STUDY ON SOLID WASTE MANAGEMENT: AN ECONOMIC ANALYSIS WITH RESPECT TO ERNAKULAM DISTRICT

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...... Dedicated to My Parents ......

MR. A.THANGAPANDIAN & MRS.C.RAMALAKSHMI

Certificate

This is to certify that the work entitled "STUDY ON SOLID WASTE MANAGEMENT: AN ECONOMIC ANALYSIS WITH RESPECT TO ERNAKULAM DISTRICT" is a bonafide research work done by Ms. Dhanalakshmi. T under my guidance and supervision. The thesis is worth submitting for the award of the Degree of Doctor of Philosophy in Management. Also certified that this thesis has not previously formed the basis of the award of any Degree, Diploma, Associateship, Fellowship or any other similar titles of recognition to the best of my knowledge.

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Declaration

I hereby declare that the thesis entitled **"STUDY ON SOLID WASTE MANAGEMENT: AN ECONOMIC ANALYSIS WITH RESPECT TO ERNAKULAM DISTRICT"** is based on the original work done by me under the guidance of Prof.(Dr.) K.C. Sankaranarayanan (Former Professor and Head of the Department, Department of Applied Economics), Cochin University of Science And Technology, Cochin – 22. I declare that this thesis has not previously formed the basis of the award of any Degree, Diploma, Associateship, Fellowship or other similar titles of recognition to the best of my knowledge.

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Date: 29.04.2011

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Contents

List of tables

List of figures

Chapter	Title Name	Page No.
I	INTRODUCTION	1-40
II	SOLID WASTE GENERATION	41-84
III	SOLID WASTE MANAGEMENT	85-105
IV	WASTE RECOVERY IN ERNAKULAM	106-131
V	SOCIO-ECONOMIC ASPECTS OF RESOURCE RECOVERY	132-151
VI	PERCEPTION OF PEOPLE LIVING NEAR DUMPING YARD	152-167
VII	SUMMARY AND CONCLUSION	168-173

BIBLIOGRAPHY

APPENDIX

LIST OF TABLES

Table No.	Title	Page No
2.4.1	Population of Ernakulam	45
2.4.2	Population Density - Ernakulam	47
2.5	Solid waste generation in Ernakulam	48
2.6(a)	Bio-medical waste – private hospitals/Dispensary	76
2.6(b)	Bio-medical waste – Governmental hospitals/Dispensaries	77
2.6(c)	Bio-medical waste – Health centre/ICDP sub centre	78
2.7.1	Physical composition of municipal solid waste	79
3.4	Performance rate of sanitary workers in Ernakulam	89
3.5	Deployment of Vehicles	90
3.8.1	A comparison of required manpower to the existing manpower	95
3.8.2	Optimum clearance by sanitary workers	96
3.8.3(a)	Carrying capacity - Vehicle	97
3.8.3(b)	Requirement of vehicles (4-5 tonnes capacity)	98
3.10	Comparison of Existing and Optimized route	100
4.6(a)	Household material recovey/3 months	111
4.6(b)	Earnings per household through material recovery in lakhs (Average earnings/3 months)	112
4.6(c)	Waste bought and sold by dealers	113
4.7	Waste recovery by rag pickers in collection points (bins) and dumpsites	114
4.9.2	Cost and benefits of biogas plant	119
4.10.1	Use of feed in biogas plant	121
4.10.2	Daily availability of biogas	121

4.10.3	Details of LPG savings due to usage of biogas	122
4.10.4	Management of biogas for domestic purpose	123
4.10.5	Impact of biogas on home garden	123
4.10.6	Impact of biogas as energy source on households	124
4.10.7	Influence of biogas on waste disposal	125
4.10.8	Gender sensitivity of biogas plant operation	125
4.10.9	Rate of satisfaction among biogas users	126
4.10.10	Reason for dissatisfaction	127
5.3	Sample data	134
5.3.1	Number of members in a family	135
5.3.2	Income	136
5.3.3	Household waste generation	137
5.3.4	Waste generation and family size	139
5.3.5	Education of household	139
5.3.6	Environmental pollution disturbances in residential area	140
5.3.7	Method of waste disposal	141
5.3.8	Segregation of waste at home	142
5.3.9	Method of reducing waste	143
5.3.10	Awareness on household hazardous waste	144
5.3.11	Disposal of household hazardous waste	145
5.3.12	Acceptance of services on solid waste management by municipalities/Corporation to public	146
5.3.13	Willingness to pay for pollution free environment	147
5.3.14	Whom to tackle the waste problem	147
6.5.1	Income of the household	156
6.5.2	Duration of the stay	156
6.5.3	Waste storage practices	157
6.5.4	Disturbance of flies	158

6.5.5	Impact on water quality	159
6.5.6	Impact on air	160
6.5.7	Solid waste related diseases	161
6.5.8	Solid waste pollution	162
6.5.9	Willingness to accept	163

LIST OF FIGURES

Fig. No.	Title	Page No.
1.8	Location map	25
2.5	Waste Generation in Tonnes	49
2.5.1(a)	Cochin Corporation – Waste generation map	52
2.5.1(b)	Kothamangalam municipality– Waste generation map	53
2.5.1(c)	Muvattupuzha municipality-waste generation map	54
2.5.1(d)	Thirupunithura municipality-waste generation map	55
2.5.1(e)	Perumbavoor municipality-waste generation map	56
2.5.1(f)	Paravur municipality-waste generation map	57
2.5.1(g)	Aluva municipality- waste generation map	58
2.5.1(h)	Angamaly municipality-waste generation map	59
2.5.1(i)	Kalamassery municipality-waste generation map	60
2.5.1(j)	Cochin Corporation – Asset map	65
2.5.1(k)	Kothamangalam municipality – Asset map	66
2.5.1(l)	Muvattupuzha municipality – Asset map	67
2.5.1(m)	Thirupunithura municipality – Asset map	68
2.5.1(n)	Perumbavoor municipality – Asset map	69
2.5.1(o)	Paravur municipality – Asset map	70
2.5.1(p)	Aluva municipality – Asset map	71
2.5.1(q)	Angamaly municipality – Asset map	72
2.5.1(r)	Kalamassery municipality – Asset map	73
2.6(a)	Bio-medical waste generation in private hospitals	76
2.6(b)	Bio-medical waste generation in Government hospitals	77
2.7.1	Composition of municipal solid waste	79
4.2	Waste Reduction Process	108
4.6(a)	Households material recovery per 3 months	111
4.6(b)	Earnings in lakhs per 3 months	112
5.3.1	Family size	135
5.3.2	Income level	136
5.3.3	Rate of household waste generation	138
5.3.5	Education of household	140
5.3.7	Method of waste disposal practices	142
5.3.9	Methods of reducing waste	143

5.3.10	Awareness on household hazardous waste	144
5.3.12	Public acceptance of municipal services	146
5.3.14	Whom to tackle the waste problem	148
6.5.3	Household waste storage practices	158
6.5.4	Presence of flies	159
6.5.6	Impact on air	161
6.5.9	Willingness to accept	163

Chapter - I

INTRODUCTION

1.1 Solid Waste

The term solid waste encompasses "the heterogeneous mass of throwaways from the urban communities as well as accumulations from agricultural, industrial and other activities" (Tchobanoglous, 1993, P.3). The total surface area of earth is around 76,096,764 sq.km. of which 22,096,525 sq.km is land area. Man inhabits 18,146.718 sq.km of land area approximately. At present the earth has a total human population of 6.055 billions (Census 2001) and the total waste generated by them is around 3.86 million metric tonnes per day. The disposal of such a huge quantity of waste is giving rise to many environmental issues. Most of the countries face the problem of land availability for the disposal of huge quantity of solid waste. The increasing population with respect to the disposal of solid waste space is running out in most of the countries. Solid waste disposal has become a major concern. The environment has a capacity to dilute, disperse and absorb the unwanted residues or waste. However, the quantity of solid waste generated has become so vast that it has exceeded the natural assimilative capacity of the earth, resulting in environmental deterioration. Several ecologist and environmentalist are questioning the consequences of the environmental pollution due to solid waste which endangers man's survival on earth. The need to find a solution to control the environmental repercussions associated is one of the major emphasis of solid waste management studies.

1.2 Solid Waste Management

Solid Waste Management is a science associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid waste in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental conditions. Solid waste management includes all administrative, financial, legal, planning and engineering function involved in solutions to all problems of solid wastes (Tchobanoglous, 1993 P.7). The solid waste management has become a world wide concern since its disposal is resulting in several environmental and health issues. The environmental and health problems related to solid waste are not a recent phenomenon. The concerns towards solid waste and health can be traced back to the history of the mankind.

1.3 Solid Waste Management – A brief history

In the history of human civilization as early as 2500BC, in the towns of Assyria and Babylon (Mesopotamia), Harappa and Mohenjodara (Asia) evidences show that considerable attention was paid towards the disposal of waste. A sophisticated drainage and solid waste disposal system could be found in Harappa and Nalanda, with the disposal site of solid waste outside the city premises. Around 1700 BC Hammurabai, a Babylonian king set up laws that governed public sanitation, health and family life.

Sharma traced the history of solid waste management in the medieval Europe. He stated that "the practice of solid waste disposal on the unpaved streets, roadways and vacant lands led to the breeding of rats and flies carrying germs of diseases, which caused the outbreak of plague. The lack of management of solid waste killed half of the European in the 14th century. The period of 1900 was called as the era of the 'Great Sanitary Awakening'. It was a period of controlling the epidemics and the instances of diseases caused by micro organisms, generated by the decaying of solid waste and the sewage in the cities. In Mumbai, between the period 1896 and 1899 around 1,14,000 died of plague. The reason for the epidemic was the uncollected garbage within the city. (Sharma, 1990, p.1). Irrespective of the historical experiences, the problem of ineffective management of solid waste still persists in many cities of India.

