yr, North Locality generated 19.42±2.5g plastic waste /capita/yr while East locality generated 19.74±2.4g plastic waste/ capita/yr.

During 2019-20 South locality generated 16.89±.83g plastic waste/capita/yr, Central locality generated 20.14±2.2g plastic waste/capita/yr, West locality generated 17.56±1.1g plastic waste /capita/yr, North Locality generated 20.99±.92g plastic waste /capita/yr while East locality generated 18.63±1.3g plastic waste/ capita/yr (Table 54; Fig.37)

Table 55:ANOVA for variation in Plastic waste generated per capita per day in various localities during 2017-18, 2018-19 and 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	43.43091	4	10.85773	18.33403	0.000134	3.47805
Within Groups	5.922174	10	0.592217			
Total	49.35309	14				

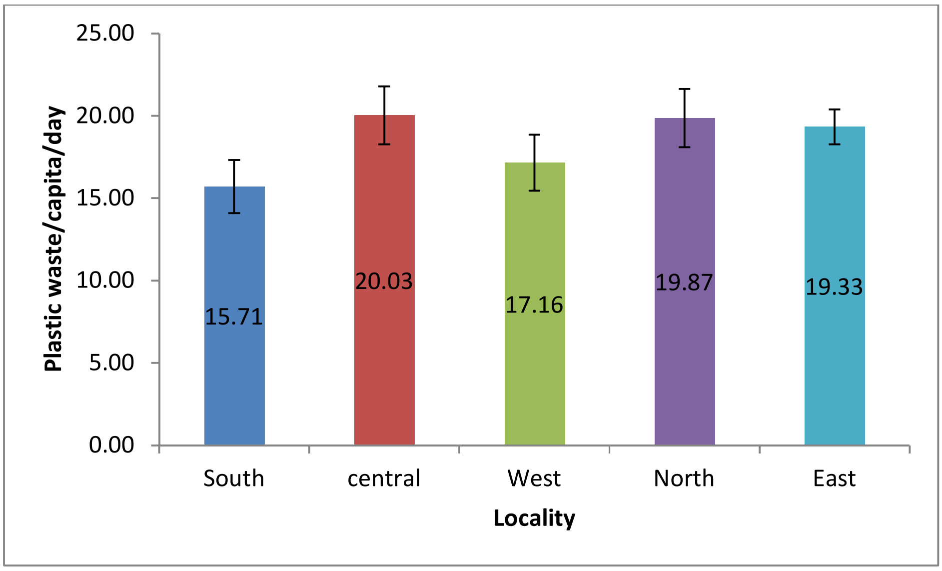

Fig.37:Plastic waste generated per capita per day in different localities during the three years

It was found that maximum plastic waste per capita per season was generated during winter season in all the three years in all localities. The maximum Plastic waste generation per capita per season was found in Central locality 5.31±.15 kg and least in south locality 4.05±.47 kg.(Table 56) In all the three seasons maximum Plastic waste generation per capita per day was found during winter season in Central locality 19.27±3.03 g and least Plastic waste generation per capita per day was found during Rainy season in South Locality 6.66±3.26 g (Table 58).The result of ANOVA analysis shows there plastic waste generation per capita per season doesn't differ significantly in all localities ($F_{2,12}$=.78,P>.005;Table 57),statistical significant difference was observed in plastic waste generation per capita per day per season in all localities ($F_{2,12}$=13.06,P<.005;Table 59).

Table 56:Plastic waste (kg) generated per capita per season during 2017-18, 2018-19, 2019-20

Location	Winter	Summer	Rainy
South	4.05±.47	3.80±.18	3.6±.10

North	4.87±.17	4.67±.99	4.49±.83
East	4.42±.15	4.09±.78	3.82±.33
West	4.13±.60	4.08±.48	3.82±.50
Central	5.31±.15	5.20±.20	4.89±.12

During winter South locality generated 4.05±.47kg plastic waste/capita, North locality generated 4.87±.17kg plastic waste/capita, East locality generated 4.42±.15kg plastic waste/capita, West locality generated 4.13±.60kg plastic waste/capita while Central locality generated 5.31±.15kg plastic waste/capita.

During summer South locality generated 3.80±.18kg plastic waste/capita, North locality generated 4.67±.99kg plastic waste/capita, East locality generated 4.09±.78kg plastic waste/capita, West locality generated 4.08±.48kg plastic waste/capita while Central locality generated 5.20±.20kg plastic waste/capita.

During summer South locality generated 3.6±.10kg plastic waste/capita, North locality generated 4.49±.83kg plastic waste/capita, East locality generated 3.82±.33kg plastic waste/capita, West locality generated 3.82±.50g plastic waste/capita while Central locality generated 4.89±.12kg plastic waste/capita (Table 56).

Table 57:ANOVA table for variation in Plastic waste generated per capita per season during 2017-18, 2018-19 and 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.469173	2	0.234587	0.788633	0.476665	3.885294
Within Groups	3.56952	12	0.29746			
Total	4.038693	14				

Table 58: Plastic waste (g) generated per capita per day during three years

Location	**Winter**	**Summer**	**Rainy**
South	13.32±3.27	8.02±4.05	6.66±3.26
North	17.12±2.22	11.56±3.16	9.61±3.42
East	15.79±3.84	11.56±3.16	7.34±2.7

West	14.97±4.16	12.90±4.7	10.18±4.19
Central	19.27±3.03	13.85±2.38	11.68±3.39

During Winter South locality generated 13.32±3.27g plastic waste/capita, North locality generated 17.12±2.22g plastic waste/capita, East locality generated 15.79±3.84 g plastic waste/capita, West locality generated 14.97±4.16g plastic waste/capita while Central locality generated 19.27±3.03g plastic waste/capita.

During summer South locality generated 8.02±4.05g plastic waste/capita, North locality generated 11.56±3.16g plastic waste/capita, East locality generated 11.56±3.16g plastic waste/capita, West locality generated 12.90±4.7g plastic waste/capita while Central locality generated 13.85±2.38g plastic waste/capita.

During Rainy season south locality generated 6.66±3.26g plastic waste/capita, North locality generated 9.61±3.42 g plastic waste/capita, East locality generated 7.34±2.7g plastic waste/capita, West locality generated 10.18±4.19g plastic waste/capita while Central locality generated 11.68±3.39g plastic waste/capita (Table 58).

Table 59:ANOVA table for variation in Plastic waste generated per capita per day in each season during 2017-18, 2018-19 and 2019-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	124.9425	2	62.47123	13.06535	0.000971	3.885294
Within Groups	57.37732	12	4.781443			
Total	182.3198	14				

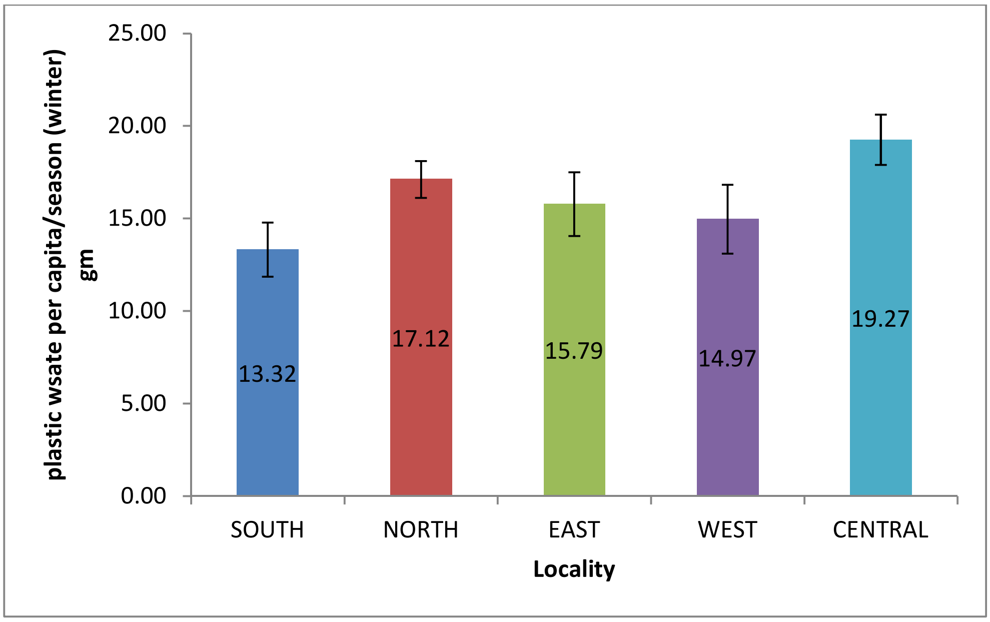

Fig. 38:Plastic waste generated per capita per day during winter in three years

During Winter South locality generated 13.32±3.27g plastic waste/capita, North locality generated 17.12±2.22g plastic waste/capita, East locality generated 15.79±3.84 g plastic waste/capita, West locality generated 14.97±4.16g plastic waste/capita while Central locality generated 19.27±3.03g plastic waste/capita (Fig. 38).

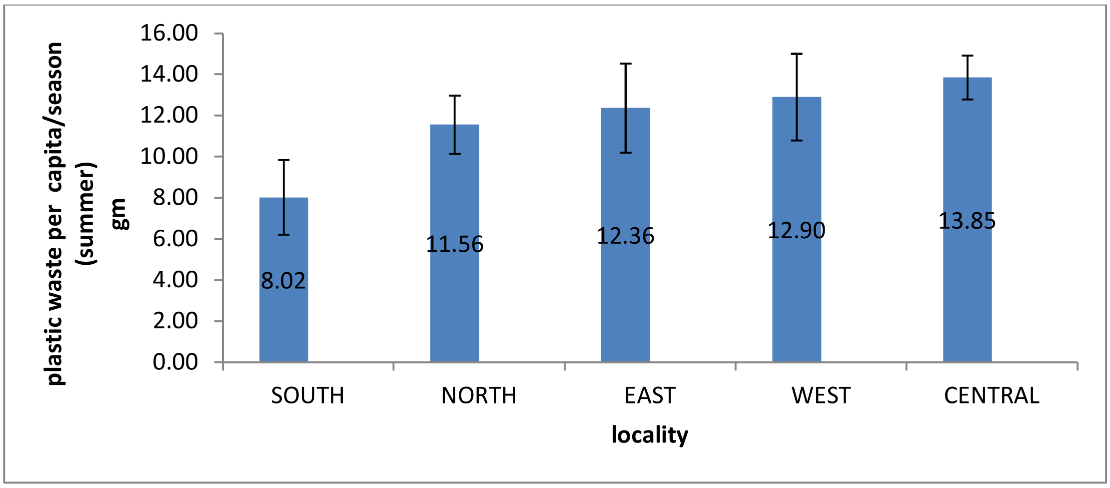

Fig.39: Plastic waste generated per capita per day during summer in three years

During summer South locality generated 8.02±4.05g plastic waste/capita, North locality generated 11.56±3.16g plastic waste/capita, East locality generated 11.56±3.16g plastic waste/capita, West locality generated 12.90±4.7g plastic waste/capita while Central locality generated 13.85±2.38g plastic waste/capita (Fig. 39)

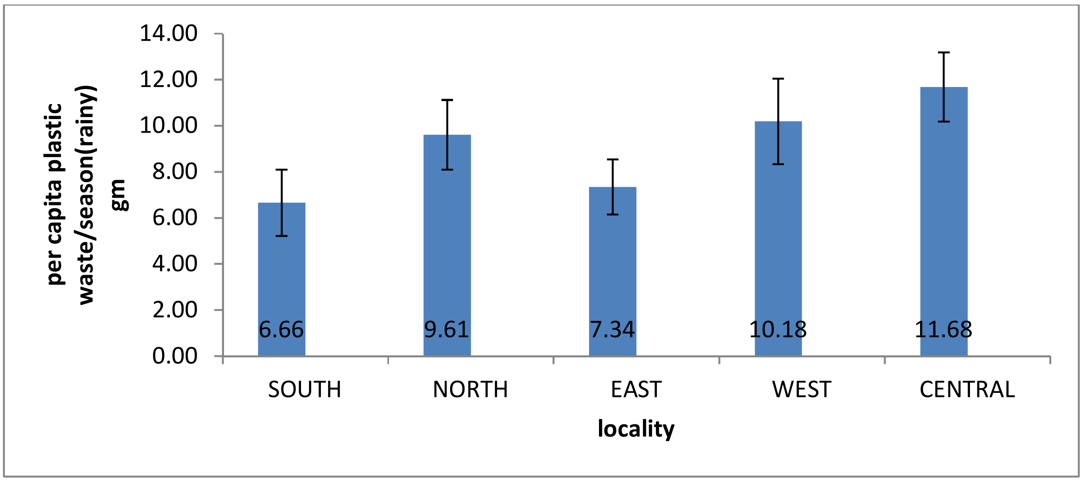

Fig. 40: Plastic waste generated per capita per day during Rainy season in three years

During Rainy season south locality generated 6.66±3.26g plastic waste/capita, North locality generated 9.61±3.42 g plastic waste/capita, East locality generated 7.34±2.7g plastic waste/capita, West locality generated 10.18±4.19g plastic waste/capita while Central locality generated 11.68±3.39g plastic waste/capita (Fig. 40).

The difference in yearly and daily generation of plastic waste (g) per capita among households of various localities may be due difference in economic status, education level, family size, level of awareness and cultural factors. A study conducted in KanTho city,Vietnam by Thanh et al.,2011 found average plastic waste produced in residential area was 17.24 gm/capita per day. Chinnathan et al., studied plastic waste management in Bangkok and reported per capita plastic waste generation 12.57 g/day. The commercial establishments such as railway stations, airports generate much higher per capita plastic waste generation. Such a study was conducted by CPCB in 2009 at three railway stations at Delhi namely Hazrat Nizamuddin,old Delhi and New Delhi railway station and generated per capita plastic waste per day 7.8 g, 9.5 g, 9.7 g respectively while per capita plastic waste generation per day at domestic and international terminal was found to 70g and 68g respectively. The Department of Environment, Government of NCT of Delhi and Shriram Institute for Industrial Research (SRI), undertook a project in 2020 entitled "Assessment and Characterization of Plastic Waste in the NCT of Delhi. The study involved assessment and characterization of plastic waste in different areas of Delhi. The average quantity of plastic waste at residential areas has been estimated as 8.30% of total solid waste, whereas at tourist areas, market places & commercial areas, public places, institutional areas and educational institutions, it is found 7.49%, 13.12%, 16.76%, 10.22% and 15.3% respectively. The study found very high per capita per day plastic waste generation in Delhi which was 53.6 g. Similarly Putri et al., 2018 studied Plastic waste management in Jakarta, Indonesia and found per capita plastic waste generation per day 12.42 g while Monjur et al., 2017studied plastic waste management in Bangladesh and reported found per capita plastic waste generation per day to be 10.93g.characteristics and waste quantity have been found to influenced by weather and seasons as studied by several researcher (Boldrin and Christensen,2009; Gidarakos et al.,2006;Gomez et al.,2009 ad Ryner ,2009).

4.6. Plastic waste generated across income groups

Maximum Plastic waste generation per capita per year was found in the households having income > 25L/yr with 6.89±.29 kg and least in the income group having family income < 1.0L/yr with 4.29±.24 kg. (Table 60).Maximum Plastic waste g/capita/day was found in income group of having household income > 25L/yr with 22.55±3.56 g while least in least in income group having family income <1.0L/yr with 14.89±2.15g (Table 62).A positive correlation was found between plastic waste kg/capita/yr ($r=.95$) and Plastic waste g/capita/day ($r=.97$)across various income groups (Fig.43; Fig.44) ANOVA in Plastic waste kg/capita/yr across various income groups reveals that there was significant difference ([F(4,4)= 4.55,P<.05; Table 61]) across all income groups in generation of plastic waste per year while statistical significant difference ([F(4,4)= 2.80,P<.05; Table 63) was found in relation to Plastic waste g)/capita/day across various income groups.

Table 60:Plastic waste/ capita/yr) across income groups

	plastic waste kg/capita/yr				
	Household income(L)/yr				
Locality	**<1.0L**	**1.0-3.5L**	**3.5-10L**	**10-25L**	**>25L**
South	4.40±.15	4.82±.26	5.00±.24	5.25±.19	8.29±.38
North	4.07±.25	4.67±.15	5.36±.17	6.64±.25	7.70±.28
West	4.11±.37	4.25±.29	4.39±.23	4.61±.21	4.91±.31
Central	4.98±.16	5.18±.24	5.30±.21	5.49±.38	7.51±.30
East	3.89±.31	4.03±.21	4.87±.32	5.07±.20	6.04±.22
Avg	4.29±.24	4.59±.39	5.12±.42	5.28±.22	6.89±.29

In South locality families having yearly income less than 1.0L/yr generated 4.40±.15kg plastic per capita/yr, income between 1.0-3.5L/yr generated 4.82±.26kg plastic per capita/yr, income between 3.5-10L/yr generated 5.00±.24kg plastic per capita/yr, income between 10-25L/yr generated 5.25±.119kg plastic per capita/yr while households with income >25L/yr generated 8.29±.38 kg plastic per capita/yr.

In North locality families having yearly income less than 1.0L generated 4.07±.25kg plastic per capita/yr, income between 1.0/-3.5Lgenerated 4.67±.15 kg plastic per capita/yr, income between 3.5-10Lgenerated 5.36±.17kg plastic per capita/yr, income between 10-25Lgenerated 6.64±.25kg plastic per capita/y while households with income >25 L/yr generated 7.70±.28kg plastic per capita/yr.

In West locality families having yearly income less than 1.0L/yr generated 4.11±.37kg plastic per capita/yr, income between 1.0-3.5L/yr generated 4.25±.29kg plastic per capita/yr, income between 3.5-10L/yr generated 4.39±.23kg plastic per capita/yr, income betwee10-25L/yr generated 4.61±.21kg plastic per capita/yr while households with income > 25 L/yr generated 4.91±.31kg plastic per capita/yr.

In Central locality families having yearly income less than 1.0L/yr generated 4.98±.16kg plastic per capita/yr, income between 1.0-3.5L/yr generated 5.18±.24kg plastic per capita/yr, income between 3.5-10L/yr generated5.30±.21kg plastic per capita/yr, income between 10-25L/yr generated 5.49±.38kg plastic per capita/yr while households with income >25L/yr generated 7.51±.30kg plastic per capita/yr.

In East locality families having yearly income less than 1.0L/yr generated 3.89±.31kg plastic per capita/yr, income between 1.0-3.5L/yr generated 4.03±.21kg plastic per capita/yr, income between 3.5-10L/yr generated 4.87±.32kg plastic per capita/yr, income between 10-25L/yr generated 5.07±.20kg plastic per capita/yr while households with income >25L/yr generated 6.04±.22kg plastic per capita/yr (Table60; Fig.41).

Table 61:ANOVA for variation in Plastic waste /capita/yr across income groups

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.32908	4	5.082271	8.127166	0.000462	2.866081
Within Groups	12.50687	20	0.625344			
Total	32.83596	24				

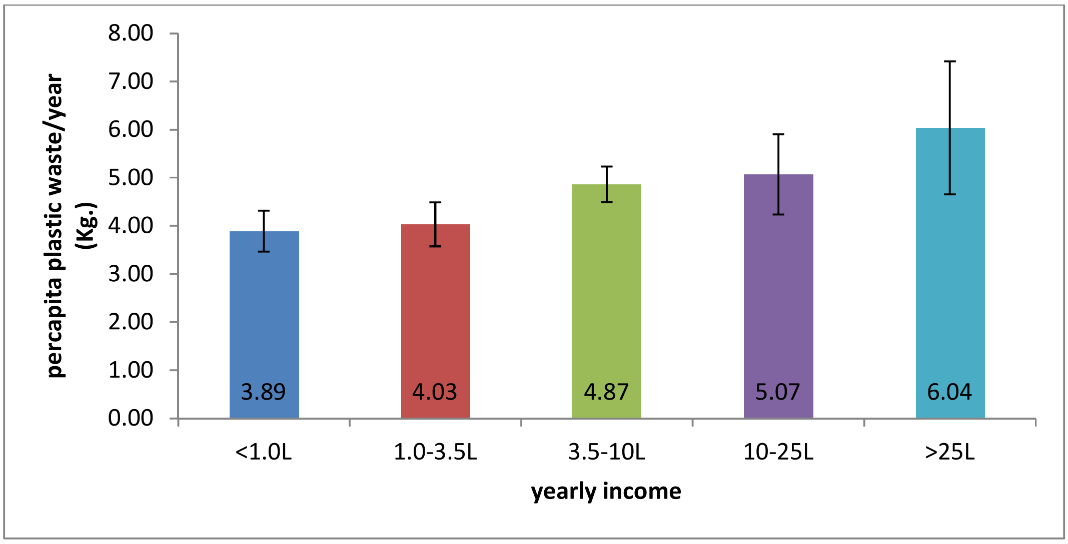

Fig.41 : **Plastic waste /capita/yr across income groups**

Table 62.: Plastic waste (gm)/capita/day across various income groups

	plastic waste g/capita/day				
	Household income(L)/yr				
Locality	**<1.0L**	**1.0-3.5L**	**3.5-10L**	**10-25L**	**>25L**
South	16.84±1.7	17.38±1.8	18.36±1.2	18.42±1.9	26.73±.98
North	13.08±2.0	13.60±1.9	14.69±1.2	24.22±2.5	24.83±2.7
West	12.89±1.3	15.70±1.4	15.37±1.90	16.18±1.4	19.34±2.1
Central	17.51±2.6	18.88±2.8	19.24±2.7	19.60±2.6	23.43±2.4
East	14.14±.83	14.61±.87	17.65±2.3	17.81±2.3	18.43±2.5
Avg	14.89±1.53	16.25±1.45	17.04±1.90	19.05±2.24	22.55±1.95

In South locality families having yearly income less than 1.0L/yr generated 16.84±1.7g plastic per capita/day, income between 1.0-3.5L/yr generated 17.38±1.8g plastic per capita/day, income between 3.5-10L/yr generated 18.36±1.2g plastic per capita/day, income between 10-25L/yr generated 18.42±1.9g plastic per capita/day while household with income >25L/yr generated 26.73±.98g plastic per capita/day.

In North locality families having yearly income less than 1.0L/yr generated 13.08±2.0g plastic per capita/day, income between 1.0-3.5L/yr generated g plastic per capita/day,income between 3.5-10L/yr generated g plastic per capita/day, income between 10-25L/yr generated 24.22±2.5g plastic per capita/day while households with income >25L/yr generated 24.83±2.7g plastic per capita/day.

In West locality families having yearly income less than 1.0L/yr generated 12.89±1.3g plastic per capita/day, income between 1.0-35L/yr generated 15.70±1.4g plastic per capita/day,income between 3.5-10L/yr generated 15.37±1.90g plastic per capita/day, income between 10-25L/yr generated 16.18±1.4g plastic per capita/day while households with income >25L/yr generated 19.34±2.1g plastic per capita/day.

In Central locality families having yearly income less than 1.0L/yr generated 17.51±2.6g plastic per capita/day, income between 1.0-3.5L/yr generated 18.88±2.8g plastic per capita/day,income between 3.5-10L/yr generated 19.24±2.7g plastic per capita/day,income between10-25L/yr generated19.60±2.6 g plastic per capita/day while household with income >25L/yr generated 23.43±2.4g plastic per capita/day.
In East locality families having yearly income less than 1.0L/yr generated 14.14±.83g plastic per capita/day, income between 1.0-3.5L/yr generated 14.61±.87g plastic per capita/day, income between 3.5-10L/yr generated 17.65±2.3g plastic per capita/day, income between 10-25L/yr generated 17.81±2.3g plastic per capita/day households with income >25L/yr generated 18.43±2.5g plastic per capita/day (Table 62; Fig.42).

Table 63:ANOVA for variation in Plastic waste /capita/day across income groups

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	177.3361	4	44.33403	6.09388	0.002245	2.866081
Within Groups	145.5035	20	7.275174			
Total	322.8396	24				

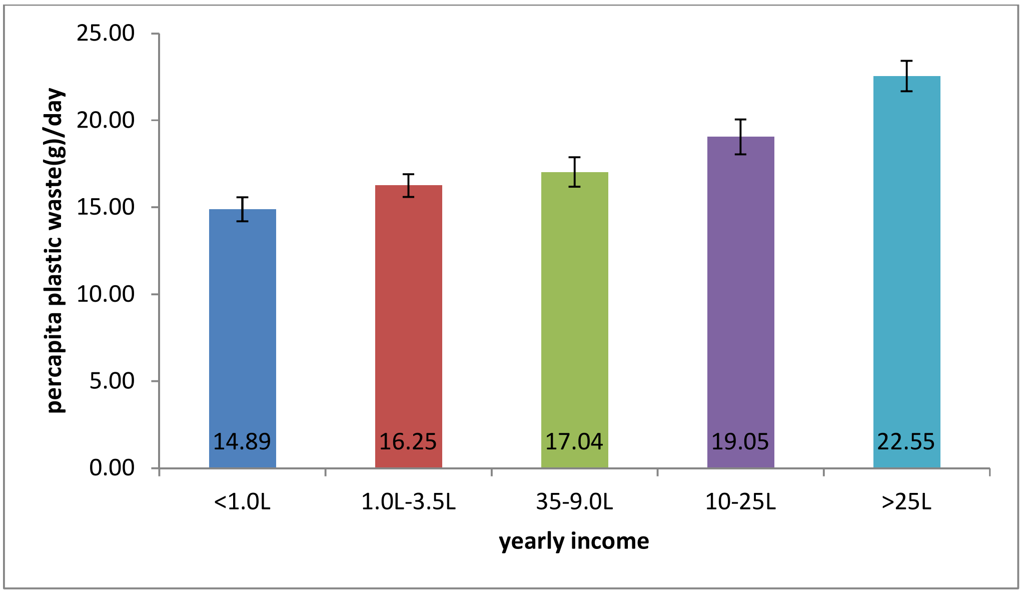

Fig.42: **Plastic waste /capita/day across income groups**

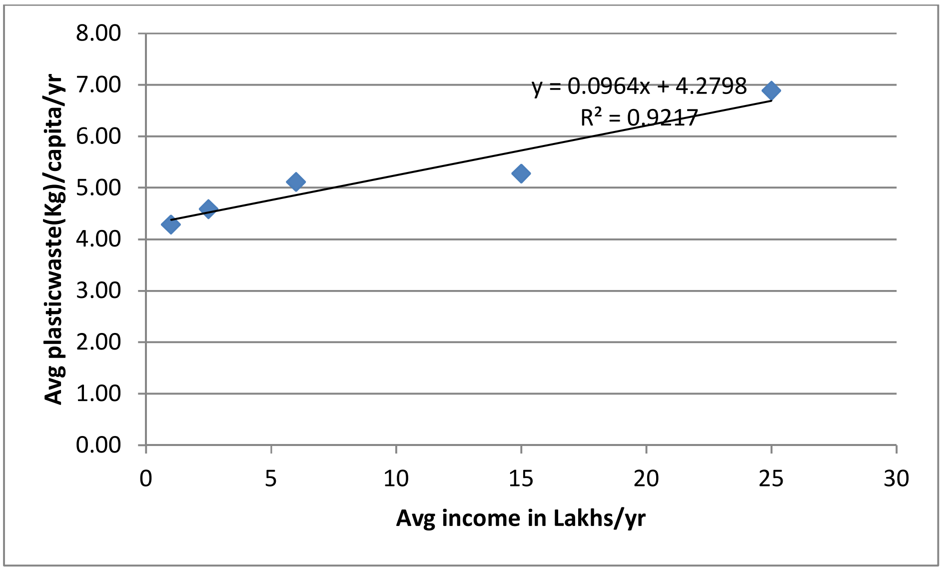

Fig.43: **Regression line of economic status and plastic waste generation Kg/capita/yr**

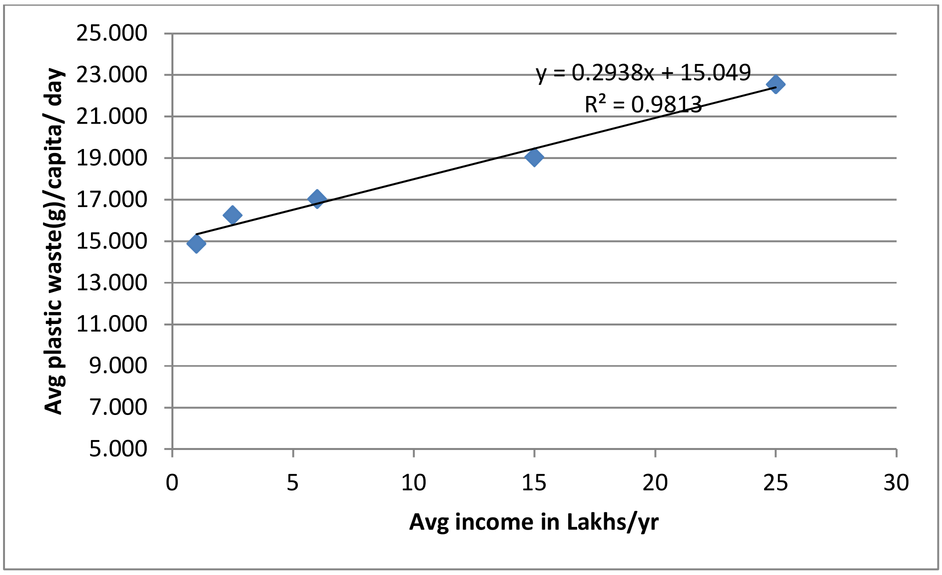

Fig.44: **Regression line of economic status and plastic waste generation g/capita/day**

Waste generation is influenced by Socioeconomic and demographic factors and have been studies by several researchers Many researchers have indicated that variation in municipal solid waste (MSW) generation and composition are associated with lifestyle, household size, socio-economic factors, industrialisation, and climatic and seasonal changes (Bandara et al., 2007; Buenrostro et al., 2011., Dennison et al.,1996., Gomez et al.,2009., Burnley,2007).Dennison et al.,1996 reported that the higher the level of economic growth and urbanisation, the greater the amount of solid waste generated. This finding is compatible with the results of the current study more income, more waste. It has been observed during course of urbanisation as economic status and earning improves the consumption pattern of households also gets changed. It is evidenced by quality of waste generated which becomes more and more dominated by inorganic fraction as opposed to very high portion of organic fraction in waste in rural areas where peoples net income is less and economic status is quite low as compared to urban areas. In Aizawl city literacy rate is very high and people are influenced by western thoughts and lifestyle. The rise in income and employment opportunities have led to sharp change in consumption pattern of people with more disposable income people tend to indulge in shopping, consuming packaged food and readymade items from departmental store. This had led to rise in plastic waste as economic prosperity brings well being.

4.7. Physical characterization of plastic waste in residential area

Plastic packaging material with 72.66±0.88 % by weight was found to dominate the plastic waste in South locality (Table 64; Fig.45).Among the plastic packaging material plastic shopping bag comprised 44.82±0.90% of total plastic waste in South Locality (Table 65; Fig.46).

Plastic Packaging material with 71.49±1.34 % by weight was found to dominate the plastic waste in North Locality (Table 66; Fig.47).Among plastic packaging material plastic shopping bag comprised 44.18±0.77% of total plastic waste in North Locality (Table 67;Fig.48).

Plastic Packaging material with 72.80±0.28 % by weight was found to dominate the plastic waste in Central Locality (Table 68; Fig.49). Among plastic packaging material plastic shopping bag comprised 44.80±0.11% of total plastic waste in Central Locality (Table 69;Fig.50).

Plastic Packaging material with 71.45±1.37 % by weight was found to dominate the plastic waste in East Locality (Table 70; Fig.51).Among plastic packaging material plastic shopping bag comprised 44.21±0.24% of total plastic waste in East Locality (Table 71;Fig.52).

Plastic Packaging material with 71.45±1.37 % by weight was found to dominate the plastic waste in West Locality (Table 72; Fig.53). Among plastic packaging material plastic shopping bag comprised 44.34±0.81% of total plastic waste in West Locality (Table 73;Fig.54).The result of ANOVA analysis reveals that there was no significant difference among various physical categories of plastic waste produced among various localities. ($F_{4,40}$=4.34E-07,$P>0.05$; Table 74; Table 75).

Table 64: Physical characterization of plastic waste in South Locality

Locality		Wt (%)	Wt (%)	Wt(%)	Avg
South	Categories	2017-18	2018-19	2019-20	
	Bottles	10.53	11.07	11.19	10.93±0.35
	Containers	3.54	3.72	3.76	3.67±0.12
	Tubes	1.39	1.57	1.61	1.52±0.12
	Packaging	73.68	72.16	72.15	72.66±0.88
	Plastic rope	0.32	0.41	0.43	0.39±0.06
	Tray	1.56	1.74	1.78	1.69±0.12
	Durable products(MU)	3.72	3.81	3.53	3.69±0.14
	Consumable Products(SU)	1.43	1.51	1.50	1.48±0.04
	Others	3.83	4.01	4.05	3.96±0.12

In South locality during year 2017-18 plastic waste was dominated by packaging material 78.68%; bottles with 10.53%; containers 3.54%;Tubes 1.39%;consumable plastic products 1.43%;durable plastic products 3.72%;plastic tray 1.56% and plastic rope with 0.32%.

During year 2018-19 plastic waste was dominated by packaging material 72.16%;bottles with 11.07%;containers 3.72%;Tubes 1.57%;consumable plastic products 1.15%;durable plastic products 3.81%;plastic tray 1.74% and plastic rope with 0.41%.

During year 2019-20 plastic waste was dominated by packaging material 72.15%;bottles with 11.19%;containers 3.76%;Tubes 1.61%;consumable plastic products 1.50%;durable plastic products 3.53%;plastic tray 1.78% and plastic rope with 0.43% (Table 64; Fig. 45).

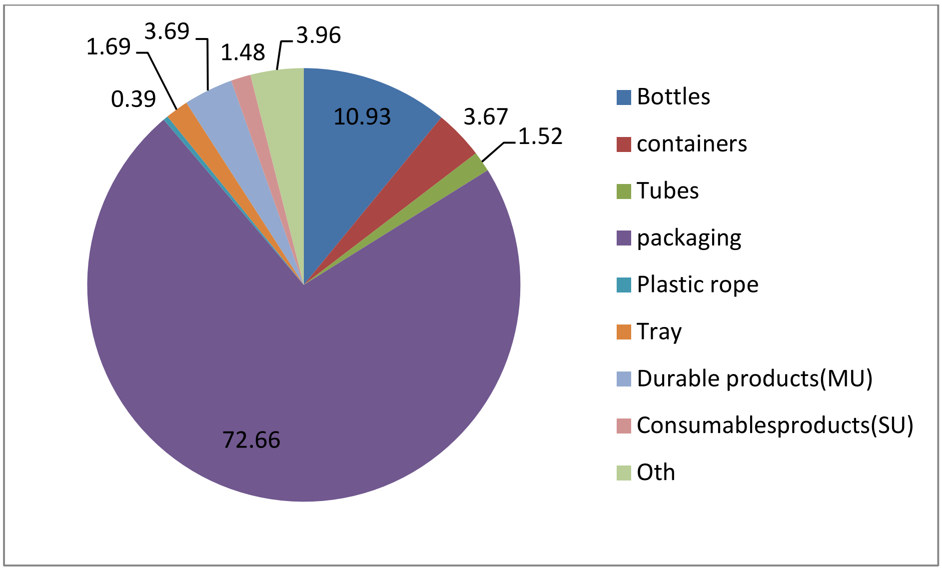

Fig.45: Composition(%) of Plastic waste by weight in South locality

Table 65: Composition(%) of packaging material by weight in south locality

Category	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	8.92	9.01	9.03	8.99±0.06
Plastic packaging for non-food	5.22	5.31	5.33	5.29±0.06
Plastic packaging for unspecified purpose	13.23	13.32	12.34	12.96±0.54
Plastic shopping bags	45.72	43.92	44.83	44.82±0.90
Buffer materials	0.59	0.60	0.62	0.60±0.02

In South locality during 2017-18 packaging plastic material was dominated by plastic shopping bags 45.72%; packaging for non food 5.22%; packaging for food items 8.92%;plastic packaging for unspecified purpose 13.23% and plastic buffer material with 0.59%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 43.92%; packaging for non food 5.31%; packaging for food items 9.01%; plastic packaging for unspecified purpose 13.32% and plastic buffer material with 0.60%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 44.83%; packaging for non food 5.33%;packaging for food items 9.03%; plastic packaging for unspecified purpose 12.34% and plastic buffer material with 0.62% (Table 65; Fig.46).

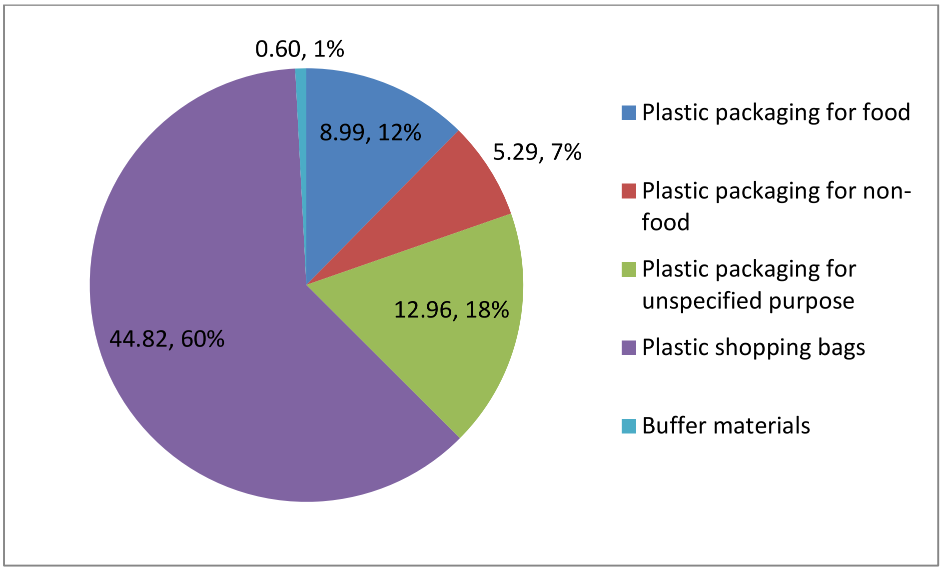

Fig.46: Composition(%) of packaging material by weight in south locality

Table 66: Physical characterization of plastic waste in North Locality

Locality	Categories	Wt(%) 2017-18	Wt (%) 2018-19	Wt (%) 2019-20	Avg
North	Bottles	12.27	11.61	10.65	11.51±0.81
	Containers	5.12	3.00	3.58	4.20±0.81
	Tubes	1.97	1.75	1.79	1.84±0.12

	Packaging	70.55	70.90	73.02	71.49±1.34
	Plastic rope	0.17	0.50	0.34	0.34±0.17
	Tray	1.64	1.98	1.90	1.84±0.18
	Durable products(MU)	3.40	3.60	3.44	3.48±0.11
	Consumable Products(SU)	1.18	1.57	1.41	1.39±0.20
	Others	3.7	4.19	3.87	3.92±0.25

In North locality during year 2017-18 plastic waste was dominated by packaging material 70.55%; bottles with 12.27%; containers 5.12%;Tubes 1.39%;consumable plastic products 1.18%;durable plastic products 3.40%;plastic tray 1.64% and plastic rope with 0.17%.

During year 2018-19 plastic waste was dominated by packaging material 70.90%;bottles with 11.61%;containers 3.00%;Tubes 1.75%;consumable plastic products 1.57%;durable plastic products 3.60%;plastic tray 1.98% and plastic rope with 0.50%.

During year 2019-20 plastic waste was dominated by packaging material 73.02%;bottles with 10.65%;containers 3.58%;Tubes 1.79%;consumable plastic products 1.41%;durable plastic products 3.44%;plastic tray 1.90% and plastic rope with 0.34% (Table 66; Fig.47).

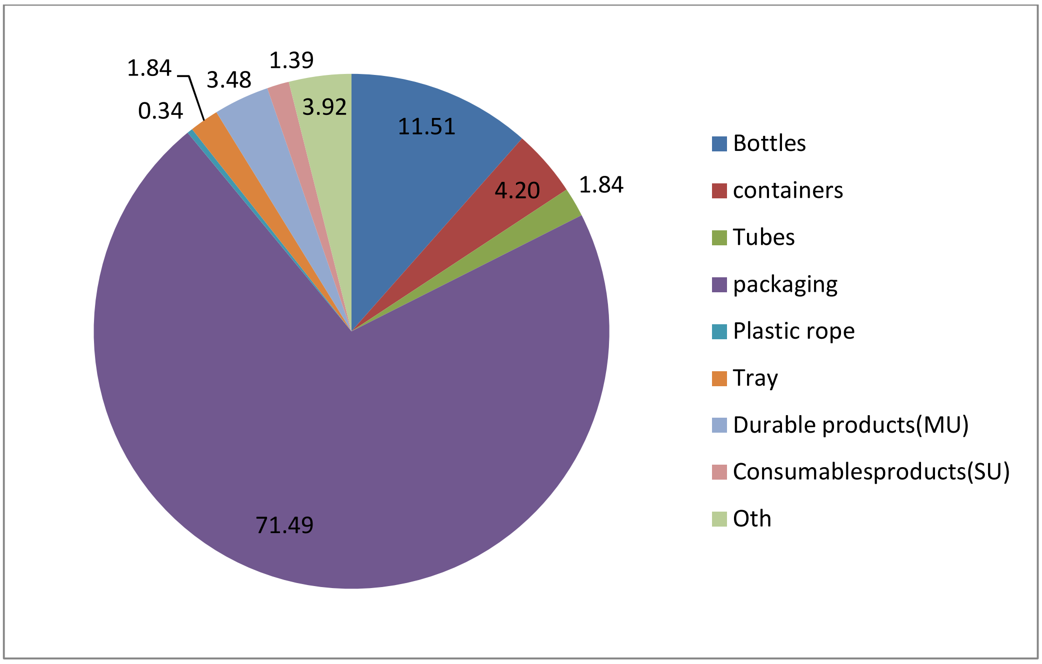

Fig. 47: Composition (%) of Plastic waste by Weight in North locality

Table 67: Composition (%) of packaging material by weight in North locality

Category	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	8.71	7.39	8.94	8.35±0.84
Plastic packaging for non-food	5.01	7.11	6.56	6.23±1.09
Plastic packaging for unspecified purpose	12.02	12.41	12.25	12.23±0.20
Plastic shopping bags	44.51	43.30	44.74	44.18±0.77
Buffer materials	0.30	0.69	0.53	0.51±0.20

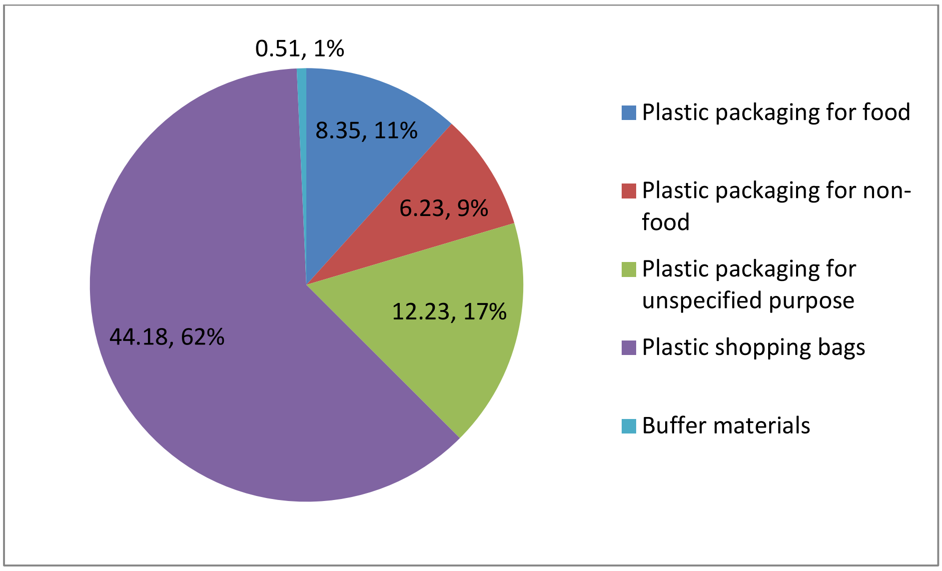

Fig.48: Composition (%) of packaging material by weight in North locality

In North locality during 2017-18 packaging plastic material was dominated by plastic shopping bags 44.51%; packaging for non food 5.01%; packaging for food items 8.71%;plastic packaging for unspecified purpose 12.02% and plastic buffer material with 0.30%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 43.30%; packaging for non food 7.11%; packaging for food items 7.39%;plastic packaging for unspecified purpose 12.41% and plastic buffer material with 0.69%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 44.74%; packaging for non food 6.56%;packaging for food items 8.94%; plastic packaging for unspecified purpose 12.25% and plastic buffer material with 0.53% (Table 67; Fig.48).

Table 68:Physical characterization of plastic waste in Central locality

Locality		Wt(%)	Wt (%)	Wt (%)	Avg
Central	Categories	2017-18	2018-19	2019-20	
	Bottles	10.77	10.83	10.95	10.85±0.09

	containers	3.62	3.64	3.68	3.65±0.03
	Tubes	1.47	1.49	1.53	1.50±0.03
	packaging	73.04	72.86	72.49	72.80±0.28
	Plastic rope	0.36	0.37	0.39	0.37±0.02
	Tray	1.64	1.66	1.70	1.67±0.03
	Durable products(MU)	3.76	3.77	3.79	3.77±0.02
	Consumable products(SU)	1.47	1.48	1.50	1.48±0.02
	Oth	3.87	3.9	3.97	3.91±0.05

In Central locality during year 2017-18 plastic waste was dominated by packaging material 73.04%; bottles with 10.77%; containers 3.62%;Tubes 1.47%;consumable plastic products 1.47%;durable plastic products 3.76%;plastic tray 1.64% and plastic rope with 0.36%.

During year 2018-19 plastic waste was dominated by packaging material 72.86%;bottles with 1083%;containers 3.64%;Tubes 1.49%;consumable plastic products 1.48%;durable plastic products 3.77%;plastic tray 1.66% and plastic rope with 0.37%.

During year 2019-20 plastic waste was dominated by packaging material 72.49%;bottles with 10.95%;containers 3.868%;Tubes 1.53%;consumable plastic products 1.50%;durable plastic products 3.79%;plastic tray 1.70% and plastic rope with 0.39% (Table 68; Fig.49).

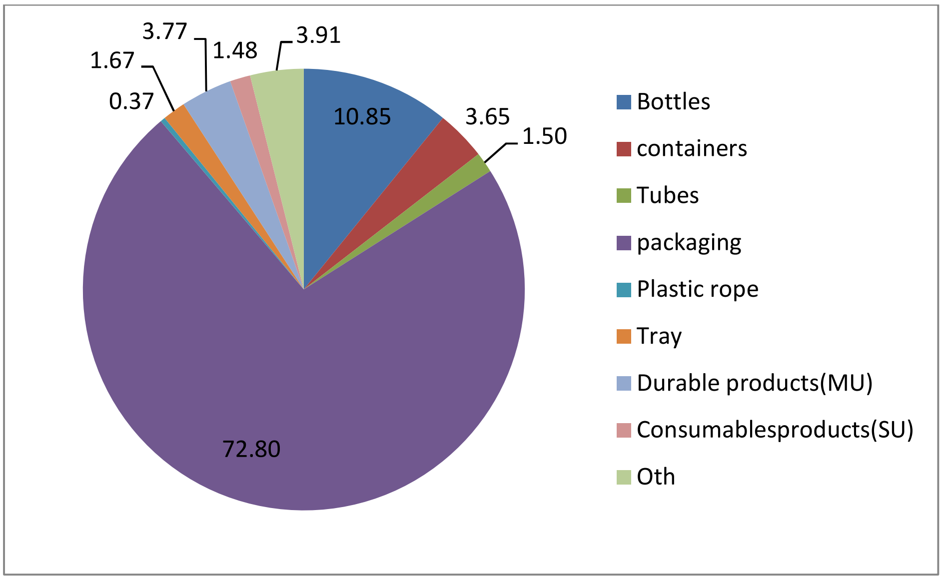

Fig.49: Composition(%) of Plastic waste by Weight in Central locality

Table 69: Composition (%) of packaging material by weight in Central locality

Categoty	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	8.96	8.97	8.45	8.79±0.30
Plastic packaging for non-food	5.26	5.27	5.29	5.27±0.02
Plastic packaging for unspecified purpose	13.27	13.28	13.30	13.28±0.02
Plastic shopping bags	44.92	44.70	44.79	44.80±0.11
Buffer materials	0.63	0.64	0.66	0.64±0.02

In central locality during 2017-18 packaging plastic material was dominated by plastic shopping bags 44.92%; packaging for non food 5.26%; packaging for food items 8.96%;plastic packaging for unspecified purpose 13.27% and plastic buffer material with 0.63%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 44.70%; packaging for non food 5.27%; packaging for food items 8.97%;plastic packaging for unspecified purpose 13.28% and plastic buffer material with 0.64%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 44.79%; packaging for non food 5.29%;packaging for food items 8.45%; plastic packaging for unspecified purpose 13.30% and plastic buffer material with 0.66% (Table 69; Fig.50).