1.4 Solid Waste Management – An Indian Experience

The World Bank reports on Appropriate Sanitation Alternative Study for Indian cities (1982) stated that over 50 infections can be transmitted from a diseased person to a healthy one, via various direct or indirect route associated with waste generation and its disposal. The unsanitary disposal of waste creates serious health hazards by encouraging the breeding of flies, mosquitoes, rodents, and other vectors of disease. It may also contribute to water, air and soil pollution and constitute public nuisance. Studies by WHO (1972), revealed that in the highly malarious area of India more than 15 anopheles vectors could be collected from a single house. Similarly, there is a considerable risk of plague in a household infected with two or more rats. During the year 1994, there was an outbreak of plague in Surat (Gujarat). The identified reason for the outbreak of plague was the breeding of vectors (rats) due to uncleared solid waste in the city.

It has been estimated, that the metropolitan cities of India generate approximately 350 to 1000 grams of waste per capita per day. As per the Indian census records, 16.7 per cent of the total population of the world is concentrated in India, i.e. around 1.027 million people live in 2.4 per cent of land area of the earth. This 16.7% of world population on an average generates 580.26 metric tonnes of solid waste per day. The country with such a huge population and a large quantity of waste generation requires an efficient management system to control the environmental repercussions associated with that. Several environmentalists, ecologists, geographers and other scientists throughout the world have attempted a number of studies in this direction. The succeeding paragraphs briefly describe the work done by various research scholars on solid waste pollution, resource recovery and its management.

1.5 Review of literature

According to Municipal Solid Wastes (Management and Handling) Rules, 2000, solid waste is defined as commercial and residential wastes generated either in solid or semi solid form, excluding industrial hazardous wastes, but including treated biomedical wastes. The United Nations Environment Programme (UNEP) defined waste as: objects which the owner does not want or use any longer, which require treatment and/or disposal. The European Community broadly defined wastes (Directive 75/442/EEC on Waste) as: any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of the national law in force.

Charles et. al (1989) indicated as by Federal law, solid waste may be a liquid, a semi liquid, or even a liquefied gas. It may be generated from industries, municipalities, business or homes. It may be a discarded article that is worn out, broken, or otherwise no longer of use, it may be a toxic substance produced as a byproduct in some industrial process.

William et.al (1990) mentioned that the waste stream is the term that describes the steady flow of varied wastes that we all produce from domestic garbage and yard wastes to industrial, commercial and construction refuse.

Frank Kreith et.al stated that Municipal Solid Waste includes wastes from residential, commercial, institutional and some industrial sources. According to Barry C.Field and Martha K.Field's book on Environmental Economics, Municipal Solid Wastes consists of trash or garbage from homes, businesses and institutions. The Municipal Solid Waste problem is not equally acute everywhere. In localities with large populations and/or constrained landfill space, the problem is one of immediate concern, in areas with the opposite characteristics, it is much less so.

According to Globalis (2005) the typical urban growth rate has been determined at around 2.5 per cent annually. Singhal et. al (2001) expressed that the growth of waste generation is out pacing the urban population growth in Indian cities.

1.5.1 Studies on solid waste management

Tchobanoglous et.al (1993) discussed that in most businesses a single choice of method is frequently unsatisfactory, inadequate and not economical. Use of an integrated approach for managing solid waste has evolved in response to the regulations developed to implement various approaches.

Urvashi Dhamija (2006) described urban solid waste as municipal solid waste because the municipality, the governmental authority at the local level due to its proximity to the site of waste generation, is considered best placed to collect it for the purposes of disposal.

Robinson (1986) defines solid waste management as the application of techniques that will ensure the orderly execution of the functions of collection, transport, processing, treatment and disposal of solid waste.

Ellis et.al (1996) did a comprehensive analysis of present and future trends of solid waste management, in developed and developing nations.

Flintoff (1984) described the variations in the solid waste management practices in developed and the developing countries, based on the case studies from UK and India.

Pruss (1999) evaluated the safe management of waste generated by hospitals and health care centers.

Ammu Joseph (1994) identified two parallel systems of solid waste management. The formal system operated by local government and the informal system represented by waste recycling through rag pickers, petty traders, entrepreneurs and workers involved in manufacturing new products from recycled products.

The Rio-Declaration (1992) of Agenda 21, calls for the promotion of "sufficient financial and technological capacities at the international, national and local levels, as appropriate to implement environmental management, including solid waste management.

Municipal solid waste management aims at an overall waste management system which is the best environmentally, economically sustainable for a particular region and socially acceptable (World Resource Foundation, 1996; McDougall et al., 2001).

Although there are no comprehensive data on waste generation rates, collection, coverage, storage, transport and disposal volumes and practices, the Central Public Health and Environmental Engineering Organisation (CPHEEO) estimated a per capita waste generation in Indian cities and towns in the range of 0.2 to 0.6 kilograms per day.

Eldon (2006) in his book on Environmental Science discussed about the interrelationships between waste generation and life style. Aravind Kumar (2004) in Environment Management described the generation and disposal practices of Municipal Solid Wastes in cities.

Sneha Palnitkar et.al (2004) in their book on 'The Intersection of Poverty and Solid Waste Management' stated that Indian urban waste is a complex mixture of household, construction, infectious, commercial, and toxic industrial elements. They also indicated several studies conducted by NEERI and other consultants that have shown that the waste generation rates are low in smaller towns whereas they are high in cities over 20 lakh population.

The main constituents of urban wastes are similar throughout the world, but the weight generated, the density and the proportion of constituents vary widely from country to country and from town to town within a country according to the level of economic development, geographic location, weather and social condition. S.V.S Rana (2007) found that as the personal income rises, kitchen waste decline, but the paper, metals and glass wastes increase. While the total weight generated rises, the density of waste declines.

Saxena (2001) estimated that the daily per capita waste generation in India ranges from 100 gram in small towns to 500 grams in large towns.

Padmalal et.al (2002) predicted that India will probably see a rise in waste generation from less than 40000 metric tonnes per year to over 125000 metric tonnes per year by the year 2030. Their composition will also vary widely, depending upon the geographical location and season.

According to Bhide and Sundareson (1983) the changes in the relative shares of different constituents of waste in the past several past decades can largely be attributed to the changing life styles and increasing consumerism.

N.K.Uberoi (2003) discussed that the accumulation of solid waste is due to the growth in populations and increase in output per capita. He further discussed about the economics of Municipal Solid Waste Management in cities.

James et.al (1993) discussed about Integrated Waste Management. They gave various options for integrated waste management as source reduction, limitations of toxicity of wastes produced, recycling, and reuse of materials, incineration, thermal reduction, sanitary landfill and land disposal.

David Gordon (1977) said that from the earliest civilization burial of wastes has always been comparatively easy in rural areas.

William et al (2007) studied that solid waste disposal is at present limited to land and the ocean. Some of the wastes can be recovered and reprocessed by a procedure commonly known as recycling. However, before the wastes can be disposed of effectively, they must be collected efficiently. These activities, i.e. collection, disposal and/or recovery form a part of the solid waste management system.

Bagcht (1994) discussed the current practices in landfill engineering. They have prepared an ideal desk reference for environmental engineers, Civil and Geotechnical engineers, Hydro geologists and others involved in hazardous and non hazardous waste disposal. This manual offers wide range of application for landfill site selection, maintaining quality control, the economic analysis of landfills, fundamentals of landfill monitoring, strategies of leachate control, gas and storm water control, estimated cost of construction, operation and maintenance and final closure of landfills.

Anji Reddy (2004) in the book of Geoinformatics for Environmental Management analyzed the probable waste disposal sites with the special reference to the protection of urban environment using remote sensing data.

1.5.2 Solid waste management in Kerala

Reghunanadhan, V.R., (2004) has stated that Kerala has three cities with the population of more than 5 lakhs. These cities generate waste in the range of 350-400 tonnes per day. He also estimated that the mean per capita waste generation is 450 grams per day. He also discussed the promotion of waste treatment initiatives in Local Self Government Institutions in Kerala through Technology Adaptation and Transfer.

Mahadevan Pillai, (2000) attempted to find out the existing system of solid waste collection and disposal practices in Palakkad municipality. He formulated a proposal for renovating the system. The preliminary report revealed that the daily collection of waste was around 30 tonnes and half of the daily produced wastes remain uncollected and this proved the inefficiency of waste collection of the Palakkad municipality.

Raghavan Nambiar, (1992) carried out a scientific study of municipal solid waste management at Kochi. This study revealed that Kochi city generated about 250 tonnes of waste per day and on per capita basis it was 0.36 kg/day. He concluded that composting is the most suitable method for treatment of solid waste in Kochi since it consisted a considerable percentage of organic waste.

Based on the Environmental Statistics (2002) the report in Kochi and Calicut the collection efficiency is less than the national average of 60 per cent.

Dileep Kumar (1995) attempted to find out the composition of sources of municipal solid waste in Thiruvananthapuram city. He estimated that the quantity of municipal solid waste generated from the Corporation area come to 264.5 tonnes per day and on per capita basis it was 0.32 kg/day. He also recommended composting as the most suitable disposal option for treatment of solid waste since 70 per cent of waste generated in the city consisted of vegetable and putriscible matter.

Jishi (2000) recommended the decentralized collection and disposal of waste as the most suitable and efficient system of waste management for Thiruvananthapuram city. She suggested the composting method not only due to its eco friendliness but also because of its promotional role in agriculture.

Babu Ambat (2003) attempted to identify types and quality of waste generated in each wards of Thiruvananthapuram city Corporation. He suggested a detailed transportation net work plan for transportation of wastes from collection points and processing this for better management.

Varkey Mathew (1999) estimated that the total quantity of waste being generated in Kottayam district is 52.3 tonnes per day. It is also observed that effective collection of waste do not take place in these areas where larger quantities of waste being generated.

Based on the studies carried out by the Centre for Earth Science Studies and data compiled by Clean Kerala Mission for all the Municipalities and Corporations of the state, the average daily per capita generation comes to 0.178kg with the very high variation from 0.034kg for Koothuparamb to 0.707kg for Thalassery (CESS, 2001; Padmalal and Maya,2002)

The physical compositions of wastes are also reported from municipalities by CESS (2001), Padmalal and Maya 2001 etc. These data indicates the dominance of compostable waste in the state indicating the high possibility of productive use of wastes.