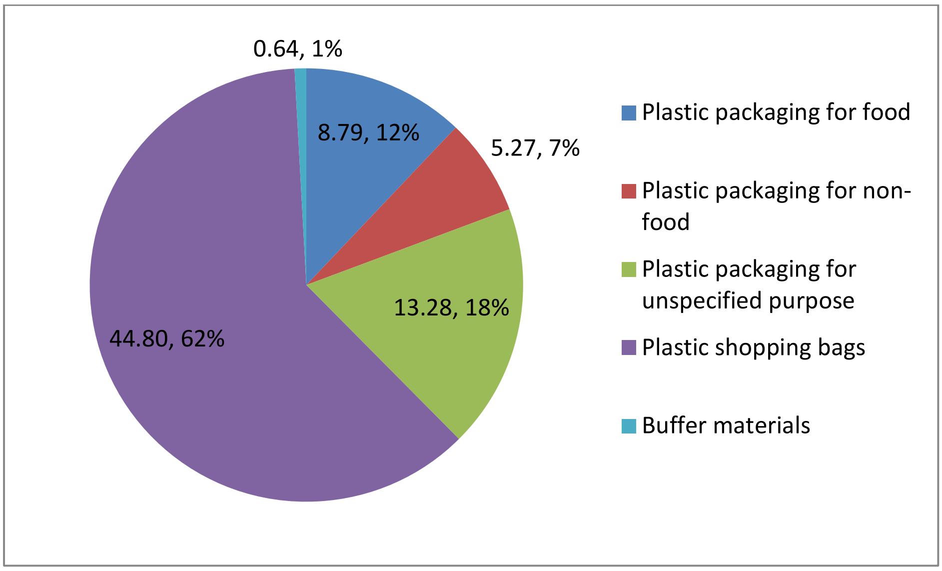

Fig.50: Composition (%) of packaging material by weight in Central locality

Table 70:Physical characterization of plastic waste in East residential area

Locality	Categories	Wt(%) 2017-18	Wt (%) 2018-19	Wt (%) 2019-20	Avg
East	Bottles	10.58	11.49	11.91	11.33±0.68
	Containers	3.68	3.86	3.82	3.79±0.09
	Tubes	1.53	1.71	1.85	1.70±0.16
	Packaging	72.72	71.64	69.99	71.45±1.37

	Plastic rope	0.39	0.48	0.55	0.47±0.08
	Tray	1.70	1.88	2.02	1.87±0.16
	Durable products(MU)	3.79	3.24	3.95	3.66±0.37
	Consumable Products(SU)	1.50	1.59	1.66	1.58±0.08
	Oth	4.11	4.11	4.25	4.16±0.08

In East locality during year 2017-18 plastic waste was dominated by packaging material 72.72%; bottles with 10.58%; containers 3.68%;Tubes 1.53%;consumable plastic products 1.50%;durable plastic products 3.79%;plastic tray 1.70% and plastic rope with 0.39%.

During year 2018-19 plastic waste was dominated by packaging material 71.64%;bottles with 11.49%;containers 3.86%;Tubes 1.71%;consumable plastic products 1.59%;durable plastic products 3.24%;plastic tray 1.88% and plastic rope with 0.48%.

During year 2019-20 plastic waste was dominated by packaging material 69.99%;bottles with 11.91%;containers 3.82%;Tubes 1.85%;consumable plastic products 1.66%;durable plastic products 3.95%;plastic tray 2.02% and plastic rope with 0.55% (Table 70; Fig.51)

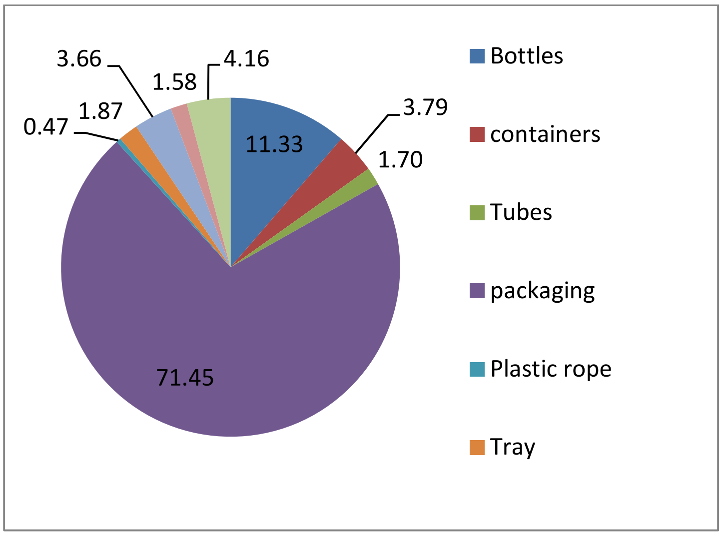

Fig.51: Composition(%) of Plastic waste by Weight in East locality

Table 71: Composition (%) of packaging material by weight in East locality

Category	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	8.99	9.08	8.15	8.74±0.51
Plastic packaging for non-food	5.29	6.38	4.45	5.37±0.97
Plastic packaging for unspecified purpose	13.3	11.39	12.46	12.38±0.96
Plastic shopping bags	44.48	44.04	44.11	44.21±0.24
Buffer materials	0.66	0.75	0.82	0.74±0.08

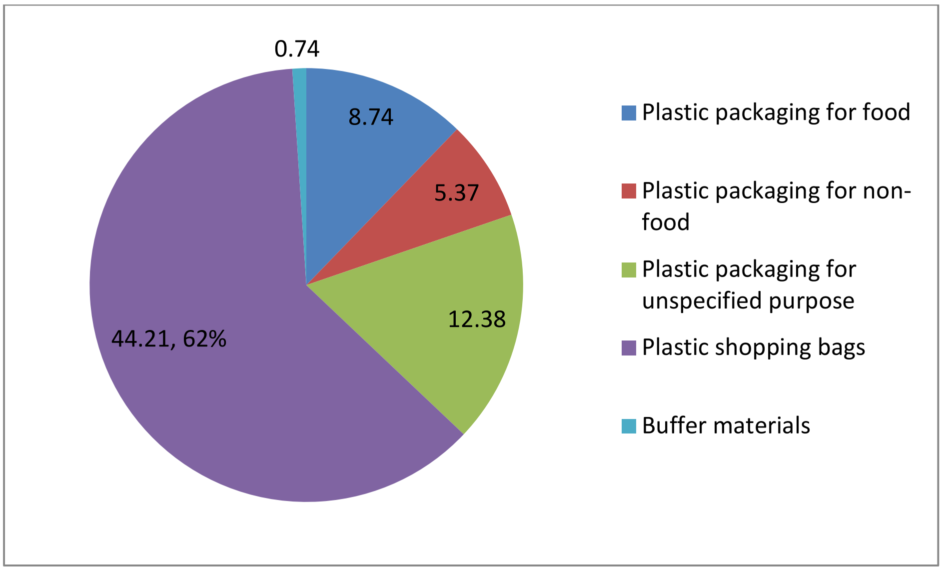

Fig.52: Composition(%) of packaging material by weight in East locality

In East locality during 2017-18 packaging plastic material was dominated by plastic shopping bags 44.48%; packaging for non food 5.29%; packaging for food items 8.99%;plastic packaging for unspecified purpose 13.03% and plastic buffer material with 0.66%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 44.04%; packaging for non food 6.38%; packaging for food items 9.08%; plastic packaging for unspecified purpose 11.39% and plastic buffer material with 0.75%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 44.11%; packaging for non food 4.45%;packaging for food items 8.15%; plastic packaging for unspecified purpose 12.46% and plastic buffer material with 0.82% (Table 71; Fig.52).

Table 72:Physical characterization of plastic waste in West Locality

Locality		Wt(%)	Wt (%)	Wt (%)	Avg
West	Categories	2017-18	2018-19	2019-20	
	Bottles	11.01	11.15	11.19	11.12±0.09
	Containers	3.70	3.72	3.76	3.73±0.03
	Tubes	1.55	1.57	1.61	1.58±0.03
	Packaging	72.32	73.07	71.81	72.40±0.63
	Plastic rope	0.40	0.41	0.43	0.41±0.02
	Tray	1.72	1.74	1.78	1.75±0.03
	Durable products(MU)	3.80	3.81	3.83	3.81±0.02
	Consumable Products(SU)	1.51	1.52	1.54	1.52±0.02
	Oth	3.99	3.01	4.05	3.68±0.58

In West locality during year 2017-18 plastic waste was dominated by packaging material 72.31%; bottles with 11.01%; containers 3.708%;Tubes 1.55%;consumable plastic products 1.51%;durable plastic products 3.80%;plastic tray 1.72% and plastic rope with 0.40%.

During year 2018-19 plastic waste was dominated by packaging material 73.07%;bottles with 11.15%;containers 3.72%;Tubes 1.57%;consumable plastic products 1.52%;durable plastic products 3.81%;plastic tray 1.74% and plastic rope with 0.41%.

During year 2019-20 plastic waste was dominated by packaging material 71.81%;bottles with 11.19%;containers 3.76%;Tubes 1.61%;consumable plastic products 1.54%;durable plastic products 3.83%;plastic tray 1.78% and plastic rope with 0.43% (Table72; Fig.53).

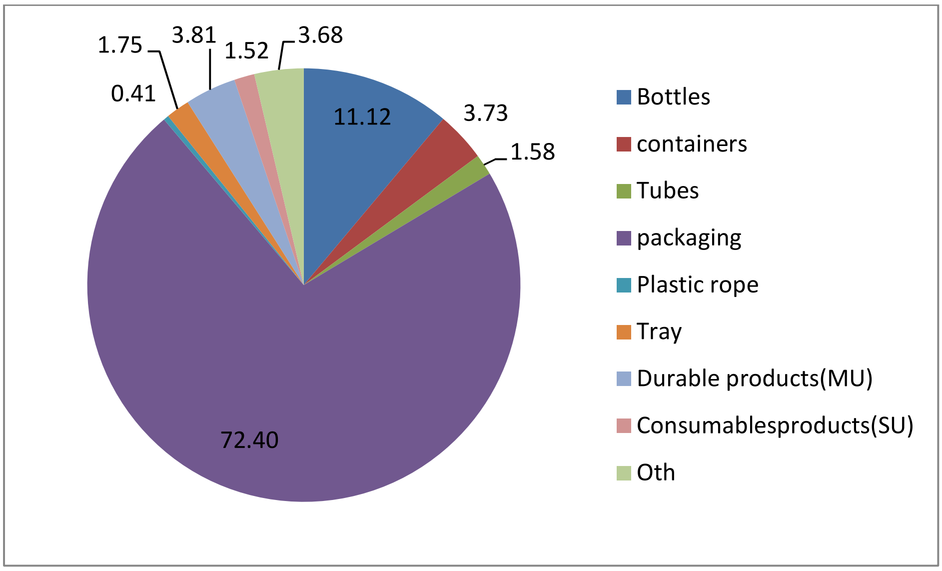

Fig.53: Composition(%) of Plastic waste by Weight in West locality

Table 73: Composition(%) of packaging material by weight in West locality

Category	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	9.00	9.01	9.03	9.01±0.02
Plastic packaging for non-food	5.30	5.25	5.33	5.29±0.04
Plastic packaging for unspecified purpose	12.55	13.32	13.34	13.07±0.45
Plastic shopping bags	44.8	44.81	43.41	44.34±0.81
Buffer materials	0.67	0.68	0.70	0.68±0.02

In West locality during 2017-18 packaging plastic material was dominated by plastic shopping bags 44.80%; packaging for non food 5.30%; packaging for food items

9.00%;plastic packaging for unspecified purpose 12.55% and plastic buffer material with 0.67%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 44.81%; packaging for non food 5.25%; packaging for food items 9.03%; plastic packaging for unspecified purpose 13.32% and plastic buffer material with 0.68%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 43.41%; packaging for non food 5.33%;packaging for food items 9.03%; plastic packaging for unspecified purpose 13.34% and plastic buffer material with 0.70% (Table 73; Fig.54).

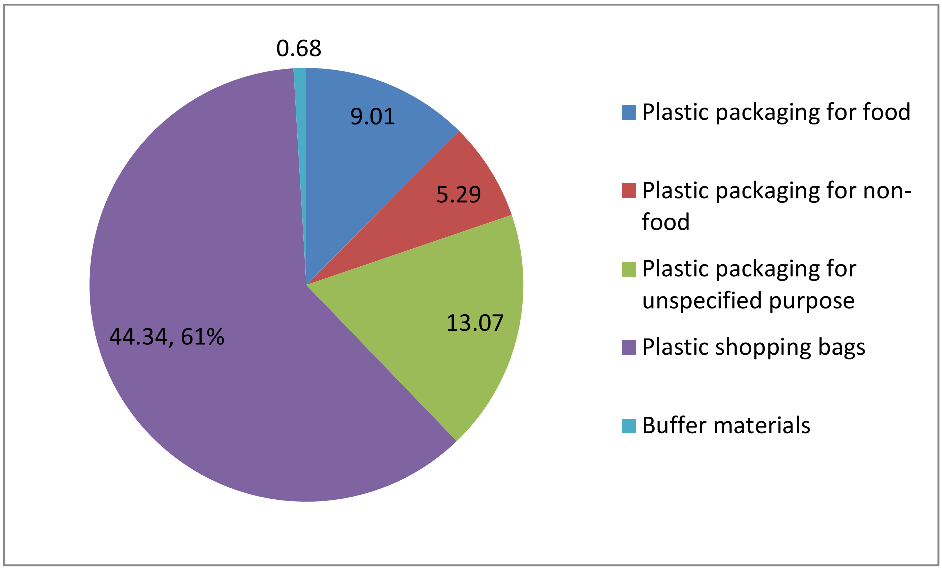

Fig.54: Composition (%) of packaging material by weight in West locality

Among five localities the packaging material contributed maximum and least amount was contributed by plastic rope (Table 74).In all localities packaging material contributed 71.45±1.37% to 72.79±0.28% among different types of plastic waste. Plastic bottles contributed 10.85±0.09% to 11.51±0.81% among different types of plastic waste.

Plastic container contributed 3.64±0.03% to 4.2±0.81% among different types of plastic waste (Table 74).

Table 74:Physical characterization of plastic waste (%) produced in different localities

Categories	**West**	**East**	**Central**	**North**	**South**
Bottles	11.11±0.09	11.32±0.68	10.85±0.09	11.51±0.81	10.93±0.35
containers	3.72±0.03	3.78±0.09	3.64±0.03	4.2±0.81	3.67±0.12
Tubes	1.57±0.03	1.69±0.16	1.49±0.03	1.83±0.12	1.52±0.12
packaging	72.4±0.63	71.45±1.37	72.79±0.28	71.49±1.34	72.66±0.88
Plastic rope	0.41±0.02	0.47±0.08	0.37±0.02	0.33±0.17	0.39±0.06
Tray	1.74±0.03	1.86±0.16	1.66±0.03	1.84±0.18	1.69±0.12
Durable products(MU)	3.81±002	3.66±0.37	3.77±0.02	3.48±0.11	3.69±0.14
Consumable products(SU)	1.52±002	1.58±0.08	1.4±0.02	1.38±0.20	1.48±0.04
Others	3.68±0.58	4.15±.08	3.91±0.05	3.92±0.25	3.96±0.12

Table 75:ANOVA Table for variation in Physical characteristics of plastic waste produced in different localities

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000924	4	0.000231	4.34E-07	1	2.605975
Within Groups	21296.71	40	532.4176			
Total	21296.71	44				

Several studies have quantified and characterized plastic waste and it was found to constitute various items such as bottles, containers, tubes, plastic carrier bags, plastic packaing, food wrappings, toys, broken plastic buckets, chair, plates, toys and disposable cups plates (CPCB,2009; CPCB,2013; CPCB-CIPET,2015; JMC,2015; CPCB,2018). Assessment of plastic waste and its management in NCT Delhi by CPCB in year 2020 reveals that Plastic packaging and bags were the major component of plastic waste especially plastic shopping bags. Plastic shopping bags appropriated for almost half of the total plastic waste, approximately 45.72% in Kenya (Bahri, 2005).

Single use or disposable plastics like plastic spoon, stirrers, bottles, disposable cups and plates are those that are designed to be used only once before being thrown away. These include light-weight plastic bags, disposable utensils, coffee cups and stirrers, soda and water bottles, food packaging. In India, around 43% of manufactured plastics are used for packaging purpose and most of these are single use (Kumar et al.,2009). According to Burnley et al.,2007 some polymers of plastic are used primarily in a single application (e.g. polyethylene in packaging) while others are used more widely (e.g. polypropylene).The average plastic waste generation rate was 17.24 g/cap/day; plastic packaging and plastic containers dominated with the high percentage, 95.64% of plastic waste. Islam et al., 2011 identified Plastic shopping bags as the major component, accounting for 45.72% of total plastic waste. Huq, 2015 found plastic packaging and plastic containers were the most numerous plastics generated, accounting for a high percentage (95.64%); plastic packaging especially appropriated for the most share of plastic waste (73.09%). The remaining consisted of plastic products with 5.20% (including single-use products, 1.48%) and plastic miscellaneous (0.16%).The versatility of plastics has led to their use in almost all major product categories. Plastics packaging is the largest application by weight, but plastics are also used widely in the textile, consumer goods, transport, and construction sectors (NPWMTF,1997). According to Hopewell et al. (2009) approximately 50 per cent of plastic consumption takes the form of single-use disposable items (e.g. packaging and disposable consumer items), 20-25% relates to infrastructural applications (e.g. pipes, cable coatings and structural materials), and the rest are found in durable consumer applications (e.g. electronic goods, furniture, vehicles). Packaging accounts for 39.4% in Europe while 42% by weight in USA of total plastic waste (Plastics Europe, 2014). Plastic packaging has the largest share (35.8%) in the market of plastic products and a short lifetime. It is also one of the main plastic waste generation sectors accounting for 46% of plastic waste generation (Andrady, 2015). Plastics are often used to protect or preserve foodstuffs and, in doing so, help to reduce food waste. Plastics are also an important input in vehicles, where their relatively light weight results in lower fuel use and greenhouse gas emissions. Around 4–12% of the MSW consists of different kinds of plastic waste from various sources (Hoornweg and Bhada-Tata 2012) The packaging of consumable goods, cans, and covers account for 35% total plastic utilization (Khajuria,2010). Moreover, 20–25% plastic is used in a wide range of diverse field of such as pipes, cables wiring, automobile, aircraft, utensils, covers, containers and the rest is from the non-durable goods (Tomar and Dadoriya, 2013).

In present study Plastic waste in residential was found to be dominated by Packaging material, Bottles and containers. As plastic products are a basic necessity in life which make our life easy and convenient. These plastic products are mainly used for storage or because plastics are light weight, durable, water resistant, easy to carry and most importantly cheap and easily available.

4.8. Chemical characterization of plastic waste in different localities

The composition of plastic waste based upon polymer type in North locality showed LDPE 27.20±0.18%; HDPE 24.05±0.68%; PP16.25±1.18%; PET 15.17±0.88%;PS 9.04±1.22%;PVC 2.29±0.34% in North locality (Table 76, Fig.55). In North locality during year 2017-18 plastic waste belonged to HDPE 24.04%;LDPE 27.04%;PET 15.82%; PS 8.69%; PP16.94%;PVC 2.15% and other categories 5.32%.During year 2018-19 plastic waste belonged to HDPE 23.38%; LDPE 27.17%; PET 14.16%; PS 8.03%; PP16.92%; PVC 2.68% and other categories 7.66%.During year 2019-20 plastic waste belonged to HDPE 24.74%;LDPE 27.40%; PET 15.52%; PS 10.39%; PP 14.89%; PVC 2.04% and other categories 5.02% (Table 76; Fig.5).

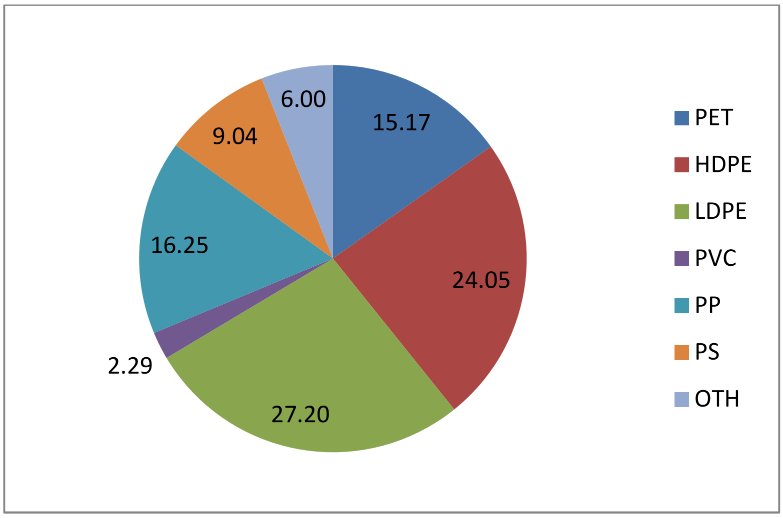

Fig.55: Chemical characterization (%) of plastic waste in North locality in three years

The composition of plastic waste based upon chemical characteristics in East locality showed LDPE 26.54±0.18%; HDPE 23.37±1.16%; PP 15.83±1.55%;PET 15.12±0.33%;PS8.29±1.22%;PVC 4.93±0.34 (Table 77, Fig.56). In East locality during year 2017-18 plastic waste belonged to HDPE 23.66%;LDPE 27.04%;PET 15.44%; PS 7.94%; PP16.19%;PVC 4.79% and other categories 4.49%.During year 2018-19 plastic waste belonged to HDPE 23.10%; LDPE 25.17%; PET 14.78%; PS 7.28%; PP17.17%; PVC 5.32% and other categories 8.18%.During year 2019-20 plastic waste belonged to HDPE 24.36%;LDPE 27.04%; PET 15.14%; PS 9.64%; PP 14.14%; PVC 4.68% and other categories 4.64% (Table 77; Fig.56).

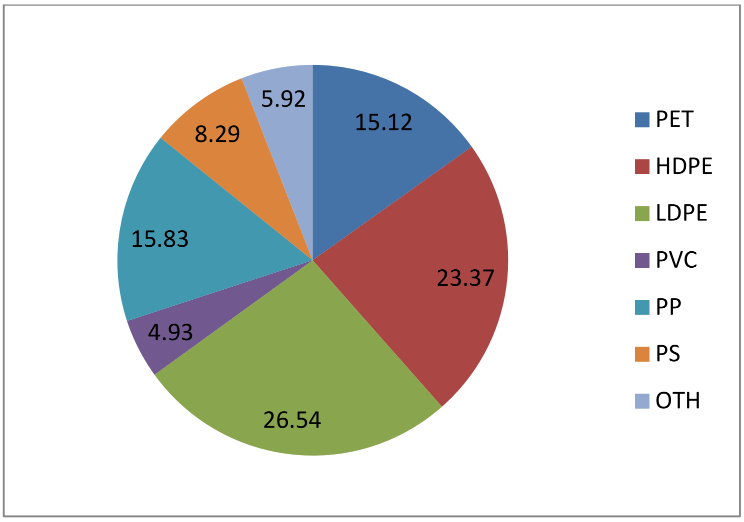

Fig.56: Chemical characterization (%) of plastic waste in East locality in three years

The composition of plastic waste based upon chemical characteristics in South locality showed LDPE 26.13±2.57%;HDPE 23.20±1.21%;PP 16.16±0.60% and PET 15.69±1.33% PS 8.99±1.68;PVC 3.54±1.08 (Table 78, Fig.57). In South locality during year 2017-18 plastic waste belonged to HDPE 23.52%;LDPE 23.63%;PET 17.01%; PS 8.98%; PP16.52%;PVC 4.73% and other categories 5.61%.During year 2018-19 plastic waste belonged to HDPE 21.86%; LDPE 28.76%; PET 14.35%; PS 7.32%; PP16.50%; PVC 3.26% and other categories 7.95%.During year 2019-20 plastic waste belonged to HDPE 24.22%;LDPE 25.99%; PET 15.71%; PS 10.68%; PP 14.14%; PVC 2.62% and other categories 5.31% (Table 78; Fig.57).

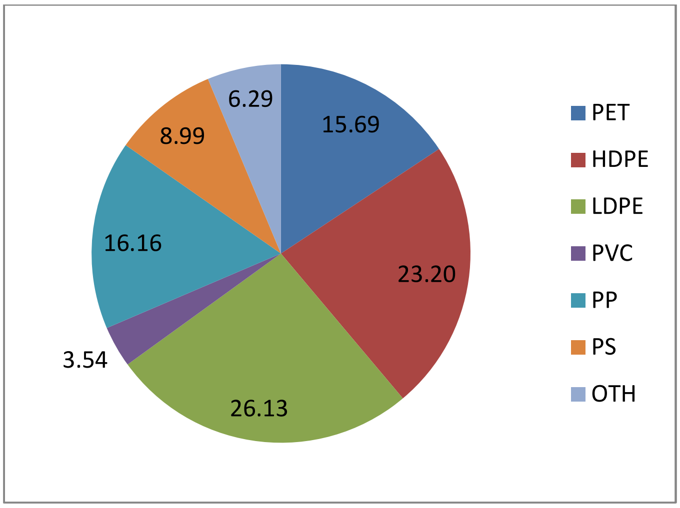

Fig.57: Chemical characterization (%) of plastic waste in South Locality in three years

The composition of plastic waste based upon chemical characteristics in West locality showed LDPE 26.93±1.20%;HDPE 21.10±1.21%;PP16.97±1.55%;PET15.89±0.33%; PS8.76±1.21 and PVC 3.29±0.92(Table 79, Fig.58). In West locality during year 2017-18 plastic waste belonged to HDPE 21.42%;LDPE 27.43%;PET 16.21%; PS 9.08%; PP 17.33%;PVC 2.82% and other categories 5.71%.During year 2018-19 plastic waste belonged to HDPE 19.76%; LDPE 25.56%; PET 15.55%; PS 7.42%; PP 18.31%; PVC 4.35% and other categories 9.05%.During year 2019-20 plastic waste belonged to HDPE 22.12%;LDPE 27.99%; PET 15.91%; PS 9.78%; PP 15.28%; PVC 2.71% and other categories 6.41% (Table 79; Fig.58).

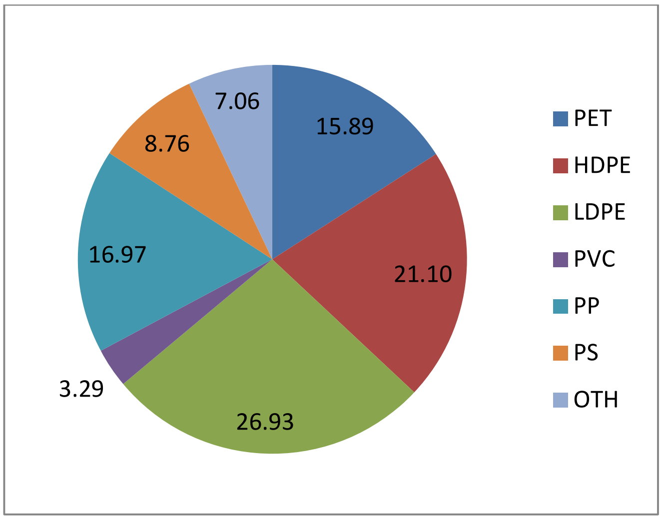

Fig.58:Chemical characterization(%) of plastic waste in West locality in three years

The composition of plastic waste based upon chemical characteristics in Central locality showed LDPE 25.70±1.69%;HDPE 21.05±1.69%;PP 17.14±1.52%;PET 15.83±1.85%;PS 8.43±0.88 and PVC 4.12±0.90 (Table 80, Fig.59). In Central locality during year 2017-18 plastic waste belonged to HDPE 19.46%;LDPE 24.04%;PET 17.82%; PS 9.08%; PP 17.33%;PVC 3.15% and other categories 7.71%.During year 2018-19 plastic waste belonged to HDPE 19.46%; LDPE 27.42%; PET 14.16%; PS 7.42%; PP 18.56%; PVC 4.93% and other categories 8.05%.During year 2019-20 plastic waste belonged to HDPE 22.82%;LDPE 25.65%; PET 15.52%; PS 8.78%; PP 15.53%; PVC 4.29% and other categories 7.41% (Table 80; Fig.59).

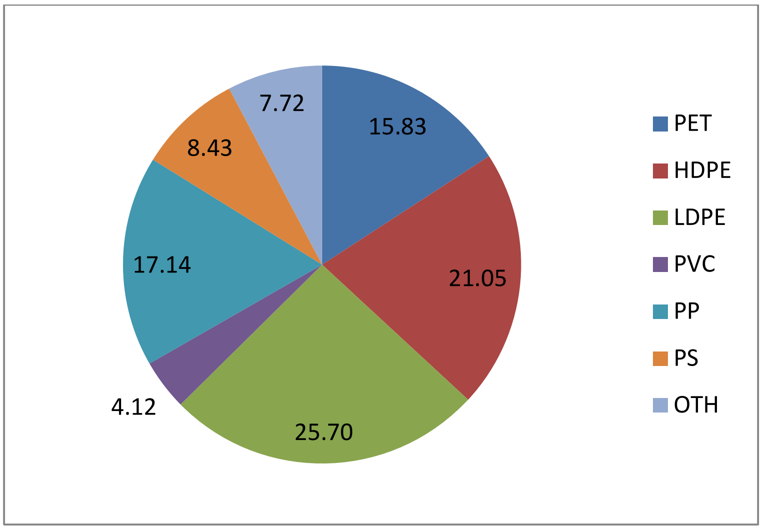

Fig.59: Chemical characterization (%) of plastic waste in Central locality in three years

In all the localities LDPE type of plastic waste was generated at maximum amount while least amount of plastic waste generated belonged to PVC category (Table 81). The result of ANOVA of chemical characteristics of plastic waste produced among various localities does not show significant difference ($F_{4,30}$=3.98E-08,P>0.05; Table 82).

Table 76: Chemical characterization (%) of plastic waste in North locality in three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	15.82	24.04	27.04	2.15	16.94	8.69	5.32
2018-19	14.16	23.38	27.17	2.68	16.92	8.03	7.66
2019-20	15.52	24.74	27.40	2.04	14.89	10.39	5.02
Avg	15.17±0.88	24.05±0.68	27.20±0.18	2.29±0.34	16.25±1.18	9.04±1.22	6.00±1.45

Table 77:Chemical characterization (%) of plastic waste in East locality in three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	15.44	23.66	27.04	4.79	16.19	7.94	4.94
2018-19	14.78	22.10	25.17	5.32	17.17	7.28	8.18
2019-20	15.14	24.36	27.4	4.68	14.14	9.64	4.64
Avg	15.12±0.33	23.37±1.16	26.54±1.20	4.93±0.34	15.83±1.55	8.29±1.22	5.92±1.96

Table 78: Chemical characterization (%) of plastic waste in South locality in three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	17.01	23.52	23.63	4.73	16.52	8.98	5.61
2018-19	14.35	21.86	28.76	3.26	16.50	7.32	7.95
2019-20	15.71	24.22	25.99	2.62	15.47	10.68	5.31
Avg	15.69±1.33	23.20±1.21	26.13±2.57	3.54±1.08	16.16±0.60	8.99±1.68	6.29±1.45

Table79: Chemical characterization (%) of plastic waste in West locality in three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	16.21	21.42	27.43	2.82	17.33	9.08	5.71
2018-19	15.55	19.76	25.56	4.35	18.31	7.42	9.05
2019-20	15.91	22.12	27.79	2.71	15.28	9.78	6.41
Avg	15.89±0.33	21.10±1.21	26.93±1.20	3.29±0.92	16.97±1.55	8.76±1.21	7.06±1.76

Table 80: Chemical characterization (%) of plastic waste in Central locality in three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	17.82	20.87	24.04	3.15	17.33	9.08	7.71
2018-19	14.16	19.46	27.42	4.93	18.56	7.42	8.05
2019-20	15.52	22.82	25.65	4.29	15.53	8.78	7.41
Avg	15.83±1.85	21.05±1.69	25.70±1.69	4.12±0.90	17.14±1.52	8.43±0.88	7.72±0.32

Table 81: Chemical Characterization (%) of plastic waste produced among various localities in three years

Polymer Type	Locality				
	Central	West	East	South	North
PET	15.83±1.85	15.89±0.33	15.12±0.33	15.69±1.33	15.17±0.88
HDPE	21.05±1.69	21.1±1.21	23.37±1.16	23.2±1.21	24.05±0.68
LDPE	25.7±1.69	26.93±1.20	26.54±1.20	26.13±2.57	27.2±0.18
PVC	4.12±0.90	3.29±0.92	4.93±0.34	3.54±1.08	2.29±0.34
PP	17.14±1.52	16.97±1.55	15.83±1.55	16.16±.60	16.25±1.18
PS	8.43±0.88	8.76±1.21	8.29±1.22	8.99±1.68	9.04±1.22
OTH	7.72±0.32	7.06±1.76	5.92±1.96	6.29±1.45	6.00±1.45

Table 82:ANOVA for variation in Chemical characteristics of plastic waste produced among various localities

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.14E-05	4	2.86E-06	3.98E-08	1	2.689628
Within Groups	2155.802	30	71.86006			
Total	2155.802	34				

In both economically less developed and industrialized countries, the four types of plastics that are most commonly present in plastic waste are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (Calero et al.,2018).

Production of plastic is dominated by polyolefins, such as polyethylenes, polystyrene, and polypropylene (Tsakona and Rucevska., 2020). In a study conducted in Bangkok, five main types of recyclable plastic were identified that enter the solid municipal waste stream were found to be high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polypropylene (PP) and polystyrene (PS) (Chinnathan et al.,al.,2017).

Plastics have been categorized either as thermoplastics or thermosets. Thermoplastics contribute to the total plastic consumption by about 80% and are used for typical plastics applications such as packaging but also in non-plastic applications such as textile fibres and coatings (Brems et al., 2012).

Pollution Control Department, Bangkok (2017) reported that most plastic wastes do not have high potential to be recycled as 80% of plastic wastes are contaminated, such as plastic bags and packaging, which are made from high density polyethylene (HDPE), polypropylene (PP) and low density polyethylene (LDPE) which act as deterrence for collection and recyling.The costs of eliminating, collecting and cleaning these types of waste are quite expensive. Hence these uncollected items predominate plastic waste.

Major composition of MPW at one of the Bangkok city's waste transfer station observed was HDPE, LDPE, and PP. PET, OTHER, and PS types of plastic showed significant amount as well whereas PVC had the lowest contribution. For the HDPE, it was from plastic shopping and waste bag while the LDPE and PP were from plastic bag and food packaging (Wichai and Chavalparit, 2019)

Plastic bags were the most common type of waste, followed by plastic straws, plastic caps and plastic food containers. Further analysis also showed that the ineffectiveness of plastic waste management resulted from production and consumption all the way to waste management after consumption. Single-use plastics and packaging for consumer goods are driving the increase in plastic pollution (Rewlutthum,2013).

Globally, 36% of plastic is used for packaging and almost a third of it (32%) leaks into the environment. Just 14% is recycled in some way, with only 2% achieving "closed loop" recycling or circularity In Africa, household plastic packaging makes up about two-thirds of the total, though this proportion is thought to be higher in Southeast Asian countries with a smaller manufacturing sector (Basir, 2013).

Composition of plastic waste discarded by households in Kenya studies by Gwada et al.,2019 and Odhiambo et al.,2014 reported composition of plastic waste by households was dominated by low density polyethylene, polyethylene terephthalate, high density polyethylene and polypropylene.

Thermoplastics include polyethylene (PE) such as low density polyethylene (LDPE) and high density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), polyamides (PA), polycarbonate (PC), polyvinyl chloride (PVC), polystyrene (PS) and poly tetrafluoroethylene (PTFE) among others, while thermosets include silicon, melamine resin and vinyl ester (Chung,2008).

Geyer et al.,2017 estimated 67% of the plastic waste in oceans belonged to the HDPE/ LDPE, 10% to PP, and 8.66% to PET amongst others different fractions of the plastic waste.Among them, polyethylene film is the most important, representing approximately

43% of the total. The largest groups in total non fiber plastics production are PE (36%), PP (21%), and PVC (12%), followed by PET,

A study conducted by CPCB indicates that the majority of the plastic waste generated in India comprised the HDPE/LDPE materials, such as polybags and multilayer pouches used for food packaging, gutkha, and so on. Further, the study also observes that households are the biggest source of this plastic waste (Bhide and Sundersan ,1983).

Ombis (2012) reported that post-consumer plastic waste in Lunga Lunga locality,Nairobi consisted of namely high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP) and polyethylene tetra phthalate (PET)

Kamala,2013 Studied composition of different types of plastic waste in Bangkok and reported very high proportion (88%) belonged to HDPE and LDPE.

Wichai and Chavalparit (2019) studied compositions of plastic wastes that were found in municipal waste management in Bangkok and reported HDPE, which is the material used to produce bags and bottles, contributed the highest proportion (46%) of plastic waste, followed by LDPE (24%) and PP (14%),PS(5%),PVC(2%).

A study conducted by CIPET & CPCB at 60 cities in 2015 indicates that the out of the total plastics waste (PW) obtained 66% belonged to HDPE/LPDE materials which is of mixed plastic wastes like Polybags, Multilayer pouches used for packing food items, Ghutkas etc. The households are the biggest source of plastics waste. In Delhi, the quantity of plastic waste has been assessed as 10.14% of total MSW which comprises of 76% of HDPE/LDPE, 7% of PVC and 10% of Polystyrene material.

Assessment and Characterization of Plastic Waste in NCT of Delhi in 2020, characterization of plastic waste indicates that HDPE and LDPE materials together constituted 86.97% of the total plastic waste, followed by PET material and PVC material, which amounted to 3.96% and 3.67% respectively. While PS material constituted 2.76% of total plastic waste.In Shahdara The characterization of plastic waste indicates that HDPE and LDPE materials together constitutes 57.03% of the total plastic waste, followed by PP material and PET material, which amounted to 31.96% and 5.90% respectively. While PS material and PVC material constituted 1.70% and 1.73% respectively.In Hauzkhas the characterization of plastic waste indicates that HDPE and LDPE materials together constituted 66.97% of the total plastic waste, followed by PET material and PVC material, which amounted to 28.38% and 2.00% respectively. While PS material constituted 1.31% of total plastic waste.

In present study in residential area very high levels of LDPE was reported which is mainly due to mass consumption of plastic carry bags and packaging, apart from that high levels of HDPE in household waste is mainly coming from juice, milk, shampoo bottle and for storing cosmetics items such as cream face wash.PP was also predominantly present in households as PP bottles are used for storing medicines, tonics, syrup and baby milk.

4.9. Plastic waste generation at commercial sites

Maximum plastic waste was observed during winter season while least during rainy season in all commercial area (Table 83). In Barabazar during winter 613.52kg;summer 439.45kg and rainy season375.51 kg of plastic waste was generated during 2017-20 (Table 4.7.b.).Overall plastic waste comprised 13.22±2.17% of total solid waste assessed during 2017-20 in Barabazar area (Table 84).

In Millenium center during winter 664.70kg;summer 536.78kg and rainy season 340.11kg of plastic waste was generated during 2017-20 (Table 4.7.c.).Overall plastic waste comprised 14.36±2.20% of total solid waste assessed during 2017-20 in Millenium center (Table 84).

In Zarkawt during winter 679.76kg;summer 506.02kg and rainy season 419.79kg of plastic waste was generated during 2017-20 (Table 4.7.d.).Overall plastic waste comprised 14.95±1.99% of total solid waste assessed during 2017-20 in Zarkawt (Table 84).

The result of ANOVA analysis shows that there was significant monthly variation within each commercial sites Bara Bazar ($F_{8,18}$=6.17,$P<0.05$);Table87.a.;Table87.d., Millenium center ($F_{8,18}$=11.14,$P<0.05$); Table87.b.; Table87.d., Zarkawt ($F_{8,18}$=7.98,$P<0.05$) Table87.c.;Table 87.d.Significant difference was observed among all three commercial sites in monthly plastic waste generation ($F_{8,18}$= 16.66,$P<0.05$; Table 87.d)

In the commercial site Barabazar maximum plastic waste was generated during year 2019-20 with 520.70 kg and minimum during 2017-18 with 443.31 kg.During assessment period 2017-20 total plastic waste generated in Barabazar was 1428.48 kg with average plastic waste generation of 476.16kg/year (Table 83)

Table 83: Seasonal plastic waste generation in all three years at Barabazar

Year	Winter	Summer	Rainy	Total
2017-18	192.68	132.05	118.58	443.31
2018-19	195.29	144.61	124.57	464.47
2019-20	225.55	162.79	132.36	520.70
Total	613.52	439.45	375.51	1428.48
Avg	204.51	146.48	125.17	476.16
Std	18.27	15.45	6.90	40.00

In the commercial site Millennium center maximum plastic waste was generated during year 2019-20 with 520.75 kg and minimum during 2017-18 with 486.83 kg.During assessment period 2017-20 total plastic waste generated in millennium center was 1561.59 kg with average plastic waste generation of 520.53kg/year (Table 85).

Table 84: Monthly Variations in plastic waste (kg) produced among different commercial sites

Barabazar	Nov	Dec	Jan	March	April	May	July	August	Sept
2017-18	47.51	69.23	75.94	46.47	47.61	37.97	39.78	33.01	45.79
2018-19	55.46	75.90	63.93	41.84	59.01	43.76	40.04	45.52	39.01
2019-20	59.69	88.12	77.74	55.12	37.13	70.54	54.75	41.55	36.06
Total	162.66	233.25	217.61	143.43	143.75	152.27	134.57	120.08	120.86
Avg	54.22	77.75	72.54	47.81	47.92	50.76	44.86	40.03	40.29
Stdev	6.18	9.58	7.51	6.74	10.94	17.37	8.57	6.39	4.99
Millennium Center	Nov	Dec	Jan	March	April	May	July	August	Sept
2017-18	67.48	89.96	73.87	52.36	45.34	51.46	43.29	30.29	32.78
2018-19	59.17	76.98	66.68	65.40	67.26	49.44	52.49	33.20	48.39
2019-20	78.93	87.94	63.69	70.50	65.09	69.93	37.29	31.09	31.29
Total	205.58	254.88	204.24	188.26	177.69	170.83	133.07	94.58	112.46
Avg	68.53	84.96	68.08	62.75	59.23	56.94	44.36	34.86	37.49
Stdev	9.92	6.98	5.23	9.36	12.08	11.29	7.66	7.23	9.47
Zarkawt	Nov	Dec	Jan	March	April	May	July	August	Sept

2017-18	72.87	81.96	74.24	59.04	64.41	40.87	51.28	38.25	39.49
2018-19	86.9	96.81	69.69	65.03	56.78	59.99	56.51	50.35	51.39
2019-20	69.71	73.73	53.85	54.88	52.88	62.14	46.29	42.61	43.62
Total	229.48	252.5	197.78	178.95	174.07	163	154.08	131.21	134.5
Avg	76.49	84.17	65.93	59.65	58.02	54.33	51.36	43.74	44.83
Stdev	9.15	11.70	10.70	5.10	5.86	11.71	5.11	6.13	6.04

Table 85: Seasonal plastic waste generation in all three years at Millenium center

Year	Winter	Summer	Rainy	Total
2017-18	231.31	149.16	106.36	486.83
2018-19	222.83	182.1	134.08	539.01
2019-20	230.56	205.52	99.67	535.75
Total	664.70	536.78	340.11	1561.59
Avg	221.56±16.23	178.92±28.31	113.37±18.24	520.53±29.23

In the commercial site Zarkawt maximum plastic waste was generated during year 2018-19 with 593.45 kg and minimum during 2019-20 with 499.71 kg.During assessment period 2017-20 total plastic waste generated in Zarkawt was 1615.57 kg with average plastic waste generation of 538.52 kg/year (Table 86)

Table 86: Seasonal plastic waste generation in all three years at Zarkawt

Year	Winter	Summer	Rainy	Total
2017-18	229.07	164.32	129.02	522.41
2018-19	253.4	181.8	158.25	593.45
2019-20	197.29	169.9	132.52	499.71
Total	679.76	506.02	419.79	1615.57
Avg	226.59±28.14	168.67±8.93	139.93±15.96	538.52±48.90

Table 87.a.: ANOVA table for Monthly Variations in plastic waste produced among in Barabazar during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4349.139	8	543.6423	6.172529	0.00067	2.510158
Within Groups	1585.341	18	88.07449			
Total	5934.479	26				

Table 87.b.: ANOVA table for Monthly Variations in plastic waste produced among in Millenium center during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6794.703	8	849.3379	11.14145	1.44E-05	2.510158
Within Groups	1372.18	18	76.23222			
Total	8166.883	26				

Table 87.c.: ANOVA table for Monthly Variations in plastic waste produced among in Zarkawt during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4488.765	8	561.0957	7.980019	0.000137	2.510158
Within Groups	1265.626	18	70.31257			
Total	5754.392	26				

Table 87.d.: ANOVA Table for monthly variations among different commercial sites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4646.044	8	580.7555	16.66855	7.46E-07	2.510158
Within Groups	627.1449	18	34.84139			
Total	5273.189	26				

During the assessment period Barabazar produced average plastic waste 13.55±1.55% in November, 19.43±2.40% in December,18.13±1.88% in January,11.95±1.69% in March, 11.98±2.74% in April, 12.69±4.34% in May,1.21±2.14% in July, 10.00±1.60% in August, 10.072±1.25% in September. Overall plastic waste accounted 13.22±2.17% of solid waste in Barabazar.

During the assessment period Millenium center produced average plastic waste 17.13±2.48 % in November, 21.24±1.75%in December, 17.02±1.31%in January, 15.68±2.34%in March, 14.80±3.02%in April, 14.23±2.82% in May, 11.09±1.92%in July, 8.71±1.81% in August, 9.37±2.37% in September.Overall plastic waste accounted 14.36±2.20% of solid waste in Millenium center.

During the assessment period Zarkawt produced average plastic waste 19.12±2.29% in November, 21.04±2.93% in December, 16.48±2.68% in January, 14.91±1.28% in March, 14.50±1.47% in April, 13.58±2.93% in May, 12.84±1.28% in July, 10.93±1.53% in August, 11.20±1.51% in September.Overall plastic waste accounted 14.95±1.99% of solid waste in Zarkawt (Table 88).

Table 88:Monthly plastic waste generation in different localities in %

Locality	Month								Overall
	Nov	Dec	Jan	March	April	May	July	August	Sept	
Barabazar	13.55± 1.55	19.43± 2.40	18.13± 1.88	11.95± 1.69	11.98± 2.74	12.69± 4.34	11.21± 2.14	10.00± 1.60	10.072± 1.25	13.22±2.17
Millenium	17.13± 2.48	21.24± 1.75	17.02± 1.31	15.68± 2.34	14.80± 3.02	14.23± 2.82	11.09± 1.92	8.71± 1.81	9.37± 2.37	14.36±2.20
Zarkawt	19.12± 2.29	21.04± 2.93	16.48± 2.68	14.91± 1.28	14.50± 1.47	13.58± 2.93	12.84± 1.28	10.93± 1.53	11.20± 1.51	14.95±1.99

4.10. Physical characterization of plastic waste in commercial area

Plastic waste was dominated by packaging material 44.55±1.4%;bottles with 25.06±0.56%;containers 8.81±0.89%;Tubes 5.59±0.35%;consumable plastic products 4.21±0.13%;durable plastic products 3.78±0.13%;plastic tray 2.99±0.26% and plastic rope with 0.55±0.13% in Barabazar(Table 89; Fig.60).Packaging plastic material was dominated by plastic shopping bags 16.84±1.03%; packaging for non food 10.72±1.03%; packaging for food items 10.30±0.77%;plastic packaging for unspecified purpose 4.39±0.13% and plastic buffer material with 2.30±0.13%(Table90; Fig.61).

In Millennium center plastic waste was dominated by packaging material 44.72±0.32%;bottles with 25.55±0.06%;containers 8.34±0.24%;Tubes 5.94±0.02%;consumable plastic products 3.89±0.48%;durable plastic products 3.75±0.01%;plastic tray 2.92±0.02% and plastic rope with 0.52±0.01% (Table 91; Fig. 62).Packaging plastic material in Millenium center was dominated by plastic shopping bags 17.48±0.01%; packaging for non food 11.36±0.01%; packaging for food items 9.27±0.31%;plastic packaging for unspecified purpose 4.36±0.01% and plastic buffer material with 2.27±0.01%(Table 92; Fig.63).

In Zarkawt plastic waste was dominated by packaging material 44.98±0.79%;bottles with 25.98±0.12%;containers 8.48±0.08%;Tubes 6.02±0.09%;consumable plastic products 3.43±0.15%;durable plastic products 3.42±0.60%;plastic tray 2.94±0.07% and plastic rope with 0.52±0.04% (Table 93; Fig.64).Packaging plastic material in Zarkawt was dominated by plastic shopping bags 16.79±1.16%; packaging for non food 11.38±0.03%; packaging for food items 9.17±0.45%;plastic packaging for unspecified purpose 4.36±0.04% and plastic buffer material with 2.27±0.04%(Table 94; Fig.65).

ANOVA reveals that there is no significant difference in physical characteristics of plastic waste within the commercial sites ($F_{2,24}$=5.208E-08,P>0.05; Table 96). The packaging material fallowed by bottles dominated plastic waste generated in all the commercial sites (Table 95).Minimum plastic waste was contributed by plastic ropes in all the three sites.

Table 89: Physical characterization of plastic waste in Barabazar

Locality	Categories	Wt % 2017-18	Wt % 2018-19	Wt % 2019-20	Avg
Barabazar	Bottles	25.39	25.39	24.41	25.06±0.56
	containers	8.19	8.42	9.84	8.81±0.89
	Tubes	5.21	5.88	5.69	5.59±0.35
	Packaging	45.85	44.76	43.04	44.55±1.42
	Plastic rope	0.46	0.49	0.70	0.55±0.13
	Tray	2.81	2.87	3.29	2.99±0.26
	Durable products(MU)	3.69	3.72	3.93	3.78±0.13
	Consumable products(SU)	4.12	4.15	4.36	4.21±0.13
	Others	4.28	4.34	4.76	4.46±0.26

In Barabazar during year 2017-18 plastic waste was dominated by packaging material 45.85%; bottles with 25.39%;containers 8.19%;Tubes 5.21%;consumable plastic products 4.12%;durable plastic products 3.69%;plastic tray 2.81% and plastic rope with 0.46%.

During year 2018-19 plastic waste was dominated by packaging material 44.76%; bottles with 25.39%; containers 8.42%;Tubes 5.88%;consumable plastic products 4.15%;durable plastic products 3.93%;plastic tray 2.87% and plastic rope with 0.49%.