1.5.3. Studies on Solid waste Pollution – A world scenario

Gorden (1977) discussed the different types of diseases associated with exposure to solid waste pollution. Bridgewater and Mumford (1979) concentrated on the vital and growing concern towards ecological and environmental degradation caused by solid waste pollution. They also discussed the various ways to recover resources from industrial, household and other activities. Loehr, Jewel and Friedman (1979) did a comprehensive study on pollution of land due to waste disposal.

Grisham (1986) analyzed the health effects and epidemiology on human beings due to uncontrolled disposal of waste. The Scientists of National Centre for Resource Recovery, London (1986), assessed the different types of land filling techniques and its environmental effects. The highlight of study is the evaluation of the decomposition of land fill and resultant environmental degradation.

Richardson (1988) in his study on solid waste management stated that the current epidemiological research indicates approximately 80 percent of human diseases are related to pollution of air, water and solid wastes.

Hagerty, Plavoni and Heer (1976) discussed the effects of solid waste pollution on the environment. Furthermore, they also evaluated the various technology adopted in USA to recover resources from solid waste.

Florey et al., (1979) are of the opinion that several researches have been conducted in recent years about the gas effect on health. In some of the studies they found remarkable effect of gas on respiratory symptoms while others had no such indication. The indoor fuel produces carbon monoxide, which leads to an increase in carbon haemoglobin.

Watts (1994) analyzed the impact of hazardous waste on ecological systems.

Attilio Bisio and Sharon Boots (1997) stated that illegal dumping of solid wastes spoils scenic resources, pollutes soil and water resources and is a potential health hazard to plants, animals and people.

Environmental law' authored by Albert Mumma deals with the main areas of Environmental law. The focus of the book is on the environmental law in England and Wales. Modern Environmental law in the UK has witnessed rapid change in the last few years. New legislations and judicial pronouncements have clarified the scope and extent of liability for environmental pollution.

Tom Tietenberg (1998) discussed the Solid Wastes problems and its remedial measures as recycling showed that as the level of waste rises and the amount of space available to store it safely without contaminating ground water declines.

James F.Berry, Mark.S and Dennison, J.D (2000) discussed the property owners' rights for property devaluation caused by off-site environmental condition.

'Waste Management' written by O.P.Kharbanda, Bombay and E.A.Stall Worthy, U.K (1990) highlights the various hazards involved in waste production and handling and the need for proper waste management. The objective of the book is to all those directly involved, about the problems in the process of solid waste management in the U.K.

Delhi Municipal Corporation treats nearly half of the city sewage at Okhla Sewage Treatment Plant. The waste gas (biogas) generated are piped to kitchens in 6000 homes at a cost of about Rs.60/- a month (India Today, May 1997).

S.P.S. Rana (1987) analyzed the cost of environmental damages and bottlenecks with the help of the concept of economic externality. The data reported by CESS (2001), Padmalal and Maya (2001), on chemical characteristics of waste is the high content of heavy metals. It indicates that dumping of waste will lead to metallic pollution of land, especially if the waste is subjected to putrefaction.

1.5.4. Studies on Solid waste pollution – An Indian scenario

Trivedi et.al (1992) analyzed the effects of solid waste pollution on the environment and health of man. V.P.Agarwal and Mendelsohn et al. (1992) attempt to measure the damage suffered in the community by examining the decline in real estate prices associated with the presence of the hazardous waste.

A.K.Bhatia (1998) defined environmental impact as any change in the physio-chemical, biological, cultural and socio-economic, environmental system that can be attributed to human activities.

Prakasan (1990) in his study on ecological, biological and pollution aspects of the Sasthamocotta lake (Kerala) revealed that one of the main factors contributing to the pollution of the lake was faecal contamination. The other pollutants, which poured into the lake, included:

a) Fertilizers that flowed into the lake during monsoon;
b) The loose mud that found its way into the water;
c) Soaps and detergents mix used by professional washermen; and
d) Waste from the filter house of the Kerala water authority.

The book 'Managing urban environment in India' published by the Times Research Foundation Calcutta is dealing with the environmental pollution in Indian cities. It gives useful guidelines for the policy makers to adopt urgent measures to launch plans to fight against urban environmental pollution.

1.5.5. Recycling and resource recovery

To prevent future problems India must take immediate steps to control waste generation, to enhance recycling recovery and reuse, and to ensure better collection and sustainable disposal. From the environmental perspective, recycling is considered as one of the best options in solid waste management hierarchy.

Ranbi et.al (2002) indicated that recycling could be categorized as the most positively received type of solid waste management practice and as an essential part of sound waste management strategies.

Meng-Shiun, W. et al (2001) Strategic program such as a promotion for recycling proved to be successful in developing countries of the world.

Yen (1975) discussed the various techniques involved in recycling of materials from solid waste recovered from industries, agricultural and domestic activities.

Chaturvedi, Bharati (2003) stated that the segregation and classification of waste continues throughout most of the recycling chain till the waste, duly segregated, reaches industries that process it and generate feedstock for recycling industries. There is close inter-dependence in many ways of the layers from top to bottom upon each other. It has been estimated that more than 1000 tonnes of recyclables are recovered from the waste which can undergo value addition of upto 700 per cent and contributes to the feedstock of over 1000 recycling unitis.

The book "Recycling and politics of urban waste" written by Mathew Candy and published by Earth scan publications, London in 1994 examines the prospects of recycling municipal, household waste. This book illustrates the key difference between recycling and incineration in view of the fact that recycling is labour intensive, whereas incineration is capital intensive.

Chermishaft et. al (1976) focused on Science and Technology adapted to produce energy from waste by different countries like Japan, Canada and Europe. Andrew Porteous (1977) discussed about the composition of refuse and recycling measures for efficient waste management. Sybil P.Parker (1977) measured the various costs inquired in solid waste management.

Holmes (1981) analysed the various aspects of recycling and resource recovery from solid wastes.

Peter (1988) discussed about resource recovery of Municipal Solid Wastes and economics. Furedy (1989) said that there is a world wide philosophy of solid waste management that is based on the principles of waste minimization and resource recovery/recycling.

Tom Tietenberg (1998) As income rise, household habits of separating and selling materials may decline unless there are lowly paid servants who are interested in the materials or there are campaigns to encourage separation.

Tchobanoglous et al (1993) discussed method to find individual components of waste stream. His method focuses on sources of waste generation. It also provides information regarding the condition of waste components prior to separation or disposal.

Recovery of Energy from Municipal solid waste in the form of methane gas is another utilization of municipal solid waste as resource. Bhide(1994) has shown than recovery process of methane gas from landfills as well as from biomethanisation would not be economical if mixed municipal solid waste are used for digestion. Here again the plastic wastes will jeoparadize the whole process.

Cointreau et. Al (1984) explained that resource recovery includes all activities of waste segregation, collection and processing which are carried out taking into consideration the economic viability of material. Also the reuse and recycling provide an opportunity to capture some of the values from the waste.

Beukering (1994), described the two techniques of resource recovery, of which reuse is the simpler process involving reutilization of material in its end use form without the necessity of reprocessing. Recycling on the other hand involves processing waste through remanufacture and conversion of parts in order to recover an original raw material.

Bever (1976) focused on the technical and economic issues surrounding the allocation and utilization of available resources and examined existing state of art of resource recovery for managing urban grime.

Melosi (1988), described that according to the earlier (prior to 1970) studies refuse management was assumed to be the main responsibility of the public officials whose prime consideration was the quick removal of waste and its destruction. During the 1970s the debate shifted to the issue of waste utilization.

Cointreau (1987) mentioned that the collection of waste and its recovery from different waste generating points is carried out by many agents, formal and informal, which represent a variety of organizational structures and relationships.

Hadher (1995) discussed that in most developing countries, including India; urban solid waste management comes under the auspices of the local municipal bodies who are the main formal stakeholders responsible for the collection, removal and disposal of garbage from public places and for the maintenance of the dumping ground.

Gidman et. al (1995) stated that sometimes the private formal sector, such as private contractors and small and large reprocessing enterprises as well as the non government and community based organizations assist the municipal authorities in collecting, treating and disposing wastes.

Fureday (1989) described along with the formal sector, in developing countries resource recovery and recycling activities are also marked by the involvement of informal sector. This comprises waste pickers, waste buyers and middlemen such as junk dealers and wholesalers.

According to the World bank (1995) the informal sector mostly refers to those employers who are classified as own account workers, eg., unpaid family workers and those who collect and treat mostly unregistered materials.

Realizing various constraints in the area of waste management, the Burman Committee (1999), constituted as per directions of Hon'ble Supreme Court, recommended that biological process (composting) should be carried out in each municipality.

1.5.6. Environmental awareness and perception

Bhatia (2007) described the basic concepts of solid waste management. He also focused on planning municipal solid waste management programmes and concentrated on environmental perspectives on waste management with respect to source reduction techniques, recycling and composting.

Bhatia (2007) described the basic concepts of solid waste management. He also focused on planning municipal solid waste management programmes and concentrated on environmental perspectives on waste management with respect to source reduction techniques, recycling and composting.

According to Lowenthal (1967) without some understanding of the bases of perception and behaviour, environmental planning becomes a mere academic exercise doomed to failure, because they are unrelated to the terms in which people think and the goals they select.

Stone (1975) put forth this suggestion in “Should Trees have standing” that everything in the natural world has an inherent value. A common notion in eastern societies is that anything that exists has inherent value because it is the manifestation of God.

According to Karan(1977), public perception of environmental pollution of industrial areas in West Bengal among different culture groups brings out the importance of perception surveys in cognition of problems and approaches to their solution.

Whyte (1977) observed that individuals and groups of people relate to environment through their perception. Their decisions and actions are influenced by perception of internal link within a problem rather than externally defined objects.

David et al (1999) Environmental perception has commonly been defined as awareness of, or feelings about, the environment, and as the act of apprehending the environment by the senses.

Vijayaraghavan (1979) reported that the age of the participants and non-participants of IDADP had negative and significant association with awareness, while education, occupation, social participation, farming experience, farm size, economic status and overall modernity maintained a positive and significant association with awareness of IDADP among participants and non-participants.

Balu (1980) found that age, education, occupation, social participation, farm size, farming experience and economic status other than cropping intensity, risk orientation and overall modernity were positively and significantly associated with the awareness of participants and non-participants of the dry land agricultural development programme.