During year 2019-20 plastic waste was dominated by packaging material 43.04%; bottles with 24.41%; containers 9.84%;Tubes 5.69%;consumable plastic products 4.36%;durable plastic products 3.93%;plastic tray 3.29% and plastic rope with 0.70%(Table 89; Fig. 66).

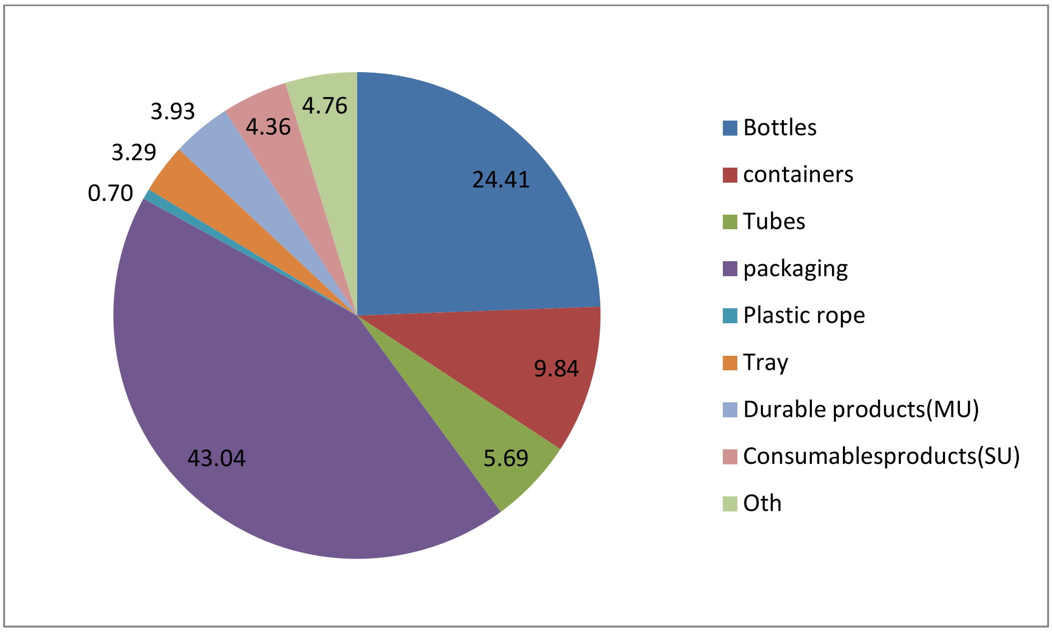

Fig. 60: Physical characterization of plastic waste in Barabazar within the three years

Table 90:Physical characterization of packaging material in Barabazar

Categories	2017-18	2018-19	2019-20	Avg.
Plastic packaging for food	10.62	9.42	10.86	10.30±0.77
Plastic packaging for non-food	11.30	11.33	9.54	10.72±1.03
Plastic packaging for unspecified purpose	4.30	4.33	4.54	4.39±0.13
Plastic shopping bags	17.42	17.45	15.66	16.84±1.03
Buffer materials	2.21	2.24	2.45	2.30±0.13

In Barabazar during 2017-18 packaging plastic material was dominated by plastic shopping bags 17.42%; packaging for non food 11.30%; packaging for food items

10.62%;plastic packaging for unspecified purpose 4.30% and plastic buffer material with 2.21%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 17.45%; packaging for non food 11.33%; packaging for food items 9.42%;plastic packaging for unspecified purpose 4.33% and plastic buffer material with 2.24%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 15.56%; packaging for non food 9.54%;packaging for food items 10.86%; plastic packaging for unspecified purpose 4.54% and plastic buffer material with 2.45% (Table 90.; Fig.61).

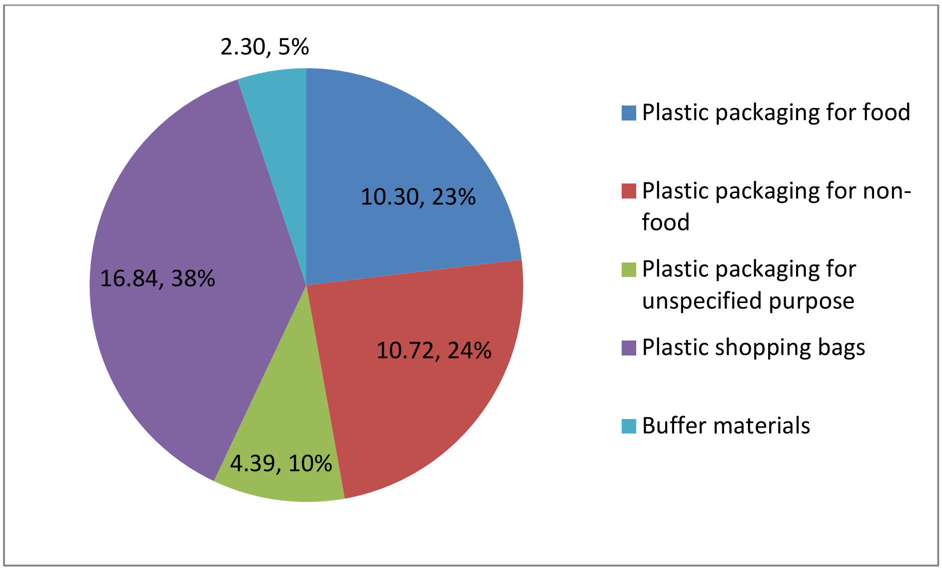

Fig. 61: Physical characterization of packaging material in Barabazar within the three years

Table 91:Physical characterization of plastic waste in Millennium center within the three years

Locality	Categories	wt %	wt %	wt %	Avg

		2017-18	2018-19	2019-20	
Millennium center	Bottles	25.50	25.53	25.62	25.55±0.06
	containers	8.06	8.46	8.49	8.34±0.24
	Tubes	5.92	5.93	5.96	5.94±0.02
	Packaging	44.85	44.35	44.95	44.72±0.32
	Plastic Rope	0.51	0.51	0.53	0.52±0.01
	Tray	2.90	2.91	2.94	2.92±0.02
	Durable products(MU)	3.74	3.74	3.76	3.75±0.01
	Consumable products(SU)	4.17	4.17	3.33	3.89±0.48
	Oth	4.37	4.38	4.41	4.39±0.02

In Millennium center during year 2017-18 plastic waste was dominated by packaging material 44.85%;bottles with 25.50%;containers 8.06%;Tubes 5.92%;consumable plastic products 4.17%;durable plastic products 3.74%;plastic tray 2.90% and plastic rope with 0.51%.

During year 2018-19 plastic waste was dominated by packaging material 44.35%;bottles with 25.53%;containers 8.46%;Tubes 5.93%;consumable plastic products 4.17%;durable plastic products 3.74%;plastic tray 2.91% and plastic rope with 0.51%.

During year 2019-20 plastic waste was dominated by packaging material 44.95%;bottles with 25.62%;containers 8.49%;Tubes 5.96%;consumable plastic products 3.33%;durable plastic products 3.76%;plastic tray 2.94% and plastic rope with 0.53%(Table 91; Fig. 62).

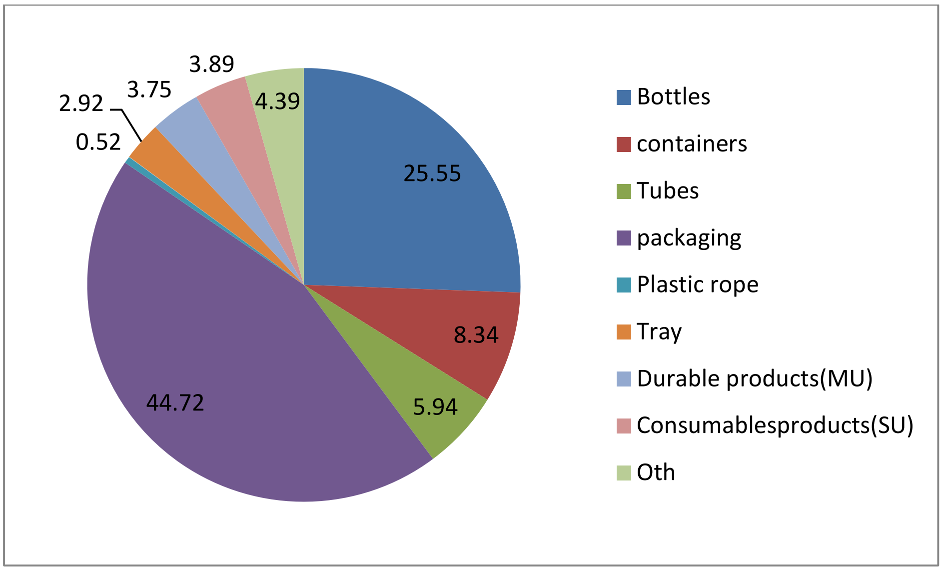

Fig.62:Physical characterization of plastic waste in Millennium center within the three years

Table 92: Physical characterization of packaging material in Millennium center within the three years

Categories	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	9.43	8.91	9.46	9.27±0.31
Plastic packaging for non-food	11.35	11.35	11.37	11.36±0.01
Plastic packaging for unspecified purpose	4.35	4.35	4.37	4.36±0.01
Plastic shopping bags	17.47	17.47	17.49	17.48±0.01
Buffer materials	2.26	2.26	2.28	2.27±0.01

In Millennium center during 2017-18 packaging plastic material was dominated by plastic shopping bags 17.47%; packaging for non food 11.35%; packaging for food items 9.43%;plastic packaging for unspecified purpose 4.35% and plastic buffer material with 2.26%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 17.47%; packaging for non food 11.35%; packaging for food items 8.91%;plastic packaging for unspecified purpose 4.35% and plastic buffer material with 2.26%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 17.49%; packaging for non food 11.37%;packaging for food items 9.46%; plastic packaging for unspecified purpose 4.37% and plastic buffer material with 2.28% (Table 92; Fig.63).

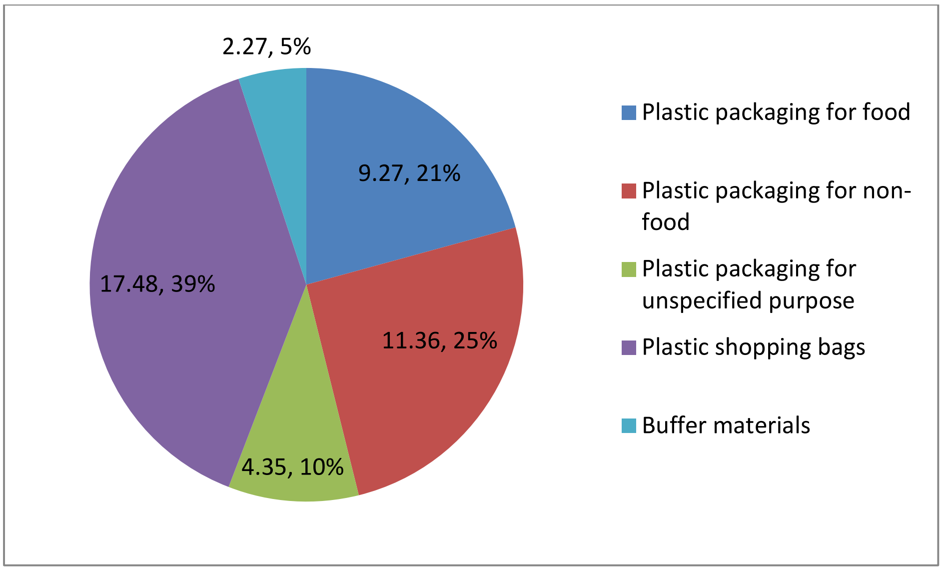

Fig.63: Physical characterization of packaging material in Millennium center within the three years

Table 93: Physical characterization of plastic waste in Zarkawt within the three years

Locality	Categories	wt % 2017-18	wt % 2018-19	wt % 2019-20	Avg
Zarkawt	Bottles	26.01	26.07	25.85	25.98±0.12
	containers	8.46	8.42	8.57	8.48±0.08
	Tubes	5.92	6.10	6.04	6.02±0.09
	packaging	44.78	45.85	44.31	44.98±0.79
	Plastic rope	0.51	0.49	0.57	0.52±0.04
	Tray	2.91	2.88	3.02	2.94±0.07
	Durable products(MU)	3.74	2.73	3.80	3.42±0.60
	Consumable products(SU)	3.31	3.60	3.37	3.43±0.15
	Oth	4.38	3.87	4.49	4.24±0.33

In Zarkawt during year 2017-18 plastic waste was dominated by packaging material 44.78%;bottles with 26.01%;containers 8.46%;Tubes 5.92%;consumable plastic products 3.31%;durable plastic products 3.74%;plastic tray 2.91% and plastic rope with 0.51%.

During year 2018-19 plastic waste was dominated by packaging material 45.85%;bottles with 26.07%;containers 8.42%;Tubes 6.10%;consumable plastic products 3.60%;durable plastic products 2.73%;plastic tray 2.88% and plastic rope with 0.49%.

During year 2019-20 plastic waste was dominated by packaging material 44.31%;bottles with 25.85%;containers 8.57%;Tubes 6.04%;consumable plastic products 3.37%;durable plastic products 3.80%;plastic tray 3.02% and plastic rope with 0.57%(Table 93;Fig.64).

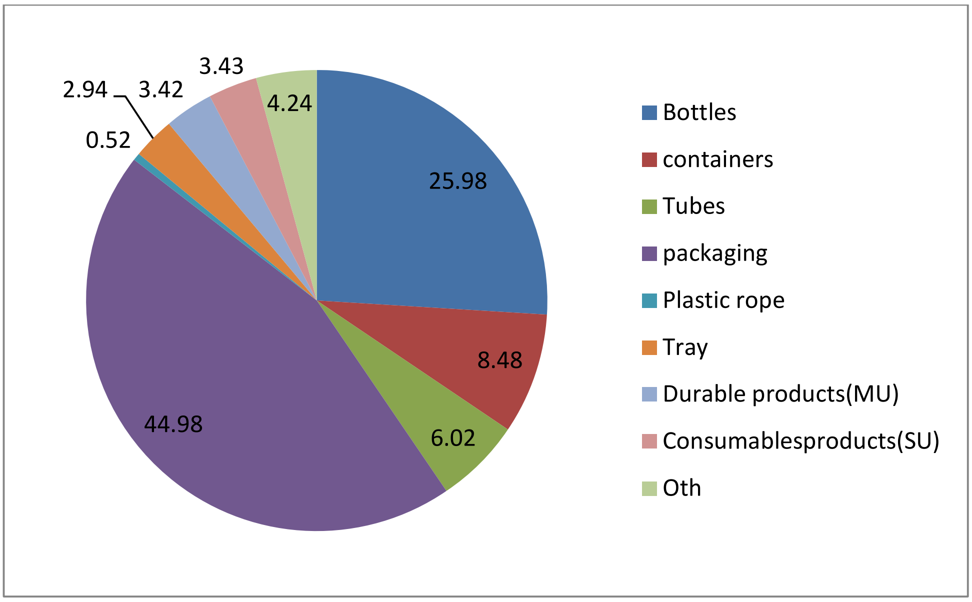

Fig. 64: Physical characterization of plastic waste in Zarkawt within the three years

Table 94: Physical characterization of packaging material in Zarkawt within the three years

Categories	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	9.44	9.42	8.66	9.17±0.45
Plastic packaging for non-food	11.35	11.39	11.41	11.38±0.03
Plastic packaging for unspecified purpose	4.35	4.34	4.41	4.36±0.04
Plastic shopping bags	17.39	15.46	17.53	16.79±1.16
Buffer materials	2.26	2.25	2.32	2.27±0.04

In Zarkawt during 2017-18 packaging plastic material was dominated by plastic shopping bags 17.39%; packaging for non food 11.35%; packaging for food items 9.44%;plastic packaging for unspecified purpose 4.35% and plastic buffer material with 2.26%.

During 2018-19 packaging plastic material was dominated by plastic shopping bags 15.46%; packaging for non food 11.39%; packaging for food items 9.42%;plastic packaging for unspecified purpose 4.34% and plastic buffer material with 2.25%.

During 2019-20 packaging plastic material was dominated by plastic shopping bags 17.53%; packaging for non food 11.41%;packaging for food items 8.66%; plastic packaging for unspecified purpose 4.41% and plastic buffer material with 2.32% (Table 94; Fig.65).

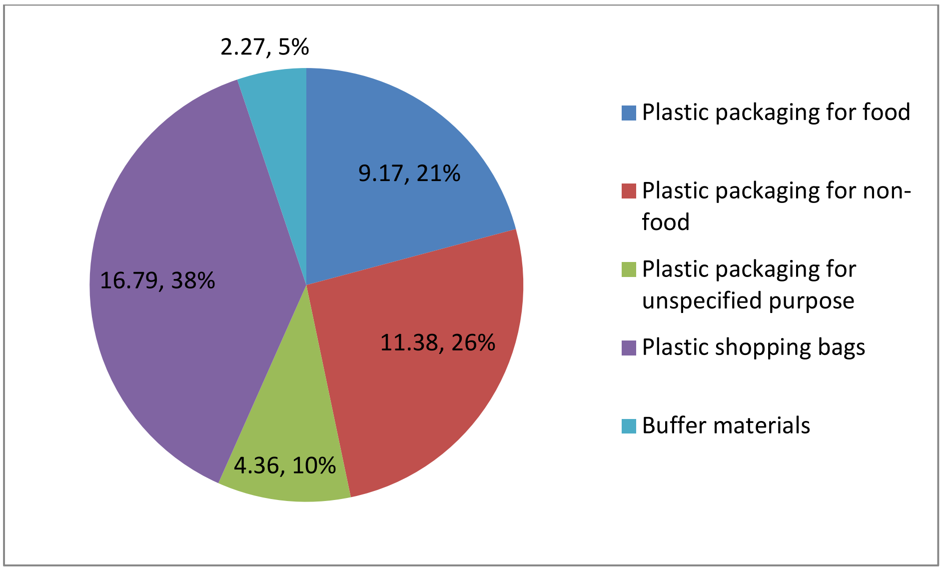

Fig.65: Physical characterization of packaging material in Zarkawt within the three years

Table 95: Physical characteristics of plastic waste in commercial area

Categories	**BB**	**MC**	**ZK**
Bottles	25.98±0.56	25.55±0.06	25.98±0.12
Containers	8.48±0.89	8.34±0.24	8.48±0.08
Tubes	6.02±0.35	5.94±0.02	6.02±0.09
Packaging	44.98±1.42	44.72±0.32	44.98±0.79

Plastic rope	0.52±0.13	0.52±0.01	0.52±0.04
Tray	2.94±0.26	2.92±0.02	2.94±0.07
Durable products(MU)	3.42±0.13	3.75±0.01	3.42±0.60
Consumables products(SU)	3.43±0.13	3.89±0.48	3.43±0.15
Oth	4.24±0.26	4.39±0.02	4.25±0.33

Table 96: ANOVA for variation in Physical characteristics of plastic waste in commercial sites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.222E-05	2	1.111E-05	5.208E-08	0.9999999	3.402826
Within Groups	5120.165	24	213.34021			
Total	5120.1651	26				

Water and soft drink bottles, bottles for milk and juice, food jar, grocery bags, packaging, bottle caps, medicine bottles, chips packs, disposal cups, cutlery, packaging foam, straws are the main items found in plastic waste generated in commercial area of Aizawl.On the contrary plastic waste in residential area is dominated by packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. One of the major reasons for such a high proportion of plastic waste is that about 50% of plastic is discarded as waste after single use. Globally per capita consumption of plastic driven products/yr is 100 and 20 kg by the people from the North-America and Asia respectively and India it is just 11 Kg/yr. Percentage of inorganic wastes in solid waste increases with the increase in income level of the people. Waste generation varies from the rural to urban region, wet to dry season as well as the composition that ultimately impacts total collection, transportation, damping and recycling system. Once plastic is discarded after its utility is over, it is known as plastic waste. Thanh et al.,2014 reported average plastic waste generation rate 17.24 g/cap/day in Vietnam and plastic waste was dominated by plastic packaging and plastic containers dominated with the high percentage, 95.64% of plastic waste. Plastic shopping bags were especially identified as the major component, accounting for 45.72% of total plastic waste.

Assessment of plastic waste and its management in NCT Delhi by CPCB in year 2020 reveals that Plastic packaging and bags were the major component of plastic waste especially plastic shopping bags. Plastic shopping bags appropriated for almost half of the total plastic waste, approximately 45.72% in Kenya (Bahri,2005).

Single use or disposable plastics like plastic spoon, stirrers, bottles, disposable cups and plates are those that are designed to be used only once before being thrown away. These include light-weight plastic bags, disposable utensils, coffee cups and stirrers, soda and water bottles, food packaging. In India, around 43% of manufactured plastics are used for packaging purpose and most of these are single use (Kumar et al.,2009). According to Burnley et al.,2007 some polymers of plastic are used primarily in a single application (e.g. polyethylene in packaging) while others are used more widely (e.g. polypropylene).The average plastic waste generation rate was 17.24 g/cap/day; plastic packaging and plastic containers dominated with the high percentage, 95.64% of plastic waste. Islam et al., 2011 identified Plastic shopping bags as the major component, accounting for 45.72% of total plastic waste. Huq,2015 found plastic packaging and plastic containers were the most numerous plastics generated, accounting for a high percentage (95.64%); plastic packaging especially appropriated for the most share of plastic waste (73.09%). The remaining consisted of plastic products with 5.20% (including single-use products, 1.48%) and plastic miscellaneous (0.16%).The versatility of plastics has led to their use in almost all major product categories. Plastics packaging is the largest application by weight, but plastics are also used widely in the textile, consumer goods, transport, and construction sectors (NPWMTF,1997). According to

Hopewell et al. (2009) approximately 50 per cent of plastic consumption takes the form of single-use disposable items (e.g. packaging and disposable consumer items), 20-25% relates to infrastructural applications (e.g. pipes, cable coatings and structural materials), and the rest are found in durable consumer applications (e.g. electronic goods, furniture, vehicles). Packaging accounts for 39.4% in Europe while 42% by weight in USA of total plastic waste (Plastics Europe, 2014). Plastic packaging has the largest share (35.8%) in the market of plastic products and a short lifetime. It is also one of the main plastic waste generation sectors accounting for 46% of plastic waste generation (Andrady, 2015). Plastics are often used to protect or preserve foodstuffs and, in doing so, help to reduce food waste. Plastics are also an important input in vehicles, where their relatively light weight results in lower fuel use and greenhouse gas emissions. Around 4–12% of the MSW consists of different kinds of plastic waste from various sources (Hoornweg and Bhada-Tata 2012) The packaging of consumable goods, cans, and covers account for 35% total plastic utilization (Khajuria,2010). Moreover, 20–25% plastic is used in a wide range of diverse field of such as pipes, cables wiring, automobile, aircraft, utensils, covers, containers and the rest is from the non-durable goods (Tomar and Dadoriya, 2013).

Plastic shopping bags that are used very popularly in Aizawl, given free of charge while purchasing at supermarkets, normal markets, self-owned shops, vendors, etc. plastic packaging for general purpose which is used to contain the goods or products that are unprocessed or un-packaged, the distributors or retailers distribute these goods and products into smaller portions in plastic packaging for easy retail.

Plastic packaging accounts for more than a third of the production of all plastic polymers and constitutes 42 and 40 per cent of the plastic demand in the USA and Europe, respectively. According to the United Nations Environment Programme (UNEP), single-use plastics, which include grocery bags, containers and bottles, constitute the majority of plastic packaging. These plastics, which are designed for immediate disposal after use, are often discarded within the same year of production.

Their increased use has contributed significantly to the increased generation of plastic wastes. In 2016, plastic wastes constitute over 12 per cent of the global waste composition, the third-highest after food and paper wastes. Plastic packaging has the largest share (35.8%) in the market of plastic products and a short lifetime. It is also one of the main plastic waste generation sectors accounting for 46% of plastic waste generation

In commercial area plastic waste is mainly coming from resaturents, shops and offices. The plastic waste dominated by packaging material 44.75±0.22%;bottles 25.53±0.46%;containers 8.53±0.24%.The plastic waste is dominated by packaging material such as wrappers, chips packets, polythene, tetra pacs, gutka and pan masala pouches, disposable cups, plates, straw and stirrers and bottles. Most important characteristics of plastic waste in commercial area is that most f plastic waste produced is single use plastics type.

4.11. Chemical characterization of plastic waste in commercial area

Plastic waste in Zarkawt area was dominated by LDPE 28.26±0.27%;HDPE 25.21±0.34%; PS12.56±1.06%.PET12.43±1.03%; PP11.83±0.34%;PVC3.81±0.87% (Table 97; Fig.66).

Plastic waste in Millenium center was dominated by LDPE 27.75±0.06%;HDPE 24.60±0.53%; PET15.15±.67%; PP11.72±1.12%;PS10.95±.72%; PVC3.50±0.51% (Table 98; Fig.67).

Plastic waste in Barabazar was dominated by LDPE 27.446±0.58%;HDPE 23.95±0.68%; PET15.17±.88%; PS11.64±1.22%; PP11.02±1.03%;PVC4.79±0.34% (Table99; Fig.68).

ANOVA reveals there is no significant difference for chemical characteristics of plastic waste among commercial sites ($F_{2,18}$=2.386E-07,P>0.05; Table 101).In all the three commercial sites LDPE and HPE type of plastic waste contributed in maximum generation whereas PVC type of plastic waste was least generated throughout the three years (Table 100).

In Zarkawt during 2017-18 plastic waste was dominated by LDPE 28.41%;HDPE 25.42%; PS 11.76%.PET 13.29%; PP 12.03%;PVC 3.31%.During 2018-19 plastic waste was dominated by LDPE 27.95%;HDPE 24.82%; PS 12.17%.PET 12.70%; PP 11.44%;PVC 4.82%.During 2019-20 plastic waste was dominated by LDPE 28.11%;HDPE 25.21%; PS 13.76%.PET 11.29%; PP 12.13%;PVC 3.21% (Table 100)

In Millennium center during 2017-18 plastic waste was dominated by LDPE 27.77%;HDPE 24.77%; PS 10.12%.PET 14.65%; PP 12.87%;PVC 3.67%.

During 2018-19 plastic waste was dominated by LDPE 27.80%;HDPE 24.01%; PS 11.36%.PET 14.89%;PP 10.64%;PVC 3.91%.During 2019-20 plastic waste was dominated by LDPE 27.69%;HDPE 25.03%; PS 11.38%.PET 15.91%; PP 11.65%;PVC 2.93% (Table 4.7.2.b.; Fig 4.7.2.b.)In Barabazar during 2017-18 plastic waste was dominated by LDPE 26.94%;HDPE 23.94%; PS 11.29%.PET 15.82%; PP 12.04%;PVC 4.65%.During 2018-19 plastic waste was dominated by LDPE 28.07%;HDPE 23.28%; PS 10.63%.PET 14.16%;PP 11.02%;PVC 5.18%.During 2019-20 plastic waste was dominated by LDPE 27.30%;HDPE 24.64%; PS 12.99%.PET 15.52%; PP 9.99%;PVC4.54% (Table 4.7.2.c.; Fig 4.7.2.c.)

Table 97: Chemical characterization (%) of plastic waste in Zarkawt in the three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	13.29	25.41	28.41	3.31	12.03	11.76	5.79
2018-19	12.70	24.82	27.95	4.82	11.44	12.17	6.10
2019-20	11.29	25.21	28.11	3.21	12.13	13.76	5.79
Avg	12.43±1.03	25.21±0.34	28.26±0.27	3.81±0.87	11.83±0.34	12.56±1.06	5.89±0.18

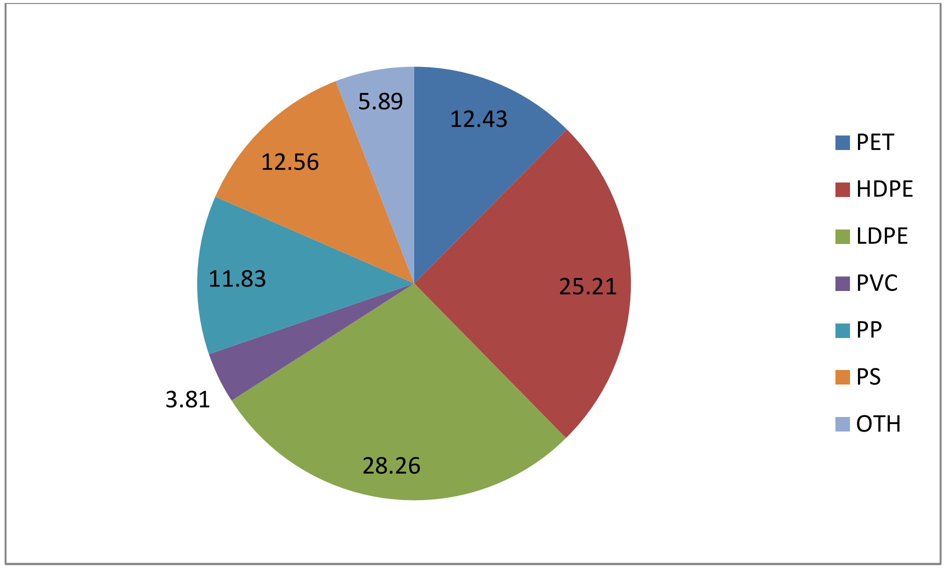

Fig.66: Chemical characterization of plastic waste in Zarkawt within the three years

Table 98: Chemical characterization (%) of plastic waste in Millennium center in the three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	14.65	24.77	27.77	3.67	12.87	10.12	6.15
2018-19	14.89	24.01	27.80	3.91	10.64	11.36	7.39
2019-20	15.91	25.03	27.69	2.93	11.65	11.38	5.41
Avg	15.15±0.67	24.60±0.53	27.75±0.06	3.50±0.51	11.72±1.12	10.95±0.72	6.32±1.00

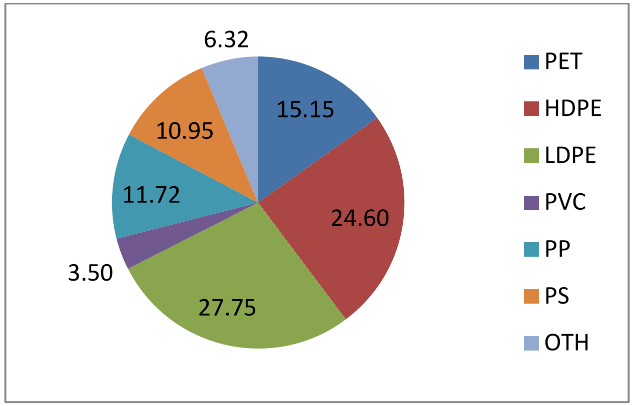

Fig.67: Chemical characterization of plastic waste in Millennium center within the three years

Table 99: Chemical characterization (%) of plastic waste in Barabazar in the three years

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	15.82	23.94	26.94	4.65	12.04	11.29	5.32
2018-19	14.16	23.28	28.07	5.18	11.02	10.63	7.66
2019-20	15.52	24.64	27.30	4.54	9.99	12.99	5.02
Avg	15.17±0.88	23.95±0.68	27.44±0.58	4.79±0.34	11.02±1.03	11.64±1.22	6.00±1.45

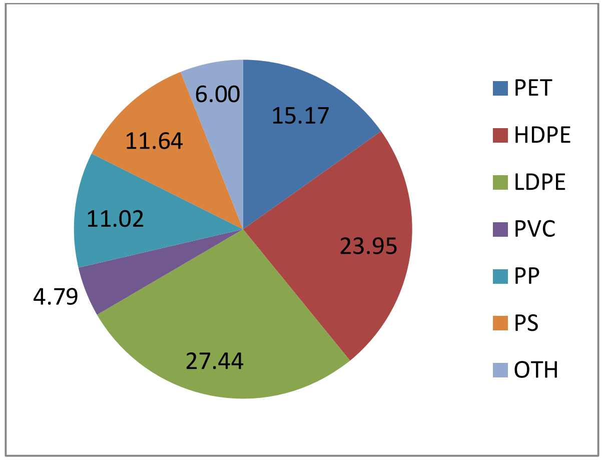

Fig.68:Chemical characterization of plastic waste in Barabazar

Table 100:Variations in chemical characteristics of plastic waste among commercial site

Category	BB	MC	ZK
PET	15.17±0.88	15.15±0.67	12.43±1.03
HDPE	23.95±0.68	24.6±053	25.21±0.34
LDPE	27.44±0.58	27.75±006	28.26±0.27
PVC	4.79±0.34	3.5±051	3.81±0.87
PP	11.02±1.03	11.72±1.12	11.83±0.34
PS	11.64±1.22	10.95±0.72	12.56±1.06
OTH	6.00±1.45	6.32±1.00	5.89±0.18

Table 101: ANOVA for variation in Chemical characteristics of plastic waste in commercial sites in all three years

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.81E-05	2	1.905E-05	2.386E-07	0.9999998	3.5545571
Within Groups	1436.9161	18	79.828671			
Total	1436.9161	20				

The polymer composition in the plastic waste stream varies depending on the source, but the most common plastic grades, polypropylene (PP) and polyethylene (PE), are presented in every waste stream.

The favorable features of plastic that contribute to its utilization in a wide range of applications, such as packaging, and in automotive and electronics segments. The building and construction segment is one of the biggest plastic users in Europe, as this segment uses 19.7% of European plastics. The great demand of plastic also affects the amount of generated plastic waste. The main sources of post-consumer waste plastics are municipal solid waste (MSW), construction and demolition waste (CDW), waste from electric and electronic equipment (WEEE), and end-of-life vehicles.

Production of plastic is dominated by polyolefins, such as polyethylenes, polystyrene, and polypropylene (Tsakona and Rucevska., 2020). In a study conducted in Bangkok, five main types of recyclable plastic were identified that enter the solid municipal waste stream were found to be high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polypropylene (PP) and polystyrene (PS) (Chinnathan et al.,al.,2017).

Plastics have been categorized either as thermoplastics or thermosets. Thermoplastics contribute to the total plastic consumption by about 80% and are used for typical plastics applications such as packaging but also in non-plastic applications such as textile fibres and coatings (Brems et al., 2012).

Pollution Control Department, Bangkok (2017) reported that most plastic wastes do not have high potential to be recycled as 80% of plastic wastes are contaminated, such as plastic bags and packaging, which are made from high density polyethylene (HDPE), polypropylene (PP) and low density polyethylene (LDPE) which act as deterrence for collection and recyling.The costs of eliminating, collecting and cleaning these types of waste are quite expensive. Hence these uncollected items predominate plastic waste.

Major composition of MPW at one of the Bangkok city's waste transfer station observed was HDPE, LDPE, and PP. PET, OTHER, and PS types of plastic showed significant amount as well whereas PVC had the lowest contribution. For the HDPE, it was from plastic shopping and waste bag while the LDPE and PP were from plastic bag and food packaging (Wichai and Chavalparit, 2019)

Plastic bags were the most common type of waste, followed by plastic straws, plastic caps and plastic food containers. Further analysis also showed that the ineffectiveness of plastic waste management resulted from production and consumption all the way to waste management after consumption. Single-use plastics and packaging for consumer goods are driving the increase in plastic pollution (Rewlutthum,2013).

Globally, 36% of plastic is used for packaging and almost a third of it (32%) leaks into the environment. Just 14% is recycled in some way, with only 2% achieving “closed loop” recycling or circularity In Africa, household plastic packaging makes up about two-thirds of the total, though this proportion is thought to be higher in Southeast Asian countries with a smaller manufacturing sector (Basir, 2013).

Composition of plastic waste discarded by households in Kenya studies by Gwada et al.,2019 and Odhiambo et al.,2014 reported composition of plastic waste by households was dominated by low density polyethylene, polyethylene terephthalate, high density polyethylene and polypropylene.

Thermoplastics include polyethylene (PE) such as low density polyethylene (LDPE) and high density polyethylene (HDPE), polyethylene terephthalate (PET), polypropylene (PP), polyamides (PA), polycarbonate (PC), polyvinyl chloride (PVC), polystyrene (PS) and poly tetrafluoroethylene (PTFE) among others, while thermosets include silicon, melamine resin and vinyl ester (Chung,2008).

Geyer et al.,2017 estimated 67% of the plastic waste in oceans belonged to the HDPE/ LDPE, 10% to PP, and 8.66% to PET amongst others different fractions of the plastic waste.Among them, polyethylene film is the most important, representing approximately 43% of the total. The largest groups in total non fiber plastics production are PE (36%), PP (21%), and PVC (12%), followed by PET,

A study conducted by CPCB indicates that the majority of the plastic waste generated in India comprised the HDPE/LDPE materials, such as polybags and multilayer pouches used for food packaging, gutkha, and so on. Further, the study also observes that households are the biggest source of this plastic waste (Bhide and Sundersan ,1983).

Ombis (2012) reported that post-consumer plastic waste in Lunga Lunga locality,Nairobi consisted of namely high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP) and polyethylene tetra phthalate (PET)

Kamala,2013 Studied composition of different types of plastic waste in Bangkok and reported very high proportion (88%) belonged to HDPE and LDPE.

Wichai and Chavalparit (2019) studied compositions of plastic wastes that were found in municipal waste management in Bangkok and reported HDPE, which is the material used to produce bags and bottles, contributed the highest proportion (46%) of plastic waste, followed by LDPE (24%) and PP (14%),PS(5%),PVC(2%).

A study conducted by CIPET & CPCB at 60 cities in 2015 indicates that the out of the total plastics waste (PW) obtained 66% belonged to HDPE/LPDE materials which is of mixed plastic wastes like Polybags, Multilayer pouches used for packing food items, Ghutkas etc. The households are the biggest source of plastics waste. In Delhi, the quantity of plastic waste has been assessed as 10.14% of total MSW which comprises of 76% of HDPE/LDPE, 7% of PVC and 10% of Polystyrene material.

Assessment and Characterization of Plastic Waste in NCT of Delhi in 2020, characterization of plastic waste indicates that HDPE and LDPE materials together constituted 86.97% of the total plastic waste, followed by PET material and PVC material, which amounted to 3.96% and 3.67% respectively. While PS material constituted 2.76% of total plastic waste.In Shahdara The characterization of plastic waste indicates that HDPE and LDPE materials together constitutes 57.03% of the total plastic waste, followed by PP material and PET material, which amounted to 31.96% and 5.90% respectively. While PS material and PVC material constituted 1.70% and 1.73% respectively.In Hauzkhas the characterization of plastic waste indicates that HDPE and LDPE materials together constituted 66.97% of the total plastic waste, followed by PET material and PVC material, which amounted to 28.38% and 2.00% respectively. While PS material constituted 1.31% of total plastic waste.

From the total plastics that have been introduced in the market since1950 polypropylene (PP) and Low-density polyethylene (LDPE) account for 17% and 16% respectively of the global plastic production followed by High density polyethylene (HDPE) (13%) and polyphthalamide (PP&A) (13%). In addition, additives used in plastic products manufacturing have also a significant share in global plastic production (6%) (Lazarevic et al., 2010)

LDPE/LLDPE and PP accounted almost equally to 41% of the worldwide plastic applications between 2002-2014. 22% of LDPE/LLDPE and PP resins were applied in the packaging sector.classification of plastics shows that LDPE governs types of plastics both in weight basis and volume basis. 14% PET, 25.6% HDPE, 0.03% PVC, 30% LDPE, 12.3% PP, 14.8% PS and 3.1% (Lahtela et al.,2019)

In commercial area plastic waste is mainly coming from restaurants, shops and offices. The plastic waste dominated by packaging material 44.75±0.22%;bottles 25.53±0.46%;containers 8.53±0.24%.The plastic waste is dominated by packaging material such as wrappers, chips packets, polythene, tetrapacks, gutka and pan masala pouches, disposable cups, plates, straw and stirrers and bottles. Most important characteristics of plastic waste in commercial area is that most f plastic waste produced is single use plastics type.

4.12 Plastic waste assessment at turial dumping site

Maximum plastic waste was observed in winters December 11.09±.55%;January9.88±1.42%;November 9.30±1.3%;followed by summer April9.28± 1.02%;March 7.53± .77%;May 6.57± .18%and least in rainy season September 6.25±.58%; August6.28 ±1.42%; July 7.50 ±.89%(**Table 104)**.Results of ANOVA analysis ($F_{8,18}$=8.68,P<0.05; Table106a.) reveals that there was significant monthly variation in Plastic waste occurrence at dumping site.

Physical Characterization of plastic waste

Highest amount of plastic waste at dumping site was found to belong to packaging 40.61±3.02%; bottles 26.17±2.28%;Containers 8.90±0.32%;,Tubes6.09±0.28%;consumable plastic products4.56±0.14%;durable plastic products3.93±0.40%;plastic trays3.68±0.27% and plastic rope with0.90±0.14%(Table 102; Fig.69).

The Result of ANOVA analysis shows that there is significant variation in physical characteristics of plastic waste at Tuirial Dumping site during 2017-20.($F_{8,18}$=322.45,P<0.05; Table 106 b).Analysis of packaging material reveals that maximum amount of packaging material belonged to plastic shopping bags 16.19±1.66% of overall plastic waste fallowed by plastic packaging for non food items9.98±1.40;,plastic packaging for food items7.06±0.1%;plastic packaging for unspecified purpose 4.74±0.14%, and plastic buffer material with2.65±0.14%(Table 103; Fig.70)

The result of ANOVA analysis reveals that variations in physical characteristics of packaging waste at Turial Dumping site during 2017-20 was found to be significant ($F_{4,10}$=13.70,P<0.05; Table 106 c.).

Table 102: Physical characterization of plastic waste at Turial dumping site

Categories	Wt(%)	Wt(%)	Wt (%)	Avg
	2017-18	2018-19	2019-20	
Bottles	27.76	23.56	27.2	26.17±2.28

Containers	8.54	9.14	9.02	8.90±0.32
Tubes	6.41	5.99	5.87	6.09±0.28
Packaging	37.8	43.8	40.24	40.61±3.02
Plastic Rope	1.05	0.85	0.79	0.90±0.14
Tray	3.99	3.59	3.47	3.68±0.27
Durable Products(MU)	4.28	3.5	4.02	3.93±0.40
Consumable Products(SU)	4.71	4.51	4.45	4.56±0.14
Oth	5.46	5.06	4.94	5.15±0.27

During year 2017-18 plastic waste comprised of packaging material 37.8% fallowed by bottles 27.76%;containers 8.54%;tubes 6.41%; consumable plastic products 4.71%;Durable plastic products 4.28%; Plastic trays 3.99%;plastic rope 1.05% and other categories 5.46%.

During year 2018-19 plastic waste comprised of packaging material 43.8% fallowed by bottles23.56%; containers 9.14%;tubes (5.99%; consumable plastic products 4.51%; Durable plastic products 3.5%;plastic trays 3.59%; plastic rope 0.85% and other categories 5.06%.

During year 2019-20 plastic waste comprised of packaging material 40.24% fallowed by bottles 27.20%; containers 9.02%; tubes 5.87%; consumable plastic products 4.45%;durable plastic products 4.02%; plastic trays 3.47%; plastic rope 0.79% and other categories 4.45%.

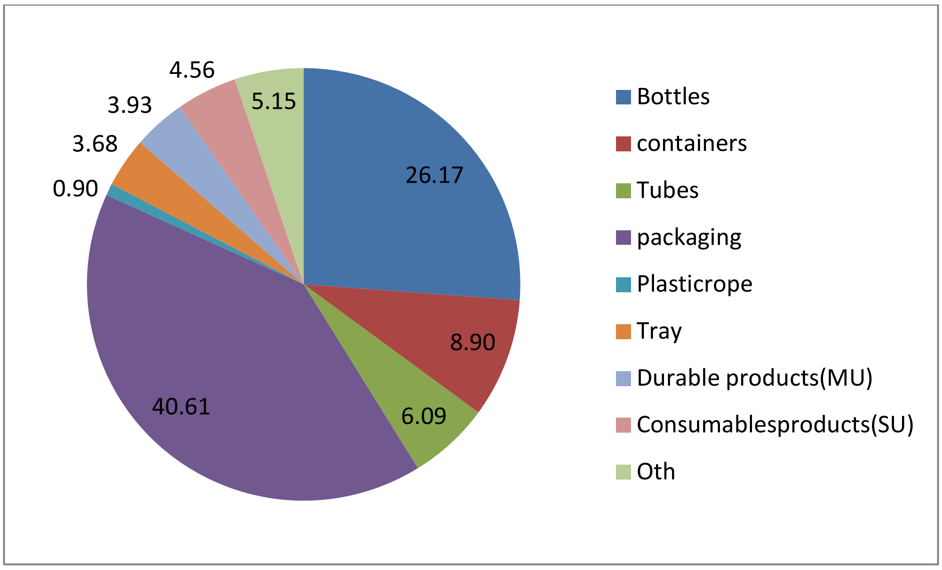

Fig.69: Percentage composition of plastic waste at Turial dumping site

During year 2017-18 Maximum amount of packaging material belonged to plastic shopping bags 18.01%% of overall plastic waste fallowed by Plastic packaging for nonfood items10.89%; Plastic packaging for food items10.21%;plastic packaging for unspecified purpose 4.89%;buffer material 2.8%.

During year 2018-19 Maximum amount of packaging material belonged to plastic shopping bags 15.81% of overall plastic waste fallowed by Plastic packaging for nonfood items10.69%;Plastic packaging for food items10.01%;plastic packaging for unspecified purpose 4.69%;buffer material 2.6%.

During year 2019-20 Maximum amount of packaging material belonged to plastic shopping bags 14.75%% of overall plastic waste fallowed by Plastic packaging for food items 9.95%;Plastic packaging for nonfood items 8.37%;plastic packaging for unspecified purpose 4.63%;buffer material 2.54%.

Table 103:Physical characterization of packaging waste (%) at Turial dumping site

Category	2017-18	2018-19	2019-20	Avg
Plastic packaging for food	10.21	10.01	9.95	10.05±0.13
Plastic packaging for non-food	10.89	10.69	8.37	9.98±1.40
Plastic packaging for unspecified purpose	4.89	4.69	4.63	4.74±0.14
Plastic shopping bags	18.01	15.81	14.75	16.19±1.66
Buffer materials	2.8	2.6	2.54	2.65±0.14

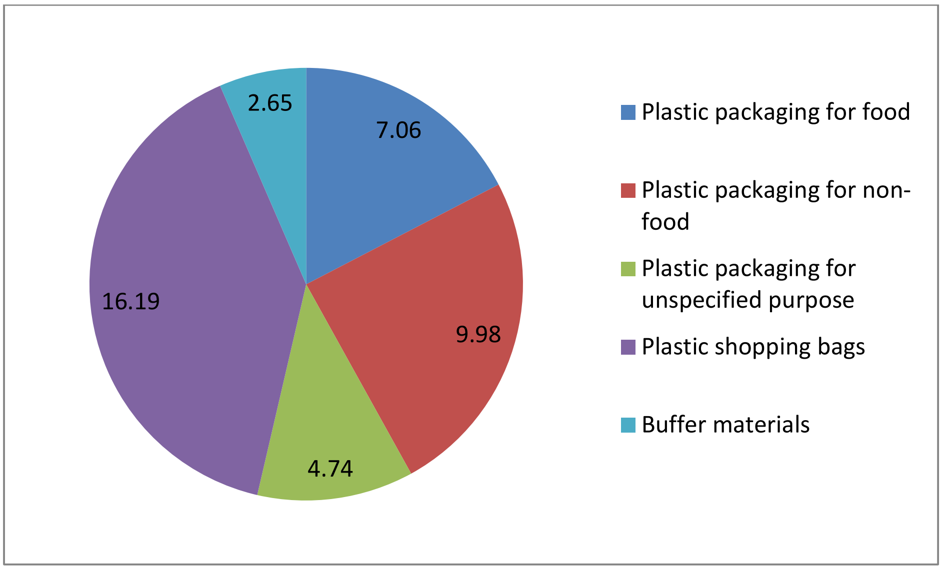

Fig.70: Percentage composition of packaging material at Tuirial dumping site

Table 104: Assessment of plastic waste (kg) at Tuirial dumping site during 2017-20

Year		Winter			Summer			Rainy		
		Nov	Dec	Jan	March	April	May	July	August	Sept
2017-18	PW	25.92	34.72	29.76	26.88	25.92	18.4	21.76	18.72	19.68
	Wt %	8.08	10.83	9.28	8.42	8.1	5.75	6.79	5.83	6.14
2018-19	PW	29.28	37.6	36.8	22.88	31.52	20.48	23.04	16.48	21.92
	Wt %	9.16	11.73	11.5	7.14	9.85	6.42	7.21	5.14	6.87
2019-20	PW	34.08	34.24	28.32	22.56	31.68	24.16	27.2	25.12	18.4
	Wt %	10.67	10.72	8.87	7.04	9.89	7.54	8.5	7.87	5.73
Avg	PW	29.76	35.52	31.63	24.11	29.71	21.01	24.00	20.11	20.00
	% Pw	9.30	11.09	9.88	7.53	9.28	6.57	7.50	6.28	6.25
Stdev	PW	4.10	1.82	4.54	2.41	3.28	2.92	2.84	4.48	1.78
	%Pw	1.30	0.55	1.42	0.77	1.02	0.90	0.89	1.42	0.58

Chemical characterization of plastic waste

Maximum amount of plastic waste belonged to HDPE 21.62±0.42% fallowed by LDPE 20.27±0.29%;PET 17.03±1.82%;PS18.97±0.31%; PP 9.98±0.33%PVC 6.48±0.52% other categories with 5.64±2.19% (Table 105;Fig.71).The result of ANOVA analysis reveals that significant variations ($F_{6,14}$=108.11,$P<0.05$; Table 106d.) in Chemical characteristics of plastic waste at Turial dumping site during 2017-20

During year 2017-18 maximum amount of plastic waste belonged to HDPE 21.37% fallowed by LDPE 20.56%;PET 17.3)%; PS18.92%; PP10.29%;PVC5.98% and other categories 5.62%.During year 2018-19 Maximum amount of plastic waste belonged to HDPE 20.28% fallowed by LDPE 20.28%; PET15.07%; PS(18.69%; PP10.01%; PVC 6.72% and other categories 7.84%.During year 2019-20 Maximum amount of plastic waste belonged to HDPE 22.11% fallowed by LDPE 19.98%; PET18.67%; PS18.97%; PP 9.63%; PVC 6.84% and other categories 3.46%.