Kayastha and Yadav (1980) found that perception has important bearing on the development of flood plains dwellers of Lower Ghaghra Plains. Narayan (1981) observes that the knowledge of how to protect and improve the environment, through suitable environmental educational programme, is vital to the infusing of environmental education programme.

Upadhyay, Chitrangad (1991) did a critical study into the possibility of implementation of environmental education as an effective remedial measure for the problem of pollution with special reference to Madhya Pradesh. The study is an endeavour to explore the possibilities inherent in the process of education which can mitigate the menace of pollution and can suggest remedial measures. The researcher feels that the process of education at various levels, formal, informal and non-formal can help in the abatement of pollution and thereby in the protection of the environment.

Feijoo (1991) studied the grasping ability of common people irrespective of instructions imparted to them. The study revealed that environmental perception correlates positively with socio-economic level of surveyed people as regardless the level of instructions, (which has been included as a variable in SEI calculation) It can be concluded that the higher the level of education the greater will be the ability to perceive negative environmental factors.

Lindell and Earle (1983) have shown that the perception of costs and benefits are strongly correlated with distance, so that an increase in the distance which one lives from an undesirable facility reduces the degree to which this individual believes she may bear the cost. This shows that the better perception of risk and the unwillingness to accept such risks has widened the need to justify the location of waste disposal facilities in an area.

Available evidence shows that solid waste has a considerable effect on the health of the inhabitants near such facilities. Bulter and Fukurai (1989) have examined the relationship between toxic waste sites and congenital anamolies (birth defect) in a string fellow acid pit dump site, located near the city of riverside California, USA. They observed that hydrological and geographical proximity to the waste site has a significant relationship to birth defects. This implies that living near the waste site would be less desirable.

Moyers (1991) observed that there was a positive correlation between birth defect, abortion and cancer in the area. This is the affirmation of impact of solid waste site on the health and property values. The inhabitants later abandoned the properties and evacuated the area because of chemicals dumped in the Love Canal. This confirms the negative impact of living near the solid waste sites.

Beede and Bloom (1995) have shown that locating near the municipal solid waste landfill in United State has a considerable adverse effect. They show that the housing values rise with the distance from the landfill, at an average of 6.2% a mile, within the two mile radius of landfill. The reason for this is that the environmental and aesthetic problem of living near a landfill diminishes as distance from it increases.

Kayastha (1987) in his report on "Environment pollution in Varanasi: A study of perceptions, problems and management" stated that it is not only the successive accumulation of pollution over the years that is responsible for the pollution of river Ganga at Varanasi. It is also due to the pollution of river Ganga by the people of upstream settlements. The vast amounts of industrial urban affluents and sewage of Kanpur, reproduce the Ganga water to a high state of pollution.

Arora (1990) discovered that regarding the concept of safe and unsafe water, homemakers gave the responses based on visual perception only. For safe water, forty eight per cent of the respondents considered water without mud as the safe water. For unsafe water fifty two per cent considered water to be unsafe water.

Ramteke and Bhatacharjee (1992) studied the bacterial pollution of drinking water sources in north Tripura district. Seventy-one drinking water sources were tested for presence of bacterial pollution, whereas ring wells and dug wells are polluted. Widespread bacterial pollution was observed in surface water sources. The significance of bacterial pollution of sources and prevalence of antibiotic resistance among Coliform is discussed in the light of public health problem.

World Commission on Environment and Development (1987) reported that little could be achieved regarding sustainable development without reorientation of attitudes and emphasis.

1.6. Scope and Issues of Research

According to the report by the Center for Research in Medical Entomology, Madurai, Kerala is the first state ever where all districts were affected by dengue fever for three consecutive years. Also, according to 'The Hindu' report, Muvattupuzha and Aluva from Ernakulam district are potential areas for an outbreak of Chickungunya, the vector borne disease. The reasons are attributed to the unclear solid waste reservoirs. The waste attracts flies, which spread diseases like typhoid, ineffective hepatitis and diarrhea. The other ideal breeding grounds for the vectors are identified as the contaminated water ways stagnant water, open drainage etc.

The development of Ernakulam is based on the progress of Cochin City, which is the biggest city in Kerala in terms of volume of trade. Also, Kochi is one of the metropolitan cities in India. The Ministry of Environment and Forest, Government of India has identified Kochi as one of the areas with high pollution potential. Based on the Environmental Statistics

(2002) the report stated that in Kochi the collection efficiency is less than the national average of 60 per cent. Many studies reveal that quality of life in Kochi is tremendously retreating. Also in Kerala state, plastic, carry bags, pet bottles and polythene packing materials choke the drains and affect the land quality. This seems to be specific to Cochin.

Environmental concerns in Ernakulam often mean more immediate and pressing local issues such as poor sanitation and health problems, air and water pollution and improper solid waste management. Garbage lying on the streets for days is a common sight in many municipalities. Sometimes a municipal truck collects and heaps the garbage inefficiently, spilling it all over. The garbage is then either dumped as landfill material on the outskirts of the city or burnt, producing foul smoke and creating unhygienic conditions. It is also reported that potential air pollutants like particulates, CO, CO_2, CH_4, N_2O, NOX, SOX, HC1, HF, H_2S, Chlorinated hydrocarbons, Dioxins/furans, Ammonia, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Nickel, Zinc, etc. emitted by these landfills into the environment are the highest in this district and are even beyond the level of tolerance. Also, the water pollutants emitted from landfills like BOD/COD, Suspended solids, Total organic compounds, AOX (Adsorbable Organic Halides), Chlorinated HCs, Dioxins/furans (TEQ), Phenols, Aluminium, Ammonium, Arsenic, Barium, Cadmium, Chloride, Chromium, Copper, Cyanide, Fluoride, Iron, Lead, Mercury, Nickel, Nitrate, Phosphate, Sulphate, Sulphide, Zinc, etc. are found to be more harmful in many ways to the life and property of human population. (Pollution Control Board, 2000; National Environmental Engineering and Research Institute, 2000). Against the above background, this research aims to focus on the present and projected practices of solid waste management which is socially acceptable, economically affordable and environmentally effective.

The present study is on various aspects of solid waste management in Ernakulam. The study will identify the existing gaps in the provision of infrastructure facilities required for effective Solid Waste Management. The study will also help to plan a proper solid waste management system especially for cities with similar nature and problem. The impact assessment in this study will highlight the environmental deterioration associated with solid waste disposal.

1.7. Issues of research

- To study the solid waste generation rate and generation activities.
- To evaluate the present solid waste management practices in Ernakulam.
- To assess the potential of resource recovery in Ernakulam
- To discuss the socio-economic impacts of households on solid waste management.
- To study the perceived consequences of various kinds of pollution on the life of the dwellers near the dumping sites such as on physical health, mental health, habits and social values.
- To recommend and suggest better methods.

1.8. Study area - Ernakulam

Kerala is on the southernmost tip of India. It stretches along the coast of the Arabian Sea and is separated from the rest of the sub continent by the steep Western Ghats. The state lies between 8^0 18 ' and 12^0 48 ' north latitude and 74^0 52' and 77^0 22' east longitude. The breadth of the state varies from 32 kms in the extreme north and south to over 120 kms in the middle. Ernakulam district of Kerala state lies between 9 degree 47’ and 10 degree 17’ and longitudes 76 degree 9’ and 76 degree 47’ and is bounded on the north by Thrissur district, on the east by Idukki district, on the south by

Kottayam and Alappuzha districts and on the west by the Arabian Sea. The lowland region, the Parur taluk, which lies in the flat delta region of the Periyar River and cut by several canals which have resulted in the formation of many Islands and entire Kochi taluk as well as the western part of Kannyannur come under the lowland region. The midland consists mainly of plain land having natural facilities of drainage via backwaters and canals. Major part of Kunnathunadu and eastern portion of Kannayannur taluk come under mid land region. The lower slopes of the highland region are under teak, and rubber cultivation. Places like Moovattupuzha, Kothamangalam, Aluva, etc come under the eastern portion formed by a section of Western ghats.

Aluva is located at 10°06’28N and 76°21’34E. Angamaly is located at 10°11’36N and 76°23’11N. Kalamassery is located at 10°02’ 39N and 76°19’02E. Perumbavur is located at 9°59’33N and 16°21’56E. Kothamangalam is located at 10°03’51N and 76°37’19E. Muvattupuzha is located at 9°59’13N and 76°34’42E. Cochin is located at 9º58’43N and 76º16’35E. Thirppunithura is located at 9°57’05N and 76°21’31E. Paravur is located at 10°08’48N and 76°13’33E. (See fig.1.8).

Ernakulam is the commercial capital of Kerala. Industrially Ernakulam district is one of the most developed districts of Kerala. All major developments in the fields of industry, transportation and IT in Kerala happen here. In addition to the achievements in the developmental indicators, Ernakulam is also much ahead in the social front as well. Ernakulam is the first district in the country to achieve cent per cent literacy. Ernakulam district is divided into 7 taluks, 15 blocks, 7 Municipalities and 88 Grama Panchayaths, in addition to the Cochin Corporation, for administrative purposes. The population in Ernakulam is 3.09 million, which is in comparison to the state average shows a trend of stabilization.

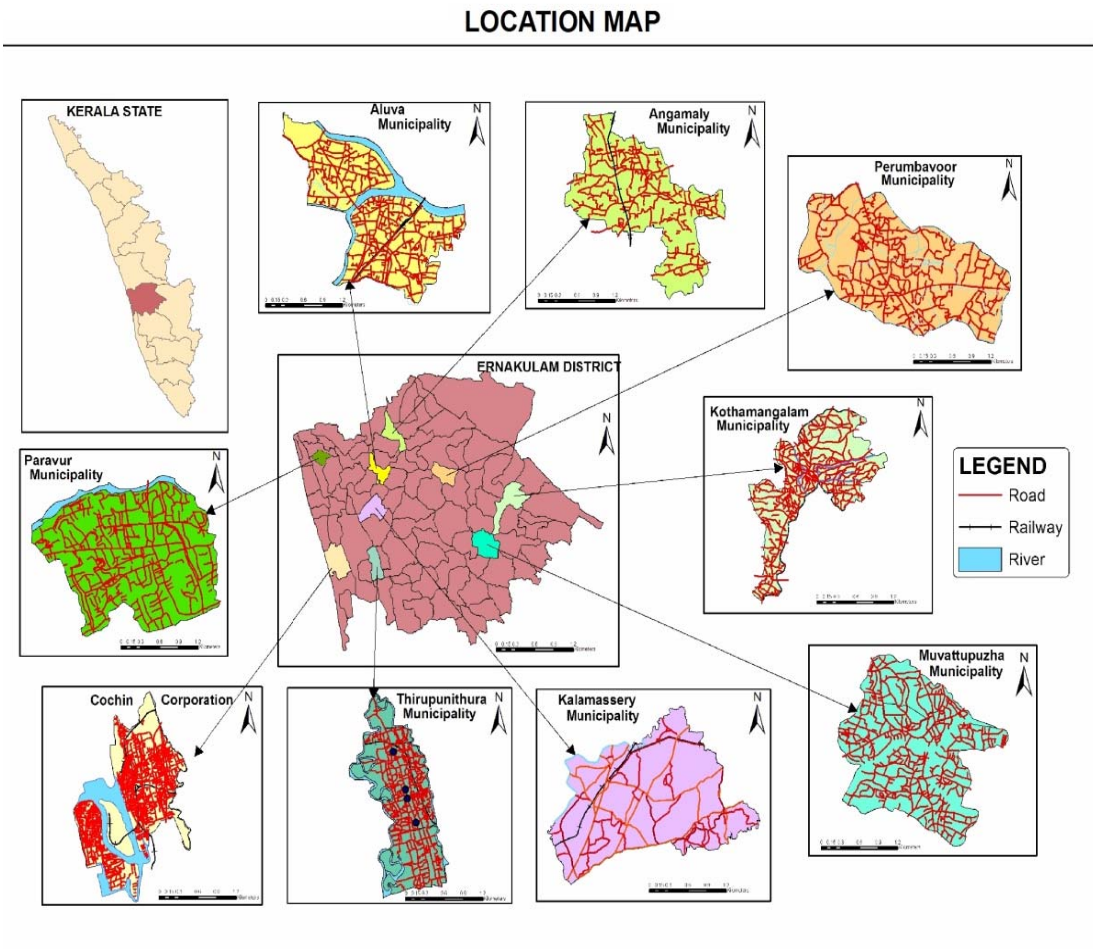

Fig 1.8

1.9. Geography of the study area

Ernakulam district of Kerala state is bounded on the north by Thrissur district, on the east by Idukki district, on the south by Kottayam and Alappuzha districts and on the west by the Lakshadweep sea. Agriculture constitutes the most important segment of the district's economy and it is the biggest source of employment. About seventy percent of the geographical area is under cultivation. The district has less than 90 sq.kms of area under forests which accounts for 3.53 per cent of the total are of the district. Of the geographical 235319 hectares, crops grown in 210438 hectares. Coconut is the principal crop followed by rubber, paddy, and tapioca. The lowland region The Parur taluk which lies in the flat delta region the periyar river and cut by several canals which have resulted in the formation many islands and entire Kochi taluk as well as the western part of Kannyannur comes under the lowland region. The midland consists mainly of plain land having natural facilities of drainage via backwaters and canals. Major part of Kunnathunadu and eastern portion of Kannayannur taluk comes under mid land region. The midland region is mainly occupied by coconut palms. Paddy, Tapioca, Pepper and pulses are also cultivated here. The lower slopes of the highland region are under teak, and rubber cultivation. Places like Moovattupuzha, Kothamangalam, Aluva, etc comes under the eastern portion formed by a section of Western ghats.

1.10. Climate

The climate is dominated by heavy rainfall during the South-west monsoon season and moderate rainfall during the post-monsoon months. Being a tropical-coastal station, the annual range of temperature is small and there is the influence of land and sea breezes. Winds are generally light to moderate throughout the year. From the standpoint of overall weather and climate, the region can be said to have the following four seasons.

1. Winter (Dec, Jan, Feb)
2. Summer (Mar, Apr, May)
3. Monsoon (or South-west monsoon) (Jun, Jul, Aug)
4. Post-monsoon (or north-east monsoon) (Sep, Oct, Nov)

The highest maximum temperature (33.9ºC) occurs in April and the lowest minimum temperature (22.41ºC) occurs in January. In July, the month of maximum rainfall, the temperature range shows higher magnitude than that of other months.

1.11. Solid waste problem in Ernakulam

Ernakulam like any other urban metro cities of India has several environmental issues. Increasing population has resulted in overcrowding and congestion. Higher population and lack of space have resulted in the development of slums. This also have been identified as one of the solid waste problem because of lack of basic infrastructure like drainage facilities, solid waste clearance etc. The urban landuse in the city includes activities like residential, industrial, commercial, recreational, educational institutions etc. All these factors which constitute an urban environment are also the principal factors contributing to the solid waste management problems experienced by the city.

Some of the important environmental issues seen in Ernakulam are air pollution, water pollution, high noise level and solid waste pollution. The air, the supplier of the essential oxygen is also the recipient of effluents from the industries, transportation, households, commercial sectors etc. These effluents include gases like sulphur di-oxide, nitrogen di-oxide, carbon di-oxide, carbon monoxide, lead, suspended particulate matter and several others. In Ernakulam the surface water includes the major Periyar river. There are some lakes and small drainage running across the Ernakulam district. The water ways are the recipient of waste produced by domestic, industries and commercial activities. The dumping of waste has rendered it to an unusable state. Thus solid waste pollution is the main problem faced by the city. The management of huge quantity of waste generated by the city is an area of concern. The lack of adequate infrastructure to remove the waste produced by various activities has become a matter of concern. Uncleared solid waste on the road sides and overflowing dustbins are a common site in the city, generating several health and environmental issues. The present study evaluates the problem of solid waste management in Ernakulam.

1.12. Ernakulam Administrative Divisions

Health department of the Corporation and municipalities are responsible for sanitation facilities, solid waste management and other public health functions. A health officer heads the health department. The collection, transportation and disposal of municipal solid waste are the responsibility of the health department while the Engineering department assists them in planning, formulation of programs and in procurement of vehicles, equipment and development of dumping site. The Project Engineer is responsible for the engineering components of solid waste management, vehicle procurement and maintenance.

1.13. Data Sources

The factors used to assess the potential of resource recovery from municipal solid waste in Ernakulam are as follows

- Population and its increase over a period of time have been acquired from the Statistics and Economics Department of Kerala State.
- Density of population of each municipality and corporation and its effects with special reference to Ernakulam has been received from the municipalities and Corporation.
- The Corporation and municipalities have provided information on quantum of waste generated by each ward. The prominent waste generating activities in each municipalities and Corporation has been assessed using Geographical Information System.
- The Kerala State Pollution Control Board has provided the data on bio-medical and industrial waste.
- The existing infrastructure facilities for solid waste management have been got from each municipalities and Corporation. The optimum requirement of infrastructure facilities for solid waste management has

been assessed by comparing it to the standard sets by Central Pollution Control Board.

- The information on family type biogas plant and compost has been received from NGOs in Ernakulam.
- The socio-economic and environmental aspect is assessed using questionnaire through survey from 1126 respondents from 8 municipalities and 1 Corporation.
- Suitable Cartographic techniques and GIS tools have been used to represent the data.

1.14. Methodology

1. Solid waste generation rate and generation activities are based on the identification of the activities generating the waste. The dominant activities that produce higher proportion of waste are developed using the municipal and corporation map of Ernakulam. The quantity of waste generated in each municipality and corporation are assessed using Geographic Information system tool.
2. The existing solid waste management practices in each municipality and corporation are evaluated in detail. The levels of infrastructure provided for solid waste clearance in each municipality are assessed by comparing it to the required optimum level services. The required level of infrastructure services are developed based on the norms set by Central Pollution Control Board and the Ministry of Environment and Forest. And also the study has been carried out on the resource recovery pattern of the reusable and recyclable waste in the household level. The data is calculated based on the sample survey from waste dealers, retailers, collectors and Kudumbasree members from different part of the study area.

3. Environmental and health impacts are assessed for dumping sites. Environmental perception of the people residing in and around the landfill is assessed using interview method. The study of disease ecology, the medical infrastructure economic status and the adaptability of people to the surroundings has also been assessed.

4. The socio-economic impact assessment study has been carried out among households for evaluating the practices of solid waste management using questionnaire through survey method.

1.15. Chapter Organization

The thesis is organized under seven chapters.

The ***first chapter*** provides an introduction to the study. It deals with the definition of solid waste and solid waste management, importance of the study, its main objectives, source of data and methodology used and a brief account of literature review on the subject.

The ***second chapter*** gives detailed information about the prominent waste generating activities in Ernakulam. It gives an overview of total waste collected in each ward per day in Ernakulam.

The ***third chapter*** assesses the trends and patterns in the solid waste management process of Ernakulam in particular with special reference to Central Pollution Control Board.

The ***fourth chapter*** has two sections and it is an attempt to analyze the potential of resource recovery from municipal solid waste in Ernakulam. It investigates the impact of resource recovery through family type biogas plants in the second section 1which is the target of the study.

Fifth chapter provides the empirical evidence relating to the socio-economic aspects of solid waste management particularly with reference to resource recovery.

Sixth chapter illustrates the perception of people living near the dumping sites. It also discusses the environmental aspects of dumping sites and its health impacts.

Seventh chapter provides the recommendations and suggestions based on the study for improvement in the treatment of work.

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Chapter - II

SOLID WASTE GENERATION

2.1 Introduction

After giving an introduction to the study, this chapter explains the process and the extend of the solid waste generation in the study area. The term waste refers to unwanted solid, liquid and gaseous substances produced by activities of man. The term solid waste is defined as materials that are solid and waste rather than recovered in one form or other, through processes like recycling, reuse, etc. The environmental degradation as a result of solid waste is one of the immediate concerns faced by the world today. The urbanization and industrialization processes are some of the main producers of solid waste. Increased economic activities and technological development have led to the generation of huge quantity of solid waste in urban areas (Trehan, 1992). The large quantity of waste and its toxic nature pose problems. An improper disposal method can trigger severe environmental pollution problems. The solid waste generation study is a scientific, social, economic and environmental issue, with its effects extending over environment, health property and other such factors. This problem essentially requires development of safe management practices that control the adverse effects caused by it. An effective management practice takes into consideration the type and quantity of solid waste generated by a particular region. The type of waste is defined on the basis of the activity that generates the waste. The quantity refers to the amount of waste generated by the activity. The generation pattern refers to type and quantity of waste produced by residential, industrial, commercial activities etc. The present chapter aims at detailed evaluation of activities generating waste and the pattern of solid waste in the study area, Ernakulam. This study is the framework towards development of safe management practice, which will control the hazards of solid waste pollution.