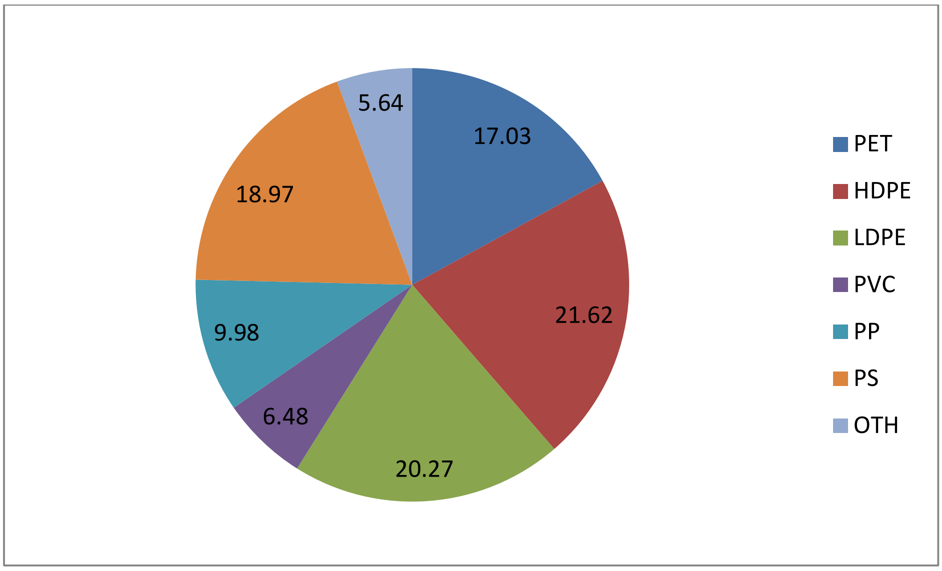

Fig.71:Chemical composition of plastic waste at Turial dumping site

Table 105: Chemical composition (%) of plastic waste at Tuirial dumping site

Year	PET	HDPE	LDPE	PVC	PP	PS	OTH
2017-18	17.35	21.37	20.56	5.89	10.29	18.92	5.62
2018-19	15.07	21.39	20.28	6.72	10.01	18.69	7.84
2019-20	18.67	22.11	19.98	6.84	9.63	19.31	3.46
Avg	17.03±1.82	21.62±0.42	20.27±0.29	6.48±0.52	9.98±0.33	18.97±0.31	5.64±2.19

Table 106 a.ANOVA for monthly variation in plastic waste at Turial dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	74.04744	8	9.25593	8.681891	7.9E-05	2.510158
Within Groups	19.19014	18	1.066119			
Total	93.23758	26				

Table106 b.ANOVA for variations in physical characteristics of plastic waste at Turial Dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4250.506	8	531.3133	322.4568	7.95E-18	2.510158
Within Groups	29.65867	18	1.647704			
Total	4280.165	26				

Table 106c.ANOVA for variations in physical characteristics of packaging waste at Turial Dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	333.3956	4	83.34891	13.70738	0.000457	3.47805
Within Groups	60.80587	10	6.080587			
Total	394.2015	14				

Table 106 d.ANOVA for variations in Chemical characteristics of plastic waste at Turial Dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	820.1716	6	136.6953	108.1124	6.51E-11	2.847726
Within Groups	17.70133	14	1.264381			
Total	837.8729	20				

Considering the composition of plastics in Waste at dumping site, packaging material constituted the greatest percentage fallowed by bottles, containers, tubes, consumable plastic products, durable plastic products, plastic trays, and least amount belonged to plastic rope. The composition of plastic waste at dumping sit was packaging 40.61±3.02%; bottles 26.17±2.28%; Containers 8.90±0.32%;, Tubes6.09±0.28%; consumable plastic products4.56±0.14%; durable plastic products3.93±0.40%; plastic trays3.68±0.27% and plastic rope with0.90±0.14%.Considering the monthly variation of different kinds of plastics according to its weight, it is seen that HDPE, LDPE, PEP and PS, PP are the most common plastics found in all the months. According to percentage, HDPE leads all others with its highest contribution. LDPE and PET is the next highest contributor among plastic waste mass. Although PS was found in large amount in the waste, due to its lightness the weight contribution is much lower. All plastics other than

PETE, HDPE, PVC, LDPE, PP and PS was included in others group with a small percentage of weight. The composition f plastic waste was HDPE 21.62±0.42% fallowed by LDPE 20.27±0.29%;PET 17.03±1.82%;PS18.97±0.31%; PP 9.98±0.33%PVC 6.48±0.52% other categories with 5.64±2.19% .Reasons for very high percentage of HDPE is that it main constituent of juice, milk and cosmetics storage bottles. Beverages and cosmetics are very predominantly used by younger generation in Aizawl city.LDPE is generated in very high quantities as it is very important constituent of packaging while PET mainly get sourced from household bottles used for storing cooking oil and drinking water. The waste at dumping site is sourced from all waste streams like commercial, residential, industrial, and institutional and construction and demolition sites. The very characteristic of plastic waste at dumping site is that it is showing very high % of PS 18.97±0.31% and PVC6.48±0.52 as PS is important constituent of disposable cups, plates, cutlery which very is very predominantly used in commercial and institutional areas while PVC is important constituent of plumbing pipes which is predominantly sourced from construction and demolition sites.

4.13 Comparison of characteristics of plastic between residential and commercial and dumping site sites

Physical characteristics

In residential area plastic waste was dominated by packaging material 72.6±0.65%, bottles 11.15±0.27%; containers 3.82±0.23% while in commercial area plastic waste dominated by packaging material 44.75±0.22%;bottles 25.53±0.46%;containers 8.53±0.24% and at dumping site plastic waste was dominated by packaging material 40.61±3.02%;bottles 26.17±2.28% and containers with 8.9±0.32%(Table 107).

Physical characteristics of plastic waste generated in commercial, residential and dumping site does not show significant variation ($F_{8,72}$=5.09E-07,P>0.05; Table 108).In all the three types of sites residential, commercial and dumping site packaging material, bottles and containers dominated while plastic rope, plastic tray and plastic tubes constituted negligible fraction. Among all sites (residential, commercial and dumping) contribution of packaging material was very high in residential area. Contribution of bottles was high in commercial area with 25.53±0.46% in commercial area and 26.17±2.28% in dumping site and 11.15±0.27% in residential area. In all sites plastic rope constituted minimum portion of plastic waste with 0.40±0.05% in residential area; 0.53±0.025 in commercial area and 0.90±0.14% in dumping site.

Table 107: Physical characteristics of plastic waste (%) at residential, commercial and dumping site during 2017-20

Cat	Resedential Area					Commercial Area			Dump Site
	West	East	Central	North	South	BB	MC	ZK	Turial
Bottles	11.11±0.09	11.32±0.68	10.85±0.09	11.51±0.81	10.93±0.35	25.98±0.56	25.55±0.06	25.98±0.12	26.17±2.28
container	3.72±0.03	3.78±0.09	3.64±0.03	4.2±0.81	3.67±0.12	8.48±0.89	8.34±0.24	8.48±0.08	8.90±0.32
Tubes	1.57±0.03	1.69±0.16	1.49±0.03	1.83±0.12	1.52±0.12	6.02±0.35	5.94±0.02	6.02±0.09	6.09±0.28
packaging	72.4±0.63	71.45±1.37	72.79±0.28	71.49±1.34	72.66±0.88	44.98±1.42	44.72±0.32	44.98±0.79	40.61±3.02
Plastic rope	0.41±0.02	0.47±0.08	0.37±0.02	0.33±0.17	0.39±0.06	0.52±0.13	0.52±0.01	0.52±0.04	0.90±0.14
Tray	1.74±0.03	1.86±0.16	1.66±0.03	1.84±0.18	1.69±0.12	2.94±0.26	2.92±0.02	2.94±0.07	3.68±0.27
Durable P	3.81±002	3.66±0.37	3.77±0.02	3.48±0.11	3.69±0.14	3.42±0.13	3.75±0.01	3.42±0.60	3.93±0.40
Cons.P	1.52±002	1.58±0.08	1.4±0.02	1.38±0.20	1.48±0.04	3.43±0.13	3.89±0.48	3.43±0.15	4.56±0.14
Oth	3.68±0.58	4.15±.08	3.91±0.05	3.92±0.25	3.96±0.12	4.24±0.26	4.39±0.02	4.25±0.33	5.15±0.27

Table 108: ANOVA for variation in Physical characteristics of plastic waste at residential, commercial and dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.001573	8	0.000197	5.09E-07	1	2.069832
Within Groups	27833.43	72	386.5755			
Total	27833.44	80				

Chemical characteristics

In residential area plastic waste comprised of PET 15.54±0.37%; HDPE22.55±1.39%; LDPE26.50±0.60%; PVC3.63±.98%; PP16.47±0.56%;PS8.70±0.33% while in commercial area plastic waste comprised of PET14.25± 1.58%;HDPE24.59±0.63%;LDPE27.82±0.41%; PVC4.03±0.67%; PP11.52±0.44%;PS11.72±0.81%. and at dumping site plastic waste comprised of PET17.03± 1.82%;HDPE21.62±0.42%;LDPE20.27±0.29%;PVC6.48±0.52%; PP9.98±0.334%;PS18.79±0.31% (Table 109).

Chemical characteristics of plastic waste generated in commercial, residential and dumping site does not show significant variation ($F_{8,54}$=1.17E-07,P>0.05; Table110).By comparing between the three sites LDPE and HDPE dominated the chemical characteristics of the plastic waste as LDPE and HDPE make up bulk of packaging material. On further observation it was found that contribution of PS was high in dumping site with 18.97±0.31 fallowed by PS11.72±0.81% in commercial area and least in residential area with 8.70±0.33%.

Table 109.Chemical characteristics (%) of plastic waste at residential, commercial and dumping site during 2017-20

	Residential					Commercial			Dump Site
Category	Central	West	East	South	North	BB	MC	ZK	Turial
PET	15.83±1.85	15.89±0.33	15.12±0.33	15.69±1.33	15.17±0.88	15.17±0.88	15.15±0.67	12.43±1.03	17.03±1.82
HDPE	21.05±1.69	21.1±1.21	23.37±1.16	23.2±1.21	24.05±0.68	23.95±0.68	24.6±053	25.21±0.34	21.62±0.42
LDPE	25.7±1.69	26.93±1.20	26.54±1.20	26.13±2.57	27.2±0.18	27.44±0.58	27.75±006	28.26±0.27	20.27±0.29
PVC	4.12±0.90	3.29±0.92	4.93±0.34	3.54±1.08	2.29±0.34	4.79±0.34	3.5±051	3.81±0.87	6.48±0.52
PP	17.14±1.52	16.97±1.55	15.83±1.55	16.16±.60	16.25±1.18	11.02±1.03	11.72±1.12	11.83±0.34	9.98±0.33
PS	8.43±0.88	8.76±1.21	8.29±1.22	8.99±1.68	9.04±1.22	11.64±1.22	10.95±0.72	12.56±1.06	18.97±0.31
OTH	7.72±0.32	7.06±1.76	5.92±1.96	6.29±1.45	6.00±1.45	6.00±1.45	6.32±1.00	5.89±0.18	5.64±2.19

Table 110: ANOVA for variation in Chemical characteristics of plastic waste at residential, commercial and dumping site during 2017-20

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.98E-05	8	8.73E-06	1.17E-07	1	2.115223
Within Groups	4042.457	54	74.86031			
Total	4042.457	62				

The comparison of plastic waste composition at residential, commercial and dumping site reveals that plastic waste generated in residential area is rich in packaging material 72.6±0.65%, bottles 11.15±0.27%; containers 3.82±0.23%.The underlying reasons for this is source of plastic waste in residential area as at level of household plastic is mainly used for bringing items from shops, grocery stores and food from restaurants which involes packaging which is mainly made up of LDPE while bottles are used for storing cooking oil and storing water which is mainly made up of PET.One important constituent of plastic waste households is PP which is mainly sourced from medicine bottles.

In commercial area plastic waste is mainly coming from restaurants, shops and offices. The plastic waste dominated by packaging material 44.75±0.22%;bottles 25.53±0.46%;containers 8.53±0.24%.The plastic waste is dominated by packaging material such as wrappers, chips packets, polythene, tetra packs, gutka and pan masala pouches, disposable cups, plates, straw and stirrers and bottles. Most important characteristics of plastic waste in commercial area is that most f plastic waste produced is single use plastics type.

At dumping site waste is received from all walks of life and waste stream include residential, commercial, institutional, industrial and construction and demolition sites.

The waste at dumping site gives a holistic picture of waste characteristic prevailing in whole city. At dumping site plastic waste was dominated by packaging material 40.61±3.02%; bottles 26.17±2.28% and containers with 8.9±0.32%.The plastic waste at dumping site was found to be rich in packaging material, bottles and containers and disposable cups and plates. The most important characteristic of plastic waste at dumpng site which distinguishes it from residential and commercial area is that it is rich in PS 18.79±0.31 and PVS 6.48±0.52%, %which is sourced from disposable cups and plates and cutlery while PVC is sourced from construction and demolition site.

4.10 Suggestions to improve Plastic waste management in Aizawl city

Aizawl Urban Area (AUA) has experienced tremendous growth of urban activities in recent times some in planned fashion and mostly in unplanned manner. Haphazard and unplanned growth tends to threat the vitality of this capital town, which now accommodates more than 50 percent of the urban population in the state. The Local Administration Department (LAD) of Aizawl is found to have a conventional and primitive system of solid waste management maintained and managed by a team of health and sanitary officers. As expected, apart from domestic sources, public and vegetable markets, hotels and restaurants, fish and meat shops, street sweepings, hospitals, other office, institutions, etc. are contributing to the solid waste(SW) load. A systematic and scientific SW collection, disposal and management are found to be absent in Aizawl.

Aizawl Municipal Corporation (AMC) should facilitate formation of self-help groups, provide identity cards and encourage integration in solid waste management including door to door collection of waste. Establish a system to recognize waste pickers or informal waste collectors and establish a system to integrate them to facilitate their participation in solid waste management including door to door collection of waste, introducing more training, systematic way of picking wastes.

AMC should prioritize development and setting up of infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste.

Establishment of reliable Plastic Waste management Centre/Firm for setting up of segregation, transportation, processing and disposal of the plastic waste within AMC areas scientific & resource recovery

Provision of storage facilities one of the immediate measures AMC need to take revamp the existing collection services structure would involve provision of covered community waste bins at proper distances for the people to deposit domestic waste. This is the first step that will ensure that people do not throw their garbage on the roads and hence do not create open dump sites. This will enable the sanitation workers to transfer waste to the transportation vehicle quickly and efficiently with minimum health risk which will help to maintain aesthetics of surroundings.

Setting up material recovery facilities or secondary storage facilities with sufficient space for sorting of recyclable materials and provide easy access. Plastics wastes should be stocked by the residents at plastics collection centre which are constructed at the suitable locations arranged cluster wise in the village. The plastics wastes should be collected by PHED (Public Health Engineering Department) from each village and transport to Block Headquarters wherein cleaning and compressed to be done by Baling Machine. Thereafter, the proper package of raw plastic wastes be dispatched to the nearest reliable plastic recycling factory available outside the State

There is a very large informal sector of rag pickers, who can collect recyclable wastes (paper, plastic, metal, glass, rubber, etc) from the streets, bins and disposal sites for their livelihood. Thus, the rag pickers can be effectively used for the collection of reusable materials especially because the use of non recyclable packaging materials like PET bottles for soft drinks, mineral wastes, and soft –foam products and metalised plastic film coated food packing materials are on the rise. During recycling, many of which will release toxic gases and ozone depleting products. So it is advisable to educate people to replace these items with eco- friendly packaging materials. The desirable home sorting mechanisms includes dry recyclable materials (e.g. glass, paper, plastic, cans etc.), kitchen and garden wastes, bulky wastes, hazardous wastes, construction and demolition wastes. Sorting can also be done just prior to waste processing or land filling.

Electricity can be produced by burning MSW as a fuel. MSW power plants, also called waste to energy (WTE) plants, are designed to dispose of MSW and to produce electricity as a byproduct of the incinerator operation. Mass Burn is the most common waste-to-energy technology, in which MSW is combusted directly in much the same way as fossil fuels are used in other direct combustion technologies. Burning MSW converts water to steam to drive a turbine connected to an electricity generator. Burning MSW can generate energy while reducing the volume of waste by up to 90 percent, an environmental benefit. However, this burning MSW in WTE plants produces comparatively high carbon dioxide emissions, a contributor to global climate change.

Encouraging use of unrecyclable plastic waste for road construction as per Indian Road congress guidelines or energy recovery or waste to oil by coordinating with MPWD or any other road construction company. Processing and disposal of Thermoset plastic should be done as waste as per the guidelines of the Central Pollution Control Boar As per the guidelines of the Central Pollution Control Board.

Municipal Corporation should prescribe user fee for solid waste management. Witch should be collected by Local Councils concerned. Municipalities should direct waste generators not to litter or burn waste and to segregate the waste at source and hand over the segregated waste to authorized the waste pickers or waste collectors authorized by the local body;

Enforcement on waste management by the waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multilayered packaging in the rural area of the. Capacity building of Village Council to be taken up by SIRD&PR (The State Institute for Rural Development and Panchayati Raj) ensuring no open burning of plastic waste and creating awareness among all stakeholders about their responsibilities.

Provide training to all wastes generators, all sections of workers including street sweepers. Create public awareness through information, education and communication campaign and educate the waste generators on the following on various aspects like minimizing generation of waste, reuse the waste to the extent possible, practice segregation of waste into bio-degradable, non- biodegradable (recyclable and combustible),sanitary waste and domestic hazardous wastes at source;

The AMC should assess properly quantity of solid waste generated daily for effective management of solid waste. Door step or house to house collection on regular and pre-informed timing should be organized by the process of ringing of bell or other means of information due to physical terrain of Aizawl city, door-to-door collection of Municipal Solid Waste was not possible; rather residents disposed off their waste from a designated collection point and it is presumed that 90 per cent of the city was covered

Heaps of garbage is burnt indiscriminately causing air pollution in and around the dumping site at Tuirial.It was noticed that the AMC did not take any steps to measure and combat the pollution of Air caused due to the burning of solid waste. The AMC should take steps for segregation of solid waste by spreading public awareness and provisioning for the same.

Policy Recommendations As consumption of plastic has increased exponentially in recent years, the indiscriminate dumping and littering of plastic waste is exerting wide spectrum of detrimental impacts on environment. The effective implementation/enforcement of Plastic Waste Management Rules 2016, amended 2018, in totality is always a challenge for local authorities.

In order to devise efficient ways of Plastic Waste Management, the following policy recommendations may be envisaged:

(a) Local Authorities/ Municipal Corporations shall devise an implementation procedure/ standard operating procedure (SOP) for management of plastic waste in adherence to the Plastic Waste Management Rules-2016 (amended 2018) ensuring door to door segregation of dry and wet waste and also at all places.

(b) The ward-wise material recovery facilities (MRF) are to be developed and optimized for their best performance. The integration of MRF with Extended Producer Responsibility (EPR), if possible, would be helpful towards the development of circular economy model.

(c) Producers and brand owners must partner with local authorities/ municipalities to ensure the formulating an EPR plan together with the procedures for its effective implementation as per The Ministry of Environment, Forests and Climate Change (MOEF&CC) / Central Pollution Control Board (CPCB) National Framework.

(d) The innovative economic models may be developed together with their implementation procedures to prompt citizens to recycle plastic waste.

(e) Sustainable alternatives of PWM, the co-processing of plastic in cement kilns, would provide environmentally viable mechanism to process non-recyclable, combustible plastic waste in addition to addressing the troubleshooting of waste management.

(f) Development of value added chain for recycled products requires optimization of innovative solutions considering mechanical properties at par with virgin plastic. Such products can cater to the demand of building sector, furniture industry, packaging, and automobile industry. (g) The MOEF&CC/ CPCB may take-up the matter with Bureau of Indian Standards (BIS) for formulation of Standard Specification for recycled plastic products.

(h) Bio-based compostable plastics provide sustainable alternatives to minimize plastic waste. The use of biodegradable plastic must be promoted, especially in large-scale applications, such as manufacturing of agricultural mulch films, superabsorbent composites used for waste water treatment, and sustained release of pesticides.

There is a further need for the up-scaling and commercialization of these products through a facilitation of research and industrial collaboration. (i) In order to create enabling environment to implement rules and procedures, it would be more appropriate to conduct capacity building programmes for stakeholders on regular basis to share best practices world over, in areas of Plastic Waste Management.

CHAPTER 5:

CONCLUSIONS

Conclusions

Seasons have deep influence on plastic waste generation. Among winters, rainy and summer season Maximum plastic waste was generated during winter season. Among all localities maximum plastic waste/household was generated in during winters in West locality while minimum plastic waste/household was generated during summers in North locality. In winters during month of December maximum plastic/household was observed while during rainy season least plastic waste/household was observed in month of August.

Maximum amount of plastic waste/household generated during winter season was 10.30 kg/household while Minimum amount of plastic waste/household was generated during rainy season with 8.13kg/household in south Locality.

Maximum amount of plastic waste/household generated during winter season was 9.93kg/household while Minimum amount of plastic waste/household was generated during rainy season with 7.72kg/household in North Locality.

Maximum amount of plastic waste/household generated during winter season was 10.22kg/household while Minimum amount of plastic waste/household was generated during rainy season with 8.03kg/household in East Locality.

Maximum amount of plastic waste/household generated during winter season was 10.11kg/household while Minimum amount of plastic waste/household was generated during rainy season with 7.90kg/household in Central Locality.

Maximum amount of plastic waste/household generated during winter season was 10.39kg/household Minimum amount of plastic waste/household was generated during rainy season with 8.18kg/household in West locality.

During 2017-18 maximum plastic waste was generated in West locality (2134.68kg) and minimum in North locality (2045.94 kg), during year 2018-19 maximum plastic waste was generated in South locality (2157.93kg) and minimum in North locality

(1994.18kg), during year 2019-20 maximum plastic waste was generated in West locality (2164.70kg) and minimum in North locality (2040.34 kg).

During year 2017-18 in south locality total plastic waste generated by 77 households having414 family members was 2059.60 kg, during 2018-19 was 2157.93kg and was 2132.23 kg during 2019-20

During year 2017-18 in North locality total plastic waste generated by 77 households having432 family members was 2045.94kg, during 2018-19 was 1994.18kg and was 2040.34kg during 2019-20

During year 2017-18 in East locality total plastic waste generated by 77 households having445 family members was 2057.86 kg, during 2018-19 was 2089.37kg and was 2153.59kg during 2019-20

During year 2017-18 in Central locality total plastic waste generated by 77 households having 443 family members was 2080.62 kg, during 2018-19 was 2191.71kg and was 2056.84 kg during 2019-20

During year 2017-18 in West locality total plastic waste generated by 77 households having396 family members was 2134.38 kg, during 2018-19 was 2102.66 kg and was 2164.70 kg during 2019-20

By comparing between the five localities it was observed that during year 2017-18 maximum plastic waste was generated in West locality (2134.68kg) and minimum in North locality (2045.94 kg), during year 2018-19 maximum plastic waste was generated in South locality (2157.93kg) and minimum in North locality (1994.18kg), during year 2019-20 maximum plastic waste was generated in West locality (2164.70kg) and minimum in North locality (2040.34 kg). Gross plastic waste generation among households of various localities was not found statistically significant for year 2017-18

Overall 4.75 kg of plastic waste per capita per year was generated in all localities. Maximum plastic waste generation per capita per year was observed in Central locality with 5.56±.99 kg and least in South locality with 4.34±1.14 kg. Overall 18.42 gm plastic waste per capita per day was produced in all localities during assessment period. Maximum plastic waste generation per capita per day was found in Central Locality 20.03±1.76 g and least in South locality 15.71±1.61g

It was found that maximum plastic waste per capita per season was generated during winter season in all the three years in all localities. The maximum Plastic waste generation per capita per season was found in Central locality 5.31±.15 kg and least in south locality 4.05±.47 kg.(Table 56) In all the three seasons maximum Plastic waste generation per capita per day was found during winter season in Central locality 19.27±3.03 g and least Plastic waste generation per capita per day was found during Rainy season in South Locality 6.66±3.26 g

Among five localities the packaging material contributed maximum and least amount was contributed by plastic rope. In all localities packaging material contributed 71.45±1.37% to 72.79±0.28%, Plastic bottles 10.85±0.09% to 11.51±0.81%, Plastic container 3.64±0.03% to 4.2±0.81%,Tubes 1.83±0.12% to1.49±0.03%,Tray 1.86±0.165 to1.66±0.03%, Durable plastic products(MU) 3.81±002% to3.48±0.11%, Consumable plastic products (SU) 1.58±0.08% to1.38±0.20% and Plastic rope 0.33±0.17% to 0.47±0.08%.

In all the localities LDPE type of plastic waste was generated at maximum amount while least amount of plastic waste generated belonged to PVC category. Chemical composition of plastic revealed that PET ranged from 15.83±1.855 to 15.12±0.33%, HDPE 24.05±0.68% to 21.05±1.69%, LDPE 27.2±0.18% to 25.7±1.69%, PVC 4.93±0.34% to 2.29±0.34%, PP 17.14±1.52% to 15.83±1.55%, PS 9.04±1.225 to 8.29±1.22%.

Maximum Plastic waste generation per capita per year was found in the households having income > 25L/yr with 6.89±.29 Kg and least in the income group having family income < 1.0L/yr with 4.29±.24 kg.Maximum Plastic waste g/capita/day was found in income group of having household income > 25L/yr with 22.55±3.56 g while least in least in income group having family income <1.0L/yr with 14.89±2.15g

In all commercial area Maximum plastic waste was observed during winter season while least during rainy season.In Barabazar during winter 613.52kg;summer 439.45kg and rainy season375.51 kg of plastic waste was generated during 2017-20.Overall plastic waste comprised 13.22±2.17% of total solid waste assessed during 2017-20 in Barabazar area.In Millenium center during winter 664.70kg;summer 536.78kg and rainy season 340.11kg of plastic waste was generated during 2017-20.Overall plastic waste comprised 14.36±2.20% of total solid waste assessed during 2017-20 in Millenium center.In Zarkawt during winter 679.76kg;summer 506.02kg and rainy season 419.79kg of plastic waste was generated during 2017-20.Overall plastic waste comprised 14.95±1.99% of total solid waste assessed during 2017-20 in Zarkawt.

During the assessment period Barabazar produced average plastic waste 13.55±1.55% in November, 19.43±2.40% in December,18.13±1.88% in January,11.95±1.69% in March, 11.98±2.74% in April, 12.69±4.34% in May,1.21±2.14% in July, 10.00±1.60% in August, 10.072±1.25% in September. Overall plastic waste accounted 13.22±2.17% of solid waste in Barabazar.

During the assessment period Millenium center produced average plastic waste 17.13±2.48 % in November, 21.24±1.75%in December, 17.02±1.31%in January, 15.68±2.34%in March, 14.80±3.02%in April, 14.23±2.82% in May, 11.09±1.92%in July, 8.71±1.81% in August, 9.37±2.37% in September.Overall plastic waste accounted 14.36±2.20% of solid waste in Millenium center.

During the assessment period Zarkawt produced average plastic waste 19.12±2.29% in November, 21.04±2.93% in December, 16.48±2.68% in January, 14.91±1.28% in March, 14.50±1.47% in April, 13.58±2.93% in May, 12.84±1.28% in July, 10.93±1.53% in August, 11.20±1.51% in September.Overall plastic waste accounted 14.95±1.99% of solid waste in Zarkawt.

Overall in all commercial area during year 2017-20 plastic waste was dominated by packaging material which ranged from 44.98±1.425 to 44.72±0.32&; bottles with 25.98±0.56% to 25.55±0.06%; containers 8.48±0.89 to 8.48±0.085;Tubes 6.02±0.35% to 5.94±0.025;consumable plastic products 3.89±0.48% to 3.43±0.13%;durable plastic products 3.75±0.01% to 3.42±0.13%;plastic tray 2.94±0.26% to 2.92±0.025and plastic rope with 0.52±0.13% to 0.52±0.01%.

Plastic waste was dominated by LDPE which ranged from 28.26±0.27% to 27.44±0.58%;HDPE 25.21±0.34% to 23.95±0.68; PS12.56±1.06% to 10.95±0.72%;PET 15.17±0.88% to 12.43±1.03%;PP 11.83±0.34% to 11.02±1.03%;PVC4.79±0.34% to 3.5±051%.

At dumping site Maximum plastic waste was observed in winters December 11.09±.55%;January9.88±1.42%;November 9.30±1.3%;followed by summer April9.28± 1.02%;March 7.53± .77%;May 6.57± .18%and least in rainy season September 6.25±.58%; August6.28 ±1.42%; July 7.50 ±.89%..

Highest amount of plastic waste at dumping site was found to belong to packaging 40.61±3.02%; bottles 26.17±2.28%;Containers 8.90±0.32%; Tubes6.09±0.28%; consumable plastic products4.56±0.14%; durable plastic products3.93±0.40%;plastic trays3.68±0.27% and plastic rope with0.90±0.14%.

Maximum amount of plastic waste belonged to HDPE 21.62±0.42% fallowed by LDPE 20.27±0.29%;PET 17.03±1.82%;PS18.97±0.31%; PP 9.98±0.33%PVC 6.48±0.52% other categories with 5.64±2.19%.

The comparison of plastic waste at residential, commercial and dumping site reveals that in residential area plastic waste was dominated by packaging material 72.6±0.65%, bottles 11.15±0.27%; containers 3.82±0.23% while in commercial area plastic waste dominated by packaging material 44.75±0.22%; bottles 25.53±0.46%; containers 8.53±0.24% and at dumping site plastic waste was dominated by packaging material 40.61±3.02%; bottles 26.17±2.28% and containers with 8.9±0.32%.

Chemical characterization in residential area plastic waste comprised of PET 15.54±0.37%; HDPE22.55±1.39%; LDPE26.50±0.60%; PVC3.63±.98%; PP16.47±0.56%;PS8.70±0.33% while in commercial area plastic waste comprised of PET14.25± 1.58%;HDPE24.59±0.63%;LDPE27.82±0.41%; PVC4.03±0.67%; PP11.52±0.44%;PS11.72±0.81%. and at dumping site plastic waste comprised of PET17.03±1.82%;HDPE21.62±0.42%;LDPE20.27±0.29%;PVC6.48±0.52%; PP9.98±0.334%; PS18.79±0.31%.

In Mizoram 266.04MT/day Soild waste is generated while at Aizawl it is 182.53MT/day.AMC claims in municipal area is there 100 % collection and transportation of SW to landfill site. Out of total soild waste generated per day in all 19 wards segregation is done in 68.67%.Waste is being treated and processed in material recovery facility at rate of 74 TPD, Composting 50TPD, Vermicomposting 22 TPD, Landfilling 44 TPD.In 2011 Plastic waste generation in 2010-11 Aizawl city was reported to be 8.5 Tonnes per day (7.95% of SW) presently in 2020-21 it is 14.51Tonnes per day.The biggest waste dumping site at Tuirial, Aizawl which has been receiving maximum wastes from Aizawl city for a number of years is overloaded and should be replaced by Waste Management Resource Centre and new sanitary Landfill. Dumping of waste at unauthorized dumping sites and waste burning should be strictly dealt with by local authority and Aizawl Municipal Corporation and scientific waste management should be promotd.General public should be encouraged to contribute in plastic waste management by decentralizing waste processing. In general solid waste in Aizawl city is managed according to Solid Waste Management Rules, 2016. The Solid Waste

Management is done in a Public Private Partnership mode. The funding is shared in the ratio of 80:20 between the AMC and the general public.

In order to regulate all matters connected with the storage, collection, transportation, processing and disposal of municipal plastic wastes and in exercise of the power conferred under Rule 6(4) of the Plastic Waste Management Rules, 2016, the Aizawl Municipal Corporation notified Aizawl Municipal Corporation Plastic Waste Management Bye-Laws, 2019. Local bodies should promote segregation at source through Local Councils Biodegradable wastes, Non biodegradable wastes, Toxic wastes, sanitary wastes and E-wastes are proposed to be segregated at source and setting up plastic waste collection centres/material recovery facilities for plastic waste, ensuring its channelizing to recyclers including through the existing formal/ informal waste recycling sector, create awareness among all the stakeholders about their responsibilities, ensuring the financial sustainability of plastic waste management, implementing Environment Protection Rules (RPR) and levy user charges, penalty etc. for effective implementation of plastic waste management. AMC should assess properly quantity of solid waste generated daily for effective management of solid waste. House to house collection on regular and pre-informed timing should be organized by the process of ringing of bell or other means of information. Local governments face enormous challenge in providing waste management services. Collection and transportation contributes to approximately three fourth of total expanse in solid waste management services. There are numerous health hazards associated with handling of contaminated plastic waste. Waste once disposed in landfills becomes prone to leaching and hence contaminate ground water and soil. Collection, segregation, Transportation, treatment and disposal is highly inadequate leading to poor state of health and environment. Key issues are limited door to door collection, lack of awareness and willingness to participate among public, unavailability of enough funds, non segregation of waste at source and lack of scientific processing, recycling and disposal technologies

Disposal of plastic waste is a serious concern for ecological and human well being.New technologies have been developed to minimize their adverse effect on the environment. Currently worldwide accepted technology used for the plastic disposal is incineration; however, the incinerators designed poorly, releases extremely toxic compounds (chlorinated dioxins and furans) therefore, raising several environmental issues. In India for safer disposal of plastic waste various technologies have been experimented like utilization of plastic waste in road construction, co-processing of plastic waste in cement kiln, co-processing of plastic waste as alternative fuel and raw material and plasma pyrolysis technology. Social and psychological aspect of plastic waste management is highly neglected hence identifying nature, magnitude, extent of underlying causes of plastic waste generation should be studied.LCA (Life Cycle Assessment) should be used to estimate environmental impact of plastics at each stage of processing, production and disposal. Sound and reliable data is lacking which is hindering effective policy formulation on plastic waste management. Generating energy from plastic waste, waste avoidance and recovery can be good option. Institutional and regulatory factors should be designed in such a way that facilitate resource recovery and does not impede recovery and recycling. Local governments should try to phase out single use plastic items in a progressive and time bound manner. Dedicated means of disposal and recovery through EPR (Extended Producer Responsibility) and PS (Product Stewardship) should be applied through appropriate policy instrument. Waste prevention and better management through Green design should be promoted as it facilitates retrieving of secondary raw materials. Green designing also helps to reduce toxicity of raw materials without compromising quality and utility of products. Plastic recycling provides an effective opportunity to dispose plastics in environmentally sound manner as recycling has huge potential for income generation and prevention of green house gas emission.Thre is a need to establish commercial level resource recovery and recycling plants. Changing consumer behavior through creating awareness and sensitization of community so as to reduce overall volume of plastics consumed and substitution with less harmful alternatives should be promoted. Focus should be on using renewable alternatives to packaging like jute or cotton, providing better waste management services, strict implementation of waste management legislations.

References

1.Abdon P.F.,Melik C.& Demirel.K.(2019).Squid-Inspired Tandem Repeat Proteins: Functional Fibers and Films. Frontiers in Chemistry.7:112-122

2.Adane L.& Muleta D.(2011).Survey on the usage of plastic bags, their disposal andadverse impacts on environment: A case study inJimma City, Southwestern Ethiopia.Journal of Toxicology and Environmental Health Sciences.3(8):234-248

3.Afroz R, Rahman A, Masud MM & Akhtar R.(2017).The knowledge, awareness, attitude and motivational analysis of plastic waste and household perspective in Malaysia. Environ Sci Pollut Res.24(3):2304–2315

4.Al-Khatib IA, Monou M, Zahra ASFA, Shaheen HQ & Kassinos D.(2010).Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district–Palestine. J Environ Manag.91(5):1131–1138

5.Al-Maaded M.,Madi N.K.,Ramazan K.,Hodzic A.& Ozerkan N.G.(2012).An Overview of soild waste management and plastic recycling in Qatar.J Polym Environ.20:186–194

6.Al-Momani, A.H.(1994).Solid waste management: Sampling,analysis and assessment of household waste in the city of Amman. International Journal of Environmental HealthResearch.4:208–222

7.Al-Salem, S.M., Lettieri, P.&Baeyens, J.(2009).Recycling and recovery routes of plastic solid waste (PSW): a review. Waste Manag.29:2625–2643

8.American Chemistry Council(2012).Resin Review: The Annual Statistical Report of the NorthAmerican Plastics Industry.85pp

9.Andrady A.,Bomgardner M., Southerton D.& Cristina A.H.(2015).Plastics in a sustainable society. MISTRA Swedish Foundation of Strategic Environmental research .Gamla Brogatan,Stockholm, Sweden.34pp

10.Anna F.,Asa S.& Stefan G.(2013).Collection & recycling of plastic waste.Improvements in existing collection and recycling systems in the Nordic countries.. Nordic Council of Ministers.Ved Stranden 18,DK-1061 Copenhagen,337 pp

11.Appiah J.K., Boatenga V.N.B. & Tagborb T.A.(2017).Use of waste plastic materials for road construction in Ghana Case Studies in Construction Materials.6:1–7

12.Aryan Y. & Samadder S.R.(2019).Life Cycle Assessment of the existing and proposed plastic waste management options in India: A case study. Journal of Cleaner Production. 211(20):1268-1283

13.Asari M, Tsuchimura M, Sakai SI, Tsukiji M.& Sagapolutele F.(2019).Analysis of mismanaged plastic waste in Samoa to suggest proper waste management in Pacific island countries. Waste Manag Res. 37(12):1207-1216

14.Ashiq A.,Vallam P.,Iyer N.S Veksha A.(2021).Life cycle assessment of plastic grocery bags and their alternatives in cities with confined waste management structure: A Singapore case study,Journal of Cleaner Production,278(12):39-56

15.Ashley R., Blackwood D., Souter N., Hendry S., Moir J. & Dunkerley J.(2005). Sustainable disposal of domestic sanitary waste. J Environ Eng 131(2):206–215
16.Assessment and Characterization of Plastic Waste in NCT of Delhi (2020) Department of Environment, Govt. of NCT of Delhi Level 6th C-Wing, Delhi Secretariat I.P.Estate, New Delhi.
17.Awasthi A.K. & Li J.(2017).Management of electrical and electronic waste: acomparative evaluation of China and India. Renew Sust Energ Rev.76:434–447
18.Bahri, G. (2005).Sustainable Management of Plastic Bag Waste: The case of NairobiKenya. Master Thesis, Sweden: Lund University.pp285
19.Bandara, N.J.G.J.,Hettiaratchi, J.P.A., Wirasinghe,S.C. & Pilapiiya, S.(2007). Relation of waste generationand composition to socio-economic factors:A case study. Environmental Monitoring and Assessment,135:31–39
20.Banerjee, T. & Srivastava, R.K.(2009).Plastics waste management and resource recovery in India. International Journal of Environment and Waste Management.8(3):45-58
21.Banerjee, T.,Srivastava, R.K.,Hung & Y.T.(2014).Plastics waste management in India:An integrated solid waste management approach, in handbook of environmental and waste management.2nd edn. Singapore: World Scientific Publishing Co.pp1–32
22.Barnes, D.K.A. & Milner, P.(2005).Drifting plastic and its consequences for sessile organis m dispersal in the Atlantic Ocean.Marine Biology.146:815- 825
23.Bashir, N.H.H.(2013). Plastic problem in Africa, Jpn J. Vet. Res.61:1–11
24.Bernache-Pérez, G., Sánchez-Colón, S.,Garmendia, A. M.,Dávila-Villarreal, A. & Sánchez-Salazar, M. E.(2016).Solid wastecharacterisation study in the Guadalajara metropolitan zone,Mexico, Waste Manage Res.19: 413–424
25.Bernardo C.A., Simões C.L.,Lígia M. & Costa P.(2016).Environmental and economic life cycle analysis of plastic waste management options. A review AIP Conference Proceedings.p 1779
26.Bernardo E.C.(2008).Solid-waste management practices of households in Manila, Philippines. Ann N Y Acad Sci.1140:420-424
27.Bernardo C.,C. Simões & Pinto L.(2016).Environmental and economic life cycle analysis of plastic waste management options.China Journal of Renewable and

Sustainable Energy. 12(10):128-142
28.Bhattacharya S.,Chandrasekhar K. & Deepthi M.V.(2016).Challenges and opportunities: Plastic Waste Management in India. The Energy and Resources Institute (TERI),LodhiRoad,New Delhi.18 pp
29.Bhide, A.D. and Sundaresan, B.B.(1983).Solid Waste Management in Developing 30 Countries, New Delhi: Indian National Scientific Documentation Centre.253 pp
31.Boldrin A. & Christensen T.H.(2009).Seasonal generation and composition of Danish garden waste. Waste Manage.30:551–557
32.Brems A.,Baeyens J. & Dewil R.(2012).Recycling and recovery of post-consumer plastic solid waste in a European context, Thermal Science. Vinča Institute of Nuclear Sciences, Belgrade. 16(3):669– 685
33.Buenrostro O. & Bocco G.(2003).Solid waste management in municipalities in Mexico: goals and perspectives. Resour Conserv Recycl.39(3):251–263
34.Buenrostro O., Bocco G. & Cram S.(2001).Classification of sources of municipal solid wastes in developing countries, Resources Conserv Recycl.32:29–41
35.Burnley S. & Coleman T.(2018).The environmental and financial benefits of recovering plastics from residual municipal waste before energy recovery. Waste Manag.79:79-86
36.Burnley S.J., Ellis J.C., Flower R., Polld A.J.& Prosser H.(2007).Assessing the composition of municipal solid waste in Wales. Resour Conserv Recycl. 49:264–283
37.Burnley, S.J.(2007).A review of municipal solid waste composition in the United Kingdom. Waste Management, 27(10):1274-1285
38.Calero M.L.,María Á.,Godoy V.,Quesada L.,Martínez D.,Peula F. & Soto JM.(2018).Characterization of Plastic Materials Present in Municipal Solid Waste: Preliminary Study For Their Mechanical Recycling Detritus.4:104-112
39.Carson H.,Nerheim M.,Carroll K. & Eriksen M.(2013).The plastic-associated microorganisms of the North Pacific Gyre. Mar Pollut Bull.75: 126– 132
40.Central Pollution Control Board (2012). Material on Plastic Waste Management. Central Pollution Control Board Publications. Parivesh Bhawan, East Arjun Nagar, Delhi. 22 pp
41.Chinnathan A.C., Asingsamanunt J. & Srisawatb S.(2017).Municipal Plastic Waste Composition Study at Transfer Station of Bangkok and Possibility of its Energy Recovery by Pyrolysis. Energy Procedia.107: 222 – 226
42.Dahlén L., & Lagerkvist A.(2008).Review:Methods for household waste composition studies. Waste Management.28:1100–1112
43.Chung S.(2008).Using plastic bag waste to assess the reliability of self-reported waste disposal data.Waste Management.28:2574–2584
44.Chung S.S. & Poon, C.S.(2001).Characterization of municipal solid waste and its

recyclable contents of Guangzhou. Waste Management Research.19:.473-485
45.Cimpan C., Maul A.,Wenzel, H.& Pretz, T.(2016).Techno-economic assessment of central sorting at material recovery facilities the case of lightweight packaging waste. J. Clean. Prod. 112: 4387–4397
46.Converting waste plastics into a resource assessment guidelines (2009).UNEP DTIE,United Nations Environment Programme, Division of Technology, Industry and Economics,International Environmental Technology Centre,Osaka.2-110 Ryokuchi Koen, Tsurumi-ku,Osaka.apan.63pp
47.CPCB.(2012).Status report on municipal solid waste management.Ministry of Environmentand Forest (MoEF), New Delhi, India.13pp
48.CPCB.(2015).Annual report for the year 2015-16 on Implementation of Plastic Waste Management Rules.Central pollution control board Ministry of Environment, Forest and Climate Change, Govt. of India Parivesh Bhawan, East Arjun Nagar Delhi.18pp
49.Dahlbo H, Poliakova V, Mylläri V, Sahimaa O. & Anderson R.(2018) Recycling potential of post-consumer plastic packaging waste in Finland. Waste Manag.71:52-61
50.Damghani A.M, Savarypour G. & Deihimfard R.(2008).Municipal solid waste management in Tehran: current practices, opportunities and challenges. Waste Manag. 28(5):929-34
51.Dangi M.B, Pretz C.R.,Urynowicz M.A., Gerow K.G. & Reddy J.M.(2011).Municipal solid waste generation in Kathmandu, Nepal. J Environ Manage.92(1):240-249
52.Degnan T. & Shinde S.L.(2019).Waste-plastic processing provides global challenges and opportunities. MRS Bulletin.44(6):436-437
53.Dennison G.J., Dodd V.A. & Whelan B.(1996).A socioeconomic based survey of household waste characteristics in the city of Dublin Ireland. I. Waste composition. Resource. Conserv Recycl.17:227–244
54.Derraik, G.B (2002).Marine Pollution Bulletin.44: 842- 852
55.Drzyzga O. & Prieto A.(2019).Plastic waste management,a matter for the community.Microb Biotechnol.12(1):66
56.Duncan E., Broderick CA., Fuller WJ. & Galloway S.T.(2018).Micro plastic ingestion ubiquitous in marine turtles.Global Change Biology.25:145-163
56.Eduardo J.P.,Deborah S.B.L. & Barbara S.(2021).Life cycle comparative assessment of pet bottle waste management options: A case study for the city of Bauru, Brazil. Waste Management.(119):226-234
57.Environmental Protection Agency, EPA (1994).Characterization of municipal solid waste in theUnited States. http://www.epa.gov

58.Eriksen, M.(2014).Plastic pollution in the world’s oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS One. 9(12):1-15
59.Faraca G. & Thomas A.(2019).Plastic waste from recycling centres: Characterisation and evaluation of plastic recyclability. Waste Manag. 15(95):388-398
60.Faraca G., Edjabou V.E., Boldrin A. & Astrup, T.(2019).Combustible waste from recyclingcentres – characterization, recycling potentials and contribution to environmental savings. Waste Manage.89:354–365
61.Faure F., Demars C.,Wieser O.,Kunz,M. & Alencastro, L.F.(2015).Plastic pollution in Swiss surface waters: nature and concentrations, interaction with pollutants. Environmental.Chemistry.12(5):582–591
62.Forrest M.J.,Jolly A.M.,Holding S.R. & Richards S.J.(1995).Emissions from processing thermoplastics. Ann. Occup. Hyg. 39:35– 53
63.Foster S.(2008).An assessment of technical, environmental and economic viability of recycling domestic mixed plastics packagingwaste in UK. Waste & Resources Action Programme,Banbury.
64.Galgani F., Hanke G. & Maes T.(2015).Global distribution, composition and abundanceof marine litter. In M. Bergmann, L. Gutow, L. & M. Klages, eds. Marine Anthropogenic Litter, Cham, Switzerland, Springer International Publishing.pp 29-56
65.Gasperi J., Dris R., Bonin T., Rocher V. & Tassin, B.(2014).Assessment of floating plastic debris in surface water alongthe Seine River. Environmental Pollution.195: 163–166
66.Gene A., Zeydan O. & Sarac S.(2019).Cost analysis of plastic solid waste recycling in an urban district in Turkey. Waste Manag Res.37(9):906-913
67.Gent R.M., Menendez M., Torano J. & Toro, S.(2011).Optimization of recovery of plastics for recycling by density media separation.Resour. Conserv.Recycl.55:472–482
68.Geyer R., Jambeck J.R. & Law, K.L.(2017).Production, use, and fate of all plastics ever made. Sci. Adv. 3(7):1-5
69.Gidarakos E., Havas G. & Ntzamilis P.(2006) Country report: municipal solid waste composition determination supporting the integrated solid waste management system in the island of Crete. Waste Manage.26:668–679
70.Giugliano M., Cernuschi S., Grosso M. & Rigamonti L.(2011).Material and energyrecovery in integrated waste management systems. An evaluation based on lifecycle assessment. Waste Manag. 31: 2092–2101
71.Gomez G., Meneses M., Ballinas L. & Castells F.(2009).Seasonal characterization of municipal solid waste (MSW) in the city of Chihuahua, Mexico.