2.2 Solid waste generation – Indian cities

A very high rate of urban growth is a major reason for the increased solid waste generation. In India, the amount of waste generated per capita is estimated to increase at a rate of 1%–1.33% annually (Shekdar 1999). The generation of solid waste is directly related to consumption patterns. Within India, there is a large intercity variation as far as per capita waste generation is concerned. According to the Central Pollution Control Board (CPCB 1995), the daily per capita generation of solid waste in small, medium and large cities/towns is about 0.1 kg, 0.3-0.4 kg and 0.5 kg, respectively. Rural households tend to generate about 25 % less waste per capita than their urban counterparts (Rhyner et al., 1976). According to TIFAC (Technology Information Forecasting and Assessment Council), Delhi, Mumbai, and Calcutta would be generating 5000 tonnes of garbage every day. This is the case during the last decade. It takes anywhere between three to seven days for the waste to be disposed from the time of its generation. Thus problem of solid waste accumulation, ineffective management system and environmental degradation is acute in many of the Indian cities. In most of the Indian cities the infrastructure of solid waste management systems do not match with the generation rate and so these cities face serious problems connected with waste management system. As a result, uncleared waste along the road sides and open grounds become breeding centre of disease spreading vectors. The epidemic of plague in Surat in the year 1994 was an event that directed attention towards the problem and the need to control the health repercussions associated with waste disposal. The problem of solid waste management in Ernakulam is similar to other metropolitan cities of India.

2.3 Data Sources and Methodology

The approaches used to evaluate the generation pattern of solid waste in the city are as follows

- The information on quantity of waste generated by each ward has been collected from Corporation and municipalities of Ernakulam district. This is generated based on quantity of waste collected and transported on a day to day basis i.e. based on the number of trips made or on approximation by municipal agencies.
- The secondary data collected from the report of Kerala State Urban Development Programme have been used to study the quality of municipal solid waste in the study area.
- The ward map of Corporation and municipalities has been used to study the distribution of activities generating waste. The study identified only the waste generating activities based on the information provided in the map.
- Generation of solid waste by different activities in each ward has been assessed by using primary and secondary data from municipalities /Corporation and State Pollution Control Board. For example, the total waste in a municipality/Corporation included residential, commercial and institutional wastes. The generation rate evaluates the concentration of waste within a given ward defined by a particular activity. Higher the rate of waste generation, more acute is the pressure and concentration of waste in a given area.
- The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing ward boundaries and to enter the data about the wards and quantity of waste generated in each ward.

- The quantity and nature of industrial waste is analyzed using the information provided by the Kerala State Pollution Control Board. The Pollution Control Board classifies the industries into red, orange and green types. The red industries generate the most hazardous category of waste. The orange industries produce comparatively less hazardous type of waste and the green are the non hazardous waste generating industries.
- The waste generated by hospitals and medical centres are referred to as bio-medical waste. The data on bio-medical waste were collected from Kerala State Pollution Control Board.
- The bio-medical waste generation has been evaluated using the total number of hospitals, health centres and a few private hospitals in the city. The total bio-medical waste generated is estimated based on the assumption that the total number of beds in each hospital and health centres are occupied and generate waste.
- The information on physical and chemical characteristics of solid waste have been gathered from the report of Kerala Sate Urban Development Programme.

2.4 Activities generating solid waste in Ernakulam

The factor that contributes the major proportion of waste generation is population, population density, residential, commercial, industrial and institutional activities. The activities identified as the main waste producers are residential, industrial, commercial, institutional and bio medical institutions. Residential waste includes solid waste generated by population as well as waste generated through daily domestic and household activities. Industries through their production processes release certain amount of toxic and other solid wastes into the environment. Commercial and institutional activities also contribute to waste generation in the city. The bio medical waste is the solid waste generated by hospitals and other health institutions. The study about type and quantity of waste generated helps to understand the management system required for its safe and efficient disposal.

2.4.1 Population Distribution

The population of the city generates municipal solid waste. The estimation of quantity of residential waste generated by each municipality is based on the population distribution in each municipality and Corporation. The increase in waste generation rate is closely associated with the increase in population in the city. This is shown in table 2.4.1.

Table 2.4.1: Population of Ernakulam

Year	Population in Lakhs	Percentage of growth
1991	28.17	-
2001	31.05	10.22
2002	31.36	0.01
2003	31.66	0.01
2004	31.97	0.01
2005	32.29	0.01
2006	32.60	0.01
2007	32.92	0.01
2008	33.25	0.01
2009	33.57	0.01
2010	33.90	0.01
2011	34.23	0.01

(Source – Kerala State Statistics and Economics Department)

2.4.2 Density of population

Urban population density is the ratio of people per square km, gross or net. Density influences both policy and structural aspects in terms of ground and house congestion when there is shortage in urban land area within a given range of accessibility to the city centre. Planners recognize that the local living habits, standards and customs as well as the services available, have considerable bearing on urban population density (Jensen, 1966). The urban population density is the elements of urban form, the city size, age and structure which changes in relation to land use, employment structure and socio-economic status of dispersal within the city. This emphasizes the importance of centrality or maximum accessibility in land use structure and patterns. The population densities decline from the city centre, regardless of time and place. As Berry et al. (1963) stated that "The competition for urban sites by different land users and differences in their abilities to pay, result in bid-rent functions of varying gradients with the highest value at the location of maximum accessibility. Thus, larger spaces at prime locations of higher accessibility are occupied by those with higher paying abilities. The residential users, therefore, occupy smaller proportion of land near the centre and larger proportions away from it. Here again, more people want to live near the centre due to its higher accessibility. However, as the land near the centre is more expensive, they consume little of it. Since land availability and extensive use increase with distance from city centre, population densities also decline with the distance. The factors influencing density in the city core and density gradients are many and changing- the age, size of residential lots, landuse, centrality and central functions and transportation technology".

Accordingly, people with higher paying abilities living in city centre who generated more waste have higher accessibility for disposing waste. And clearance of waste by municipal services is better in city centre due to good infrastructure facilities when compared with other places which have narrow lanes with no infrastructure facilities. The higher the population density away from city centre to other areas the more acute is the problem of solid waste management. (See table 2.4.2)

Table 2.4.2: Population Density – Ernakulam

Sl.No	Name of Municipality	Total Population	Total area (sq.km.)	Density (Persons/sq.km)
1	Perumbavoor	26547	13.605	1951.26
2	Muvattupuzha	29246	13.183	2218.46
3	Kothamangalam	37173	13.01	2857.26
4	Paravur	30059	9.02	3332.48
5	Thrippunithura	59884	18.69	3204.06
6	Kalamassery	63116	27.00	2337.62
7	Aluva	24110	7.18	3357.93
8	Angamaly	33409	28.24	1183.03
9	Kochi	595575	94.88	6277.13

(Source – Kerala State Statistics and Economics Department)

The high density and high concentration of waste together constitute an acute problem of exposure to solid waste pollution and related health hazard.

2.5 waste generation activities

Waste is generated in all areas but there is large variation in its type and quantity. According to R. K. Garg., (2002), the quantity and nature of the waste generated vary with the activities and with the level of technological development in a country. "The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system." (E. Tinmaz & I. Demir., 2005). Nowadays municipalities and Corporations are affected with inadequate management systems. Better management systems for waste not only requires of waste generation but also requires information regarding variation in each ward.

Systematic analysis helps to chalk out appropriate remedies for the solid waste management. GIS could help in dealing with several factors simultaneously which need to be considered while planning waste management. “GIS is a system of computer hardware and software, designed to allow users to collect, manage, analyze and retrieve large volume of spatially referenced data and associated attribute data collected from a variety of sources.”(S. Upasna & M. S. Natwat., 2003). The results arrived with GIS identified areas which generate more or a different category of waste. Also there is a general categorization in the waste generation which helps to analyze waste generation trends. These trends are useful while planning waste management.

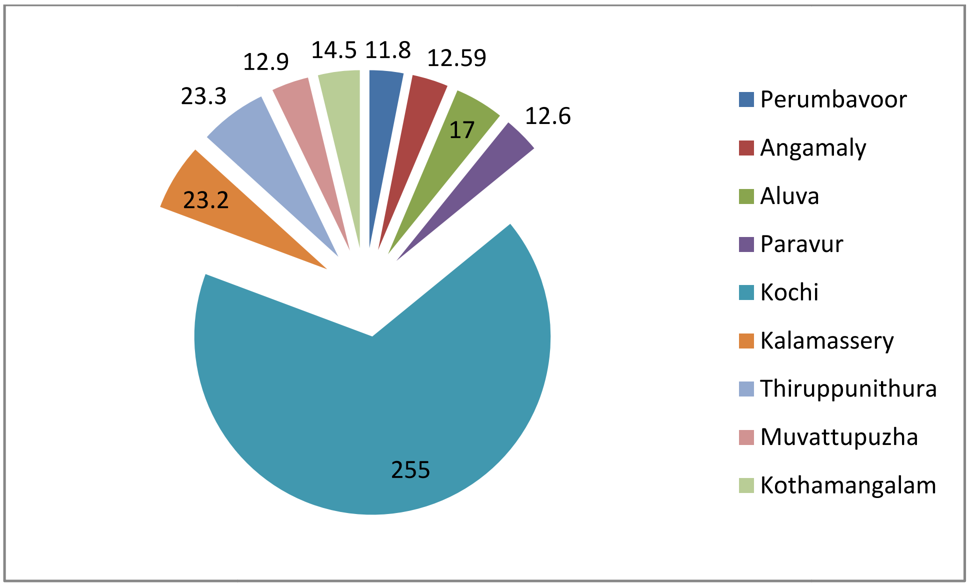
The generating pattern of solid waste in each municipality depends on activities generating waste. The generation rate for each ward is based on clearance of waste by local body. Total waste generated in Ernakulam is presented in Table 2.5 and is represented diagrammatically in fig. 2.5.