Waste Manag. 29:2018–2024
72.Gourmelon G.(2015).Global Plastic Production Rises. Recycling Lags. Worldwatch Institute.7 pp
73.Grazhdani D.(2016).Assessing the variables affecting on the rate of solid waste generation and recycling: An empirical analysis in Prespa Park. Waste Manag.48:3-13
74.Grossmann D., Hudson, J. F. & Marks D.H.(1974). Waste generation models for solid waste collection. Journal ofthe Environmental Engineering Division.100: 1219–1230
75.Gwada B.,G. Ogendi.,S.M.,Makindi & S. Trott.(2019).Composition of plastic waste discarded by households and its management approaches.Global J. Environ. Sci. Manage. 5(1): 83-94
76.Halden R.U.(2010).Plastics and Health Risks. Annu. Rev. Public Health. 31:179-194
77.Hans G.E.(1993).An Introduction to Plastics.Wiley,Weinheim Boschstrasse, Germany.409pp
78.Harris M.E. & Walker B.(2010).A Novel, Simplified Scheme for Plastics Identification. American Chemical Society and Division of Chemical Education, Inc.Journal of Chemical Education. 87(2):38-52
79.Hartmann N.B.,Rist S.,Bodin J.,Jensen L.H.S., Schmidt S.N.,Mayer P., Meibom A.& Baun A.(2017).Microplastics as Vectors for Environmental Contaminants: Exploring Sorption, Desorption, and Transfer to Biota. Integr. Environ. Assess. Manag.13 (3):488-493
80.Hassan M.N., Rahman R.A., Chong T.L., Zakaria Z. & Awang M. (2000).Waste recycling in Malaysia: problems and prospects. Waste Manage Res.18(4):320–328
81.Hazra T. & Goel S.(2009).Solid waste management in Kolkata, India: practices and challenges. Waste Manag.29(1):470-8
82.Hockett D.,Lober D.J. & Pilgrim K.(1995).Determinantsof per capita municipal solid waste generation in the subeasternUnited States. Journal of Environmental Management,45:205–217
83.Hoornweg D.& Bhada-Tata P.(2012).What a waste a global review of solid waste management. World Bank
84.Hopewell H., Robert D.R. & Edward K.E.(2009).Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society.364 (1526):2115–2126
85.Horn O.,Nalli S.,Cooper D. & Nicell J.(2004).Plasticizer metabolites in the environment. Water Research.38(17):3693-3698
86.Huq M.S.T.(2015).Environmental Challenges of Plastics Waste in Bangladesh

(2017).Plastic Waste Management for Sustainable Urbanization in Asia:Lessons from experiences of Japan.Asia Petrochemical Industry Conference. pp 1–44
87.ICPE(2006). Indian Center for Plastics in Environment Ministry of Environment, Forests and Climate Change, Government of India.17(4).12
88.Islam MS (2011b) Prospects and challenges of plastic industries in Bangladesh. J Chem Eng C(1):16–21
89.Ismail Z.Z. & Hashmi, A.L.(2008).Use of waste plastic in concrete mixture as 40 aggregate replacement. Waste Management 28: 2041–2047
90.Jadoon A, Batool S.A. & Chaudhry M.N.(2014).Assessment of factors affecting household solid waste generation and its composition in Gulberg Town, Lahore, Pakistan. J Mater Cycles Waste Manag.16:73–81
91.Jambeck J.R., Geyer R., Wilcox C., Siegler T.R., Perryman M., Andrady A., Narayan R. & Law K.L.(2015).Marine pollution. Plastic waste inputs from land into the ocean. Science.13;347(6223):768-771
92.Jang Y.C., Hong S., Lee J., Lee M.J. & Shim W.J.(2014).Estimation of lost tourism revenue in Geoje Island from the 2011 marine debris pollution event in South Korea.Mar. Pollut. Bull.81 (1): 49–54
93.Lee H., Shim W.J. & Kwon J.H.(2014).Sorption capacity of plastic debris for hydrophobic organic chemicals. Sci. Total Environ.471:1545- 1552
94.Jayasiri H.B.,Purushothama, C.S., & VennilaA.(2013).Quantitative analysis of plastic debris on recreational beaches in Mumbai, India. Marine Pollution Bulletin. 77:107–112
95.Jhansi Municipal Corporation (2015-16). Detailed project report on plastic waste management Jhansi, Uttar Pradesh. 2015-201.149pp
96.Jin J.,Wang Z. & Ran S.(2006).Solid waste management in Macao: practices and challenges. Waste Manage.26:1045–1051
97.Joshi R. & Ahmed S.(2016).Status and challenges of municipal solid waste. Management in India: A review. Cogent Environmental Science.2(1):1-18
98.Kamala R.(2013). Evaluation of plastic waste management in Thailand using material flow analysis. Master's thesis. Bangkok, Asian Institute of Technology.326 pp
99.Kamran A., Chaudhry M.N.& Batool S.A.(2015).Effects of socio-economic status and seasonal variation on municipal solid waste composition: a baseline study for future planning and development.Environ Sci Eur.27(16):1-8
100.Kaza S., Yao L., Bhada-Tata P. & Van W.F.(2018).What a waste 2.0: a global snapshot of solid waste management to 2050. Urban development.Washington D.C.The World Bank.272pp
101.Khajuria A., Yamamoto Y. & Morioka T.(2010).Estimation of municipal solid

waste generation and landfill area in Asian developing countries. J Environ Biol. 31:649–654

102.Khan D., Kumar A. & Samadder S.R.(2016).Impact of socioeconomic status on municipal solid waste generation rate. Waste Manag.49:15-25

103.Koelmans A.A., Bakir A. & Burton G.A.(2016).Microplastic as a Vector for Chemicals in the Aquatic Environment:Critical Review and Model-Supported Reinterpretation of Empirical Studies. Environmental Science and Technology,50:3315−3326

104.Krishna S.,S.Anbalagan K.Kasilingam P.Smrithi S. & Anbazhagi, S.(2020).Assessment of plastic debris in remote islands of the Andaman and Nicobar Archipelago, India. Marine Pollution Bulletin. 151:110841

105.Kumar A., Samadder S.R., Kumar N. & Singh C.(2018).Estimation of the generation rate of different types of plastic wastes and possible revenue recovery from informal recycling. Waste Manag.79:781-790

106.Kumar A. & Samadder S.R.(2017).An empirical model for prediction of household solid waste generation rate - A case study of Dhanbad, India. Waste Manag.68:3-15

107.Kumar R.V., Sharma H.B., Ranjan V.P., Samal B., Bhattacharya J.,Dubey B.K. & Goel S.(2021).Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic Science of The Total Environment.750:141514

108.Kumar S., Panda A.K. & Singh R.K.(2011). A review on tertiary recyclingof high-density polyethylene to fuel. ResourConservRecycl.55(11):893–910

109.Kumar S, Bhattacharyya J.K., Vaidya A.N., Chakrabarti T., Devotta S. & Akolkar A.B.(2009).Assessment of the Status of Municipal SWM in Metro Cities, State Capitals, Class I Cities, and Class II Towns in India: An Insight'. Waste Management.29 (2): 883–95

110.Lahtela V.,Hyvärinen H. & Kärki T.(2019).Composition of Plastic Fractions in Waste Streams: Toward More Efficient Recycling and Utilization. Polymers. 11:69

111.Laist, D.W.(1997).Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J. M. and D. B. Rogers (Eds.), Marine Debris:Sources, Impacts and Solutions. Springer-Verlag.pp 99-139

112.Lazarevic D., Aoustin E., Buclet N. & Brandt N.(2010).Plastic waste management in the context of a European recycling society: Comparing results and uncertainties in a life cycle perspective. Resour. Conserv. Recycl.55:246–259

113.Lebreton L., Slat B. & Ferrari F.(2018).Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Scientific Reports.8:1-15

114.MacArthur Ellen Foundation (2016).The New Plastics Economy .Rethinking the future of plastics: McKinsey & Company.60 pp
115.Tsakona M. & Rucevska I.(2020).Baseline report on plastic waste.Plastic Waste Partnership working group First meeting Beau Vallon, Seychelles..61pp
116.Martin C.M.B.,Maria AU.,Ana P.R. & Nicolás G.(2017).Plastic pollution in freshwater ecosystems:macro,meso,and microplastic debris in a floodplain lakeEnviron Monit Assess 189:581
117.Medina M.(1997).The effect of income on municipalsolid waste generation rates for countries of varyinglevels of economic development: A model. Journal of Resource Management and Technology.24(3):149–155
118.Melzer D., Rice N.E. & Lewis C.(2010).Association of urinary bisphenol a concentration with heart disease.PLoS One.5 (1):1-9
119.Molgaard C.(1995).Environmental impacts by disposal of plastic from municipal solid waste. Resources, Conservation and Recycling.15(5): l–63
120.Monjur M., Mahadi H., Fazlur R. & Mohammad U.(2017).Towards the effective plastic waste management in Bangladesh: a review. Environ Sci Pollut Res. 24:27021–27046
121.Moore C., Lattin G. & Zellers A.(2011).Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. Journal of Integrated Coastal Zone Management.11:65–73
122.Morritt D., Stefanoudis P.V., Pearce D.,Crimmen, A. & Clark P.F.(2014).Plastic in the Thames: a river runs through it.Marine Pollution Bulletin.78:196–200
123.Mudgal S., Lyons L. & Bain J.(2011).Plastic Waste in the Environment– Revised Final Report for European Commission DG Environment. Bio Intelligence Service
124.Munir E., Harefa R.S.M. Priyani, N. & Suryanto, D.(2018). Plastic degrading fungi Trichoderma viride and Aspergillus nomius isolated from local landfill soil in Medan. IOP Conf Series: Earth Environ Sci.126:1-7
125.Nabeel BI.(2010).Management of PET Plastic BottlesWaste Through Recycling inKhartoum State.Sudan Academy of ScienceEngineering Research and Industrial Technology Council.74 pp
126.Narayan, P.(2001).Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles. IIIEE. Lund University, Sweden.pp 24-25
127.Nnorom I.C. & Osibanjo O.(2008).Sound Management of Brominated Flame Retarded (BFR) Plastics from Electronic Wastes: State ofthe Art and Options in Nigeria. Resour Conserv Recycl 52(12):1362–1372
128.Norful M.,Yuanyuan., Maalla Z. & Adipah S.(2020).Determinants of Household Solid Waste Generation and Composition in Homs City, Syria. J Environ Public

Health.2020:1-15
129.NPWMTF (1997).National Plastics Waste Management Task Force (NPWMTF) 16 Report, Ministry of Environment and Forest, Government of India, New Delhi.
130.Odhiambo O.R.,Musalagani A.C., Lyanda N.J. & Songok J.R.(2014).The plastic waste menace in Kenya : A Nairobi city situation, Int. J. Curr. Res. 6(4): 6175–6179
131.Olusola O.A.,Sisanda D.O. & Jeremiah A.(2020).Challenges of plastic waste generation and management in sub-Saharan Africa: A review. Waste Management.110: 24-42

132.Ombis L.A.(2012).Managing Plastic Waste in Urban Kenya.PhD thesis, Wageningen University, Wageningen, NL.277 pp
133.Paco A.,Duarte K.,Da Costa J.P.,Santos P.S.M., Pereira R. & Pereira M.E.(2017).Biodegradation of polyethylene microplastics by the marine fungus Zalerion maritimum. Sci Total Environ.586:10–15
134.Payne J., Paul M. & Matthew D.(2019).A circular economy approach to plastic waste Polymer Degradation and Stability..165: 170-181
135.Pivnenko K.,Eriksen M.K.,Martín-Fernández J.A.,Eriksson E. & Astrup T.F.(2016).Recycling of plastic waste: Presence of phthalates in plastics from households and industry. Waste Manag.54:44-52
136.Pivnenko K.,Jakobse,L.G.,Eriksen M.K., Damgaard A. & Astrup T.F.(2015). Challenges in plastics recycling. In: Margherita diPula S. (ed.) Proceedings Sardinia 2015: 15th international waste management and landfill symposium Cagliari, Italy. CISA Publisher,Padova,Italy. pp 47-51
137.Planning Commission Report.(2014).Reports of the task force on waste to energy (Vol-I) (in the context of Integrated MSW management).154pp
138.Plastics Europe (2014).Plastics:The Facts 2014: An analysis of European plastics production, demand and waste data. Plastics Europe Report.259 pp
140.Pollution Control Department (2017).Thailand State of Pollution Report 2016. Bangkok. No. 06-065
141.Putri A R.,Takashi F. & Masaki T.(2018).Plastic waste management in Jakarta, Indonesia: evaluation of material flow and recycling scheme. Journal of Material Cycles and Waste Management 20:2140–2149
142.PWM Rues (2016).Annual report for the year 2015-16 on Implementation of Plastic Waste Management Rules.Central pollution control board Ministry of Environment, Forest and Climate Change, Govt. of India PariveshBhawan, East Arjun Nagar,Delhi.

143.Qiang M.,Shen M. & Xie H.(2019). Loss of tourism revenue induced by coastal environmental pollution: a length-of-stay perspective. Journal of Sustainable Tourism. 28:1-18
144.Qu X.Y.,Li Z.S., Xie X.Y., Sui Y.M., Yang L. & Chen Y.(2009).Survey of composition and generation rate of household wastes in Beijing, China. Waste Manag.29(10):2618-24
145.Ramesh V., Biswal M., Mohanty S & Nayal S.K.(2010).Recycling engineering plastics from waste electrical and electronic equipment:Influence of virgin polycarbonate and impact modifier on final performance of blends. Waste Manage. Res. 32:379–388
146.Raynaud J.(2014).Valuing plastics: the business case for measuring. Managing and disclosing plastic use in the consumer goods industry.UNEP.116pp
147.Rewlutthum K.(2013).Evaluation of plastic waste management in Thailand.Asian Institute of Technology, Thailand.173pp
148.Rhyner C.R.(1992).Monthly variations in solid waste generation. Waste Manag Res 10:67–71
149.Rigamonti L., Grosso M. & Giugliano M.(2010).Life cycle assessment of sub-units composing a MSW management system. J. Clean. Prod.18:1652–1662
150.Sadri S.S & Thompson R.C.(2014).On the quantity and composition of floating plastic debris entering and leaving the Tamar Estuary, Southwest England. Marine Pollution Bulletin. 81:55–60
151.Selke M.(2003).Plastics in packaging.In A. L. Andrady. (Eds.), Plastics and the environment.John Wiley and Sons.pp139- 184
152.Seng B., Kaneko H., Hirayama K. & KatayamaH.K.(2011).Municipal solid waste management in Phnom Penh, capital city of Cambodia. Waste Manag Res.29 (5):491-500
153.Shaato R., Aboho S.Y., Oketunde F.O., Eneji I.S. & Unazi G.(2007).Survey of solid waste generation and composition in a rapidly growing urban area in Central Nigeria. Waste Manag.27(3):352-8
154.Sharholy M., Ahmad K., Mahmood G. & Trivedi R.C.(2018).Municipal Waste Management in Indian Cities: A Review'.Science Direct Waste Management 28: 459–67
155.Singh P. & Sharma V.P.(2016).Integrated plastic waste management: environmental and improved health approaches. Proc Environ Sci.35:692–700
156.Srivastava A.,Jain R.K.,Patel M.L. & Saxena A.(2010).Assessment of Plastic Waste Generation and Inventorization of Plastic Manufacturing Units in Madhya Pradesh. Journal of Solid Waste Technology & Management.36(1):620-630
157.Strapasson R.,Amico S.C., Pereira M.F.R. & SydenstrickerT.H.D.(2005).Tensile

and impact behavior of polypropylene/low polyethylene blends. Polym. Test. 24:468–473

158.Subramanian P.M.(2000).Plastics recycling and wastemanagement in the US.Resources, Conservation andRecycling.28: 253–263

159.Sujauddin M., Huda M.S. & Hoque R.(2008)Householdsolid waste characteristics and management in Chittagong,Bangladesh. Waste Manage. 28:1688–1695

160.Tanmoy K.,Bhagat R.,M. & Bhattacharyya P.(2012).Municipal Solid Waste Generation, Composition, and Management: The World Scenario, Critical Reviews in Environmental Science and Technology.42(15):1509-1630

161.Thanh N.P.,Yasuhiro M. & Takeshi F.(2011).Assessment of plastic waste generation and its potential recycling of household solid waste in Can Tho City, Vietnam. Environ Monit Assess.175:23–35

162.Thanh N.P., Matsui Y. & Fujiwara T.(2011).Household solid waste generation and characteristic in a Mekong Delta city, Vietnam. J Environ Manage.91(11):2307-21

163.Thompson R.C.,Charles J.M.,Frederick S.V.S. & Shanna H.S.(2009).Plastics, the Environment and Human Health:current consensus and future trends.The Royal Society: 2153-2166

164.Tomar V.S. & Dadoriya NS.(2013).Environment solid waste management in Gwalior. Glob Res Anal.2(4):149–151

165.Tsakona M., Rucevska I.(2020).Baseline report on plastic waste. UNEP Secretariat.54 pp

166.USEPA(1990).Methods to manage and control plastic wastes. Report to congress.pp 89-051

167.UNEP(2018).Single-use Plastics. A Roadmap for Sustainability, United Nations Environment Programme.

168.UNEP.(2006).Ecosystems and Biodiversity in Deep Waters and High Seas. UNEP Regional Seas Reports and Studies No. 178. UNEP/ IUCN, Switzerland.

169.USEPA.(2000).Municipal Solid Waste in the United States: 2000. Facts and Figures.Executive Summary. Office of solid waste management and emergency response.320pp

170.Valentina B., Paola F.A., Thomas F.A., Anders D.(2018). Life Cycle Assessment of grocery carrier bags.The Danish Environmental Protection AgencyEnvironmental Project no. 1985.144 pp

171.Wahab D.A.,Abidin A.,Azhari C.H.(2007).Recycling trends in the plastics manufacturing and recycling companies in Malaysia. J Appl Sci 7(7):1030–1035

172.Wertz, K.L.(1976). Economic factors influencing households'reproduction of

refuse. Journal of Environmental Economics and Management 2:263–272
173.Wichai N. & Chavalparit O.(2019).3Rs Policy and plastic waste management in Thailand Journal of Material Cycles and Waste Management. 21:10–22
174.Wierckx N.,Narancic T.,Eberlein C., Wei R., Drzyzga O. & Magnin, A.(2018) Plastic biodegradation: Challenges and opportunities. In Handbook of Hydrocarbon and Lipid Microbiology Series. Consequences of Microbial Interaction with Hydrocarbons, Oils and Lipids: Biodegradation and Bioremediation. Steffan, R. (ed.). Cham: Springer.794pp
175.Matthews V.(1993).Overview of Plastics Recycling in Europe Plastics, Rubber, and Composites Processing and Applications.19:197-204
176.Wilson D.C.(2015).Global Waste Management Outlook,International Solid Waste Association and United National Environment Programme:54pp
177.Wilson, D.C.(2009).Building recycling rates through the informal sector", Waste Management,29(2):629-635
178.Woods J.S.,Rodder G. & Verones.F.(2019).An effect factor approach for quantifying the entanglement impact on marine species of macroplastic debris within life cycle impact assessment Ecological Indicators.99: 61-66
179.Zbyszewski M. & Corcoran P.L.(2011).Distribution and degradation of freshwater plastic particles along the beaches of Lake Huron, Canada. Water Air Soil Pollution.220, 365-372
180.Zeng Y., Trauth K.M., Peyton R.L. & Banerji S.K.(2005).Characterization of solid waste disposed at Columbia Sanitary Landfill in Missouri. Waste Manage Res.23(1): 62–71
181.Zhang H. & Wen Z.G.(2014).The consumption and recycling collection system of PET bottles: a case study of Beijing, China. Waste Manag.34(6):987-98

Appendix 1: Gross plastic waste generation (kg) in South Locality during 2017-18

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
lalrinthara	8	1.92	2.01	1.80	2.36	1.31	1.50	1.33	1.87	1.51	15.62
J.Malsawmtluanga	4	2.17	2.24	2.11	2.43	2.68	1.32	1.56	1.92	1.26	17.69
lalnunzira	3	1.83	2.01	1.89	2.93	1.55	1.53	2.30	2.47	1.46	17.97
Thansela	4	2.48	2.74	2.63	2.54	2.46	2.99	2.04	2.10	2.87	22.85
Lathanzuala	7	3.60	1.78	1.59	3.02	2.73	2.90	3.17	2.45	2.81	24.06
H B Vanlalhriata	5	3.57	4.35	4.07	1.85	3.95	3.81	2.97	1.46	3.66	29.69
Lalmingmawia	6	5.10	5.42	5.21	5.31	4.32	3.16	4.61	4.77	3.14	41.05
Zadawla	7	1.86	2.46	2.33	1.27	2.47	1.53	1.34	0.92	1.44	15.62
Zothanpuia	6	1.57	2.57	2.40	2.41	3.33	2.24	1.16	1.89	2.16	19.71
Gospelthanga	4	2.33	2.53	2.38	1.79	3.30	1.80	1.93	1.39	1.73	19.17
S Thalthluanga	10	4.61	5.38	5.14	4.80	4.03	4.01	4.00	4.32	3.91	40.20
Lalbiakfela	5	1.63	1.43	1.14	3.87	4.42	1.13	1.11	3.35	0.95	19.02
H K Lalsanzuala	8	4.27	2.91	2.68	3.77	3.62	3.71	3.74	3.29	3.65	31.63
Robert Lalduhawma	3	1.33	1.85	1.60	2.87	1.50	0.85	0.71	2.34	0.82	13.85
Vanlalvena	5	3.72	3.63	3.43	3.05	3.07	2.97	3.17	2.66	2.91	28.62
Lalawmpuia	4	1.02	1.03	0.77	1.40	1.64	1.70	0.45	0.91	1.57	10.48
Lalhmingliana Hmar	8	2.30	1.95	1.77	1.38	3.51	3.27	1.84	0.96	3.17	20.14
Vanlalruata	6	4.44	5.32	5.20	5.68	3.56	4.28	3.91	5.31	4.16	41.87
C malsawma	5	3.28	3.02	2.80	3.04	3.74	3.81	2.69	2.60	3.78	28.76
F Remthanga	6	1.91	1.99	1.81	2.50	1.42	2.25	1.36	2.08	2.07	17.39
H Lalringheta	8	3.63	4.93	4.71	2.82	3.09	3.27	3.15	2.34	3.18	31.12
H S Lalremsiama	3	2.28	1.95	1.87	3.96	2.42	2.52	1.65	3.45	2.33	22.44
Rotluanga	3	2.47	2.83	2.64	2.01	3.98	1.98	2.01	1.57	1.92	21.40
Laldingliana	7	4.72	6.28	6.19	2.96	4.21	4.31	4.17	2.43	4.14	39.41
Lalthanzova	2	2.16	1.94	1.69	1.86	1.81	1.79	1.64	1.42	1.68	15.99
LV Zothansanga	6	1.26	1.98	1.84	0.77	1.78	0.71	0.68	0.24	0.74	9.99
M B Sahi	3	0.71	3.41	3.20	1.25	1.01	0.80	1.51	0.76	0.66	13.30

Henry Lalfakawma	6	3.65	3.70	3.59	2.81	2.92	5.81	3.20	2.31	5.78	33.77
Lalruatpuia	3	2.13	2.34	2.18	2.97	2.40	1.76	1.58	2.37	1.73	19.46
Zothantluanga	10	5.05	6.32	6.03	5.71	4.13	4.88	4.50	5.27	4.72	46.61
Vanalzauva	3	4.76	4.46	4.21	5.07	3.98	3.79	4.32	4.69	3.83	39.10
Lalsiamliana	8	3.93	6.41	6.22	2.50	5.35	3.81	3.38	2.05	3.69	37.34
F Lalpekhlua	9	2.14	1.95	1.81	1.34	1.89	2.01	1.57	0.87	1.97	15.55
Lalbiaksanga	5	3.20	3.04	2.81	2.51	3.08	2.43	2.68	1.94	2.38	24.05
R Lalfakzuala	7	1.29	3.37	3.27	0.45	0.62	0.71	0.75	0.83	0.62	11.89
Simon Barzon	6	5.23	4.47	4.24	4.08	5.89	3.74	4.68	3.67	3.70	39.70
R C Ramdinthara	5	2.59	3.47	3.18	2.83	3.86	1.83	2.03	2.30	1.73	23.82
Paul Zoramthanga	5	4.70	4.49	4.17	2.98	3.09	3.48	4.15	2.41	3.34	32.80
V lalremruata	3	2.21	3.46	3.29	2.31	1.55	2.44	1.66	1.75	2.28	20.94
Rammuansanga	6	3.36	3.63	3.47	1.98	2.93	2.74	2.73	1.58	2.71	25.13
P C Lalruatzela	4	1.71	2.27	2.08	1.24	2.37	1.41	1.19	0.81	1.39	14.47
Rumliana	7	4.13	4.77	4.64	5.94	3.00	3.81	3.62	5.41	3.76	39.08
David Lalremsiama	4	1.59	1.39	1.15	1.43	0.74	1.38	0.97	0.85	1.16	10.66
S Kamliana	5	4.67	4.36	4.17	3.14	3.20	2.85	4.02	2.75	2.76	31.91
David Lalremruata	8	2.61	3.34	3.28	2.96	2.59	1.55	2.05	2.40	1.35	22.13
Immanuel	3	2.15	2.10	1.92	1.55	4.00	3.02	1.53	1.09	2.90	20.27
J malsawma	6	4.62	4.46	4.29	7.97	2.38	5.63	4.05	7.39	5.60	46.38
Lalruatfela	5	2.26	2.60	2.43	1.38	1.94	1.32	1.75	0.79	1.22	15.68
Z D Thanglura	7	4.52	3.05	2.77	4.90	8.91	3.87	3.89	4.42	3.84	40.16
Richard Lalenkawla	6	4.19	3.62	3.45	5.96	3.30	2.78	3.72	5.44	2.70	35.16
Lalrintluanga	4	2.49	2.29	2.15	3.01	2.44	1.70	1.99	2.56	1.69	20.32
L T Lala	4	2.33	2.40	2.28	2.11	2.10	2.08	1.84	1.49	1.91	18.54
R D Lalremruata	3	1.90	1.46	1.21	1.79	1.88	1.31	1.28	1.23	1.14	13.19
T K Lama	7	2.93	4.45	4.31	2.22	2.31	4.31	2.39	1.74	4.20	28.86
Lalramchhana	5	3.57	3.33	3.20	3.41	5.02	2.89	3.00	2.97	2.79	30.18
Daniel Lalremruata	5	3.65	3.36	3.22	4.04	3.79	3.87	3.19	3.55	3.86	32.52
Lalrinchhana	3	4.89	4.31	4.05	3.87	3.91	3.67	4.28	3.47	3.59	36.05
R Malsawmdawngliana	8	2.47	2.52	2.34	2.02	1.84	1.02	1.89	1.56	0.94	16.60
B K Rana	5	4.57	8.37	8.18	2.11	3.41	2.82	4.15	1.57	2.68	37.85
Vanlalruata	6	3.73	4.43	4.17	3.80	2.98	4.88	3.14	3.27	4.74	35.14
Lalchhuangliana	2	3.42	1.75	1.64	2.05	1.90	3.37	2.77	1.64	3.19	21.75
Ricky Zorempela	5	2.85	3.36	3.22	5.25	1.77	2.38	2.30	4.79	2.17	28.10

Laltlansanga	6	3.95	9.48	9.19	3.85	1.97	2.77	3.40	3.38	2.60	40.57
Lalrosanga	9	4.94	3.87	3.69	7.25	2.81	3.90	4.48	6.82	3.83	41.60
Sainghniga	5	1.73	4.41	4.24	3.31	1.89	1.09	1.28	2.80	1.01	21.77
Francis Lalruatzela	2	2.19	14.89	14.65	2.81	2.95	2.00	1.63	2.33	1.88	45.33
F Rintluanaga	8	4.58	9.41	9.22	2.95	4.50	5.83	4.01	2.37	5.79	48.65
Zorinsanga	4	3.38	1.96	1.75	2.69	2.36	3.24	2.87	2.27	3.07	23.58
T Lalmawia	6	1.08	1.65	1.57	2.44	2.02	0.82	0.59	1.90	0.70	12.78
J lalruatsanga	1	4.59	3.80	3.57	2.17	7.90	4.22	4.12	1.68	4.17	36.23
Lalrinliana Tlau	6	2.11	1.65	1.49	2.37	2.37	1.60	1.61	1.80	1.57	16.59
Zoliankhuma	8	5.34	2.27	2.13	1.74	2.48	9.71	4.83	1.22	9.75	39.47
Vanlalpianruala	9	0.76	1.53	1.25	0.98	0.75	0.93	1.51	0.59	0.84	9.13
Lalmalsawma	4	3.81	4.96	4.85	2.60	2.99	2.58	3.20	1.96	2.38	29.33
Joseph Vanlalsanga	6	1.64	2.44	2.25	1.78	0.91	2.11	1.22	1.31	1.95	15.59
Zonatahn Zaithanunga	9	4.99	4.27	4.16	7.95	2.88	4.82	4.42	7.44	4.73	45.66
Laldingliana	4	5.16	3.58	3.49	2.99	5.21	5.92	4.66	2.40	5.74	39.14
414 members		**3.09**	**3.57**	**3.39**	**3.01**	**2.97**	**2.84**	**2.60**	**2.53**	**2.75**	***2059.60***

Appendix 2: Gross plastic waste generation (kg) in South Locality during 2018-19

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
lalrinthara	8	2.12	2.17	1.91	2.55	1.56	1.57	1.43	2.14	1.48	16.93
J.Malsawmtluanga	4	2.16	2.43	2.23	2.62	2.70	1.43	1.69	2.02	1.41	18.68
lalnunzira	3	1.92	2.23	1.98	2.95	1.75	1.58	2.40	2.46	1.66	18.94
Thansela	4	2.61	3.00	2.70	2.81	2.65	3.19	2.03	2.32	3.07	24.37
Lathanzuala	7	3.83	1.85	1.79	3.04	3.00	2.98	3.30	2.69	2.99	25.47
H B Vanlalhriata	5	3.64	4.50	4.16	2.04	4.11	3.95	3.27	1.46	3.87	31.00
Lalmingmawia	6	5.36	5.54	5.48	5.44	4.37	3.30	4.74	4.95	3.32	42.49
Zadawla	7	1.96	2.73	2.45	1.40	2.76	1.75	1.40	1.08	1.63	17.16
Zothanpuia	6	1.85	2.76	2.57	2.50	3.42	2.45	1.18	2.06	2.31	21.09
Gospelthanga	4	2.60	2.60	2.50	2.03	3.34	1.97	1.93	1.51	1.83	20.31
S Thalthluanga	10	4.79	5.47	5.36	4.82	4.18	4.21	4.13	4.39	3.99	41.33
Lalbiakfela	5	1.84	1.52	1.22	3.99	4.41	1.28	1.25	3.55	1.14	20.21

H K Lalsanzuala	8	4.39	3.13	2.80	3.98	3.68	3.94	3.75	3.37	3.72	32.77
Robert Lalduhawma	3	1.54	1.87	1.81	2.95	1.62	0.94	0.84	2.42	0.86	14.86
Vanlalvena	5	3.85	3.72	3.56	3.24	3.08	3.04	3.34	2.65	3.05	29.53
Lalawmpuia	4	1.12	1.05	0.87	1.48	1.66	1.90	0.63	1.04	1.75	11.49
Lalhmingliana Hmar	8	2.49	2.17	1.97	1.51	3.79	3.45	1.88	1.04	3.32	21.60
Vanlalruata	6	4.60	5.49	5.28	5.98	3.70	4.37	4.18	5.31	4.38	43.28
C malsawma	5	3.37	3.15	2.96	3.30	3.82	3.95	2.79	2.73	3.90	29.95
F Remthanga	6	2.00	2.11	1.93	2.63	1.51	2.38	1.41	2.16	2.36	18.50
H Lalringheta	8	3.88	5.10	4.88	2.96	3.17	3.30	3.24	2.57	3.35	32.44
H S Lalremsiama	3	2.42	2.06	1.96	4.15	2.53	2.70	1.72	3.61	2.57	23.71
Rotluanga	3	2.58	2.99	2.71	2.29	4.15	2.01	2.22	1.75	2.10	22.80
Laldingliana	7	5.00	6.47	6.17	3.07	4.36	4.48	4.31	2.68	4.25	40.79
Lalthanzova	2	2.26	2.00	1.80	2.07	1.83	1.82	1.82	1.50	1.86	16.97
LV Zothansanga	6	1.43	2.21	2.04	0.92	1.92	0.99	0.84	0.48	0.90	11.72
M B Sahi	3	0.73	3.50	3.34	1.28	1.07	0.80	1.77	0.93	0.79	14.22
Henry Lalfakawma	6	3.94	3.92	3.70	2.95	3.13	5.93	3.34	2.59	5.81	35.30
Lalruatpuia	3	2.31	2.54	2.32	3.00	2.48	1.92	1.82	2.61	1.88	20.87
Zothantluanga	10	5.13	6.43	6.17	5.80	4.23	4.93	4.62	5.30	4.95	47.56
Vanalzauva	3	4.91	4.65	4.33	5.18	4.04	4.07	4.43	4.80	3.94	40.35
Lalsiamliana	8	4.12	6.52	6.44	2.66	5.36	4.07	3.56	2.09	3.87	38.68
F Lalpekhlua	9	2.35	2.04	1.88	1.63	2.03	2.16	1.70	1.04	2.11	16.93
Lalbiaksanga	5	3.43	3.23	2.89	2.63	3.28	2.60	2.72	2.13	2.48	25.38
R Lalfakzuala	7	1.37	3.50	3.45	0.66	0.76	0.81	0.98	0.13	0.87	12.52
Simon Barzon	6	5.44	4.54	4.39	4.24	5.92	3.81	4.92	3.74	3.78	40.78
R C Ramdinthara	5	2.60	3.64	3.42	3.09	4.09	2.01	2.05	2.46	1.88	25.24
Paul Zoramthanga	5	4.83	4.47	4.42	3.01	3.15	3.54	4.32	2.49	3.54	33.76
V lalremruata	3	2.52	3.52	3.45	2.41	1.74	2.57	1.93	1.88	2.46	22.47
Rammuansanga	6	3.37	3.77	3.58	2.22	3.12	2.95	2.89	1.75	2.91	26.55
P C Lalruatzela	4	1.89	2.42	2.27	1.53	2.52	1.62	1.30	1.01	1.48	16.02
Rumliana	7	4.22	4.98	4.74	5.97	3.09	3.92	3.63	5.54	3.78	39.85
David Lalremsiama	4	1.61	1.54	1.40	1.49	0.90	1.39	1.10	1.09	1.42	11.93
S Kamliana	5	4.85	4.54	4.43	3.40	3.42	2.91	4.24	2.84	2.84	33.46
David Lalremruata	8	2.82	3.60	3.33	3.16	2.66	1.65	2.18	2.69	1.44	23.54
Immanuel	3	2.33	2.27	2.10	1.57	4.16	3.10	1.73	1.10	2.99	21.34

J malsawma	6	4.80	4.47	4.40	8.13	2.56	5.77	4.24	7.57	5.76	47.70
Lalruatfela	5	2.45	2.63	2.56	1.47	2.05	1.59	1.91	0.97	1.40	17.02
Z D Thanglura	7	4.54	3.24	2.94	5.00	9.06	4.09	4.09	4.56	3.95	41.47
Richard Lalenkawla	6	4.46	3.72	3.64	6.09	3.55	2.91	3.75	5.69	2.97	36.78
Lalrintluanga	4	2.53	2.56	2.37	3.18	2.48	1.91	1.99	2.59	1.81	21.42
L T Lala	4	2.42	2.52	2.45	2.21	2.29	2.15	1.93	1.76	2.18	19.92
R D Lalremruata	3	2.02	1.51	1.31	1.89	1.94	1.38	1.45	1.51	1.35	14.35
T K Lama	7	3.17	4.69	4.48	2.41	2.43	4.47	2.46	1.80	4.38	30.27
Lalramchhana	5	3.73	3.46	3.28	3.60	5.15	2.95	3.10	3.16	2.97	31.40
Daniel Lalremruata	5	3.82	3.62	3.31	4.11	4.03	4.09	3.32	3.73	3.98	34.00
Lalrinchhana	3	5.09	4.46	4.36	4.09	4.02	3.85	4.55	3.55	3.78	37.75
RMdawngliana	8	2.71	2.61	2.33	2.14	2.08	1.16	2.04	1.77	1.11	17.95
B K Rana	5	4.75	8.35	8.32	2.13	3.53	2.87	4.23	1.78	2.79	38.76
Vanlalruata	6	3.82	4.62	4.37	3.90	3.03	5.05	3.32	3.51	4.82	36.44
Lalchhuangliana	2	3.49	2.04	1.77	2.19	2.03	3.52	2.89	1.73	3.45	23.09
Ricky Zorempela	5	3.00	3.64	3.39	5.39	1.99	2.40	2.46	4.86	2.47	29.59
Laltlansanga	6	4.00	9.55	9.48	3.97	2.15	2.88	3.45	3.65	2.85	41.97
Lalrosanga	9	5.13	3.96	3.70	7.41	2.98	4.06	4.62	7.00	3.99	42.83
Sainghniga	5	1.93	4.64	4.42	3.41	2.16	1.11	1.34	2.94	1.16	23.11
F Lalruatzela	2	2.35	15.04	14.89	3.04	3.04	2.27	1.73	2.46	2.10	46.92
F Rintluanaga	8	4.79	9.51	9.27	3.08	4.73	6.05	4.16	2.47	5.86	49.91
Zorinsanga	4	3.54	1.96	1.95	2.77	2.56	3.38	3.02	2.38	3.36	24.92
T Lalmawia	6	1.24	1.80	1.70	2.66	2.22	0.91	0.73	2.04	0.88	14.16
J lalruatsanga	1	4.84	3.88	3.75	2.23	7.94	4.44	4.28	1.76	4.19	37.29
Lalrinliana Tlau	6	2.24	1.67	1.54	2.51	2.55	1.72	1.86	1.87	1.70	17.66
Zoliankhuma	8	5.49	2.36	2.24	1.93	2.53	9.95	4.97	1.32	9.84	40.62
Vanlalpianruala	9	0.98	1.62	1.51	1.16	0.89	1.03	1.65	0.70	0.89	10.43
Lalmalsawma	4	3.82	5.15	4.93	2.64	3.17	2.68	3.37	2.13	2.54	30.43
Joseph Vanlalsanga	6	1.78	2.57	2.45	1.97	1.04	2.16	1.36	1.48	2.18	16.99
Zonatahn Zaithanunga	9	5.19	4.50	4.21	8.01	3.16	4.88	4.63	7.54	4.92	47.04
Laldingliana	4	5.34	3.82	3.56	3.00	5.48	6.05	4.93	2.64	5.83	40.65
414 members		**3.24**	**3.72**	**3.53**	**3.15**	**3.10**	**2.98**	**2.74**	**2.66**	**2.91**	***2157.93***

Appendix 3: Gross plastic waste generation (kg) in South Locality during 2019-20

Head of Family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
lalrinthara	8	2.08	2.09	1.94	2.49	1.45	1.64	1.54	1.96	1.51	16.71
J Malsawmtluanga	4	2.21	2.44	2.17	2.55	2.79	1.37	1.67	2.02	1.35	18.55
lalnunzira	3	1.91	2.16	1.88	3.04	1.74	1.68	2.40	2.54	1.59	18.93
Thansela	4	2.68	2.93	2.72	2.72	2.59	3.03	2.03	2.20	2.99	23.88
Lathanzuala	7	3.77	1.93	1.74	3.14	2.89	2.91	3.26	2.57	2.81	25.02
H B Vanlalhriata	5	3.67	4.43	4.18	2.03	3.96	3.85	3.10	1.55	3.75	30.51
Lalmingmawia	6	5.20	5.59	5.40	5.36	4.44	3.38	4.73	4.85	3.26	42.20
Zadawla	7	2.01	2.57	2.40	1.50	2.62	1.69	1.45	0.92	1.49	16.63
Zothanpuia	6	1.75	2.69	2.49	2.50	3.46	2.38	1.25	1.97	2.27	20.75
Gospelthanga	4	2.51	2.64	2.49	1.96	3.42	1.93	1.91	1.42	1.87	20.13
S Thalthluanga	10	4.66	5.43	5.25	4.79	4.15	4.15	4.18	4.36	4.07	41.03
Lalbiakfela	5	1.77	1.47	1.27	4.04	4.53	1.23	1.25	3.55	1.05	20.16
H K Lalsanzuala	8	4.32	3.04	2.77	3.88	3.74	3.90	3.72	3.48	3.76	32.61
Robert Lalduhawma	3	1.40	1.85	1.69	2.97	1.72	1.02	0.92	2.48	0.89	14.95
Vanlalvena	5	3.80	3.74	3.58	3.19	3.08	3.04	3.31	2.70	2.96	29.39
Lalawmpuia	4	1.05	1.14	0.93	1.39	1.74	1.78	0.56	0.94	1.66	11.18
Lalhmingliana Hmar	8	2.43	2.11	1.98	1.57	3.70	3.29	1.88	1.02	3.29	21.27
Vanlalruata	6	4.61	5.46	5.28	5.84	3.67	4.48	4.04	5.32	4.37	43.08
C malsawma	5	3.34	3.14	2.88	3.19	3.87	3.93	2.78	2.75	3.83	29.71
F Remthanga	6	1.94	2.21	1.96	2.65	1.53	2.27	1.46	2.14	2.24	18.39
H Lalringheta	8	3.75	5.01	4.84	2.97	3.11	3.35	3.22	2.53	3.26	32.04
H S Lalremsiama	3	2.38	2.15	1.98	4.06	2.52	2.63	1.79	3.67	2.47	23.65
Rotluanga	3	2.64	2.87	2.69	2.19	4.06	2.01	2.14	1.65	2.03	22.27
Laldingliana	7	4.87	6.44	6.19	3.07	4.40	4.40	4.34	2.53	4.24	40.46
Lalthanzova	2	2.32	1.97	1.73	1.94	1.92	1.88	1.68	1.43	1.72	16.58
LV Zothansanga	6	1.30	2.07	1.88	0.83	1.90	0.90	0.79	0.40	0.80	10.86
M B Sahi	3	0.78	3.56	3.39	1.36	1.08	0.84	1.65	0.84	0.73	14.23
Henry Lalfakawma	6	3.82	3.88	3.65	2.89	3.03	5.91	3.26	2.45	5.86	34.74
Lalruatpuia	3	2.24	2.45	2.24	3.02	2.54	1.91	1.69	2.49	1.76	20.34
Zothantluanga	10	5.06	6.32	6.23	5.82	4.25	4.96	4.58	5.34	4.88	47.44

Vanalzauva	3	4.97	4.48	4.41	5.21	4.10	3.99	4.40	4.74	3.92	40.20
Lalsiamliana	8	4.01	6.48	6.39	2.55	5.34	3.92	3.48	2.16	3.88	38.21
F Lalpekhlua	9	2.19	2.09	1.83	1.49	2.04	2.10	1.75	1.06	2.05	16.59
Lalbiaksanga	5	3.28	3.06	2.95	2.64	3.17	2.61	2.76	2.08	2.54	25.09
R Lalfakzuala	7	1.37	3.57	3.28	0.58	0.64	0.85	0.86	0.05	0.74	11.94
Simon Barzon	6	5.37	4.55	4.32	4.18	5.96	3.87	4.86	3.65	3.78	40.53
R C Ramdinthara	5	2.59	3.52	3.29	2.98	4.04	1.98	2.16	2.54	1.86	24.97
Paul Zoramthanga	5	4.81	4.52	4.40	3.02	3.07	3.57	4.33	2.55	3.50	33.76
V lalremruata	3	2.33	3.56	3.29	2.39	1.64	2.55	1.82	1.92	2.38	21.87
Rammuansanga	6	3.45	3.65	3.54	2.16	3.08	2.86	2.89	1.64	2.75	26.01
P C Lalruatzela	4	1.88	2.44	2.17	1.40	2.49	1.49	1.38	0.97	1.48	15.70
Rumliana	7	4.17	4.96	4.73	6.02	2.99	3.86	3.69	5.58	3.77	39.78
David Lalremsiama	4	1.68	1.46	1.27	1.50	0.89	1.41	1.10	1.02	1.32	11.64
S Kamliana	5	4.76	4.49	4.38	3.31	3.32	2.93	4.13	2.82	2.81	32.94
David Lalremruata	8	2.79	3.55	3.33	3.06	2.66	1.59	2.20	2.55	1.52	23.24
Immanuel	3	2.18	2.26	2.03	1.57	4.07	3.12	1.65	1.10	3.00	20.97
J malsawma	6	4.76	4.50	4.34	7.98	2.44	5.84	4.12	7.54	5.75	47.28
Lalruatfela	5	2.37	2.66	2.43	1.37	1.99	1.45	1.74	0.91	1.37	16.29
Z D Thanglura	7	4.54	3.06	2.92	5.04	9.02	4.02	4.09	4.46	3.84	40.99
Richard Lalenkawla	6	4.30	3.71	3.52	6.01	3.46	2.94	3.84	5.60	2.80	36.18
Lalrintluanga	4	2.55	2.49	2.22	3.05	2.51	1.79	2.02	2.56	1.73	20.92
L T Lala	4	2.42	2.55	2.38	2.11	2.22	2.20	1.94	1.69	2.03	19.52
R D Lalremruata	3	1.91	1.54	1.30	1.96	1.96	1.40	1.34	1.41	1.33	14.15
T K Lama	7	3.02	4.57	4.39	2.27	2.38	4.43	2.54	1.87	4.26	29.72
Lalramchhana	5	3.55	3.49	3.29	3.53	5.09	2.95	3.02	3.05	2.86	30.83
Daniel Lalremruata	5	3.79	3.57	3.28	4.05	3.90	4.01	3.27	3.61	3.94	33.43
Lalrinchhana	3	4.99	4.39	4.25	4.07	4.09	3.73	4.41	3.51	3.71	37.14
RMalsawmdawnglia	8	2.61	2.54	2.38	2.10	1.95	1.09	2.00	1.65	1.09	17.42
B K Rana	5	4.74	8.45	8.26	2.16	3.44	2.95	4.17	1.65	2.84	38.67
Vanlalruata	6	3.79	4.58	4.36	3.86	3.08	4.96	3.21	3.46	4.89	36.19
Lalchhuangliana	2	3.51	1.86	1.70	2.23	2.10	3.42	2.91	1.69	3.33	22.74
Ricky Zorempela	5	3.04	3.53	3.33	5.45	1.99	2.42	2.47	4.93	2.40	29.57
Laltlansanga	6	4.01	9.56	9.32	4.06	2.04	2.77	3.45	3.55	2.77	41.53
Lalrosanga	9	5.11	3.85	3.73	7.37	2.93	3.91	4.49	6.91	3.87	42.17
Sainghniga	5	1.86	4.47	4.28	3.45	2.02	1.11	1.39	2.97	1.00	22.55

F.Lalruatzela	2	2.27	14.94	14.76	2.93	2.97	2.19	1.84	2.38	2.10	46.36
F Rintluanaga	8	4.71	9.53	9.32	2.97	4.63	5.90	4.10	2.48	5.85	49.47
Zorinsanga	4	3.51	2.01	1.80	2.84	2.48	3.32	2.95	2.34	3.25	24.49
T Lalmawia	6	1.28	1.83	1.61	2.62	2.14	0.94	0.66	2.12	0.90	14.10
J lalruatsanga	1	4.79	3.97	3.69	2.22	8.02	4.32	4.16	1.77	4.24	37.18
Lalrinliana Tlau	6	2.27	1.76	1.55	2.44	2.44	1.72	1.80	1.95	1.65	17.58
Zoliankhuma	8	5.39	2.44	2.21	1.81	2.59	9.84	4.90	1.41	9.83	40.41
Vanlalpianruala	9	0.93	1.55	1.40	1.15	0.89	1.06	1.60	0.68	0.92	10.19
Lalmalsawma	4	3.92	5.08	4.92	2.66	3.16	2.66	3.32	2.15	2.59	30.46
Joseph Vanlalsanga	6	1.86	2.57	2.33	1.92	1.08	2.18	1.30	1.35	2.09	16.67
Z.Zaithanunga	9	5.14	4.41	4.21	8.05	3.01	4.88	4.55	7.52	4.82	46.59
Laldingliana	4	5.38	3.67	3.58	3.02	5.38	6.01	4.85	2.61	5.84	40.34
414 members		**3.20**	**3.68**	**3.49**	**3.11**	**3.08**	**2.95**	**2.71**	**2.63**	**2.86**	***2132.23***

Appendix 4: Gross plastic waste generation (kg) in North Locality during 2017-18

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Jacob	6	1.96	1.98	1.85	2.42	1.36	1.54	1.33	1.88	1.37	15.69
John Lalpeka	7	2.07	2.26	2.14	2.38	2.63	1.33	1.58	1.88	1.20	17.46
Zonunkima	4	1.85	2.00	1.84	2.91	1.52	1.51	2.24	2.38	1.45	17.71
Lalrampuia Pachau	3	2.48	2.76	2.56	2.55	2.40	3.00	1.96	2.11	2.89	22.71
F Lalrozara	5	3.63	1.76	1.58	3.02	2.75	2.86	3.15	2.47	2.71	23.93
Lalrosanga	7	3.52	4.29	4.06	1.92	3.86	3.72	3.06	1.44	3.65	29.51
Malsawmkima vancchawng	10	5.08	5.38	5.25	5.26	4.24	3.26	4.61	4.72	3.07	40.87
Lanunmawia	5	1.81	2.45	2.35	1.35	2.50	1.55	1.32	0.80	1.41	15.53
L V Thantluanga	7	1.60	2.60	2.44	2.42	3.33	2.20	1.10	1.93	2.15	19.75
Benjain Laldingpuia	3	2.34	2.56	2.32	1.85	3.23	1.83	1.88	1.37	1.73	19.11
Lalchhanhima	9	4.61	5.35	5.13	4.77	4.09	4.01	4.04	4.23	3.88	40.09
R Lalengmawia	4	1.64	1.30	1.19	3.87	4.38	1.10	1.10	3.42	0.94	18.94
RChawngdingthara	5	4.20	2.91	2.67	3.80	3.64	3.73	3.66	3.29	3.63	31.54

V L Ruata	5	1.26	1.82	1.63	2.78	1.49	0.87	0.79	2.32	0.72	13.69
Vanlalnunpuia	5	3.71	3.59	3.46	3.08	3.03	2.95	3.17	2.59	2.84	28.43
R Malsawmtluanga	6	0.96	0.95	0.77	1.31	1.58	1.61	0.43	0.82	1.56	9.99
Malsawmzuala Pallan	7	2.33	2.00	1.84	1.38	3.52	3.22	1.77	0.89	3.08	20.03
Ramthangaka	10	4.50	5.33	5.11	5.73	3.64	4.35	3.95	5.25	4.23	42.08
Henry Vanlalchhunga	4	3.20	2.94	2.77	3.09	3.74	3.81	2.63	2.58	3.74	28.51
Lalmuanpuia	5	1.82	2.03	1.88	2.49	1.42	2.16	1.29	1.96	2.11	17.16
Michael L	5	3.68	4.87	4.74	2.84	3.02	3.21	3.16	2.31	3.13	30.96
RRomoingliana	6	2.18	1.96	1.83	3.95	2.39	2.47	1.62	3.51	2.35	22.26
Vincent Lalremsanga	7	2.55	2.76	2.65	2.08	3.94	1.91	1.94	1.55	1.83	21.20
Issac Hnamte	7	4.73	6.28	6.14	2.91	4.21	4.21	4.25	2.47	4.14	39.33
Lalruatsanga	6	2.17	1.85	1.64	1.86	1.77	1.74	1.63	1.32	1.63	15.60
I ssac Vanlaldina	4	1.16	2.03	1.82	0.77	1.83	0.73	0.68	0.23	0.71	9.96
John Zonunthara	4	0.67	3.40	3.25	1.19	0.88	0.76	1.57	0.74	0.66	13.11
Joseph L	5	3.66	3.76	3.60	2.87	2.95	5.80	3.09	2.32	5.77	33.83
Lalchhanhima	3	2.08	2.35	2.11	2.94	2.42	1.73	1.54	2.42	1.65	19.24
David Hamar	10	4.98	6.25	6.03	5.73	4.11	4.79	4.39	5.20	4.67	46.14
Sammy Lianzuala	7	4.77	4.44	4.20	5.13	3.87	3.85	4.24	4.60	3.72	38.82
S K Das	5	3.95	6.45	6.20	2.44	5.23	3.83	3.38	1.96	3.74	37.18
Saitluanga Sailo	8	2.10	1.93	1.77	1.34	1.91	2.05	1.55	0.87	1.92	15.43
Israel Laenkima	9	3.21	3.00	2.78	2.52	3.04	2.46	2.65	1.97	2.33	23.98
Lalnuntluanga	3	1.32	3.44	3.25	0.48	0.53	0.68	0.76	0.02	0.61	11.08
Lalmuankima	3	5.29	4.39	4.22	4.09	5.79	3.79	4.67	3.62	3.66	39.52
Dennis Ramdinmawia	4	2.52	3.38	3.20	2.82	3.86	1.84	1.94	2.40	1.68	23.63
Laltahnfala	5	4.78	4.38	4.25	2.89	3.05	3.38	4.24	2.39	3.32	32.68
kanan Lalramawia	6	2.31	3.41	3.19	2.26	1.52	2.42	1.72	1.81	2.31	20.93
Lalhminglua	5	3.34	3.58	3.39	2.01	2.96	2.80	2.72	1.50	2.69	24.99
Lalramluahpuia	6	1.76	2.24	2.05	1.29	2.27	1.37	1.20	0.78	1.31	14.27
Malsawmtluanga	6	4.07	4.75	4.60	5.90	2.90	3.82	3.54	5.40	3.66	38.63
Lalmalsawma Sailo	7	1.50	1.32	1.12	1.36	0.81	1.31	1.00	0.88	1.22	10.52
Lalnunpuia	5	4.54	4.38	4.21	3.23	3.15	2.79	4.03	2.70	2.74	31.76
Lalrinliana	8	2.64	3.38	3.23	2.92	2.52	1.41	2.06	2.40	1.39	21.92
freddy Sailo	8	2.14	2.10	1.95	1.54	3.98	3.06	1.52	0.95	2.92	20.14
kapzauva	9	4.59	4.44	4.18	7.89	2.35	5.61	4.08	7.37	5.54	46.05
James Gangte	9	2.20	2.52	2.39	1.33	1.94	1.34	1.65	0.80	1.28	15.45

C Lalrinchhana	4	4.48	2.98	2.80	4.88	8.87	3.82	3.91	4.38	3.74	39.85
B Vanlalvena	6	4.26	3.57	3.37	5.93	3.30	2.80	3.67	5.46	2.69	35.04
F Lalalmuansanga	3	2.46	2.29	2.12	3.00	2.38	1.69	1.89	2.52	1.65	20.01
Vanlaldinga	7	2.28	2.37	2.23	2.01	2.13	2.01	1.74	1.57	1.96	18.29
Arnab Majumadar	5	1.83	1.40	1.25	1.76	1.77	1.22	1.24	1.28	1.21	12.96
Henry Lahmingthanga	8	2.97	4.45	4.32	2.15	2.20	4.26	2.41	1.70	4.13	28.58
L Lalbiaksanga	6	3.47	3.38	3.19	3.42	4.93	2.82	2.91	2.96	2.75	29.84
Lalmuanpuia	8	3.68	3.36	3.25	3.99	3.80	3.85	3.12	3.46	3.77	32.27
Lalfakzuala	3	4.86	4.33	4.15	3.84	3.88	3.65	4.28	3.39	3.59	35.97
Y Jitendra Singh	9	2.41	2.48	2.29	2.05	1.83	1.05	1.87	1.50	0.95	16.44
Bappa Das	5	4.64	8.24	8.13	2.00	3.34	2.76	4.05	1.55	2.76	37.47
Ronny L	6	3.71	4.36	4.20	3.76	2.95	4.79	3.18	3.33	4.73	35.00
Richard L	3	3.40	1.84	1.56	2.12	2.00	3.32	2.81	1.60	3.20	21.84
Lalbiakluna	7	2.87	3.34	3.18	5.26	1.76	2.34	2.30	4.75	2.26	28.06
M Hmingthanga	4	3.88	9.47	9.24	3.86	1.90	2.66	3.37	3.45	2.60	40.41
Varhlunkuma	9	4.99	3.79	3.60	7.29	2.78	3.84	4.46	6.85	3.72	41.33
Lalhanzuala Varte	1	1.73	4.39	4.25	3.27	1.89	0.99	1.21	2.78	0.94	21.44
B Zirkunga	5	2.22	14.79	14.60	2.74	2.90	1.97	1.64	2.30	1.94	45.10
C Lalrinpuia	10	4.56	9.31	9.16	2.93	4.51	5.83	4.05	2.44	5.68	48.47
Vanlalsiama Pachau	6	3.39	1.86	1.73	2.66	2.33	3.19	2.85	2.25	3.08	23.33
Issac Remtluanga	4	1.11	1.75	1.50	2.43	1.94	0.76	0.59	1.97	0.73	12.78
Andrew Zonuntluanga	9	4.60	3.84	3.57	2.14	7.84	4.23	4.05	1.60	4.09	35.94
C Chhuankhuma	3	2.15	1.60	1.44	2.30	2.30	1.58	1.61	1.83	1.53	16.33
Demkhawa	2	5.27	2.28	2.09	1.73	2.42	9.80	4.75	1.21	9.67	39.23
C Lalrokima	6	0.79	1.45	1.29	1.06	0.80	0.86	1.45	0.57	0.85	9.10
Lalnunpuia	8	3.75	5.04	4.77	2.52	3.02	2.50	3.18	1.98	2.44	29.18
Lalfinga	3	1.69	2.42	2.28	1.79	0.95	2.07	1.19	1.24	1.94	15.56
Lalzuailiana	6	4.98	4.29	4.16	7.85	2.89	4.86	4.52	7.40	4.73	45.66
Emanuel	7	5.26	3.58	3.44	2.91	5.26	5.84	4.68	2.47	5.73	39.16
432 members		**3.08**	**3.55**	**3.38**	**2.99**	**2.94**	**2.82**	**2.58**	**2.50**	**2.73**	***2045.94***

Appendix 5: Gross plastic waste generation (kg) in North Locality during 2018-19

Head offamily	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Jacob	6	1.85	1.94	1.75	2.32	1.26	1.42	1.29	1.80	1.33	14.96
John Lalpeka	7	2.01	2.20	2.03	2.30	2.51	1.25	1.48	1.82	1.15	16.73
Zonunkima	4	1.72	1.90	1.75	2.82	1.48	1.42	2.17	2.29	1.35	16.89
Lalrampuia Pachau	3	2.45	2.71	2.55	2.49	2.35	2.87	1.89	2.00	2.80	22.10
F Lalrozara	5	3.59	1.73	1.55	2.88	2.69	2.73	3.01	2.40	2.66	23.24
Lalrosanga	7	3.48	4.20	4.03	1.82	3.77	3.68	2.96	1.32	3.59	28.84
Malsawmkima vancchawng	10	5.02	5.38	5.16	5.19	4.18	3.12	4.52	4.66	3.06	40.27
Lanunmawia	5	1.77	2.42	2.22	1.24	2.43	1.44	1.23	0.77	1.35	14.87
L V Thantluanga	7	1.53	2.53	2.36	2.28	3.24	2.19	0.99	1.81	2.07	18.98
Benjain Laldingpuia	3	2.32	2.43	2.25	1.77	3.19	1.79	1.77	1.26	1.69	18.46
Lalchhanhima	9	4.50	5.25	5.05	4.63	3.98	3.94	3.95	4.16	3.83	39.28
R Lalengmawia	4	1.60	1.25	1.06	3.83	4.28	0.96	1.04	3.30	0.90	18.22
R.Chawngdingthara	5	4.11	2.81	2.61	3.71	3.53	3.62	3.59	3.23	3.53	30.74
V L Ruata	5	1.24	1.70	1.51	2.74	1.46	0.78	0.66	2.24	0.69	13.01
Vanlalnunpuia	5	3.61	3.53	3.32	3.02	2.91	2.88	3.07	2.49	2.77	27.60
R Malsawmtluanga	6	0.91	0.90	0.70	1.27	1.47	1.57	0.35	0.75	1.50	9.41
Malsawmzuala Pallan	7	2.29	1.92	1.71	1.36	3.48	3.14	1.72	0.88	3.03	19.53
Ramthangaka	10	4.44	5.26	5.08	5.64	3.53	4.23	3.86	5.15	4.12	41.31
Henry Vanlalchhunga	4	3.14	2.93	2.71	3.00	3.65	3.78	2.57	2.53	3.67	27.98
Lalmuanpuia	5	1.78	1.98	1.78	2.41	1.36	2.12	1.21	1.91	2.04	16.59
Michael Laldingmawia	5	3.58	4.81	4.63	2.75	2.97	3.14	3.04	2.25	3.03	30.19
Raymond Romoingliana	6	2.14	1.91	1.73	3.90	2.34	2.37	1.59	3.41	2.30	21.69
Vincent Lalremsanga	7	2.44	2.72	2.52	1.96	3.84	1.85	1.89	1.49	1.76	20.46
Issac Hnamte	7	4.71	6.20	6.01	2.85	4.17	4.15	4.13	2.38	4.05	38.64
Lalruatsanga	6	2.09	1.75	1.60	1.75	1.70	1.69	1.54	1.24	1.59	14.94
I ssac Vanlaldina	4	1.14	1.90	1.75	0.67	1.72	0.66	0.59	0.20	0.60	9.23
John Zonunthara	4	0.59	3.32	3.13	1.14	0.84	0.65	1.44	0.64	0.57	12.32
Joseph Lalchhuanmawia	5	3.59	3.68	3.50	2.73	2.85	5.77	3.05	2.23	5.65	33.06
Lalchhanhima	3	2.05	2.26	2.05	2.84	2.36	1.69	1.48	2.33	1.59	18.64
David Hamar	10	4.88	6.17	5.99	5.61	4.01	4.72	4.34	5.10	4.67	45.49
Sammy Lianzuala	7	4.71	4.32	4.15	5.02	3.82	3.75	4.18	4.54	3.69	38.18

S K Das	5	3.89	6.31	6.13	2.40	5.18	3.76	3.31	1.90	3.65	36.51
Saitluanga Sailo	8	2.02	1.85	1.69	1.31	1.87	1.94	1.50	0.80	1.85	14.83
Israel Laenkima	9	3.14	2.92	2.73	2.42	2.98	2.39	2.57	1.93	2.30	23.37
Lalnuntluanga	3	1.21	3.32	3.12	0.38	0.50	0.63	0.65	-0.10	0.52	10.22
Lalmuankima	3	5.16	4.31	4.15	4.01	5.77	3.69	4.65	3.53	3.57	38.83
Dennis Ramdinmawia	4	2.44	3.30	3.13	2.76	3.79	1.73	1.90	2.29	1.63	22.98
Laltahnfala	5	4.68	4.34	4.14	2.82	2.93	3.35	4.13	2.30	3.25	31.94
kanan Lalramawia	6	2.21	3.30	3.14	2.22	1.48	2.35	1.65	1.71	2.23	20.27
Lalhminglua	5	3.21	3.52	3.34	1.94	2.85	2.68	2.66	1.43	2.61	24.23
Lalramluahpuia	6	1.69	2.20	2.01	1.22	2.22	1.33	1.13	0.74	1.23	13.77
Malsawmtluanga	6	4.03	4.71	4.51	5.81	2.82	3.68	3.45	5.31	3.60	37.91
Lalmalsawma Sailo	7	1.44	1.26	1.08	1.33	0.68	1.24	0.93	0.82	1.15	9.92
Lalnunpuia	5	4.51	4.33	4.11	3.10	3.10	2.73	3.99	2.62	2.64	31.13
Lalrinliana	8	2.54	3.31	3.14	2.88	2.47	1.40	2.02	2.38	1.27	21.40
freddy Sailo	8	2.02	2.03	1.84	1.42	3.87	2.95	1.46	0.93	2.86	19.39
kapzauva	10	4.55	4.32	4.12	7.80	2.22	5.57	3.96	7.30	5.50	45.33
James Gangte	9	2.13	2.46	2.28	1.20	1.84	1.26	1.60	0.72	1.19	14.67
C Lalrinchhana	4	4.36	2.92	2.75	4.84	8.80	3.77	3.82	4.32	3.67	39.24
B Vanlalvena	6	4.18	3.51	3.33	5.87	3.24	2.72	3.61	5.37	2.64	34.46
F Lalalmuansanga	3	2.38	2.24	2.09	2.90	2.36	1.60	1.81	2.42	1.56	19.36
Vanlaldinga	7	2.23	2.31	2.13	1.98	2.05	1.93	1.68	1.44	1.84	17.60
Arnab Majumadar	5	1.76	1.29	1.12	1.70	1.73	1.18	1.18	1.19	1.08	12.24
Henry Lahmingthanga	8	2.86	4.42	4.24	2.09	2.16	4.18	2.32	1.62	4.10	27.99
L Lalbiaksanga	6	3.41	3.25	3.10	3.35	4.90	2.79	2.88	2.83	2.69	29.19
Lalmuanpuia	8	3.58	3.32	3.14	3.88	3.75	3.81	3.04	3.39	3.71	31.63
Lalfakzuala	3	4.80	4.20	4.01	3.82	3.82	3.58	4.21	3.30	3.51	35.25
Y Jitendra Singh	9	2.37	2.34	2.19	1.94	1.78	0.97	1.84	1.45	0.84	15.72
Bappa Das	5	4.53	8.20	8.04	1.94	3.28	2.74	3.98	1.48	2.65	36.84
Ronny L	6	3.63	4.31	4.14	3.71	2.89	4.74	3.07	3.20	4.65	34.34
Richard L	3	3.28	1.71	1.54	2.04	1.89	3.25	2.72	1.56	3.17	21.16
Lalbiakluna	7	2.78	3.33	3.15	5.19	1.71	2.26	2.24	4.69	2.16	27.51
M Hmingthanga	4	3.80	9.36	9.19	3.84	1.83	2.62	3.26	3.33	2.53	39.76
Varhlunkuma	9	4.90	3.72	3.55	7.24	2.75	3.78	4.35	6.73	3.67	40.69
Lalhanzuala Varte	1	1.65	4.32	4.13	3.20	1.82	0.97	1.11	2.73	0.87	20.80

B Zirkunga	5	2.11	14.76	14.59	2.70	2.80	1.95	1.58	2.24	1.87	44.60
C Lalrinpuia	10	4.48	9.28	9.10	2.82	4.44	5.74	3.96	2.31	5.66	47.78
Vanlalsiama Pachau	6	3.34	1.82	1.61	2.63	2.24	3.12	2.79	2.11	3.03	22.68
Issac Remtluanga	4	1.03	1.63	1.46	2.36	1.87	0.74	0.48	1.91	0.65	12.14
Andrew Zonuntluanga	9	4.56	3.71	3.51	2.04	7.79	4.10	3.99	1.55	4.04	35.29
C Chhuankhuma	3	2.09	1.55	1.33	2.20	2.25	1.56	1.53	1.70	1.48	15.68
Demkhawa	2	5.24	2.21	2.01	1.68	2.32	9.71	4.69	1.16	9.58	38.60
C Lalrokima	6	0.67	1.36	1.18	0.97	0.71	0.85	1.34	0.46	0.73	8.27
Lalnunpuia	8	3.67	4.92	4.72	2.43	2.93	2.45	3.14	1.96	2.36	28.59
Lalfinga	3	1.62	2.36	2.18	1.69	0.85	1.96	1.06	1.21	1.86	14.80
Lalzuailiana	6	4.96	4.26	4.07	7.81	2.83	4.73	4.40	7.31	4.66	45.02
Emanuel	7	5.16	3.51	3.36	2.87	5.18	5.78	4.57	2.35	5.67	38.44
432 members		**3.01**	**3.48**	**3.30**	**2.92**	**2.87**	**2.75**	**2.50**	**2.42**	**2.66**	***1994.18***

Appendix 6: Gross plastic waste generation (kg) in North Locality during 2019-20

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Jacob	6	1.86	2.03	1.76	2.40	1.31	1.49	1.35	1.85	1.37	15.43
John Lalpeka	7	2.09	2.32	2.14	2.33	2.57	1.26	1.50	1.84	1.25	17.28
Zonunkima	4	1.74	1.97	1.76	2.85	1.55	1.51	2.24	2.36	1.41	17.39
Lalrampuia Pachau	3	2.54	2.75	2.57	2.54	2.40	2.93	1.98	2.05	2.85	22.62
F Lalrozara	5	3.60	1.79	1.61	3.00	2.71	2.87	3.05	2.46	2.69	23.77
Lalrosanga	7	3.57	4.23	4.10	1.86	3.84	3.70	2.96	1.44	3.64	29.34
Malsawmkima V	10	5.09	5.39	5.19	5.28	4.23	3.17	4.54	4.69	3.06	40.65
Lanunmawia	5	1.81	2.47	2.32	1.35	2.54	1.55	1.34	0.87	1.42	15.66
L V Thantluanga	7	1.62	2.65	2.45	2.34	3.30	2.25	1.03	1.89	2.10	19.63
Benjain Laldingpuia	3	2.37	2.48	2.37	1.85	3.23	1.83	1.82	1.32	1.71	18.98
Lalchhanhima	9	4.57	5.28	5.16	4.69	4.08	3.94	3.99	4.22	3.87	39.81
R Lalengmawia	4	1.69	1.28	1.17	3.91	4.35	1.02	1.16	3.35	0.96	18.88
Robert Chawngdingthara	5	4.19	2.84	2.71	3.82	3.64	3.68	3.64	3.27	3.64	31.44

V L Ruata	5	1.28	1.82	1.58	2.78	1.51	0.87	0.78	2.30	0.80	13.71
Vanlalnunpuia	5	3.67	3.59	3.44	3.05	2.94	2.91	3.09	2.55	2.84	28.08
R Malsawmtluanga	6	0.93	0.92	0.77	1.36	1.52	1.66	0.46	0.77	1.51	9.91
Malsawmzuala Pallan	7	2.37	1.97	1.78	1.47	3.52	3.21	1.80	0.97	3.09	20.17
Ramthangaka	10	4.45	5.36	5.13	5.75	3.60	4.27	3.90	5.24	4.24	41.95
Henry Vanlalchhunga	4	3.21	2.95	2.79	3.08	3.75	3.87	2.65	2.60	3.74	28.63
Lalmuanpuia	5	1.80	2.04	1.80	2.50	1.36	2.18	1.27	1.94	2.14	17.03
Michael Laldingmawia	5	3.66	4.85	4.71	2.88	3.08	3.17	3.06	2.36	3.17	30.93
Raymond Romoingliana	6	2.22	1.97	1.80	3.98	2.43	2.47	1.67	3.52	2.37	22.42
Vincent Lalremsanga	7	2.52	2.74	2.59	2.03	3.88	1.91	1.93	1.50	1.82	20.92
Issac Hnamte	7	4.71	6.29	6.05	2.97	4.26	4.27	4.18	2.46	4.17	39.34
Lalruatsanga	6	2.13	1.80	1.64	1.81	1.72	1.75	1.57	1.36	1.64	15.42
I ssac Vanlaldina	4	1.14	1.99	1.80	0.69	1.76	0.78	0.62	0.25	0.67	9.71
John Zonunthara	4	0.66	3.40	3.25	1.17	0.89	0.75	1.47	0.75	0.63	12.96
Joseph Lalchhuanmawia	5	3.71	3.77	3.55	2.77	2.88	5.84	3.08	2.32	5.76	33.67
Lalchhanhima	3	2.07	2.33	2.15	2.92	2.43	1.71	1.52	2.38	1.61	19.12
David Hamar	10	4.94	6.27	6.01	5.72	4.14	4.79	4.42	5.19	4.70	46.19
Sammy Lianzuala	7	4.82	4.36	4.20	5.09	3.93	3.88	4.25	4.59	3.76	38.87
S K Das	5	3.90	6.36	6.17	2.52	5.21	3.85	3.36	2.00	3.76	37.12
Saitluanga Sailo	8	2.05	1.96	1.72	1.33	1.96	2.05	1.57	0.89	1.89	15.42
Israel Laenkima	9	3.18	2.96	2.80	2.50	3.10	2.43	2.67	2.04	2.37	24.04
Lalnuntluanga	3	1.30	3.39	3.23	0.45	0.59	0.68	0.70	0.01	0.63	10.98
Lalmuankima	3	5.21	4.34	4.20	4.03	5.83	3.76	4.67	3.55	3.68	39.26
Dennis Ramdinmawia	4	2.55	3.37	3.21	2.84	3.87	1.84	1.96	2.33	1.67	23.66
Laltahnfala	5	4.71	4.39	4.23	2.84	3.03	3.36	4.19	2.44	3.26	32.45
kanan Lalramawia	6	2.27	3.39	3.21	2.26	1.57	2.39	1.66	1.78	2.30	20.83
Lalhminglua	5	3.32	3.60	3.41	2.03	2.88	2.74	2.74	1.56	2.70	24.99
Lalramluahpuia	6	1.74	2.26	2.07	1.30	2.28	1.45	1.25	0.82	1.27	14.45
Malsawmtluanga	6	4.05	4.79	4.56	5.83	2.86	3.79	3.55	5.39	3.69	38.50
Lalmalsawma Sailo	7	1.55	1.31	1.13	1.37	0.76	1.28	0.94	0.87	1.18	10.38
Lalnunpuia	5	4.59	4.40	4.18	3.19	3.14	2.80	4.04	2.74	2.73	31.81
Lalrinliana	8	2.64	3.42	3.16	2.97	2.55	1.44	2.06	2.43	1.31	21.97
freddy Sailo	8	2.12	2.10	1.86	1.48	3.98	2.99	1.57	0.99	2.91	19.98
kapzauva	10	4.54	4.37	4.16	7.83	2.33	5.67	4.02	7.39	5.54	45.85
James Gangte	9	2.16	2.50	2.35	1.33	1.91	1.31	1.65	0.82	1.30	15.32

C Lalrinchhana	4	4.47	2.96	2.85	4.83	8.82	3.82	3.90	4.38	3.75	39.78
B Vanlalvena	6	4.25	3.61	3.40	5.94	3.33	2.85	3.64	5.47	2.74	35.23
F Lalalmuansanga	3	2.46	2.28	2.12	3.02	2.42	1.75	1.85	2.49	1.65	20.02
Vanlaldinga	7	2.30	2.39	2.22	2.06	2.12	2.00	1.77	1.52	1.92	18.30
Arnab Majumadar	5	1.75	1.43	1.21	1.77	1.79	1.30	1.21	1.31	1.15	12.92
Henry Lahmingthanga	8	2.93	4.42	4.25	2.18	2.26	4.23	2.38	1.65	4.18	28.47
L Lalbiaksanga	6	3.44	3.34	3.15	3.45	4.91	2.89	2.96	2.98	2.75	29.86
Lalmuanpuia	8	3.64	3.38	3.21	4.00	3.77	3.89	3.11	3.43	3.80	32.21
Lalfakzuala	3	4.82	4.31	4.10	3.86	3.93	3.68	4.26	3.36	3.61	35.92
Y Jitendra Singh	9	2.44	2.46	2.26	2.03	1.90	1.06	1.86	1.48	0.90	16.38
Bappa Das	5	4.60	8.28	8.07	2.01	3.39	2.85	4.05	1.56	2.75	37.57
Ronny L	6	3.66	4.43	4.22	3.80	2.95	4.79	3.15	3.24	4.70	34.93
Richard L	3	3.37	1.75	1.62	2.15	1.97	3.31	2.77	1.63	3.26	21.84
Lalbiakluna	7	2.89	3.37	3.17	5.32	1.75	2.31	2.35	4.80	2.27	28.22
M Hmingthanga	4	3.94	9.45	9.26	3.91	1.90	2.71	3.33	3.41	2.56	40.47
Varhlunkuma	9	4.97	3.82	3.57	7.29	2.82	3.79	4.39	6.76	3.78	41.19
Lalhanzuala Varte	1	1.69	4.43	4.22	3.31	1.89	1.04	1.24	2.78	0.89	21.48
B Zirkunga	5	2.24	14.78	14.68	2.74	2.84	2.01	1.61	2.34	1.96	45.20
C Lalrinpuia	3	4.51	9.34	9.11	2.92	4.47	5.87	4.03	2.43	5.71	48.39
Vanlalsiama Pachau	6	3.40	1.88	1.68	2.65	2.32	3.25	2.86	2.18	3.14	23.35
Issac Remtluanga	4	1.09	1.67	1.50	2.44	1.91	0.75	0.58	1.99	0.76	12.69
Andrew Zonuntluanga	9	4.58	3.79	3.60	2.10	7.84	4.19	4.06	1.64	4.15	35.94
C Chhuankhuma	3	2.15	1.59	1.44	2.24	2.31	1.62	1.61	1.73	1.53	16.21
Demkhawa	2	5.28	2.32	2.09	1.75	2.36	9.78	4.79	1.20	9.63	39.19
C Lalrokima	6	0.78	1.44	1.28	1.04	0.82	0.85	1.40	0.54	0.81	8.96
Lalnunpuia	8	3.69	4.95	4.76	2.51	2.95	2.53	3.20	1.98	2.43	28.99
Lalfinga	3	1.66	2.40	2.20	1.74	0.95	2.02	1.11	1.23	1.95	15.27
Lalzuailiana	6	5.05	4.35	4.12	7.86	2.88	4.76	4.43	7.39	4.67	45.50
Emanuel	7	5.23	3.64	3.39	2.89	5.18	5.83	4.61	2.44	5.76	38.96
432 members		**3.07**	**3.55**	**3.36**	**2.99**	**2.93**	**2.82**	**2.56**	**2.49**	**2.73**	***2040.34***

Appendix 7: Gross plastic waste generation (kg) in East Locality during 2017-18

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
MS Dawngliana	4	1.87	2.00	1.76	2.38	1.37	1.55	1.35	1.87	1.48	15.64
Lalremruata	4	2.09	2.28	2.14	2.45	2.63	1.38	1.60	1.90	1.25	17.71
Lalhimpuia	5	1.82	2.03	1.84	2.92	1.54	1.55	2.29	2.42	1.48	17.87
J C Dingluia	8	2.51	2.80	2.67	2.60	2.45	2.93	1.99	2.12	2.88	22.95
JV Lalropuia	6	3.71	1.76	1.61	2.97	2.77	2.89	3.07	2.52	2.71	24.01
JV Lalremruata	9	3.59	4.24	4.09	1.89	3.87	3.74	2.97	1.47	3.73	29.59
R Lalramchanna	6	5.07	5.38	5.22	5.29	4.31	3.20	4.57	4.72	3.14	40.90
Lalchhandama	3	1.87	2.55	2.34	1.33	2.59	1.47	1.37	0.78	1.37	15.66
Lalthanpuia	5	1.63	2.61	2.47	2.38	3.36	2.29	1.06	1.86	2.11	19.78
Thanzuala	7	2.35	2.51	2.41	1.87	3.25	1.93	1.89	1.34	1.84	19.37
Thangdela	3	4.61	5.35	5.18	4.78	4.01	4.03	4.11	4.29	3.97	40.33
Lalnunpuia	9	1.73	1.30	1.17	3.91	4.43	1.12	1.17	3.38	0.96	19.16
Lalmalsawma	7	4.20	2.93	2.76	3.75	3.62	3.78	3.73	3.31	3.59	31.67
Lalchandama	5	1.25	1.84	1.61	2.84	1.58	0.89	0.74	2.28	0.80	13.83
Lalruatsanga	5	3.71	3.60	3.49	3.16	2.97	2.99	3.12	2.56	2.82	28.41
Lalthanpuia	6	1.02	1.02	0.84	1.37	1.64	1.69	0.43	0.89	1.60	10.50
Isak L	4	2.31	1.95	1.80	1.45	3.55	3.25	1.82	0.96	3.07	20.16
Lalruatfela	7	4.52	5.40	5.23	5.72	3.61	4.35	3.93	5.28	4.23	42.26
Lawmsanga	3	3.22	3.01	2.78	3.07	3.73	3.81	2.70	2.61	3.82	28.77
Lalremruata	6	1.90	2.10	1.83	2.46	1.40	2.20	1.36	1.97	2.07	17.30
Victor	4	3.67	4.95	4.70	2.84	3.13	3.22	3.12	2.42	3.14	31.18
Lalrinkima	7	2.19	1.95	1.77	4.04	2.47	2.42	1.67	3.43	2.39	22.34
Lalthmawia	8	2.54	2.76	2.63	2.00	3.92	1.95	2.02	1.54	1.89	21.25
Malsawmtluanga	5	4.71	6.30	6.11	2.98	4.22	4.24	4.29	2.42	4.18	39.46
Vanlalruati	7	2.22	1.84	1.66	1.83	1.72	1.83	1.60	1.36	1.74	15.80
Zoremsanga	3	1.22	2.04	1.85	0.81	1.81	0.71	0.70	0.33	0.69	10.16
David L	3	0.74	3.44	3.25	1.18	0.89	0.73	1.55	0.77	0.64	13.19
V Thangbiaklala	5	3.64	3.70	3.59	2.80	2.90	5.80	3.16	2.35	5.73	33.65
H Lalduhsaka	8	2.09	2.40	2.19	2.86	2.40	1.77	1.53	2.36	1.75	19.33
Lalhriatpuia	4	4.94	6.29	6.08	5.76	4.08	4.86	4.48	5.25	4.76	46.49
Lalbuatsaiha	8	4.86	4.47	4.24	5.11	3.95	3.90	4.34	4.59	3.71	39.15

Lalrawmlawma	3	4.03	6.46	6.23	2.54	5.23	3.86	3.37	2.03	3.74	37.49
Rosanga	9	2.09	1.91	1.70	1.33	1.99	2.02	1.53	0.89	1.95	15.42
Vanlalruata	5	3.21	3.08	2.90	2.46	3.09	2.52	2.64	1.98	2.32	24.18
Buanthasanga	7	1.24	3.43	3.22	0.43	0.61	0.68	0.78	-0.01	0.58	10.96
PC Vanlalzara	3	5.23	4.46	4.18	4.09	5.84	3.69	4.75	3.61	3.72	39.56
Lalrohlua	6	2.53	3.44	3.28	2.88	3.93	1.86	1.94	2.39	1.73	23.97
Lalbiaksanga	4	4.82	4.37	4.29	2.94	3.05	3.39	4.15	2.35	3.39	32.75
Zohmingmawia	9	2.33	3.44	3.26	2.26	1.62	2.36	1.68	1.83	2.37	21.16
F Lalbiaksanga	8	3.36	3.54	3.40	2.01	2.92	2.74	2.73	1.50	2.74	24.92
H Lalsiamthanga	5	1.73	2.28	2.09	1.28	2.32	1.42	1.27	0.80	1.40	14.59
Lalsangliana	7	4.11	4.86	4.62	5.85	2.99	3.77	3.54	5.43	3.74	38.91
BLalchhandama	3	1.48	1.33	1.21	1.47	0.72	1.26	0.94	0.89	1.24	10.55
Henry L	4	4.56	4.39	4.27	3.18	3.24	2.81	4.05	2.69	2.79	31.97
Lalrinsanga	6	2.61	3.37	3.25	2.96	2.54	1.52	2.14	2.43	1.32	22.12
R.Lalmuanpuia	6	2.11	2.04	1.89	1.53	3.97	3.03	1.55	1.02	2.88	20.03
B Dengkhuma	8	4.67	4.38	4.16	7.94	2.30	5.64	4.09	7.36	5.62	46.15
A Vanlalthanga	7	2.29	2.51	2.38	1.27	1.88	1.34	1.72	0.81	1.24	15.43
Lalhmangaizuala	5	4.52	3.03	2.89	4.95	8.83	3.92	3.92	4.47	3.80	40.33
Laldhua	9	4.30	3.53	3.45	6.02	3.31	2.85	3.77	5.49	2.78	35.49
Zamthankhuma	7	2.48	2.38	2.11	2.96	2.41	1.71	1.97	2.46	1.64	20.11
JZonummawia	4	2.38	2.42	2.25	2.01	2.12	2.02	1.76	1.53	1.95	18.44
Lalchhawliana	9	1.78	1.37	1.22	1.77	1.81	1.34	1.29	1.31	1.20	13.08
Zarzoliana Hmar	6	2.96	4.50	4.32	2.15	2.19	4.25	2.35	1.71	4.18	28.60
Lalmalsawma V	3	3.45	3.34	3.23	3.45	5.02	2.86	2.97	2.98	2.85	30.14
Lalthlengliana	8	3.61	3.35	3.22	3.97	3.87	3.93	3.08	3.46	3.81	32.30
J Lalrempuia	5	4.90	4.28	4.15	3.93	3.99	3.72	4.38	3.45	3.58	36.38
H Sangmawia	8	2.51	2.42	2.27	2.02	1.87	1.05	1.96	1.55	0.88	16.53
Rothanga Ralte	8	4.61	8.27	8.08	2.06	3.33	2.80	4.16	1.53	2.72	37.55
Ngurthangsanga	5	3.69	4.44	4.16	3.83	2.96	4.83	3.15	3.30	4.69	35.05
Zamthansanga	7	3.35	1.86	1.56	2.14	2.00	3.28	2.83	1.66	3.23	21.90
Lalruatkima	2	2.89	3.40	3.20	5.36	1.89	2.38	2.32	4.81	2.17	28.42
Rosangpuia	10	3.92	9.47	9.24	3.85	1.98	2.68	3.32	3.39	2.67	40.53
Lalremenga	8	5.02	3.85	3.67	7.32	2.86	3.85	4.49	6.77	3.77	41.60
Vanlalruatkima	6	1.74	4.38	4.26	3.31	1.98	1.09	1.20	2.77	0.95	21.68

Zohmingliana	6	2.25	14.83	14.72	2.81	2.82	1.99	1.62	2.30	1.90	45.23
Zomuana	2	4.53	9.42	9.16	2.94	4.49	5.90	4.03	2.41	5.74	48.61
JLalmingchhuan	8	3.39	1.92	1.75	2.70	2.30	3.21	2.84	2.29	3.17	23.57
Bney Hmar	7	1.05	1.77	1.59	2.53	1.99	0.87	0.64	1.94	0.73	13.10
R K Lalnunzira	4	4.60	3.78	3.61	2.06	7.90	4.21	4.05	1.65	4.16	36.01
C Lalnunsanga	2	2.22	1.64	1.45	2.26	2.31	1.66	1.70	1.81	1.58	16.64
Alvin Lalrinkima	8	5.30	2.30	2.08	1.74	2.40	9.83	4.83	1.25	9.70	39.44
Liangura	5	0.81	1.40	1.21	1.02	0.76	0.96	1.47	0.56	0.86	9.05
R Zothantluanga	9	3.74	5.04	4.85	2.49	3.06	2.52	3.27	1.97	2.50	29.44
Vanlalsiama	2	1.67	2.40	2.24	1.76	0.92	2.00	1.19	1.28	1.92	15.39
Lalrinchana	6	5.05	4.30	4.14	7.94	2.98	4.80	4.54	7.45	4.75	45.95
Vanlalpeka	5	5.23	3.68	3.47	2.94	5.28	5.90	4.68	2.39	5.73	39.29
445 memebrs		**3.09**	**3.57**	**3.39**	**3.01**	**2.96**	**2.84**	**2.60**	**2.51**	**2.75**	***2057.86***

Appendix 8: Gross plastic waste generation (kg) in East Locality during 2018-19

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
MS Dawngliana	4	2.0	2.0	1.9	2.4	1.4	1.5	1.4	1.9	1.4	16.01
Lalremruata	4	2.2	2.3	2.1	2.5	2.7	1.4	1.7	2.0	1.3	18.12
Lalhimpuia	5	1.8	2.0	1.8	3.0	1.7	1.6	2.4	2.3	1.4	18.07
J C Dingluia	8	2.5	2.8	2.6	2.7	2.5	3.0	2.0	2.2	2.9	23.15
JV Lalropuia	6	3.7	1.9	1.7	3.1	2.9	3.0	3.1	2.5	2.7	24.37
JV Lalremruata	9	3.5	4.4	4.2	1.9	3.8	3.8	3.1	1.4	3.8	29.95
R Lalramchanna	10	5.1	5.5	5.2	5.3	4.4	3.3	4.6	4.8	3.3	41.38
Lalchhandama	3	1.9	2.5	2.4	1.4	2.5	1.6	1.4	1.0	1.5	16.26
Lalthanpuia	5	1.7	2.6	2.5	2.5	3.4	2.2	1.1	2.0	2.2	20.18
Thanzuala	7	2.3	2.5	2.3	2.0	3.2	1.9	1.9	1.4	1.7	19.25
Thangdela	10	4.5	5.3	5.3	4.7	4.2	4.0	4.0	4.2	4.0	40.18
Lalnunpuia	9	1.6	1.3	1.2	3.9	4.5	1.1	1.1	3.4	0.9	18.97
Lalmalsawma	7	4.2	2.9	2.6	3.8	3.6	3.7	3.7	3.4	3.7	31.61

Lalchandama	5	1.4	1.8	1.7	2.9	1.5	0.9	0.8	2.4	0.7	14.19
Lalruatsanga	5	3.8	3.7	3.4	3.1	3.1	2.9	3.1	2.7	2.9	28.83
Lalthanpuia	6	1.1	1.0	0.8	1.4	1.6	1.7	0.4	0.9	1.6	10.32
Isak Lalremsanga	4	2.5	2.0	1.9	1.5	3.6	3.2	1.9	0.9	3.1	20.67
Lalruatfela	10	4.5	5.4	5.2	5.8	3.7	4.4	4.0	5.2	4.3	42.58
Lawmsanga	3	3.3	3.0	2.8	3.0	3.8	3.9	2.7	2.6	3.9	29.02
Lalremruata	6	1.9	2.0	1.9	2.6	1.4	2.3	1.4	2.0	2.2	17.68
Victor	4	3.7	5.0	4.8	2.9	3.1	3.2	3.2	2.3	3.2	31.23
Lalrinkima	7	2.2	2.1	1.9	3.9	2.5	2.5	1.7	3.5	2.5	22.78
Lalthmawia	8	2.5	2.8	2.6	2.1	4.1	2.0	2.0	1.6	1.8	21.69
Malsawmtluanga	5	4.8	6.3	6.1	3.0	4.4	4.3	4.2	2.4	4.2	39.66
Vanlalruati	7	2.2	1.8	1.7	1.9	1.8	1.8	1.6	1.4	1.7	15.84
Zoremsanga	3	1.3	2.0	1.9	0.9	1.9	0.8	0.7	0.3	0.8	10.39
David Lalmuanpuia	3	0.7	3.5	3.2	1.3	0.9	0.7	1.5	0.9	0.6	13.32
V Thangbiaklala	5	3.7	3.8	3.6	2.8	3.0	5.9	3.2	2.3	5.7	34.00
H Lalduhsaka	8	2.1	2.4	2.2	3.0	2.4	1.9	1.6	2.4	1.8	19.67
Lalhriatpuia	10	5.0	6.3	6.1	5.7	4.1	4.9	4.5	5.2	4.7	46.40
Lalbuatsaiha	8	4.9	4.4	4.3	5.2	3.9	3.9	4.4	4.7	3.8	39.34
Lalrawmlawma	3	3.9	6.5	6.3	2.6	5.4	3.8	3.5	2.1	3.8	37.94
Rosanga	9	2.1	1.9	1.8	1.3	2.0	2.2	1.6	1.0	2.0	15.92
Vanlalruata	5	3.3	3.0	2.9	2.4	3.2	2.5	2.7	1.9	2.4	24.21
Buanthasanga	7	1.3	3.5	3.3	0.5	0.6	0.7	0.7	0.1	0.6	11.43
PC Vanlalzara	3	5.2	4.4	4.3	4.1	5.9	3.9	4.7	3.7	3.7	39.84
Lalrohlua	6	2.6	3.4	3.3	2.8	3.9	1.9	2.1	2.3	1.7	23.89
Lalbiaksanga	4	4.9	4.5	4.3	3.0	3.0	3.4	4.2	2.5	3.4	33.29
Zohmingmawia	9	2.3	3.5	3.3	2.4	1.5	2.5	1.7	1.8	2.4	21.46
F Lalbiaksanga	8	3.4	3.7	3.4	2.0	2.9	2.9	2.8	1.6	2.7	25.43
H Lalsiamthanga	5	1.8	2.3	2.1	1.4	2.3	1.4	1.3	0.9	1.3	14.68
Lalsangliana	7	4.1	4.9	4.6	6.0	3.0	3.9	3.7	5.4	3.7	39.34
BLalchhandama	3	1.5	1.5	1.3	1.5	0.9	1.4	1.0	0.9	1.3	11.31
Henry Lalnunhlima	4	4.7	4.5	4.3	3.3	3.3	2.9	4.1	2.8	2.7	32.54
Lalrinsanga	6	2.7	3.5	3.3	3.1	2.5	1.5	2.1	2.4	1.4	22.61
RLalmuanpuia	6	2.1	2.1	1.9	1.5	4.0	3.1	1.7	1.1	2.9	20.40
B Dengkhuma	8	4.6	4.4	4.3	7.9	2.4	5.7	4.1	7.4	5.7	46.42
Andrew V	7	2.2	2.6	2.5	1.3	1.9	1.4	1.7	0.8	1.3	15.71

Lalhmangaizuala	5	4.6	3.0	2.8	4.9	9.0	3.9	4.0	4.4	3.7	40.24
Laldhua	9	4.2	3.6	3.5	5.9	3.4	2.8	3.8	5.5	2.8	35.72
Zamthankhuma	7	2.6	2.4	2.2	3.1	2.4	1.7	2.0	2.6	1.7	20.55
John Zonummawia	4	2.4	2.4	2.2	2.1	2.2	2.1	1.7	1.5	2.1	18.59
Lalchhawliana	9	1.9	1.5	1.3	1.9	1.8	1.4	1.2	1.3	1.3	13.55
Zarzoliana Hmar	6	3.0	4.6	4.3	2.3	2.4	4.2	2.4	1.8	4.2	29.19
Lalmalsawma V	3	3.5	3.5	3.2	3.4	5.0	2.9	2.9	2.9	2.9	30.25
Lalthlengliana	8	3.7	3.4	3.3	4.0	3.9	4.0	3.1	3.5	3.9	32.92
Jereme Lalrempuia	5	5.0	4.3	4.2	3.9	4.0	3.7	4.4	3.5	3.6	36.53
H Sangmawia	8	2.4	2.4	2.4	2.2	1.9	1.1	2.0	1.5	0.9	16.76
Rothanga Ralte	8	4.6	8.4	8.0	2.1	3.4	2.9	4.1	1.5	2.8	37.84
Ngurthangsanga	5	3.7	4.5	4.3	3.9	3.0	4.9	3.1	3.3	4.7	35.29
Zamthansanga	7	3.4	1.9	1.7	2.1	1.9	3.3	2.9	1.7	3.3	22.21
Lalruatkima	2	3.0	3.5	3.2	5.2	1.8	2.4	2.4	4.9	2.2	28.62
Rosangpuia	10	3.9	9.6	9.2	3.9	2.1	2.8	3.4	3.4	2.7	41.07
Lalremenga	8	5.0	3.9	3.7	7.4	2.9	3.8	4.4	6.8	3.9	41.60
Vanlalruatkima	6	1.7	4.4	4.3	3.3	2.0	1.0	1.2	2.9	0.9	21.74
Zohmingliana	6	2.2	14.8	14.7	2.9	2.8	2.1	1.7	2.4	2.0	45.65
Zomuana	2	4.7	9.4	9.2	2.9	4.5	5.9	4.1	2.4	5.8	48.84
Jacob L	8	3.4	1.9	1.7	2.8	2.3	3.2	2.9	2.2	3.1	23.58
Bney Hmar	7	1.2	1.7	1.6	2.4	2.0	0.8	0.5	2.0	0.8	13.20
R K Lalnunzira	4	4.8	3.8	3.6	2.2	8.0	4.3	4.1	1.7	4.3	36.64
C Lalnunsanga	2	2.1	1.7	1.5	2.3	2.4	1.7	1.6	1.8	1.5	16.75
Alvin Lalrinkima	8	5.3	2.4	2.1	1.8	2.5	9.9	4.8	1.2	9.7	39.64
Liangura	5	0.8	1.6	1.3	1.0	0.8	0.9	1.4	0.5	0.9	9.24
Robert Z	9	3.9	5.1	4.8	2.5	3.0	2.6	3.3	2.1	2.5	29.70
Vanlalsiama	2	1.7	2.6	2.4	1.9	1.0	2.1	1.3	1.4	1.9	16.06
Lalrinchana	6	5.1	4.5	4.1	8.0	3.0	4.8	4.6	7.4	4.7	46.28
Vanlalpeka	5	5.3	3.6	3.4	3.0	5.4	5.8	4.8	2.5	5.8	39.62
445 memmers		**3.12**	**3.61**	**3.42**	**3.04**	**3.00**	**2.88**	**2.63**	**2.54**	**2.78**	***2079.37***

Appendix 9: Gross plastic waste generation (kg) in East Locality during 2019-20

Head of family	Family size	Winter			summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
MS Dawngliana	4	2.06	2.18	1.91	2.58	1.45	1.60	1.54	1.96	1.51	16.79
Lalremruata	4	2.24	2.42	2.20	2.54	2.80	1.47	1.73	1.95	1.40	18.74
Lalhimpuia	5	1.94	2.22	1.96	3.11	1.73	1.70	2.50	2.60	1.61	19.37
J C Dingluia	8	2.62	2.85	2.75	2.75	2.57	3.20	2.15	2.26	3.08	24.21
JV Lalropuia	6	3.79	1.88	1.68	3.06	2.95	3.02	3.23	2.63	2.81	25.04
JV Lalremruata	9	3.69	4.42	4.20	1.98	4.10	3.94	3.21	1.63	3.88	31.05
R Lalramchanna	10	5.23	5.62	5.35	5.35	4.43	3.37	4.69	4.84	3.24	42.11
Lalchhandama	3	1.98	2.56	2.45	1.56	2.66	1.69	1.52	1.02	1.57	17.02
Lalthanpuia	5	1.79	2.84	2.54	2.58	3.46	2.35	1.15	2.01	2.38	21.09
Thanzuala	7	2.50	2.66	2.42	1.90	3.31	1.96	2.02	1.56	1.86	20.19
Thangdela	10	4.78	5.50	5.37	4.90	4.24	4.21	4.10	4.41	3.98	41.47
Lalnunpuia	9	1.76	1.40	1.32	4.05	4.46	1.26	1.32	3.51	1.17	20.25
Lalmalsawma	7	4.35	3.03	2.83	3.91	3.80	3.84	3.90	3.53	3.80	32.98
Lalchandama	5	1.53	1.91	1.72	2.92	1.74	1.00	0.85	2.51	1.01	15.18
Lalruatsanga	5	3.91	3.76	3.51	3.28	3.22	3.18	3.32	2.72	3.07	29.96
Lalthanpuia	6	1.05	1.07	1.03	1.56	1.70	1.86	0.65	1.04	1.70	11.67
Isak L	4	2.55	2.16	1.96	1.64	3.73	3.38	1.90	1.01	3.34	21.67
Lalruatfela	10	4.74	5.45	5.29	5.93	3.80	4.43	4.05	5.37	4.33	43.38
Lawmsanga	3	3.37	3.15	2.91	3.19	3.87	4.04	2.85	2.81	3.94	30.13
Lalremruata	6	1.92	2.28	2.02	2.57	1.61	2.29	1.39	2.19	2.35	18.61
Victor	4	3.87	4.97	4.91	2.99	3.12	3.33	3.19	2.41	3.25	32.03
Lalrinkima	7	2.30	2.20	1.99	4.14	2.65	2.69	1.86	3.65	2.57	24.05
Lalthmawia	8	2.71	3.01	2.69	2.17	4.04	2.13	2.12	1.75	1.97	22.59
Malsawmtluang	5	4.99	6.38	6.28	3.09	4.43	4.32	4.30	2.67	4.29	40.74
Vanlalruati	7	2.37	2.03	1.76	1.88	1.82	1.97	1.83	1.48	1.88	17.02
Zoremsanga	3	1.43	2.07	2.02	0.80	1.99	0.97	0.84	0.39	0.86	11.36
David L	3	0.77	3.49	3.38	1.35	1.13	0.94	1.62	0.94	0.73	14.36
VThangbiaklala	5	3.88	3.81	3.79	2.98	3.14	6.01	3.35	2.40	5.80	35.17
H Lalduhsaka	8	2.26	2.57	2.30	3.09	2.58	1.90	1.70	2.57	1.80	20.79
Lalhriatpuia	10	5.16	6.35	6.19	5.92	4.30	5.04	4.58	5.30	4.96	47.80
Lalbuatsaiha	8	5.03	4.61	4.43	5.18	4.03	3.95	4.36	4.72	3.95	40.26

Lalrawmlawma	3	4.14	6.65	6.37	2.55	5.36	3.94	3.55	2.17	3.91	38.64
Rosanga	9	2.35	2.04	1.98	1.46	2.13	2.16	1.65	0.99	2.14	16.90
Vanlalruata	5	3.36	3.10	2.97	2.55	3.13	2.54	2.83	2.15	2.60	25.22
Buanthasanga	7	1.45	3.61	3.38	0.58	0.74	0.80	0.99	0.14	0.80	12.47
PC Vanlalzara	3	5.41	4.48	4.43	4.21	5.95	3.86	4.85	3.73	3.77	40.69
Lalrohlua	6	2.61	3.63	3.35	3.03	4.05	1.95	2.14	2.53	1.93	25.21
Lalbiaksanga	4	4.85	4.48	4.41	3.01	3.13	3.63	4.31	2.47	3.39	33.66
Zohmingmawia	9	2.44	3.45	3.31	2.52	1.69	2.65	1.87	2.02	2.40	22.36
F Lalbiaksanga	8	3.49	3.70	3.54	2.11	3.10	2.90	2.83	1.69	2.80	26.16
HLalsiamthanga	5	1.88	2.40	2.28	1.50	2.49	1.58	1.36	0.87	1.53	15.88
Lalsangliana	7	4.20	4.97	4.69	6.11	2.98	3.94	3.76	5.51	3.82	39.98
Benjamin L	3	1.75	1.48	1.35	1.47	0.99	1.42	1.11	1.05	1.35	11.97
Henry L	4	4.83	4.64	4.40	3.42	3.27	2.87	4.19	2.84	2.84	33.29
Lalrinsanga	6	2.77	3.63	3.37	3.07	2.64	1.54	2.19	2.52	1.51	23.23
Robert L	6	2.23	2.29	1.99	1.66	4.01	3.12	1.77	1.19	3.17	21.41
B Dengkhuma	8	4.74	4.55	4.30	8.01	2.40	5.73	4.28	7.48	5.75	47.24
Andrew V	7	2.44	2.64	2.49	1.42	2.10	1.53	1.76	0.86	1.41	16.65
Lalhmangaizual	5	4.69	3.14	3.00	5.09	8.95	3.96	4.11	4.60	3.99	41.54
Laldhua	9	4.33	3.69	3.59	6.17	3.43	2.91	3.79	5.55	2.86	36.32
Zamthankhuma	7	2.59	2.53	2.24	3.19	2.62	1.84	2.12	2.68	1.80	21.60
John Z	4	2.43	2.48	2.39	2.19	2.35	2.17	1.93	1.68	2.00	19.63
Lalchhawliana	9	2.05	1.52	1.31	1.88	2.05	1.37	1.33	1.44	1.42	14.34
Zarzoliana Hmar	6	3.18	4.64	4.49	2.27	2.41	4.50	2.63	1.93	4.34	30.39
Lalmalsawma V	3	3.70	3.48	3.34	3.55	5.02	2.92	3.16	3.14	2.88	31.18
Lalthlengliana	8	3.82	3.60	3.41	4.05	3.91	4.07	3.21	3.60	3.87	33.55
Jereme L	5	5.05	4.37	4.20	4.13	4.08	3.74	4.49	3.49	3.75	37.31
H Sangmawia	8	2.55	2.61	2.46	2.12	2.09	1.20	2.02	1.59	1.09	17.73
Rothanga Ralte	8	4.83	8.44	8.26	2.17	3.55	2.87	4.14	1.70	2.78	38.74
Ngurthangsanga	5	3.80	4.63	4.40	3.85	3.10	4.95	3.23	3.53	4.78	36.27
Zamthansanga	7	3.42	1.89	1.67	2.19	2.05	3.48	3.02	1.83	3.41	22.95
Lalruatkima	2	2.98	3.49	3.39	5.51	1.96	2.54	2.38	4.94	2.34	29.53
Rosangpuia	10	4.03	9.51	9.49	4.06	2.02	2.77	3.44	3.48	2.76	41.55
Lalremenga	8	5.09	4.02	3.67	7.44	2.97	4.04	4.64	6.99	3.94	42.80
Vanlalruatkima	6	1.93	4.58	4.40	3.44	2.16	1.09	1.39	2.93	1.16	23.06

Zohmingliana	6	2.27	14.98	14.84	3.00	2.96	2.11	1.86	2.54	1.98	46.54
Zomuana	2	4.63	9.50	9.38	3.00	4.69	6.02	4.17	2.49	5.94	49.81
Jacob L	8	3.58	2.05	1.90	2.90	2.47	3.45	3.09	2.41	3.19	25.03
Bney Hmar	7	1.26	1.93	1.61	2.70	2.06	0.94	0.73	2.20	0.78	14.20
R K Lalnunzira	4	4.81	4.00	3.67	2.23	8.03	4.33	4.29	1.75	4.23	37.33
C Lalnunsanga	2	2.34	1.84	1.53	2.38	2.51	1.81	1.71	1.90	1.69	17.71
Alvin L	8	5.47	2.46	2.34	1.93	2.51	9.89	4.99	1.45	9.86	40.90
Liangura	5	0.97	1.62	1.33	1.12	0.96	1.00	1.50	0.72	0.93	10.13
Robert Z	9	3.88	5.23	5.04	2.70	3.12	2.61	3.41	2.25	2.56	30.79
Vanlalsiama	2	1.86	2.65	2.44	1.91	1.10	2.08	1.28	1.37	2.17	16.85
Lalrinchana	6	5.19	4.53	4.34	7.97	3.03	5.02	4.70	7.48	4.91	47.18
Vanlalpeka	5	5.40	3.79	3.66	3.10	5.45	5.98	4.81	2.53	5.91	40.61
445 members		**3.24**	**3.71**	**3.53**	**3.14**	**3.10**	**2.97**	**2.74**	**2.65**	**2.89**	***2153.59***

Appendix 10: Gross plastic waste generation (kg) in Central Locality during 2017-18

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Lalmanghaia	3	2.10	2.00	2.00	2.43	1.49	1.51	1.52	2.00	1.47	16.52
Anand Gurung	7	2.26	2.23	2.03	2.54	2.62	1.41	1.55	1.89	1.18	17.70
R Biaktluanga	3	1.79	2.00	1.83	2.92	1.52	1.65	2.28	2.28	1.56	17.81
Lalchawlliana	9	2.64	2.69	2.80	2.50	2.38	3.04	1.89	2.11	2.83	22.86
R H Mingthanga	5	3.73	1.80	1.72	3.11	2.90	2.89	3.09	2.64	2.93	24.81
Elkana Rosanzela	7	3.48	4.23	4.10	2.08	3.88	3.86	2.99	1.47	3.81	29.89
Vanlaqlhumpuia	3	5.26	5.55	5.21	5.31	4.20	3.37	4.71	4.83	3.06	41.50
Laltanpuia	3	1.99	2.46	2.48	1.34	2.66	1.50	1.38	0.76	1.61	16.17
Vankhuma	5	1.80	2.50	2.51	2.52	3.42	2.40	1.11	1.88	2.34	20.47
Lalmanghaisanga	5	2.50	2.66	2.41	1.77	3.25	2.00	1.82	1.45	1.74	19.60
Lalchhuansanga	10	4.76	5.25	5.09	4.79	4.04	4.19	4.16	4.42	3.85	40.54
Vanlalbela	6	1.84	1.45	1.07	4.06	4.53	1.04	1.09	3.32	1.02	19.41
Hmanghaizuala	5	4.24	3.06	2.69	3.94	3.63	3.87	3.83	3.40	3.61	32.26
Jerry Lallawmawma	3	1.21	1.96	1.52	2.75	1.60	0.95	0.88	2.41	0.82	14.10
Lalzawna	5	3.82	3.57	3.39	3.02	3.15	3.00	3.17	2.53	2.83	28.47

MC Vanlalreuata	3	0.99	0.94	0.95	1.49	1.62	1.74	0.61	0.92	1.68	10.92
Lallianhaka	8	2.45	1.93	1.82	1.42	3.63	3.37	1.87	0.87	3.23	20.59
William Sailo	10	4.48	5.44	5.24	5.63	3.60	4.24	4.06	5.20	4.16	42.05
Michael Jacke	3	3.17	3.00	2.96	3.03	3.93	3.90	2.77	2.67	3.91	29.33
PaulLaltumsanga	4	1.85	2.18	2.03	2.49	1.48	2.17	1.42	2.14	2.07	17.82
Rockfeller Sailo	9	3.62	5.04	4.64	2.85	3.15	3.29	3.14	2.47	3.30	31.51
Lalthanmawia	3	2.27	2.01	1.82	4.13	2.43	2.52	1.78	3.49	2.46	22.91
Zothansanga hmar	3	2.44	2.92	2.66	2.22	4.09	1.97	1.89	1.64	1.99	21.81
H Lalruatkima	5	4.82	6.28	6.19	2.84	4.38	4.19	4.17	2.49	4.26	39.61
Lalhminsanga Hmar	7	2.24	1.84	1.71	1.73	1.67	1.76	1.74	1.46	1.79	15.93
H Tlanthanga	3	1.27	2.12	1.80	0.67	1.89	0.77	0.64	0.37	0.62	10.12
Ramhluna	6	0.68	3.47	3.32	1.35	0.85	0.90	1.66	0.75	0.60	13.57
R Lallawama	4	3.82	3.86	3.56	2.90	3.03	5.94	3.12	2.36	5.70	34.27
K B Thapa	3	2.25	2.52	2.08	3.02	2.57	1.77	1.58	2.51	1.83	20.12
Lalrinawma	10	5.04	6.43	6.24	5.83	4.15	4.85	4.32	5.34	4.66	46.87
Lallviliana	7	4.81	4.52	4.17	5.18	3.98	3.98	4.30	4.59	3.78	39.30
Vanlalhmuaka	3	4.09	6.40	6.20	2.55	5.27	3.83	3.44	1.96	3.64	37.39
C Lalremdika	5	2.14	2.02	1.75	1.52	2.08	1.96	1.70	0.85	1.84	15.85
Zazika	6	3.20	3.19	2.80	2.63	3.24	2.42	2.59	1.93	2.26	24.25
Lalremzuala	9	1.28	3.46	3.26	0.61	0.73	0.90	0.90	0.13	0.59	11.86
H Lalhlira	4	5.30	4.51	4.12	4.00	6.02	3.82	4.82	3.69	3.74	40.00
H Laldintluanga	7	2.72	3.33	3.17	2.90	3.96	1.85	1.97	2.30	1.82	24.03
Zokaia	2	4.84	4.54	4.12	2.82	3.02	3.54	4.21	2.52	3.28	32.88
Lalruatfela Pacuau	8	2.28	3.55	3.32	2.34	1.68	2.44	1.70	1.76	2.29	21.36
Vanlalmalsawmkim	4	3.38	3.51	3.36	2.19	2.95	2.67	2.83	1.68	2.79	25.36
Peter Lalrosiama	3	1.70	2.28	2.10	1.39	2.38	1.54	1.15	0.74	1.50	14.76
Donald Lalrokima	5	4.24	4.88	4.65	6.06	2.93	3.97	3.48	5.56	3.74	39.51
Lalengzama	8	1.53	1.35	1.28	1.52	0.67	1.40	1.08	0.98	1.40	11.20
C lalkhuma	5	4.49	4.33	4.34	3.21	3.28	2.72	4.00	2.72	2.85	31.92
PB Kawalianhuma	4	2.69	3.57	3.27	3.08	2.55	1.39	2.23	2.57	1.40	22.73
Lapianmawia	7	2.22	2.12	2.03	1.39	3.89	3.18	1.58	0.97	2.86	20.23
Zoramchhana	9	4.73	4.53	4.39	7.80	2.45	5.57	4.05	7.45	5.66	46.62
Larohlua	3	2.31	2.49	2.26	1.41	2.10	1.34	1.70	0.92	1.46	16.00
Rothumliana	5	4.35	3.17	2.84	4.80	8.93	3.76	3.96	4.56	3.83	40.21
Zoremsanga	6	4.28	3.52	3.38	5.99	3.43	2.84	3.89	5.37	2.67	35.36

Vanlalmuanga	5	2.44	2.42	2.09	3.13	2.47	1.81	2.08	2.54	1.78	20.75
A D Sailo	7	2.27	2.37	2.12	2.23	2.08	1.96	1.87	1.45	1.98	18.32
Lalduhawma	4	1.87	1.58	1.37	1.86	1.79	1.22	1.29	1.45	1.14	13.57
K Sangkunga	3	2.89	4.53	4.23	2.21	2.33	4.18	2.42	1.61	4.32	28.73
C Lalzarliana	6	3.41	3.48	3.27	3.38	5.05	2.80	3.10	2.93	2.72	30.14
C lalmalsawma	3	3.73	3.52	3.13	3.87	3.77	3.81	3.23	3.43	3.80	32.29
C Lalzamlova	7	4.93	4.38	4.26	3.96	3.93	3.75	4.35	3.48	3.62	36.66
C Lalruatfela	5	2.38	2.58	2.29	2.04	1.89	1.12	1.99	1.62	0.97	16.87
P C Lalrinfela	9	4.80	8.28	7.99	2.09	3.41	2.77	4.12	1.71	2.68	37.86
Lalbiaktluanga	4	3.81	4.43	4.13	3.79	2.94	4.89	3.33	3.29	4.91	35.54
V L Thlamuanpuia	7	3.51	1.97	1.68	2.17	1.99	3.41	2.85	1.58	3.32	22.48
Vanlalrova	8	2.98	3.31	3.20	5.32	1.85	2.32	2.47	4.93	2.24	28.61
H Valbuanga	9	3.94	9.39	9.16	4.09	1.89	2.85	3.33	3.36	2.62	40.63
H Lalcharliana	2	5.04	3.79	3.79	7.33	2.85	3.75	4.31	6.95	3.87	41.66
David Lalruatkima	3	1.75	4.45	4.13	3.37	1.99	0.94	1.37	2.86	1.05	21.91
Lalrinsanga	4	2.27	14.88	14.65	2.86	2.94	2.10	1.68	2.28	1.96	45.61
Lalchhuanliana	7	4.58	9.33	9.32	2.90	4.70	5.99	4.03	2.31	5.71	48.86
Lalramthara	8	3.53	1.98	1.65	2.78	2.42	3.38	2.84	2.26	3.27	24.10
J Lalrempuia	2	1.12	1.63	1.44	2.64	2.05	0.94	0.51	1.89	0.80	13.02
Biakthansaga	4	4.71	3.76	3.72	2.10	7.98	4.27	4.18	1.61	4.09	36.41
Hminthanzuala	9	2.15	1.62	1.55	2.40	2.50	1.56	1.74	1.92	1.43	16.87
Lalhmaruaia	2	5.26	2.31	2.10	1.64	2.33	9.78	4.82	1.16	9.69	39.08
Lalfamkima	4	0.87	1.54	1.19	0.97	0.87	1.06	1.48	0.62	0.85	9.45
Lasankima	5	3.83	4.91	4.78	2.58	3.09	2.51	3.22	2.00	2.57	29.49
Lalawmpuii	8	1.76	2.58	2.39	1.87	0.81	2.07	1.27	1.38	2.06	16.18
Lalnunkima	4	5.08	4.38	4.10	7.84	2.93	4.75	4.39	7.42	4.75	45.65
S Lalawmsanga	9	5.32	3.56	3.52	2.91	5.38	5.79	4.68	2.51	5.87	39.54
443 members		**3.11**	**3.61**	**3.40**	**3.05**	**2.98**	**2.83**	**2.61**	**2.54**	**2.74**	***2080.62***

Appendix 11: Gross plastic waste generation (kg) in Central Locality during 2018-19 (n=77)

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	

Lalmanghaia	3	1.99	2.05	1.88	2.45	1.41	1.57	1.41	1.95	1.47	16.18
Anand Gurung	7	2.15	2.36	2.15	2.43	2.66	1.39	1.59	1.94	1.27	17.94
R Biaktluanga	8	1.87	2.07	1.87	2.94	1.62	1.56	2.33	2.43	1.47	18.17
Lalchawlliana	9	2.56	2.85	2.68	2.65	2.47	3.04	2.01	2.16	2.93	23.33
R H Mingthanga	5	3.73	1.86	1.68	3.03	2.82	2.89	3.16	2.55	2.81	24.52
Elkana Rosanzela	7	3.64	4.34	4.17	1.95	3.91	3.84	3.08	1.46	3.75	30.13
Vanlaqlhumpuia	3	5.17	5.51	5.30	5.30	4.34	3.29	4.65	4.83	3.20	41.58
Laltanpuia	8	1.92	2.56	2.34	1.38	2.58	1.57	1.39	0.88	1.48	16.11
Vankhuma	5	1.70	2.67	2.47	2.45	3.39	2.30	1.14	1.96	2.24	20.31
Lalmanghaisanga	5	2.44	2.57	2.40	1.87	3.29	1.93	1.91	1.41	1.83	19.65
Lalchhuansanga	10	4.64	5.39	5.19	4.81	4.11	4.05	4.11	4.29	3.97	40.55
Vanlalbela	6	1.74	1.39	1.20	3.94	4.40	1.14	1.20	3.46	1.01	19.48
Hmanghaizuala	5	4.27	2.93	2.76	3.86	3.68	3.76	3.71	3.38	3.70	32.05
Jerry L	8	1.38	1.85	1.67	2.87	1.62	0.91	0.80	2.38	0.82	14.29
Lalzawna	5	3.77	3.66	3.47	3.15	3.05	3.01	3.23	2.64	2.92	28.89
MC Vanlalreuata	3	1.03	1.06	0.87	1.39	1.64	1.71	0.50	0.88	1.63	10.69
Lallianhaka	8	2.43	2.06	1.86	1.49	3.62	3.25	1.88	1.01	3.19	20.78
William Sailo	10	4.57	5.39	5.23	5.79	3.69	4.37	4.02	5.31	4.27	42.63
Michael Jacke	3	3.27	3.06	2.89	3.17	3.80	3.89	2.72	2.66	3.80	29.25
PaulLaltumsanga	4	1.93	2.12	1.92	2.54	1.48	2.27	1.37	2.05	2.16	17.84
Rockfeller Sailo	9	3.72	4.96	4.76	2.89	3.13	3.26	3.17	2.43	3.18	31.49
Lalthanmawia	3	2.28	2.07	1.88	4.05	2.47	2.52	1.72	3.53	2.41	22.94
Zothansanga hmar	9	2.60	2.88	2.69	2.09	3.99	2.01	2.04	1.62	1.89	21.80
H Lalruatkima	5	4.81	6.36	6.17	2.99	4.30	4.29	4.27	2.51	4.21	39.90
Lalhminsanga Hmar	7	2.23	1.91	1.72	1.88	1.83	1.82	1.69	1.40	1.71	16.19
H Tlanthanga	3	1.27	2.06	1.89	0.80	1.86	0.82	0.73	0.32	0.73	10.47
Ramhluna	6	0.72	3.46	3.29	1.26	0.97	0.80	1.58	0.79	0.67	13.55
R Lallawama	4	3.76	3.80	3.61	2.88	2.98	5.87	3.22	2.40	5.79	34.30
K B Thapa	9	2.18	2.38	2.22	2.94	2.47	1.82	1.63	2.45	1.75	19.84
Lalrinawma	10	5.04	6.32	6.11	5.77	4.15	4.89	4.49	5.25	4.78	46.79
Lallviliana	7	4.85	4.50	4.31	5.17	3.99	3.93	4.32	4.66	3.84	39.56
Vanlalhmuaka	3	4.03	6.45	6.30	2.56	5.35	3.87	3.45	2.04	3.77	37.83
C Lalremdika	5	2.17	1.99	1.82	1.45	2.02	2.09	1.62	0.96	1.97	16.09
Zazika	6	3.28	3.07	2.90	2.56	3.14	2.51	2.74	2.05	2.42	24.68
Lalremzuala	9	1.34	3.46	3.26	0.53	0.62	0.79	0.82	0.05	0.69	11.56

H Lalhlira	4	5.32	4.45	4.27	4.14	5.89	3.81	4.77	3.65	3.70	39.99
H Laldintluanga	7	2.59	3.45	3.28	2.90	3.95	1.89	2.06	2.41	1.79	24.32
Zokaia	2	4.81	4.46	4.30	2.94	3.08	3.46	4.28	2.45	3.40	33.17
Lalruatfela Pacuau	8	2.32	3.46	3.28	2.36	1.61	2.48	1.76	1.84	2.39	21.49
Vanlalmalsawmkima	4	3.38	3.65	3.48	2.07	2.96	2.84	2.83	1.59	2.75	25.53
Peter Lalrosiama	9	1.81	2.37	2.16	1.35	2.36	1.47	1.29	0.84	1.37	15.00
Donald Lalrokima	5	4.16	4.86	4.66	5.94	2.99	3.83	3.60	5.48	3.77	39.27
Lalengzama	8	1.57	1.41	1.24	1.46	0.84	1.36	1.04	0.96	1.26	11.14
C lalkhuma	5	4.65	4.47	4.29	3.24	3.21	2.88	4.11	2.75	2.80	32.40
PB Kawalianhuma	4	2.70	3.45	3.26	3.01	2.60	1.52	2.15	2.51	1.43	22.63
Lapianmawia	7	2.17	2.16	1.99	1.55	4.03	3.07	1.63	1.05	3.00	20.64
Zoramchhana	9	4.66	4.48	4.27	7.97	2.36	5.72	4.13	7.46	5.64	46.67
Larohlua	3	2.26	2.62	2.43	1.37	1.96	1.44	1.74	0.86	1.32	15.99
Rothumliana	5	4.53	3.06	2.86	4.95	8.94	3.90	3.97	4.44	3.83	40.47
Zoremsanga	6	4.29	3.66	3.45	6.02	3.36	2.87	3.75	5.50	2.79	35.69
Vanlalmuanga	5	2.53	2.39	2.20	3.03	2.47	1.75	1.95	2.54	1.69	20.55
A D Sailo	7	2.38	2.48	2.30	2.09	2.17	2.11	1.81	1.62	1.98	18.94
Lalduhawma	4	1.88	1.45	1.27	1.83	1.85	1.32	1.33	1.35	1.25	13.53
K Sangkunga	9	3.02	4.53	4.35	2.23	2.27	4.33	2.46	1.77	4.23	29.19
C Lalzarliana	6	3.56	3.40	3.22	3.49	5.02	2.92	3.01	3.00	2.85	30.46
C lalmalsawma	3	3.70	3.47	3.26	4.04	3.88	3.93	3.17	3.54	3.84	32.83
C Lalzamlova	7	4.92	4.36	4.17	3.97	3.99	3.74	4.36	3.45	3.63	36.57
C Lalruatfela	5	2.52	2.49	2.32	2.08	1.90	1.10	1.99	1.59	0.99	16.97
P C Lalrinfela	9	4.70	8.36	8.17	2.09	3.43	2.89	4.13	1.61	2.80	38.19
Lalbiaktluanga	4	3.76	4.48	4.26	3.84	3.02	4.86	3.22	3.37	4.79	35.60
V L Thlamuanpuia	7	3.41	1.86	1.65	2.18	2.01	3.39	2.90	1.68	3.30	22.37
Vanlalrova	8	2.93	3.44	3.28	5.36	1.86	2.37	2.36	4.86	2.28	28.74
H Valbuanga	9	3.97	9.51	9.31	3.97	1.99	2.75	3.43	3.48	2.69	41.09
H Lalcharliana	2	5.04	3.85	3.65	7.36	2.90	3.90	4.50	6.89	3.82	41.89
David Lalruatkima	3	1.79	4.45	4.28	3.36	2.00	1.08	1.26	2.88	1.01	22.10
Lalrinsanga	4	2.26	14.89	14.71	2.85	2.94	2.08	1.70	2.38	1.99	45.79
Lalchhuanliana	7	4.63	9.41	9.21	2.94	4.59	5.90	4.06	2.48	5.82	49.04
Lalramthara	8	3.48	1.94	1.76	2.77	2.39	3.27	2.93	2.28	3.19	24.01
J Lalrempuia	2	1.15	1.76	1.61	2.51	2.03	0.87	0.63	2.03	0.77	13.35
Biakthansaga	4	4.69	3.87	3.66	2.16	7.92	4.25	4.16	1.66	4.17	36.53

Hminthanzuala	9	2.25	1.65	1.48	2.33	2.41	1.71	1.66	1.84	1.60	16.92
Lalhmaruaia	2	5.37	2.33	2.18	1.81	2.49	9.82	4.82	1.29	9.74	39.85
Lalfamkima	4	0.84	1.52	1.31	1.11	0.88	0.98	1.50	0.62	0.86	9.61
Lasankima	5	3.81	5.08	4.86	2.59	3.06	2.57	3.28	2.06	2.49	29.80
Lalawmpuii	8	1.76	2.50	2.31	1.85	0.99	2.10	1.19	1.35	1.99	16.05
Lalnunkima	4	5.10	4.38	4.21	7.94	3.00	4.87	4.55	7.47	4.80	46.31
S Lalawmsanga	9	5.27	3.66	3.50	2.98	5.32	5.93	4.73	2.52	5.80	39.72
443 members		**3.12**	**3.62**	**3.44**	**3.06**	**2.98**	**2.85**	**2.62**	**2.56**	**2.76**	***2091.71***

Appendix 12: Gross plastic waste generation (kg) in Central Locality during 2019-20

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Lalmanghaia	3	1.98	2.02	1.74	2.33	1.36	1.52	1.35	1.86	1.46	15.61
Anand Gurung	7	2.07	2.32	2.07	2.39	2.60	1.39	1.61	1.93	1.24	17.63
R Biaktluanga	8	1.80	2.06	1.80	2.87	1.54	1.47	2.25	2.43	1.45	17.66
Lalchawlliana	9	2.58	2.74	2.56	2.53	2.42	2.93	1.99	2.09	2.90	22.72
R H Mingthanga	5	3.65	1.83	1.60	2.92	2.76	2.87	3.16	2.47	2.82	24.09
Elkana Rosanzela	7	3.63	4.25	4.07	1.85	3.84	3.69	3.05	1.37	3.68	29.44
Vanlaqlhumpuia	3	5.07	5.52	5.23	5.25	4.34	3.26	4.52	4.81	3.10	41.10
Laltanpuia	8	1.85	2.49	2.35	1.39	2.58	1.51	1.26	0.85	1.39	15.67
Vankhuma	5	1.59	2.60	2.45	2.37	3.30	2.30	1.14	1.94	2.10	19.77
Lalmanghaisanga	5	2.43	2.58	2.31	1.80	3.21	1.79	1.81	1.33	1.85	19.10
Lalchhuansanga	10	4.64	5.39	5.21	4.72	4.06	4.09	3.97	4.27	3.90	40.26
Vanlalbela	6	1.70	1.43	1.19	3.94	4.32	1.05	1.09	3.34	1.04	19.10
Hmanghaizuala	5	4.22	2.82	2.73	3.89	3.65	3.72	3.69	3.31	3.60	31.62
Jerry Lallawmawma	8	1.30	1.84	1.69	2.79	1.63	0.87	0.83	2.37	0.82	14.14
Lalzawna	5	3.72	3.57	3.36	3.03	3.03	3.02	3.19	2.53	2.92	28.36
MC Vanlalreuata	3	1.02	1.02	0.81	1.39	1.63	1.72	0.36	0.80	1.64	10.38
Lallianhaka	8	2.30	2.05	1.88	1.51	3.51	3.17	1.84	0.92	3.16	20.34
William Sailo	10	4.54	5.35	5.10	5.69	3.70	4.36	4.01	5.33	4.31	42.38
Michael Jacke	3	3.27	3.04	2.81	3.16	3.83	3.83	2.75	2.53	3.78	28.99
PaulLaltumsanga	4	1.80	1.99	1.86	2.50	1.38	2.19	1.28	1.96	2.15	17.08

Rockfeller Sailo	9	3.74	4.98	4.74	2.88	3.07	3.29	3.20	2.32	3.19	31.39
Lalthanmawia	3	2.28	2.00	1.83	4.03	2.39	2.44	1.66	3.43	2.31	22.37
Zothansanga hmar	9	2.56	2.75	2.68	2.00	3.87	1.92	1.95	1.57	1.93	21.22
H Lalruatkima	5	4.75	6.38	6.13	3.00	4.26	4.20	4.24	2.44	4.20	39.61
Lalhminsanga Hmar	7	2.15	1.92	1.68	1.76	1.72	1.69	1.64	1.29	1.64	15.49
H Tlanthanga	3	1.18	2.04	1.80	0.73	1.78	0.82	0.66	0.25	0.66	9.92
Ramhluna	6	0.67	3.43	3.15	1.22	0.94	0.71	1.53	0.79	0.66	13.10
R Lallawama	4	3.70	3.81	3.54	2.86	2.89	5.79	3.22	2.35	5.70	33.87
K B Thapa	9	2.11	2.39	2.19	2.94	2.41	1.78	1.56	2.45	1.72	19.53
Lalrinawma	10	5.00	6.18	6.10	5.70	4.06	4.78	4.49	5.13	4.74	46.15
Lallviliana	7	4.83	4.36	4.24	5.15	3.90	3.83	4.22	4.57	3.79	38.89
Vanlalhmuaka	3	3.92	6.36	6.29	2.55	5.25	3.77	3.44	2.06	3.71	37.34
C Lalremdika	5	2.06	1.98	1.68	1.36	1.90	2.07	1.58	0.88	1.91	15.40
Zazika	6	3.17	3.08	2.83	2.43	3.13	2.53	2.69	1.96	2.33	24.15
Lalremzuala	9	1.30	3.44	3.18	0.42	0.54	0.75	0.76	0.65	0.69	11.72
H Lalhlira	4	5.27	4.43	4.25	4.03	5.90	3.70	4.77	3.59	3.63	39.56
H Laldintluanga	7	2.48	3.37	3.26	2.90	3.97	1.82	1.95	2.32	1.75	23.80
Zokaia	2	4.74	4.40	4.30	2.90	2.96	3.49	4.29	2.46	3.26	32.79
Lalruatfela Pacuau	8	2.26	3.45	3.23	2.37	1.62	2.42	1.73	1.87	2.36	21.31
Vanlalmalsawmkima	4	3.37	3.54	3.40	2.07	2.91	2.81	2.71	1.59	2.63	25.02
Peter Lalrosiama	9	1.78	2.26	2.17	1.34	2.28	1.41	1.25	0.81	1.37	14.66
Donald Lalrokima	5	4.06	4.83	4.67	5.90	2.92	3.79	3.53	5.38	3.72	38.79
Lalengzama	8	1.52	1.35	1.19	1.44	0.78	1.24	1.03	0.89	1.18	10.62
C lalkhuma	5	4.54	4.37	4.16	3.13	3.22	2.86	4.07	2.70	2.80	31.84
PB Kawalianhuma	4	2.67	3.37	3.26	2.96	2.54	1.42	2.07	2.43	1.40	22.11
Lapianmawia	7	2.17	2.05	1.84	1.57	3.96	3.01	1.56	1.05	3.02	20.21
Zoramchhana	9	4.58	4.43	4.17	7.85	2.30	5.74	3.99	7.48	5.65	46.19
Larohlua	3	2.21	2.55	2.39	1.23	1.87	1.32	1.75	0.84	1.29	15.44
Rothumliana	5	4.45	3.01	2.86	4.89	8.84	3.83	3.87	4.45	3.76	39.96
Zoremsanga	6	4.30	3.56	3.45	6.00	3.38	2.89	3.73	5.52	2.80	35.62
Vanlalmuanga	5	2.50	2.41	2.23	2.98	2.41	1.79	1.87	2.47	1.57	20.23
A D Sailo	7	2.32	2.45	2.23	2.04	2.17	2.01	1.76	1.53	2.00	18.51
Lalduhawma	4	1.82	1.45	1.22	1.83	1.75	1.24	1.28	1.32	1.25	13.16
K Sangkunga	9	2.88	4.49	4.24	2.16	2.25	4.21	2.38	1.66	4.19	28.44
C Lalzarliana	6	3.48	3.35	3.12	3.44	4.92	2.80	2.94	2.87	2.71	29.62

C lalmalsawma	3	3.74	3.39	3.26	4.03	3.82	3.89	3.18	3.50	3.84	32.65
C Lalzamlova	7	4.82	4.28	4.16	3.88	4.00	3.66	4.39	3.41	3.56	36.15
C Lalruatfela	5	2.48	2.47	2.22	1.96	1.82	1.00	1.92	1.59	0.99	16.45
P C Lalrinfela	9	4.60	8.27	8.15	2.09	3.38	2.78	4.14	1.59	2.74	37.73
Lalbiaktluanga	4	3.71	4.45	4.21	3.77	3.00	4.75	3.15	3.32	4.75	35.12
V L Thlamuanpuia	7	3.45	1.84	1.63	2.12	1.90	3.28	2.79	1.56	3.31	21.88
Vanlalrova	8	2.81	3.44	3.23	5.23	1.78	2.30	2.38	4.76	2.26	28.19
H Valbuanga	9	3.88	9.51	9.30	3.93	1.89	2.66	3.42	3.45	2.59	40.61
H Lalcharliana	2	5.02	3.85	3.60	7.33	2.80	3.80	4.41	6.81	3.80	41.41
David Lalruatkima	3	1.80	4.48	4.17	3.37	2.00	0.99	1.23	2.87	1.02	21.92
Lalrinsanga	4	2.28	14.84	14.59	2.78	2.91	2.06	1.63	2.25	1.98	45.32
Lalchhuanliana	7	4.59	9.38	9.17	2.88	4.54	5.85	3.99	2.37	5.71	48.48
Lalramthara	8	3.42	1.84	1.70	2.79	2.32	3.19	2.93	2.16	3.09	23.44
J Lalrempuia	2	1.05	1.74	1.54	2.42	1.97	0.88	0.61	1.97	0.78	12.95
Biakthansaga	4	4.65	3.87	3.60	2.14	7.88	4.20	4.12	1.59	4.19	36.23
Hminthanzuala	9	2.20	1.56	1.36	2.36	2.35	1.64	1.66	1.75	1.59	16.46
Lalhmaruaia	2	5.32	2.23	2.15	1.68	2.42	9.83	4.81	1.30	9.73	39.48
Lalfamkima	4	0.80	1.38	1.19	1.09	0.89	0.87	1.43	0.53	0.83	9.01
Lasankima	5	3.80	5.07	4.80	2.55	2.94	2.52	3.29	1.98	2.42	29.37
Lalawmpuii	8	1.65	2.52	2.24	1.73	0.95	2.03	1.08	1.34	1.92	15.46
Lalnunkima	4	5.11	4.27	4.18	7.97	2.91	4.85	4.53	7.44	4.71	45.95
S Lalawmsanga	9	5.22	3.61	3.46	2.93	5.29	5.82	4.61	2.38	5.84	39.15
443 members		**3.09**	**3.58**	**3.38**	**3.00**	**2.95**	**2.83**	**2.60**	**2.52**	**2.76**	***2056.84***

Appendix 13: Gross plastic waste generation (kg) in West Locality during 2017-18

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	Apri	May	Jul	Aug	Sept	

						1					
Lalmuankuga Sailo	4	1.99	2.17	1.93	2.56	1.46	1.64	1.55	2.05	1.49	16.83
Lalbiakdika	4	2.18	2.42	2.17	2.51	2.78	1.46	1.72	2.08	1.30	18.61
Llarinthara	1	1.94	2.09	1.88	3.03	1.68	1.70	2.33	2.55	1.50	18.71
Hrangthanzuala	4	2.61	2.96	2.69	2.70	2.60	3.09	2.02	2.20	2.95	23.81
Thanseia	5	3.77	1.86	1.71	3.08	2.89	2.97	3.23	2.62	2.85	24.96
Estherlalrinsangi	7	3.65	4.45	4.20	1.99	4.02	3.90	3.19	1.45	3.75	30.60
Zothanpuia	8	5.19	5.53	5.33	5.31	4.35	3.33	4.76	4.84	3.28	41.92
Lalmingmawia	4	1.98	2.63	2.36	1.48	2.66	1.59	1.46	1.00	1.60	16.76
lalrindika sailo	5	1.79	2.79	2.50	2.47	3.46	2.41	1.15	1.96	2.33	20.87
Lalawma	4	2.54	2.69	2.45	1.96	3.35	2.04	1.90	1.41	1.91	20.26
K Malsawmzuala	8	4.72	5.39	5.26	4.87	4.14	4.08	4.18	4.39	4.00	41.04
vanlaluata	4	1.78	1.52	1.29	4.07	4.51	1.22	1.28	3.51	1.14	20.31
Thankunga	7	4.33	3.02	2.82	3.96	3.79	3.78	3.76	3.47	3.81	32.74
Lalzidinga	2	1.47	1.95	1.75	2.95	1.60	0.95	0.94	2.47	0.85	14.92
L G Zama	6	3.86	3.72	3.53	3.24	3.19	3.11	3.20	2.71	3.04	29.59
H Lalneihthanga	4	1.09	1.17	0.90	1.43	1.74	1.77	0.59	0.89	1.70	11.29
Zomingthanga	4	2.52	2.17	1.99	1.59	3.72	3.35	1.98	1.11	3.26	21.67
Lalzueinga	8	4.55	5.39	5.28	5.89	3.80	4.46	4.13	5.39	4.41	43.29
H Rozama	6	3.38	3.05	2.97	3.27	3.88	4.01	2.81	2.66	3.82	29.82
David Laremsiama	3	1.96	2.15	1.96	2.62	1.49	2.26	1.46	2.13	2.18	18.20
Zaduha	6	3.79	5.06	4.78	2.91	3.24	3.39	3.24	2.51	3.22	32.14
Lalthantluanga	4	2.36	2.08	1.89	4.12	2.47	2.61	1.74	3.56	2.51	23.32
Lalropuia	5	2.66	2.88	2.80	2.12	4.09	2.13	2.08	1.67	1.93	22.35
Falalremliana	8	4.89	6.39	6.25	3.00	4.31	4.35	4.41	2.60	4.21	40.41
John mark	4	2.35	2.03	1.79	1.92	1.88	1.85	1.70	1.52	1.78	16.83
Chuailova	4	1.31	2.11	1.98	0.83	1.90	0.94	0.75	0.43	0.81	11.06
Kevin Zodingpuia	1	0.81	3.48	3.37	1.30	1.06	0.79	1.64	0.84	0.73	14.01
Chhunthawmliana	7	3.76	3.81	3.63	2.94	3.02	5.90	3.22	2.40	5.90	34.55
V L Chhanhima	4	2.19	2.50	2.33	3.05	2.53	1.94	1.62	2.55	1.83	20.54
Ralzika	10	5.02	6.33	6.14	5.87	4.29	5.00	4.61	5.35	4.90	47.52
Vanlalduhawma	8	4.99	4.49	4.43	5.21	4.04	4.03	4.34	4.75	3.83	40.11
H Rosanzuala	7	4.08	6.57	6.34	2.63	5.37	3.93	3.56	2.07	3.82	38.35
K Lalrotlinga	3	2.27	2.09	1.89	1.52	2.06	2.18	1.74	1.00	2.00	16.75
Samuel Ralsun	5	3.35	3.10	2.95	2.67	3.15	2.52	2.81	2.15	2.48	25.17

F Lalzualina	2	1.41	3.45	3.35	0.65	0.64	0.80	0.92	0.05	0.68	11.94
JosephVanlalghaka	9	5.39	4.54	4.29	4.17	5.91	3.80	4.86	3.74	3.79	40.49
Vanlaldika Pachau	4	2.71	3.55	3.38	3.01	3.99	1.87	2.05	2.53	1.81	24.90
Issac Laldingmawia	8	4.93	4.55	4.38	2.99	3.13	3.51	4.29	2.54	3.47	33.79
Zoramliana Colney	4	2.36	3.57	3.31	2.47	1.65	2.56	1.85	1.92	2.42	22.11
V L Rema	5	3.43	3.76	3.47	2.16	3.10	2.88	2.82	1.62	2.76	25.99
Lalrintluanga	3	1.94	2.45	2.28	1.36	2.46	1.52	1.28	0.88	1.43	15.60
Daniel Lalremruata	7	4.16	4.90	4.73	6.02	3.01	3.85	3.69	5.57	3.87	39.80
Ricky Vanlalruiaia	4	1.66	1.46	1.25	1.50	0.87	1.49	1.09	1.00	1.37	11.70
R H Lalrinhlua	8	4.73	4.52	4.38	3.33	3.27	2.91	4.13	2.84	2.90	33.00
Zoramiana	4	2.78	3.49	3.30	3.02	2.70	1.60	2.18	2.51	1.52	23.09
Llaremruata Sailo	3	2.16	2.26	1.97	1.68	4.02	3.13	1.67	1.07	3.03	20.98
Vicky Lalemsiama	10	4.71	4.52	4.29	7.99	2.45	5.78	4.17	7.49	5.65	47.04
H Lalmuankima	3	2.33	2.70	2.53	1.36	2.10	1.49	1.84	0.94	1.39	16.68
H Vanlalchandamma	9	4.58	3.19	2.97	4.97	9.06	4.00	4.00	4.52	3.89	41.17
H Thanga	7	4.36	3.71	3.45	6.08	3.44	2.88	3.76	5.57	2.80	36.05
Vanlalruata	4	2.52	2.49	2.28	3.14	2.60	1.77	2.04	2.67	1.75	21.26
Lalsanzuala	3	2.39	2.56	2.40	2.18	2.21	2.20	1.94	1.62	2.05	19.55
Lalchhanhima	4	1.90	1.46	1.33	1.84	1.97	1.40	1.37	1.44	1.32	14.04
John Krosmawia	5	3.12	4.55	4.39	2.36	2.36	4.38	2.53	1.80	4.26	29.76
R Vanlabia	6	3.56	3.50	3.25	3.60	5.06	3.01	3.09	3.11	2.95	31.12
Lalremchhuanga	7	3.76	3.54	3.37	4.12	3.96	4.02	3.22	3.54	3.88	33.41
Lalremkunga	8	4.95	4.46	4.26	4.01	4.07	3.84	4.40	3.49	3.72	37.19
Lalrindsanga	3	2.60	2.55	2.42	2.09	2.01	1.12	2.06	1.71	1.08	17.65
F Zonuntluanga	8	4.77	8.44	8.27	2.11	3.49	2.96	4.19	1.61	2.91	38.75
V Lalthantlinga	6	3.75	4.51	4.37	3.93	3.11	5.00	3.23	3.45	4.80	36.15
Vanramhluna	5	3.49	1.85	1.79	2.18	2.05	3.39	3.00	1.71	3.34	22.80
Lalchunnunga	5	2.94	3.56	3.33	5.38	2.00	2.43	2.41	4.86	2.30	29.21
Lallianpuia	7	4.08	9.55	9.32	4.03	1.99	2.83	3.41	3.56	2.73	41.49
Zoramchhana	8	5.13	3.90	3.77	7.37	3.01	3.99	4.57	6.87	3.93	42.53
J Lalthanpuia	4	1.93	4.49	4.39	3.37	2.04	1.16	1.35	2.88	1.00	22.60
James Lalntlunga	4	2.33	15.01	14.71	2.91	3.03	2.15	1.78	2.42	2.10	46.44
Lalduhsaka	8	4.72	9.48	9.33	3.06	4.67	5.90	4.18	2.54	5.86	49.72
Lalhuriatlunga	5	3.46	1.96	1.79	2.89	2.48	3.39	2.93	2.40	3.23	24.53
Lalruatliana	2	1.26	1.77	1.70	2.64	2.05	0.89	0.69	2.11	0.83	13.93

J Rallingthanga	8	4.75	3.90	3.69	2.24	8.01	4.29	4.27	1.68	4.23	37.05
Thanlinchhuanga	3	2.23	1.74	1.50	2.44	2.45	1.71	1.81	1.87	1.69	17.44
Phillip Lallawmsanzuala	9	5.43	2.43	2.16	1.87	2.57	9.85	4.92	1.31	9.74	40.29
Duhawma	1	0.95	1.53	1.36	1.11	0.91	1.00	1.50	0.61	0.96	9.92
Ramdinsanga C	7	3.82	5.18	4.92	2.64	3.11	2.66	3.32	2.15	2.54	30.35
Dtangchhuangkima	3	1.83	2.50	2.42	1.95	1.01	2.21	1.24	1.35	2.03	16.52
Lalrammuanthara	8	5.09	4.44	4.28	8.01	3.07	4.93	4.61	7.53	4.88	46.84
J H Zoremsanga	9	5.38	3.78	3.51	3.00	5.38	5.93	4.80	2.60	5.88	40.25
396 members		**3.18**	**3.68**	**3.49**	**3.12**	**3.05**	**2.91**	**2.68**	**2.62**	**2.82**	***2134.38***

Appendix 14: Gross plastic waste generation (kg) in West Locality during 2018-19

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	April	May	Jul	Aug	Sept	
Lalmuankuga Sailo	4	1.9	2.1	1.9	2.5	1.4	1.6	1.4	2.0	1.5	16.3
Lalbiakdika	4	2.1	2.4	2.2	2.4	2.7	1.4	1.7	2.0	1.3	18.3
Llarinthara	1	1.9	2.0	1.9	3.0	1.6	1.6	2.3	2.5	1.5	18.4
Hrangthanzuala	4	2.6	2.8	2.6	2.6	2.5	3.0	2.0	2.2	2.9	23.3
Thanseia	5	3.7	1.8	1.7	3.1	2.9	2.9	3.2	2.5	2.8	24.6
Estherlalrinsangi	7	3.6	4.4	4.2	2.0	4.0	3.8	3.1	1.4	3.8	30.2
Zothanpuia	8	5.2	5.5	5.3	5.3	4.3	3.3	4.6	4.9	3.2	41.6
Lalmingmawia	4	1.9	2.5	2.3	1.4	2.6	1.6	1.4	0.9	1.5	16.1
lalrindika sailo	5	1.7	2.7	2.5	2.5	3.4	2.4	1.1	2.0	2.3	20.4
Lalawma	4	2.4	2.6	2.4	1.9	3.3	1.9	2.0	1.4	1.8	19.7
K Malsawmzuala	8	4.6	5.4	5.3	4.8	4.1	4.1	4.2	4.4	4.0	40.7
vanlaluata	4	1.8	1.5	1.3	3.9	4.4	1.1	1.2	3.5	1.1	19.8
Thankunga	7	4.3	2.9	2.8	3.8	3.7	3.8	3.7	3.4	3.7	32.2
Lalzidinga	2	1.4	1.8	1.6	3.0	1.7	0.9	0.9	2.4	0.8	14.6
L G Zama	6	3.7	3.7	3.6	3.2	3.1	3.0	3.2	2.7	3.0	29.1
H Lalneihthanga	4	1.1	1.1	0.9	1.5	1.7	1.7	0.5	0.9	1.7	10.8
Zomingthanga	4	2.4	2.1	1.9	1.5	3.7	3.3	1.9	1.0	3.2	20.9

Lalzueinga	8	4.5	5.4	5.2	5.8	3.6	4.4	4.1	5.3	4.3	42.5
H Rozama	6	3.3	3.1	2.9	3.2	3.9	3.9	2.7	2.7	3.8	29.3
David Laremsiama	3	1.9	2.1	2.0	2.6	1.6	2.3	1.4	2.0	2.2	17.9
Zaduha	6	3.8	5.0	4.8	3.0	3.1	3.3	3.2	2.4	3.2	31.7
Lalthantluanga	4	2.3	2.1	1.9	4.1	2.5	2.5	1.7	3.6	2.5	23.1
Lalropuia	5	2.6	2.9	2.7	2.1	4.0	2.1	2.1	1.6	1.9	21.9
Falalremliana	8	4.9	6.4	6.2	3.0	4.3	4.3	4.3	2.5	4.2	40.1
John mark	4	2.2	2.0	1.7	1.9	1.8	1.8	1.7	1.4	1.7	16.3
Chuailova	4	1.3	2.1	1.9	0.9	1.9	0.8	0.8	0.4	0.7	10.8
Kevin Zodingpuia	1	0.8	3.5	3.3	1.3	1.0	0.8	1.6	0.8	0.7	13.7
Chhunthawmliana	7	3.8	3.8	3.6	2.9	3.0	5.9	3.3	2.4	5.8	34.5
V L Chhanhima	4	2.2	2.4	2.2	3.0	2.5	1.8	1.7	2.5	1.7	20.0
Ralzika	10	5.1	6.4	6.1	5.8	4.2	4.9	4.5	5.3	4.8	47.0
Vanlalduhawma	8	4.9	4.5	4.3	5.2	4.0	3.9	4.4	4.6	3.8	39.5
H Rosanzuala	7	4.0	6.5	6.3	2.6	5.3	3.9	3.4	2.1	3.8	37.9
K Lalrotlinga	4	2.2	2.0	1.8	1.5	2.1	2.1	1.6	0.9	2.0	16.2
Samuel Ralsun	5	3.3	3.0	2.9	2.6	3.1	2.5	2.8	2.1	2.4	24.8
F Lalzualina	2	1.4	3.5	3.3	0.5	0.6	0.8	0.9	0.1	0.7	11.7
JosephVanlalghaka	9	5.4	4.5	4.2	4.2	5.9	3.8	4.8	3.7	3.7	40.2
Vanlaldika Pachau	4	2.6	3.5	3.3	2.9	3.9	1.8	2.0	2.4	1.8	24.4
Issac Laldingmawia	8	4.8	4.4	4.3	3.0	3.1	3.5	4.3	2.5	3.4	33.4
Zoramliana Colney	4	2.3	3.5	3.2	2.4	1.6	2.5	1.8	1.9	2.4	21.7
V L Rema	5	3.4	3.6	3.5	2.1	3.0	2.9	2.8	1.7	2.8	25.8
Lalrintluanga	3	1.8	2.3	2.2	1.3	2.4	1.5	1.3	0.9	1.4	15.1
Daniel Lalremruata	7	4.2	4.8	4.7	6.0	3.0	3.8	3.7	5.5	3.8	39.4
Ricky Vanlalruiaia	4	1.7	1.5	1.2	1.5	0.9	1.3	1.0	1.0	1.3	11.4
R H Lalrinhlua	8	4.7	4.4	4.3	3.3	3.3	2.9	4.2	2.8	2.9	32.6
Zoramiana	4	2.7	3.5	3.3	3.0	2.6	1.6	2.1	2.5	1.5	22.8
Llaremruata Sailo	3	2.1	2.1	2.0	1.6	4.0	3.1	1.7	1.1	3.0	20.7
Vicky Lalemsiama	10	4.7	4.4	4.3	8.0	2.4	5.8	4.1	7.5	5.6	46.8
H Lalmuankima	3	2.3	2.6	2.4	1.3	2.0	1.4	1.7	0.9	1.3	16.0
H Vanlalchandamma	9	4.6	3.1	2.9	5.0	9.0	3.9	4.0	4.4	3.8	40.7
H Thanga	7	4.3	3.7	3.5	6.0	3.4	2.9	3.8	5.6	2.8	35.8
Vanlalruata	4	2.5	2.4	2.2	3.1	2.5	1.8	2.0	2.6	1.7	20.7
Lalsanzuala	3	2.3	2.5	2.3	2.1	2.2	2.1	1.8	1.6	2.0	19.0

Lalchhanhima	4	1.9	1.5	1.3	1.8	1.9	1.3	1.3	1.3	1.3	13.8
John Krosmawia	5	3.1	4.6	4.4	2.3	2.3	4.3	2.5	1.8	4.2	29.3
R Vanlabia	6	3.6	3.4	3.2	3.5	5.0	3.0	3.1	3.0	2.8	30.5
Lalremchhuanga	7	3.7	3.5	3.3	4.0	3.9	3.9	3.2	3.5	3.8	33.0
Lalremkunga	8	4.9	4.3	4.2	4.0	3.9	3.7	4.4	3.4	3.6	36.6
Lalrindsanga	3	2.6	2.6	2.3	2.1	1.9	1.1	2.0	1.6	1.0	17.2
F Zonuntluanga	8	4.7	8.4	8.2	2.1	3.5	2.9	4.2	1.6	2.8	38.2
V Lalthantlinga	6	3.7	4.5	4.3	3.9	3.0	4.9	3.2	3.4	4.8	35.8
Vanramhluna	5	3.4	1.9	1.7	2.2	2.1	3.3	2.9	1.7	3.3	22.5
Lalchunnunga	5	2.9	3.5	3.3	5.4	1.9	2.4	2.4	4.9	2.3	28.9
Lallianpuia	7	4.0	9.6	9.3	3.9	2.0	2.7	3.5	3.5	2.7	41.2
Zoramchhana	8	5.0	3.9	3.7	7.4	2.9	3.9	4.5	6.9	3.8	42.0
J Lalthanpuia	4	1.8	4.5	4.3	3.3	2.0	1.1	1.3	2.9	1.0	22.4
James Lalntlunga	4	2.3	14.9	14.8	2.8	3.0	2.1	1.8	2.4	2.0	46.1
Lalduhsaka	8	4.7	9.4	9.3	2.9	4.6	5.9	4.1	2.5	5.8	49.1
Lalhuriatlunga	5	3.4	2.0	1.7	2.8	2.4	3.3	3.0	2.3	3.2	24.1
Lalruatliana	2	1.2	1.8	1.6	2.5	2.1	0.8	0.6	2.0	0.9	13.5
J Rallingthanga	8	4.7	3.9	3.7	2.2	7.9	4.3	4.2	1.7	4.2	36.7
Thanlinchhuanga	3	2.3	1.7	1.4	2.3	2.4	1.7	1.7	1.8	1.6	16.9
P.Lallawmsanzuala	9	5.3	2.4	2.2	1.8	2.5	9.9	4.8	1.3	9.8	39.9
Duhawma	1	0.8	1.5	1.4	1.1	0.9	0.9	1.6	0.6	0.9	9.7
Ramdinsanga C	7	3.9	5.1	4.9	2.6	3.1	2.6	3.2	2.1	2.5	29.9
Dtangchhuangkima	3	1.8	2.5	2.4	1.9	0.9	2.2	1.2	1.4	2.0	16.3
Lalrammuanthara	8	5.1	4.4	4.2	8.0	3.0	4.9	4.5	7.5	4.8	46.4
J H Zoremsanga	9	5.3	3.6	3.5	3.0	5.4	5.9	4.8	2.5	5.8	39.8
396 members		**3.2**	**3.6**	**3.5**	**3.1**	**3.0**	**2.9**	**2.7**	**2.6**	**2.8**	***2102.66***

Appendix 15: Gross plastic waste generation (kg) in West Locality during 2019-20

Head of family	Family size	Winter			Summer			Rainy			Total
		Nov	Dec	Jan	March	Apri	May	Jul	Aug	Sept	

						l					
Lalmuankuga Sailo	4	2.01	2.06	1.89	2.48	1.47	1.65	1.43	2.15	1.60	16.72
Lalbiakdika	4	2.33	2.46	2.19	2.47	2.84	1.46	1.76	2.11	1.47	19.09
Llarinthara	1	2.05	2.26	1.94	3.09	1.64	1.57	2.49	2.48	1.58	19.10
Hrangthanzuala	4	2.58	2.85	2.79	2.81	2.56	3.21	2.05	2.23	3.13	24.21
Thanseia	5	3.86	1.88	1.88	3.24	3.01	3.08	3.22	2.77	2.98	25.91
Estherlalrinsangi	7	3.77	4.38	4.21	2.03	3.99	4.04	3.08	1.52	3.86	30.89
Zothanpuia	8	5.38	5.49	5.45	5.46	4.34	3.48	4.77	4.88	3.29	42.53
Lalmingmawia	4	2.07	2.64	2.38	1.46	2.73	1.72	1.50	1.05	1.52	17.07
lalrindika sailo	5	1.69	2.82	2.56	2.56	3.49	2.39	1.23	1.97	2.27	20.97
Lalawma	4	2.63	2.78	2.53	2.07	3.50	2.13	2.06	1.47	1.97	21.13
K Malsawmzuala	8	4.73	5.42	5.33	4.99	4.15	4.16	4.27	4.38	3.97	41.41
vanlaluata	4	1.93	1.45	1.27	3.97	4.59	1.18	1.35	3.53	1.10	20.37
Thankunga	7	4.44	3.01	2.80	4.03	3.71	3.86	3.74	3.46	3.78	32.83
Lalzidinga	2	1.40	2.06	1.74	3.03	1.82	1.05	0.96	2.40	1.05	15.53
L G Zama	6	3.79	3.86	3.58	3.22	3.17	3.21	3.26	2.70	3.04	29.82
H Lalneihthanga	4	1.24	1.24	0.88	1.47	1.78	1.81	0.48	1.01	1.79	11.70
Zomingthanga	4	2.59	2.12	1.96	1.49	3.80	3.27	2.03	1.00	3.22	21.48
Lalzueinga	8	4.78	5.52	5.34	5.93	3.81	4.55	4.08	5.34	4.33	43.67
H Rozama	6	3.37	3.19	2.88	3.19	3.90	4.08	2.90	2.85	3.82	30.19
David Laremsiama	3	1.98	2.15	2.09	2.60	1.70	2.47	1.59	2.17	2.19	18.94
Zaduha	6	3.73	5.14	4.91	3.10	3.17	3.31	3.25	2.44	3.25	32.31
Lalthantluanga	4	2.29	2.06	2.06	4.12	2.69	2.67	1.82	3.73	2.61	24.05
Lalropuia	5	2.62	3.08	2.71	2.21	4.10	2.10	2.08	1.72	1.96	22.57
Falalremliana	8	4.89	6.53	6.25	3.12	4.38	4.44	4.42	2.71	4.33	41.05
John mark	4	2.31	2.07	1.93	2.05	1.97	2.01	1.86	1.40	1.74	17.34
Chuailova	4	1.32	2.25	1.98	0.95	1.91	0.85	0.94	0.49	0.91	11.58
Kevin Zodingpuia	1	0.81	3.49	3.29	1.31	1.16	0.91	1.63	0.95	0.88	14.41
Chhunthawmliana	7	3.75	3.97	3.71	2.98	3.09	6.09	3.32	2.47	5.83	35.20
V L Chhanhima	3	2.29	2.54	2.28	3.06	2.52	2.00	1.77	2.49	1.79	20.73
Ralzika	10	5.20	6.36	6.33	5.92	4.36	4.96	4.50	5.37	4.90	47.91
Vanlalduhawma	8	4.97	4.67	4.50	5.35	4.16	4.09	4.38	4.66	3.93	40.70
H Rosanzuala	7	4.11	6.48	6.34	2.69	5.55	4.08	3.65	2.16	3.93	38.98
K Lalrotlinga	4	2.18	2.13	1.98	1.64	2.11	2.08	1.82	1.05	2.05	17.03
Samuel Ralsun	5	3.40	3.22	2.99	2.74	3.14	2.51	2.88	2.21	2.49	25.58

F Lalzualina	2	1.40	3.48	3.40	0.74	0.74	0.92	0.83	0.16	0.85	12.52
JosephVanlalghaka	9	5.35	4.57	4.29	4.22	5.97	3.95	4.86	3.84	3.73	40.78
Vanlaldika Pachau	4	2.60	3.48	3.27	3.03	3.99	1.99	2.13	2.53	1.82	24.83
Issac Laldingmawia	8	4.87	4.67	4.28	2.99	3.12	3.51	4.29	2.58	3.55	33.86
Zoramliana Colney	4	2.41	3.57	3.45	2.47	1.72	2.59	1.83	1.95	2.59	22.57
V L Rema	5	3.49	3.74	3.58	2.22	3.08	3.03	2.86	1.62	2.85	26.48
Lalrintluanga	3	1.90	2.39	2.30	1.49	2.51	1.52	1.30	1.06	1.44	15.90
Daniel Lalremruata	7	4.38	4.98	4.87	6.14	3.08	3.88	3.69	5.59	3.96	40.55
Ricky Vanlalruiaia	4	1.78	1.47	1.41	1.50	0.87	1.52	1.23	0.97	1.46	12.19
R H Lalrinhlua	8	4.69	4.53	4.43	3.33	3.27	3.08	4.19	2.84	2.98	33.33
Zoramiana	4	2.78	3.45	3.49	3.13	2.61	1.59	2.27	2.68	1.51	23.50
Llaremruata Sailo	3	2.21	2.29	2.10	1.69	4.00	3.20	1.69	1.12	3.00	21.30
Vicky Lalemsiama	10	4.75	4.48	4.44	7.99	2.58	5.89	4.32	7.58	5.71	47.74
H Lalmuankima	3	2.36	2.63	2.46	1.39	1.99	1.51	1.81	0.90	1.53	16.58
H Vanlalchandamma	9	4.73	3.20	3.04	4.98	9.09	4.02	4.18	4.49	4.02	41.76
H Thanga	7	4.50	3.67	3.68	6.03	3.46	3.05	3.82	5.53	3.00	36.74
Vanlalruata	4	2.61	2.56	2.24	3.24	2.56	1.76	2.09	2.71	1.86	21.63
Lalsanzuala	3	2.53	2.68	2.45	2.22	2.20	2.09	1.93	1.83	2.05	19.98
Lalchhanhima	4	1.92	1.61	1.34	1.85	1.90	1.54	1.48	1.42	1.28	14.33
John Krosmawia	5	3.12	4.64	4.58	2.44	2.45	4.50	2.51	1.87	4.33	30.44
R Vanlabia	6	3.76	3.61	3.22	3.49	5.08	2.93	2.99	3.07	2.90	31.05
Lalremchhuanga	7	3.72	3.56	3.33	4.14	3.89	4.02	3.24	3.76	4.00	33.65
Lalremkunga	8	5.03	4.49	4.35	4.11	4.01	3.78	4.44	3.52	3.75	37.48
Lalrindsanga	3	2.71	2.62	2.45	2.15	2.06	1.31	2.16	1.74	1.04	18.24
F Zonuntluanga	8	4.84	8.49	8.21	2.22	3.63	2.99	4.28	1.78	2.99	39.44
V Lalthantlinga	6	3.83	4.65	4.30	3.99	3.10	4.91	3.37	3.37	4.99	36.50
Vanramhluna	5	3.54	1.95	1.80	2.24	2.18	3.37	2.87	1.86	3.33	23.14
Lalchunnunga	5	2.93	3.55	3.39	5.43	2.05	2.40	2.59	5.06	2.34	29.73
Lallianpuia	7	4.12	9.59	9.42	3.96	2.08	2.83	3.41	3.63	2.76	41.80
Zoramchhana	8	5.19	4.07	3.72	7.49	2.98	3.96	4.57	6.92	3.85	42.76
J Lalthanpuia	4	1.87	4.57	4.34	3.49	2.07	1.24	1.41	3.05	1.11	23.15
James Lalntlunga	4	2.30	15.01	14.91	2.87	3.09	2.12	1.80	2.58	2.20	46.88
Lalduhsaka	8	4.72	9.55	9.34	3.04	4.69	6.01	4.11	2.58	5.97	50.02
Lalhuriatlunga	5	3.59	2.03	1.93	2.86	2.53	3.32	2.92	2.28	3.21	24.65
Lalruatliana	2	1.26	1.87	1.67	2.67	2.08	0.98	0.80	2.13	0.95	14.41

J Rallingthanga	8	4.87	4.06	3.74	2.30	8.14	4.31	4.15	1.79	4.28	37.63
Thanlinchhuanga	3	2.24	1.83	1.60	2.38	2.44	1.74	1.89	1.86	1.60	17.58
P.Lallawmsanzuala	9	5.39	2.39	2.32	1.92	2.58	9.83	4.98	1.50	9.76	40.66
Duhawma	1	0.88	1.52	1.44	1.17	1.00	1.07	1.67	0.64	0.99	10.37
Ramdinsanga C	7	3.91	5.26	4.98	2.70	3.23	2.57	3.42	2.14	2.63	30.84
Dtangchhuangkima	3	1.94	2.53	2.33	2.05	1.01	2.15	1.41	1.42	2.10	16.95
Lalrammuanthara	8	5.09	4.42	4.28	8.10	2.99	5.04	4.60	7.46	4.99	46.96
J H Zoremsanga	9	5.50	3.81	3.66	3.07	5.46	5.92	4.94	2.57	5.96	40.88
396 members		**3.25**	**3.73**	**3.54**	**3.17**	**3.11**	**2.99**	**2.75**	**2.67**	**2.91**	***2164.70***

Appendix:16 Gross plastic waste(kg) generation/Household in all five localities during 2017-18

South	North	East	Central	West
15.62	15.69	15.64	16.52	16.83
17.69	17.46	17.71	17.70	18.61
17.97	17.71	17.87	17.81	18.71
22.85	22.71	22.95	22.86	23.81
24.06	23.93	24.01	24.81	24.96
29.69	29.51	29.59	29.89	30.60
41.05	40.87	40.90	41.50	41.92
15.62	15.53	15.66	16.17	16.76
19.71	19.75	19.78	20.47	20.87
19.17	19.11	19.37	19.60	20.26
40.20	40.09	40.33	40.54	41.04
19.02	18.94	19.16	19.41	20.31
31.63	31.54	31.67	32.26	32.74
13.85	13.69	13.83	14.10	14.92
28.62	28.43	28.41	28.47	29.59
10.48	9.99	10.50	10.92	11.29
20.14	20.03	20.16	20.59	21.67
41.87	42.08	42.26	42.05	43.29
28.76	28.51	28.77	29.33	29.82
17.39	17.16	17.30	17.82	18.20
31.12	30.96	31.18	31.51	32.14
22.44	22.26	22.34	22.91	23.32
21.40	21.20	21.25	21.81	22.35
39.41	39.33	39.46	39.61	40.41
15.99	15.60	15.80	15.93	16.83
9.99	9.96	10.16	10.12	11.06
13.30	13.11	13.19	13.57	14.01
33.77	33.83	33.65	34.27	34.55
19.46	19.24	19.33	20.12	20.54
46.61	46.14	46.49	46.87	47.52
39.10	38.82	39.15	39.30	40.11
37.34	37.18	37.49	37.39	38.35
15.55	15.43	15.42	15.85	16.75

24.05	23.98	24.18	24.25	25.17
11.89	11.08	10.96	11.86	11.94
39.70	39.52	39.56	40.00	40.49
23.82	23.63	23.97	24.03	24.90
32.80	32.68	32.75	32.88	33.79
20.94	20.93	21.16	21.36	22.11
25.13	24.99	24.92	25.36	25.99
14.47	14.27	14.59	14.76	15.60
39.08	38.63	38.91	39.51	39.80
10.66	10.52	10.55	11.20	11.70
31.91	31.76	31.97	31.92	33.00
22.13	21.92	22.12	22.73	23.09
20.27	20.14	20.03	20.23	20.98
46.38	46.05	46.15	46.62	47.04
15.68	15.45	15.43	16.00	16.68
40.16	39.85	40.33	40.21	41.17
35.16	35.04	35.49	35.36	36.05
20.32	20.01	20.11	20.75	21.26
18.54	18.29	18.44	18.32	19.55
13.19	12.96	13.08	13.57	14.04
28.86	28.58	28.60	28.73	29.76
30.18	29.84	30.14	30.14	31.12
32.52	32.27	32.30	32.29	33.41
36.05	35.97	36.38	36.66	37.19
16.60	16.44	16.53	16.87	17.65
37.85	37.47	37.55	37.86	38.75
35.14	35.00	35.05	35.54	36.15
21.75	21.84	21.90	22.48	22.80
28.10	28.06	28.42	28.61	29.21
40.57	40.41	40.53	40.63	41.49
41.60	41.33	41.60	41.66	42.53
21.77	21.44	21.68	21.91	22.60
45.33	45.10	45.23	45.61	46.44
48.65	48.47	48.61	48.86	49.72
23.58	23.33	23.57	24.10	24.53
12.78	12.78	13.10	13.02	13.93
36.23	35.94	36.01	36.41	37.05

16.59	16.33	16.64	16.87	17.44
39.47	39.23	39.44	39.08	40.29
9.13	9.10	9.05	9.45	9.92
29.33	29.18	29.44	29.49	30.35
15.59	15.56	15.39	16.18	16.52
45.66	45.66	45.95	45.65	46.84
39.14	39.16	39.29	39.54	40.25
2059.60	2045.94	2057.86	2080.62	2134.38

Appendix: 17 Gross plastic waste (kg) generation/Household in all five localities during 2018-19

South	North	East	Central	West
16.93	14.96	16.01	16.18	16.30
18.68	16.73	18.12	17.94	18.25
18.94	16.89	18.07	18.17	18.44
24.37	22.10	23.15	23.33	23.31
25.47	23.24	24.37	24.52	24.62
31.00	28.84	29.95	30.13	30.25
42.49	40.27	41.38	41.58	41.59
17.16	14.87	16.26	16.11	16.11
21.09	18.98	20.18	20.31	20.42
20.31	18.46	19.25	19.65	19.69
41.33	39.28	40.18	40.55	40.75
20.21	18.22	18.97	19.48	19.77
32.77	30.74	31.61	32.05	32.17
14.86	13.01	14.19	14.29	14.56
29.53	27.60	28.83	28.89	29.08
11.49	9.41	10.32	10.69	10.84
21.60	19.53	20.67	20.78	20.91
43.28	41.31	42.58	42.63	42.54
29.95	27.98	29.02	29.25	29.34
18.50	16.59	17.68	17.84	17.89
32.44	30.19	31.23	31.49	31.70
23.71	21.69	22.78	22.94	23.13
22.80	20.46	21.69	21.80	21.88

40.79	38.64	39.66	39.90	40.13
16.97	14.94	15.84	16.19	16.34
11.72	9.23	10.39	10.47	10.76
14.22	12.32	13.32	13.55	13.75
35.30	33.06	34.00	34.30	34.51
20.87	18.64	19.67	19.84	20.02
47.56	45.49	46.40	46.79	47.01
40.35	38.18	39.34	39.56	39.50
38.68	36.51	37.94	37.83	37.86
16.93	14.83	15.92	16.09	16.19
25.38	23.37	24.21	24.68	24.77
12.52	10.22	11.43	11.56	11.75
40.78	38.83	39.84	39.99	40.23
25.24	22.98	23.89	24.32	24.38
33.76	31.94	33.29	33.17	33.44
22.47	20.27	21.46	21.49	21.67
26.55	24.23	25.43	25.53	25.81
16.02	13.77	14.68	15.00	15.15
39.85	37.91	39.34	39.27	39.41
11.93	9.92	11.31	11.14	11.35
33.46	31.13	32.54	32.40	32.64
23.54	21.40	22.61	22.63	22.78
21.34	19.39	20.40	20.64	20.71
47.70	45.33	46.42	46.67	46.81
17.02	14.67	15.71	15.99	16.04
41.47	39.24	40.24	40.47	40.72
36.78	34.46	35.72	35.69	35.84
21.42	19.36	20.55	20.55	20.71
19.92	17.60	18.59	18.94	18.99
14.35	12.24	13.55	13.53	13.75
30.27	27.99	29.19	29.19	29.34
31.40	29.19	30.25	30.46	30.49
34.00	31.63	32.92	32.83	32.98
37.75	35.25	36.53	36.57	36.60
17.95	15.72	16.76	16.97	17.16
38.76	36.84	37.84	38.19	38.22
36.44	34.34	35.29	35.60	35.78

23.09	21.16	22.21	22.37	22.53
29.59	27.51	28.62	28.74	28.92
41.97	39.76	41.07	41.09	41.19
42.83	40.69	41.60	41.89	42.01
23.11	20.80	21.74	22.10	22.38
46.92	44.60	45.65	45.79	46.14
49.91	47.78	48.84	49.04	49.15
24.92	22.68	23.58	24.01	24.09
14.16	12.14	13.20	13.35	13.54
37.29	35.29	36.64	36.53	36.72
17.66	15.68	16.75	16.92	16.91
40.62	38.60	39.64	39.85	39.88
10.43	8.27	9.24	9.61	9.68
30.43	28.59	29.70	29.80	29.95
16.99	14.80	16.06	16.05	16.26
47.04	45.02	46.28	46.31	46.38
40.65	38.44	39.62	39.72	39.83
2157.93	1994.18	2079.37	2091.71	2102.66

Appendix: 18 Gross plastic waste (kg) generation/Household in all five localities during 2019-20

South	North	East	Central	West
16.71	15.43	16.79	15.61	16.72
18.55	17.28	18.74	17.63	19.09
18.93	17.39	19.37	17.66	19.10
23.88	22.62	24.21	22.72	24.21
25.02	23.77	25.04	24.09	25.91
30.51	29.34	31.05	29.44	30.89
42.20	40.65	42.11	41.10	42.53
16.63	15.66	17.02	15.67	17.07
20.75	19.63	21.09	19.77	20.97
20.13	18.98	20.19	19.10	21.13
41.03	39.81	41.47	40.26	41.41
20.16	18.88	20.25	19.10	20.37
32.61	31.44	32.98	31.62	32.83

14.95	13.71	15.18	14.14	15.53
29.39	28.08	29.96	28.36	29.82
11.18	9.91	11.67	10.38	11.70
21.27	20.17	21.67	20.34	21.48
43.08	41.95	43.38	42.38	43.67
29.71	28.63	30.13	28.99	30.19
18.39	17.03	18.61	17.08	18.94
32.04	30.93	32.03	31.39	32.31
23.65	22.42	24.05	22.37	24.05
22.27	20.92	22.59	21.22	22.57
40.46	39.34	40.74	39.61	41.05
16.58	15.42	17.02	15.49	17.34
10.86	9.71	11.36	9.92	11.58
14.23	12.96	14.36	13.10	14.41
34.74	33.67	35.17	33.87	35.20
20.34	19.12	20.79	19.53	20.73
47.44	46.19	47.80	46.15	47.91
40.20	38.87	40.26	38.89	40.70
38.21	37.12	38.64	37.34	38.98
16.59	15.42	16.90	15.40	17.03
25.09	24.04	25.22	24.15	25.58
11.94	10.98	12.47	11.72	12.52
40.53	39.26	40.69	39.56	40.78
24.97	23.66	25.21	23.80	24.83
33.76	32.45	33.66	32.79	33.86
21.87	20.83	22.36	21.31	22.57
26.01	24.99	26.16	25.02	26.48
15.70	14.45	15.88	14.66	15.90
39.78	38.50	39.98	38.79	40.55
11.64	10.38	11.97	10.62	12.19
32.94	31.81	33.29	31.84	33.33
23.24	21.97	23.23	22.11	23.50
20.97	19.98	21.41	20.21	21.30
47.28	45.85	47.24	46.19	47.74
16.29	15.32	16.65	15.44	16.58
40.99	39.78	41.54	39.96	41.76
36.18	35.23	36.32	35.62	36.74

20.92	20.02	21.60	20.23	21.63
19.52	18.30	19.63	18.51	19.98
14.15	12.92	14.34	13.16	14.33
29.72	28.47	30.39	28.44	30.44
30.83	29.86	31.18	29.62	31.05
33.43	32.21	33.55	32.65	33.65
37.14	35.92	37.31	36.15	37.48
17.42	16.38	17.73	16.45	18.24
38.67	37.57	38.74	37.73	39.44
36.19	34.93	36.27	35.12	36.50
22.74	21.84	22.95	21.88	23.14
29.57	28.22	29.53	28.19	29.73
41.53	40.47	41.55	40.61	41.80
42.17	41.19	42.80	41.41	42.76
22.55	21.48	23.06	21.92	23.15
46.36	45.20	46.54	45.32	46.88
49.47	48.39	49.81	48.48	50.02
24.49	23.35	25.03	23.44	24.65
14.10	12.69	14.20	12.95	14.41
37.18	35.94	37.33	36.23	37.63
17.58	16.21	17.71	16.46	17.58
40.41	39.19	40.90	39.48	40.66
10.19	8.96	10.13	9.01	10.37
30.46	28.99	30.79	29.37	30.84
16.67	15.27	16.85	15.46	16.95
46.59	45.50	47.18	45.95	46.96
40.34	38.96	40.61	39.15	40.88
2132.23	2040.34	2153.59	2056.84	2164.70

Appendix 19 Questionnaire

Please fill necessary details

Locality:

- Name……………………………………………………
- Sex……………………………………………………
- Age……………………………………………………
- Occupation……………………………………………
- Yearly Income…………………………………………

Questions	**Yes**	**No**
Do you know about Reuse, Reduce and Recycle		
Do you carry your own bag while going for shopping		
Do you segregate the waste at your home before disposal		
Is there door to door waste collection facility in your locality		
Is waste is being collected by Municipality every week		
Public awareness can greatly reduce plastic waste generation		
Present legislations are enough to curb the menace of plastic waste		
Plastic waste management(PWM) should be part of course curriculum in elementary studies		
Municipalities are fulfilling their duty efficiently with regard to PWM		
Plastic waste can be sustainably managed with community participation		

Appendix 20 Pilot study

In order to examine the composition of street waste in Aizawl.42 waste bags were collected from 20 roadside collection points along residential streets. In total, 317.1 kg of waste in 42 plastic bags was collected, well mixed and then sorted. The total weight of each category was then measured. This survey was conducted in 10 January 2018.

Day	Biodegradable	Non biodegradable
1	52.3	47.7
2	43.2	56.8
3	46.2	53.8
4	43	57
5	44.2	55.8
6	49.7	50.3
7	47	53
	46.51±3.80%	53.49±3.80%

Day	Kitchen/Veg	Paper	Garden	Textile	Plastic	Metal	Glass	Inert
1	16.03	20.23	9.68	6.36	11.98	7.16	7.26	21.3
2	10.367	19.66	6.37	6.78	10.1	11.12	13.31	22.28
3	14.74	18.54	6.44	6.46	12.5	8.31	7.99	25.01
4	15.47	19.77	3.47	4.27	13.63	9.86	10.17	23.33
5	12.22	19.02	9.5	3.46	10.75	12.28	9.09	23.67
6	14.97	18.87	7.165	8.68	14.28	8.71	6.25	21.07
7	11.28	19.08	10.04	6.57	12.31	8.79	9.22	22.69
Total	13.59±2.25	19.31±0.59	7.53±2.38	6.09±1.73	12.22±1.47	9.46±1.76	9.04±2.30	22.76±1.38

PARTICULARS OF CANDIDATE

NAME OF CANDIDATE: ANIL PRATAP SINGH

DEGREE: PhD

DEPARTMENT: ENVIRONMENTAL SCIENCE

TITLE OF THESIS: A STUDY ON PLASTIC WASTE MANAGEMENT IN AIZAWL CITY, MIZORAM

DATE OF ADMISSION:16/04/2018

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1. DRC: 17/04/2018

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3. SCHOOL BOARD: 24/04/18

MZU REGISTRATON NO: 2006567

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2. Singh A.P.;Devi A.S.(2021).A study on plastic waste generation in Aizawl city, Mizoram. International Journal of Advanced Scientific Research and Management, Volume 6 Issue 7, ISSN 2455-6378
3. Singh A.P.;Devi A.S.(2019).Plastic Waste Management: A Review International Journal of Advanced Scientific Research and Management, Volume 4 Issue 5, ISSN 2455-6378
4. Singh A.P.;Devi A.S.(2019).Plastic Waste:A Review. International Journal of Advanced Scientific Research and Management, Volume 4 Issue 3, ISSN 2455-6378
5. Singh A.P.;Devi A.S.(2019).Bio-Plastics: A sustainable alternative to conventional petroleum based plastics. International Journal of Advanced Scientific Research and Management, Volume 4 Issue 4, ISSN 2455-6378
6. Singh A.P.;Devi A.S.(2019).Microplastics and single use plastics: A curse of over consumerism. International Journal of Advanced Scientific Research and Management, Volume 4 Issue 4, ISSN 2455-6378
7. Singh A.P.;Devi A.S.(2019).Environmental Plastic Pollution.InternationalJournal of Advanced Scientific Research and Management, Volume 4 Issue .ISSN 2455-6378

Papers presented at international conference

1. International Conference on Recycling and Waste Management-(ICRWM-21) Warangal, India.31st January 2021,

2. Recent Advances & Innovations in Technology, Management & Applied Sciences.(ICRAITMS-2021). Dhulapally, Secunderabad, 19th& 20th March 2021

PHOTO PLATES

Collection of Plastic waste

Transport of plastic waste by taxi

Transport of plastic waste by Pick up

Storing plastic waste for analysis

	
Sorting of plastic waste into various physical forms	**Weighing balance**
	
Digital weighing balance	**Weighing balance**

	
Waste dumpling site	**Burning of waste**

landfill site at Turial

Aizawl Solid waste management Center

Recycling facilities for plastic waste

Storage of waste for recycling

Waste collection by municipality vehicle

	
Collection and transportation of plastic waste	**Plastic waste at collection point**
	
Open dumping of plastic waste	**Burning of waste**

	
Plastic waste in bazaar	**Plastic waste in household**
	
Plastic waste in commercial area	**Municipal vehicle collecting waste**

A STUDY ON PLASTIC WASTE MANAGEMENT IN AIZAWL CITY, MIZORAM

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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DEPARTMENT OF ENVIRONMENTAL SCIENCE

SCHOOLOF EARTH SCIENCES AND NATURAL RESOURCES MANAGEMENT

JANUARY,2022

A STUDY ON PLASTIC WASTE MANAGEMENT IN AIZAWL CITY, MIZORAM

By

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Department of Environmental Science

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Submitted

in partial fulfillment of the requirement for the Degree of Doctor of Philosophy in Environmental Science of Mizoram university, Aizawl.

ABSTRACT

Waste is necessary evil. During the process of economic development, urbanization and modernization the consumption pattern of societies get changed so do the waste characteristics. Plastics are incredible human invention which is versatile, could be widely used in the field of industrial production and our daily lives. The indiscriminate use and production of plastic waste has become a serious concern. As consumption of plastic has increased exponentially in recent years, the indiscriminate dumping and littering of plastic waste is exerting wide spectrum of detrimental impacts on environment and human health, the magnitude of which varies from place to place. The assessment and characterization of plastic wastes help to understand the magnitude of plastic waste to envisage strategies for its management in efficient ways.

Plastic waste is generated from variety of sources mainly from industrial, commercial and residential activities. Industrial waste is produced due to processing, manufacturing, and packaging activities. For ex automotive industries produce plastic waste like spare parts, fan blades, bumpers, seat covers and grill etc. In industries during construction phase pipe and fittings, sheets and waste tiles, electrical switches, cable sheath, screens are generated. In commercial areas workshops, supermarkets, wholesalers generate reasonable amount of plastic waste which mostly comprising of packaging material. Hotels and restaurants produce plastic waste in the form of bottles, straws, wrappers and packaging materials. Residential area like colonies, housing societies, apartments and park generate plastic waste mainly due to littering and non segregation of waste at source. Once dumped openly plastic waste contaminate rivers, streams, oceans, air and soil. Around 80% of plastic getting in to world's oceans come from land based sources. Important land based sources are water and sewer discharge, tourism, fishing, illegal dumping and industrial activities. Important sea based activities responsible for generating plastic litter are commercial fishing, boating, shipping industry ,oil and gas exploration activities. Burning leads to release of toxic gases and chemicals like dioxin, recycling if not managed properly leads to several environmental and occupational

hazards. During production process of plastics benzenes, xylenes and ethylene oxides are released which are known to cause birth defects, cancer and immune disorders.

Major waste generating sources identified in Aizawl city are residential, commercial, industrial, institutional, construction& demolition and agriculture sector. Residential waste commonly includes Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g. consumer electronics, white goods, batteries, oil, tires and household hazardous wastes). Industrial waste includes Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes. Commercial waste includes Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes. Construction& demolition waste includes wood, steel, concrete, dirt, etc. Major sources of plastic waste in Aizawl city were identified to be households, grocery stores, whole sale shops, private stores, show rooms, hotels and restaurants, offices. Major plastic items identified were single use plastic items like bottles, straw, stirrers, disposable cups, plates, wrappers, packaging material.

The present study was carried out with main objective of to quantify and characterize the plastic waste in selected residential, commercial areas and Turial dumping site of Aizawl city, document plastic waste management strategies prevalent in Aizawl city and to suggest suitable measures.

Waste quantification and characterization of plastic waste in residential area, commercial sites and Tuirial dumping site focused on measurement of plastic being generated and further assessment of physical categories and chemical categorization of plastic waste.385 households representing North, South, East, West and Central Aizawl were surveyed during 2017-18,2018-19,2019-20.Every year survey was conducted for a duration of 9 months duration and data were collected monthly, covering 3 seasons Winter (November, December, January),Summer (March, April, May), Rainy (July, August, September).Plastic waste assessment in residential area was conducted according procedure outlined by Thanh et al.,(2011). Three Commercial sites were selected for waste assessment, within each commercial site five collection points were selected for plastic waste collection. Plastic waste assessment and characterization in residential and commercial area were done according to Plastic waste assessment guidelines established by UNEP (2009),Household survey guidelines (2005) by Department of Economic and Social Affairs while Identification of plastic polymer type was done according to procedure established by Harris and Walker (2010).At dumping site located at Tuirial waste assessment was conducted according to ASTM (Standard Test Method for determination of composition of unprocessed municipal solid waste).

Samples were collected biweekly from residential area, commercial sites and Turial dumping site. Sampling was carried during winter (November, December, January), summar (March,April,May) and rainy season (July,August,September).This was to study the impact of seasons on waste stream characteristics. In residential area MSW was assessed from each household twice a week on Tuesday and Saturday and plastic fraction was sorted, weighed and recorded. In each commercial area, 5 collection point were selected and from each collection point 10 kg of MSW was collected by quartering technique twice a week on Tuesday and Saturday and from MSW plastic fraction plastic waste was segregated, sorted and weighed. At dumping site 20kg of MSW was collected by quartering technique twice a week on Tuesday and Saturday from MSW plastic fraction plastic waste was segregated and sorted and weighed. Data from the sorting events was processed and Microsoft Excel software packages. Descriptive statistics were initially generated followed by further statistical tests for variance using Analysis of Variance (ANOVA). The results from statistical analysis were compared to establish any similarities or differences.

Several environmental issues regarding plastic waste arise predominately due to the throwaway culture and lack of waste management system, inadequate resources, in-appropriate technologies, management apathy and low efficiency of system are unable to give fruitful results. Undoubtedly, it is the habit of people and lack of infrastructure for management of solid waste. Problems have been identified in the collection, transportation and disposal system along with the quantified plastic waste. The existing policies have not been able to provide any respite for associated problems. The present work can be broadly categorized in to four categories namely 1.Assessment of plastic waste in residential area, commercial sites and dumping site. 2. Physical and chemical characterization of plastic waste.3Comparison of the characteristics of plastic waste characteristics among residential area commercial sites and dumping site.4.Document waste management strategies prevalent in Aizawl City.The present study undertook an assessment of plastic waste getting generated in Aizawl city and suggested ways to sustainably manage plastic waste.

Seasons have deep influence on plastic waste generation. Among winters, rainy and summer season Maximum plastic waste was generated during winter season. Among all localities maximum plastic waste/household was generated in during winters in West locality while minimum plastic waste/household was generated during summers in North locality. In winters during month of December maximum plastic/household was observed while during rainy season least plastic waste/household was observed in month of August.

Maximum amount of plastic waste/household generated during winter season was 10.30 kg/household while Minimum amount of plastic waste/household was generated during rainy season with 8.13kg/household in south Locality.

During 2017-18 maximum plastic waste was generated in West locality (2134.68kg) and minimum in North locality (2045.94 kg), during year 2018-19 maximum plastic waste was generated in South locality (2157.93kg) and minimum in North locality (1994.18kg), during year 2019-20 maximum plastic waste was generated in West locality (2164.70g) and minimum in North locality (2040.34 kg).

By comparing between the five localities it was observed that during year 2017-18 maximum plastic waste was generated in West locality (2134.68kg) and minimum in North locality (2045.94 kg), during year 2018-19 maximum plastic waste was generated in South locality (2157.93kg) and minimum in North locality (1994.18kg), during year

2019-20 maximum plastic waste was generated in West locality (2164.70kg) and minimum in North locality (2040.34 kg). Gross plastic waste generation among households of various localities was not found statistically significant for year 2017-18

Overall 4.75 kg of plastic waste per capita per year was generated in all localities. Maximum plastic waste generation per capita per year was observed in Central locality with 5.56±.99 kg and least in South locality with 4.34±1.14 kg. Overall 18.42 gm plastic waste per capita per day was produced in all localities during assessment period. Maximum plastic waste generation per capita per day was found in Central Locality 20.03±1.76 g and least in South locality 15.71±1.61g

It was found that maximum plastic waste per capita per season was generated during winter season in all the three years in all localities. The maximum Plastic waste generation per capita per season was found in Central locality 5.31±.15 kg and least in south locality 4.05±.47 kg.In all the three seasons maximum Plastic waste generation per capita per day was found during winter season in Central locality 19.27±3.03 g and least Plastic waste generation per capita per day was found during Rainy season in South Locality 6.66±3.26 g

Among five localities the packaging material contributed maximum and least amount was contributed by plastic rope. In all localities packaging material contributed 71.45±1.37% to 72.79±0.28%, Plastic bottles 10.85±0.09% to 11.51±0.81%, Plastic container 3.64±0.03% to 4.2±0.81%,Tubes 1.83±0.12% to1.49±0.03%,Tray 1.86±0.165 to1.66±0.03%, Durable plastic products(MU) 3.81±002% to3.48±0.11%, Consumable plastic products (SU) 1.58±0.08% to1.38±0.20% and Plastic rope 0.33±0.17% to 0.47±0.08%.

In all the localities LDPE type of plastic waste was generated at maximum amount while least amount of plastic waste generated belonged to PVC category.Chemical composition of plastic revealed that PET ranged from 15.83±1.855 to 15.12±0.33%, HDPE 24.05±0.68% to 21.05±1.69%, LDPE 27.2±0.18% to 25.7±1.69%, PVC

4.93±0.34% to 2.29±0.34%, PP 17.14±1.52% to 15.83±1.55%, PS 9.04±1.225 to 8.29±1.22%.

Maximum Plastic waste generation per capita per year was found in the households having income > 25L/yr with 6.89±.29 kg and least in the income group having family income < 1.0L/yr with 4.29±.24 kg.Maximum Plastic waste g/capita/day was found in income group of having household income > 25L/yr with 22.55±3.56 g while least in least in income group having family income <1.0L/yr with 14.89±2.15g

In all commercial area Maximum plastic waste was observed during winter season while least during rainy season.In Barabazar during winter 613.52kg;summer 439.45kg and rainy season375.51 kg of plastic waste was generated during 2017-20..Overall plastic waste comprised 13.22±2.17% of total solid waste assessed during 2017-20 in Barabazar area.In Millenium center during winter 664.70kg;summer 536.78kg and rainy season 340.11kg of plastic waste was generated during 2017-20.Overall plastic waste comprised 14.36±2.20% of total solid waste assessed during 2017-20 in Millenium center.In Zarkawt during winter 679.76kg;summer 506.02kg and rainy season 419.79kg of plastic waste was generated during 2017-20.Overall plastic waste comprised 14.95±1.99% of total solid waste assessed during 2017-20 in Zarkawt.

During the assessment period Barabazar produced average plastic waste 13.55±1.55% in November, 19.43±2.40% in December,18.13±1.88% in January,11.95±1.69% in March, 11.98±2.74% in April, 12.69±4.34% in May,1.21±2.14% in July, 10.00±1.60% in August, 10.072±1.25% in September. Overall plastic waste accounted 13.22±2.17% of solid waste in Barabazar.

During the assessment period Millenium center produced average plastic waste 17.13±2.48 % in November, 21.24±1.75%in December, 17.02±1.31%in January, 15.68±2.34%in March, 14.80±3.02%in April, 14.23±2.82% in May, 11.09±1.92%in July, 8.71±1.81% in August, 9.37±2.37% in September.Overall plastic waste accounted 14.36±2.20% of solid waste in Millenium center.

During the assessment period Zarkawt produced average plastic waste 19.12±2.29% in November, 21.04±2.93% in December, 16.48±2.68% in January, 14.91±1.28% in March, 14.50±1.47% in April, 13.58±2.93% in May, 12.84±1.28% in July, 10.93±1.53% in August, 11.20±1.51% in September.Overall plastic waste accounted 14.95±1.99% of solid waste in Zarkawt.

Overall in all commercial area during year 2017-20 plastic waste was dominated by packaging material which ranged from 44.98±1.425 to 44.72±0.32&; bottles with 25.98±0.56% to 25.55±0.06%; containers 8.48±0.89 to 8.48±0.085;Tubes 6.02±0.35% to 5.94±0.025;consumable plastic products 3.89±0.48% to 3.43±0.13%;durable plastic products 3.75±0.01% to 3.42±0.13%;plastic tray 2.94±0.26% to 2.92±0.025and plastic rope with 0.52±0.13% to 0.52±0.01%.

Plastic waste was dominated by LDPE which ranged from 28.26±0.27% to 27.44±0.58%;HDPE 25.21±0.34% to 23.95±0.68; PS12.56±1.06% to 10.95±0.72%;PET 15.17±0.88% to 12.43±1.03%;PP 11.83±0.34% to 11.02±1.03%;PVC4.79±0.34% to 3.5±051%.

At dumping site Maximum plastic waste was observed in winters December 11.09±.55%;January9.88±1.42%;November 9.30±1.3%;followed by summer April9.28± 1.02%;March 7.53± .77%;May 6.57± .18%and least in rainy season September 6.25±.58%; August6.28 ±1.42%; July 7.50 ±.89%..

Highest amount of plastic waste at dumping site was found to belong to packaging 40.61±3.02%; bottles 26.17±2.28%;Containers 8.90±0.32%; Tubes6.09±0.28%; consumable plastic products4.56±0.14%; durable plastic products3.93±0.40%;plastic trays3.68±0.27% and plastic rope with0.90±0.14%.

Maximum amount of plastic waste belonged to HDPE 21.62±0.42% fallowed by LDPE 20.27±0.29%;PET 17.03±1.82%;PS18.97±0.31%; PP 9.98±0.33%PVC 6.48±0.52% other categories with 5.64±2.19%.

The comparison of plastic waste at residential, commercial and dumping site reveals that in residential area plastic waste was dominated by packaging material 72.6±0.65%, bottles 11.15±0.27%; containers 3.82±0.23% while in commercial area plastic waste dominated by packaging material 44.75±0.22%; bottles 25.53±0.46%; containers 8.53±0.24% and at dumping site plastic waste was dominated by packaging material 40.61±3.02%; bottles 26.17±2.28% and containers with 8.9±0.32%.

Chemical characterization in residential area plastic waste comprised of PET 15.54±0.37%; HDPE22.55±1.39%; LDPE26.50±0.60%; PVC3.63±.98%; PP16.47±0.56%;PS8.70±0.33% while in commercial area plastic waste comprised of PET14.25± 1.58%;HDPE24.59±0.63%;LDPE27.82±0.41%; PVC4.03±0.67%; PP11.52±0.44%;PS11.72±0.81%. and at dumping site plastic waste comprised of PET17.03±1.82%;HDPE21.62±0.42%;LDPE20.27±0.29%;PVC6.48±0.52%; PP9.98±0.334%; PS18.79±0.31%.

In Mizoram 266.04MT/day Soild waste is generated while at Aizawl it is 182.53MT/day.AMC claims in municipal area is there 100 % collection and transportation of SW to landfill site. Out of total soild waste generated per day in all 19 wards segregation is done in 68.67%.Waste is being treated and processed in material recovery facility at rate of 74 TPD, Composting 50TPD, Vermicomposting 22 TPD, Landfilling 44 TPD.In 2011 Plastic waste generation in 2010-11 Aizawl city was reported to be 8.5 Tonnes per day (7.95% of SW) presently in 2020-21 it is 14.51Tonnes per day.The biggest waste dumping site at Tuirial, Aizawl which has been receiving maximum wastes from Aizawl city for a number of years is overloaded and should be replaced by Waste Management Resource Centre and new sanitary Landfill. Dumping of waste at unauthorized dumping sites and waste burning should be strictly dealt with by local authority and Aizawl Municipal Corporation and scientific waste management should be promotd.General public should be encouraged to contribute in plastic waste management by decentralizing waste processing. In general solid waste in Aizawl city is managed according to Solid Waste Management Rules, 2016. The Solid Waste

Management is done in a Public Private Partnership mode. The funding is shared in the ratio of 80:20 between the AMC and the general public.

In order to regulate all matters connected with the storage, collection, transportation, processing and disposal of municipal plastic wastes and in exercise of the power conferred under Rule 6(4) of the Plastic Waste Management Rules, 2016, the Aizawl Municipal Corporation notified Aizawl Municipal Corporation Plastic Waste Management Bye-Laws, 2019. Local bodies should promote segregation at source through Local Councils. A proposal is being formulated to segregate waste at source in to biodegradable wastes, non biodegradable wastes, toxic wastes, sanitary wastes and E-wastes by setting up plastic waste collection centres/material recovery facilities. For effective implementation of plastic waste management,ensuring its channelizing to recyclers including through the existing formal/ informal waste recycling sector, creating awareness among all the stakeholders about their responsibilities, ensuring the financial sustainability of plastic waste management, implementing Environment Protection Rules (RPR) and levy user charges, penalty etc. are important steps. AMC should assess quantity of solid waste generated daily for effective management of solid waste. House to house collection on regular and pre-informed timing should be organized by the process of ringing of bell or other means of information.

Local governments face enormous challenge in providing waste management services. Collection and transportation contributes to approximately three fourth of total expanse in solid waste management services. There are numerous health hazards associated with handling of contaminated plastic waste. Waste once disposed in landfills becomes prone to leaching and hence contaminate ground water and soil. Collection, segregation, transportation, treatment and disposal is highly inadequate in Aizawl which is leading to poor state of health and environment. Key issues are limited door to door collection, lack of awareness and willingness to participate among public, unavailability of enough funds, non segregation of waste at source and lack of scientific processing, recycling and disposal technologies

Disposal of plastic waste is a serious concern for ecological and human well being. New technologies have been developed to minimize their adverse effect on the environment. Currently worldwide accepted technology used for the plastic disposal is incineration; however, the incinerators designed poorly, releases extremely toxic compounds (chlorinated dioxins and furans) therefore, raising several environmental issues. In India for safer disposal of plastic waste various technologies have been experimented like utilization of plastic waste in road construction, co-processing of plastic waste in cement kiln, co-processing of plastic waste as alternative fuel and raw material and plasma pyrolysis technology. Social and psychological aspect of plastic waste management is highly neglected hence identifying nature, magnitude, extent of underlying causes of plastic waste generation should be studied.LCA (Life Cycle Assessment) should be used to estimate environmental impact of plastics at each stage of processing, production and disposal. Sound and reliable data is lacking which is hindering effective policy formulation on plastic waste management. Generating energy from plastic waste, waste avoidance and recovery can be good option for plastic waste management. Institutional and regulatory factors should be designed in such a way that facilitate resource recovery and does not impede recovery and recycling. Local governments should try to phase out single use plastic items in a progressive and time bound manner. Dedicated means of disposal and recovery through EPR (Extended Producer Responsibility) and PS (Product Stewardship) should be applied through appropriate policy instrument. Waste prevention and better management through Green design should be promoted as it facilitates retrieving of secondary raw materials. Green designing also helps to reduce toxicity of raw materials without compromising quality and utility of products. Plastic recycling provides an effective opportunity to dispose plastics in environmentally sound manner as recycling has huge potential for income generation and prevention of green house gas emission.Thre is a need to establish commercial level resource recovery and recycling plants. Changing consumer behavior through creating awareness and sensitization of community so as to reduce overall volume of plastics consumed and substitution with less harmful alternatives should be promoted. Focus should be on using renewable alternatives to packaging like jute or cotton, providing better waste management services, strict implementation of waste management legislations.