Table 2.5: Solid waste generation in Ernakulam

Name of Municipality/Corporation	Waste Generation in Tonnes
Perumbavoor	11.8
Angamaly	12.59
Aluva	17.0
Paravur	12.60
Kochi	255.0
Kalamassery	23.2
Thiruppunithura	23.3
Muvattupuzha	12.9
Kothamangalam	14.5
Total	382.89

Source: The Corporation and Municipalities

Fig 2.5
Waste Generation in Tonnes



The present study highlights the generation of solid waste through various activities in each municipality. The distribution of various activities in each ward generating municipal solid waste is shown in Appendices 1,2,3,4,5,6,7,8 and 9. The map provided by municipalities/Corporation has been used for the present study. The map identified the following waste generating sources.

- Household
- Household and Commercial
- Commercial
- Market and Commercial

2.5.1 Distribution of waste generation activities

The waste generation pattern of activities shows the following results

- Generation of waste through household activities

The household activities generate lot of organic kitchen waste, paper and polythenes. The quantity of residential waste generated in each ward is estimated based on population distribution in each ward. The increase in waste is very closely associated with increase in population in the municipality or the city and their socio-economic factors.

The quantum of waste generated in different wards within the Cochin Corporation is as follows. Vaduthala, Gandhi Nagar, Perumanoor, Island south, Puttardesham, Nambiapuram, Konam, Manasheri and *Moolamkuzhi* generated greater around 1.0 – 2.0 tonnes of waste per day. Kunnumpuram, Ponekkara, *Puthukkalavattam*, Elamakkara North, *Thattazham*, Island North, Thevara, Edakochi, *Thazhuppu* and *Katebhagam* wards generate less than 1.0 tonne of waste per day. See in fig. 2.5.1(a). The wards, viz; Kalladu, Valiyapara, Maramangalam, *Kuthukuzhi*, *Kumbathumuri*, *Karukadom*, *Puthupad*y karaikunnam,*Venduvazhy Pottakkal*, Kothamangalam south, Ramalloor and *Karingazha* within Kothamangalam municipality generated as much as 0.2 - 0.3 tonnes of waste per day while *Valadithandu* generated only less than 0.2 tonnes per day. (See in fig. 2.5.1(b)). The wards, viz; *Central Vazhappilly*, Vyavasaya Park, Janasakthy, Sangamam, Murikkally, *Nellimala*, Housing Board Colony, Petta, *Kallungalkkudy*, East High School, *Randarkara*, *Perumattom*, M.I.E.T School and *Molekkudy* falling in Muvattupuzha municipality generated wastes between 0.15 to 0.25 tonnes per day. But *Kizhakkekara* and *Pandarimala* wards in the same municipality produced only less than 0.15 tonnes per day. See fig. 2.5.1(c). *Ayyampillykavu*, *Marankulangara*, Vadakkaymoothi, Mathoor, Nannappilly, *Thamarakulangara*, Pottayil, *Elumana*, *kizhekkavameethi*, *Nakathuruth*, *Chathari*, *Chakkiyattukulangara*, *Ambalam*, *Panakkal*, *Vellakkanakkal*, *Vallivathara*, *Thammandi*, *Puthiyakavy* and Mekara wards of Thrippunithura municipality generated 0.2 - 0.4 tonnes of waste per day. Thondoor and *Puthenkulangara* wards of the same municipality generated waste less than

0.2 tonnes per day. See fig. 2.5.1(d). Likewise, *Vallam* North, *Palaya Vallam* Road, Rayon, Kaduval, *Marudhu kavala*, Masjid, Sasthamangalam, *Karattupalli*, *Kanjarakad*, Ashram, *Kothankudi* and *kunnanpillydara* wards in Perumbavoor municipality generated 0.20 - 0.25 tonnes of waste per day and Neelam kulangara generated less than 0.2 tonnes of waste per day. (See fig. 2.5.1(d). *Kannan Kulangara*, *Pallamthuruth,* Sandi Nagar, *Pallithalam, Vaniyakad, Vazhi Kulangara, Kizhakkeprem*, Kesari and *Thonniyakavu* wards of Paravur municipality generated between 0.25 - 0.3 tonnes of waste per day, *Mattummel Neendoor, Thaivep, Kannanchirra*, *Nanthyattu Kunnu*, *Peruvaram Kizhakkilprem and Nandikulangara* wards generated less than 0.25 tonnes of waste per day. (See fig. 2.5.1(e). *Mangalapuzha* Semetry, Mana, St.John's Church, *Thirukunnuthu, Snehalayam, Oomer Kuzhithadam* and Matharasa wards in Aluva municipality generated between 0.25 - 0.35 tonnes of waste per day. In Manapuram and Power House wards under the same municipality produced less than 0.25 tonnes per day represented in fig. 2.5.1(f). *Chakkar Parambu, Pechanicadu, Mangatukara*, Champannur, Mythiri, Nassrath, Deepthi, *Nayathode,* Mini industrial and Vengur Road wards in Angamaly municipality the waste generation rate is 0.20 – 0.25 tonnes per day. But waste generation rate is less than 0.20 tonnes per day in Jose puram, JBS, *Kavaraparambu, Chethikode* and Airport wards in the same municipality. (See fig. 2.5.1(g). Sundaragiri, Santhi Nagar Annexe, Toll gate, Hill valley, *Puthuppallipuram,* Library, *Kannamkulam*, University, Saint Joseph, *Punnakkattu, Moolepadam, Vadakodu, kangarapady*, Mini Townhall, *Vauanakkodu, Thevakkal*, Medical college, HMT estate, *Kuroopra*, *Peringazha*, Rockwell and *Vidakuzha* wards of Kalamassery municipality generated between 0.2 0 – 0.40 tonnes of waste per day. But Pipe line ward in the same municipality generated less than 0.20 tonnes of waste per day. See fig. 2.5.1(h).

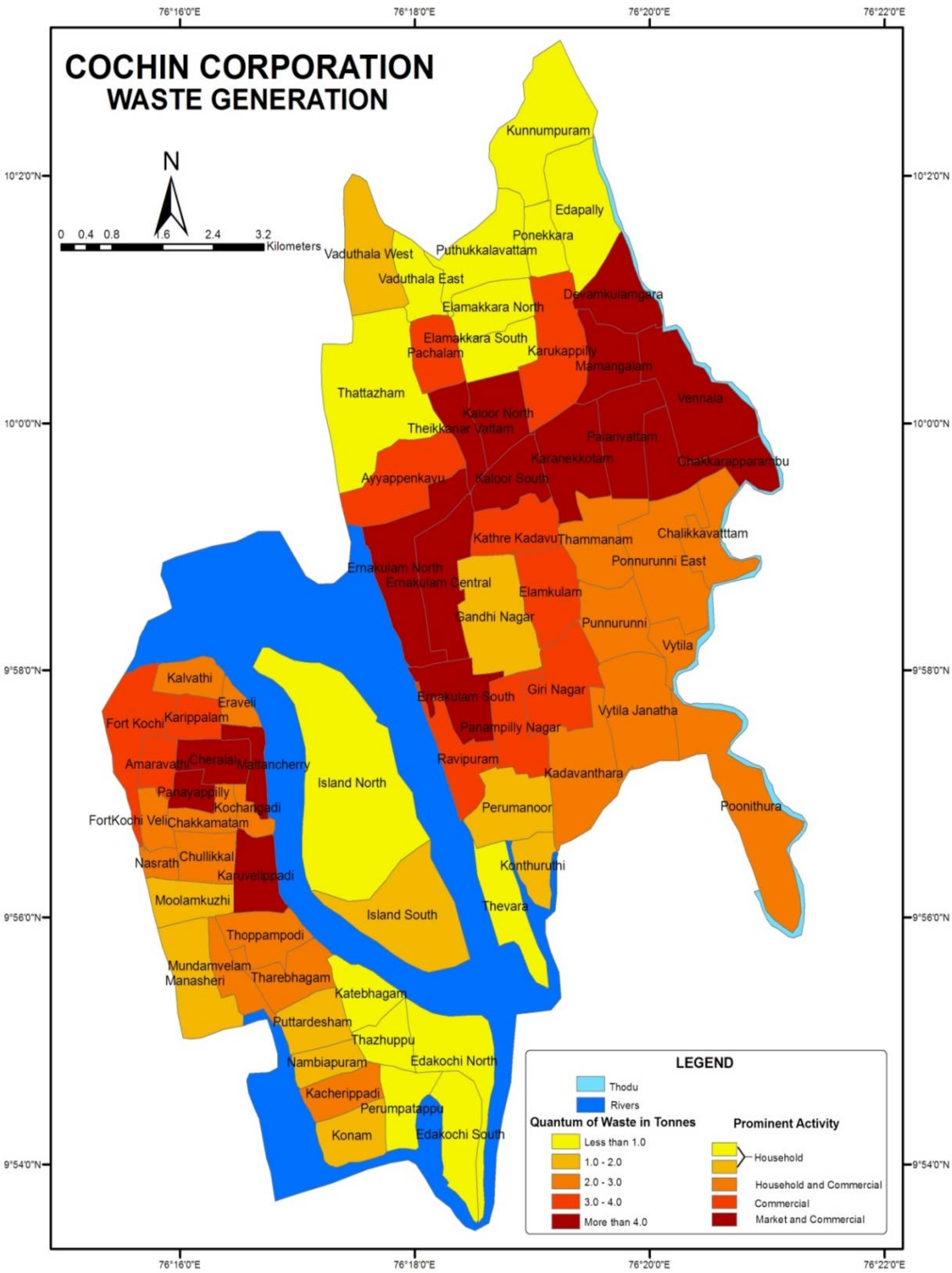

COCHIN CORPORATION
WASTE GENERATION
N
0 0.4 0.8 1.6 2.4 3.2 Kilometers
76°16'0"E
76°18'0"E
76°20'0"E
76°22'0"E
10°2'0"N
10°0'0"N
9°58'0"N
9°56'0"N
9°54'0"N
Kunnumpuram
Edapally
Ponekkara
Vaduthala West
Puthukkalavattam
Vaduthala East
Devamkulamgara
Elamakkara North
Elamakkara South
Pachalam
Karukappilly
Mamangalam
Thattazham
Vennala
Kaloor North
Theikkanar Vattam
Palarivattam
Karanekkotam
Chakkaraparambu
Ayyappenkavu
Kaloor South
Kathre Kadavu
Thammanam
Chalikkavatttam
Ponnurunni East
Ernakulam North
Ernakulam Central
Elamkulam
Gandhi Nagar
Punnurunni
Vytila
Kalvathi
Eraveli
Fort Kochi
Karippalam
Ernakulam South
Giri Nagar
Vytila Janatha
Panampilly Nagar
Amaravathi
Cheralai
Mattancherry
Ravipuram
Island North
Kadavanthara
Panayappilly
Kochangadi
Perumanoor
Poonithura
FortKochi Veli
Chakkamatam
Nasrath
Chullikkal
Konthuruthi
Karuvelippadi
Moolamkuzhi
Thevara
Island South
Thoppampodi
Mundamvelam
Manasheri
Tharebhagam
Katebhagam
Puttardesham
Thazhuppu
Nambiapuram
Edakochi North
Kacherippadi
Perumpatappu
Konam
Edakochi South
LEGEND
Thodu
Rivers
Quantum of Waste in Tonnes
Less than 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
More than 4.0
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial

Fig. 2.5.1(a)

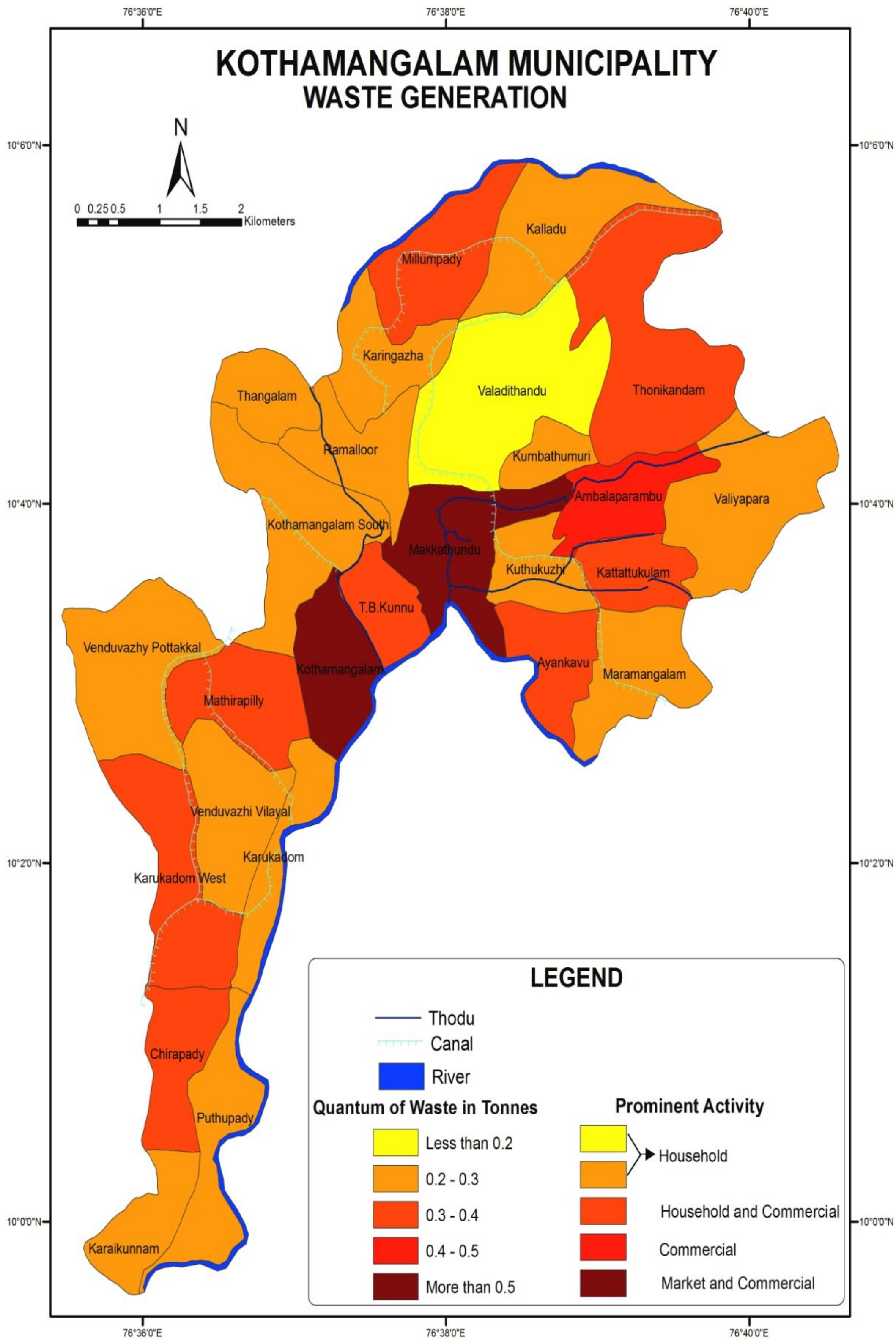

KOTHAMANGALAM MUNICIPALITY
WASTE GENERATION
N
0 0.25 0.5 1 1.5 2 Kilometers
76°36'0"E
76°38'0"E
76°40'0"E
10°6'0"N
10°4'0"N
10°2'0"N
10°0'0"N
Kalladu
Millumpady
Karingazha
Valadithandu
Thonikandam
Thangalam
Ramalloor
Kumbathumuri
Ambalaparambu
Valiyapara
Kothamangalam South
Makkathundu
Kuthukuzhi
Kattattukulam
T.B.Kunnu
Venduvazhy Pottakkal
Kothamangalam
Ayankavu
Maramangalam
Mathirapilly
Venduvazhi Vilayal
Karukadom
Karukadom West
Chirapady
Puthupady
Karaikunnam
LEGEND
Thodu
Canal
River
Quantum of Waste in Tonnes
Less than 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
More than 0.5
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial

Fig. 2.5.1(b)

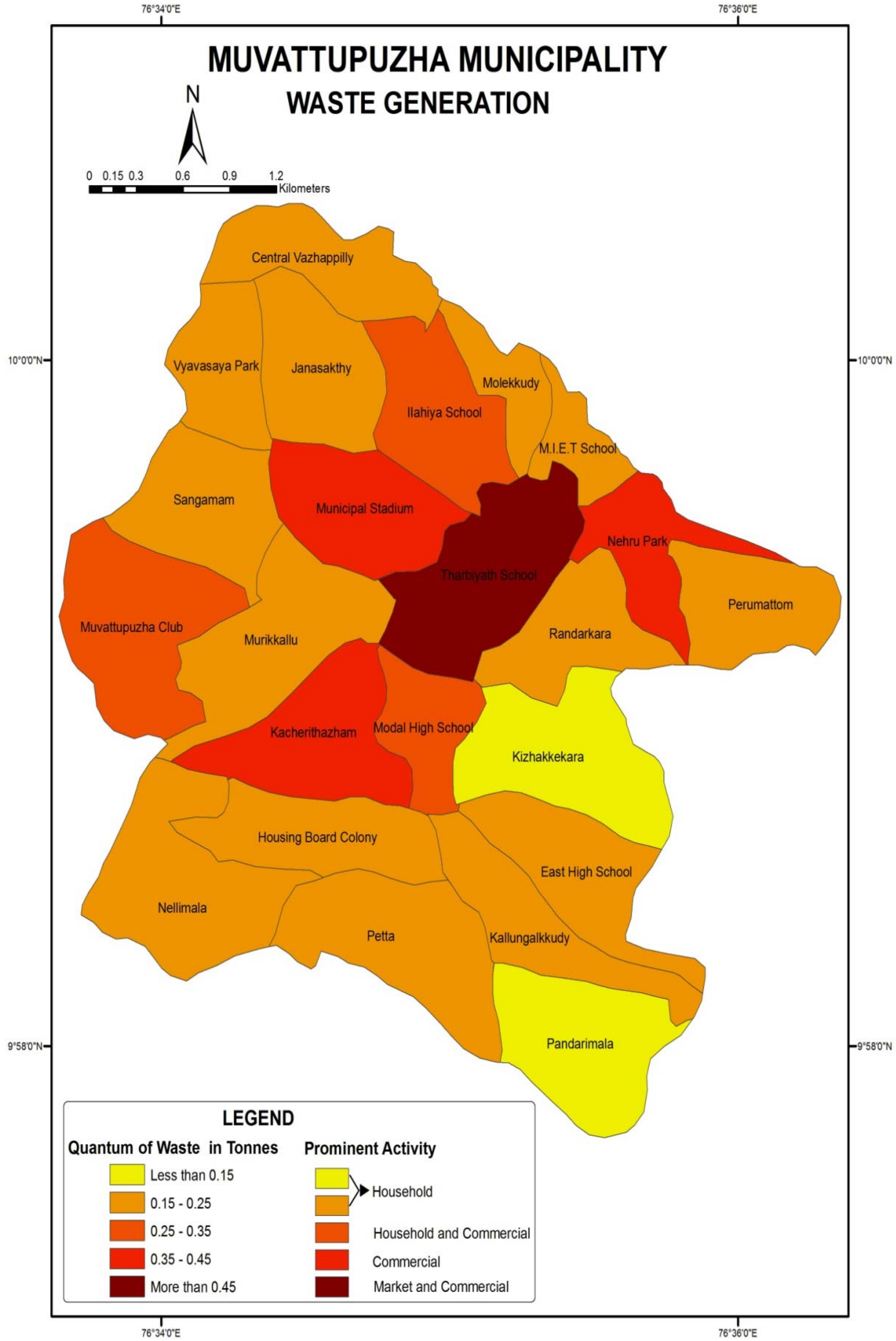

76°34'0"E
76°36'0"E
MUVATTUPUZHA MUNICIPALITY
WASTE GENERATION
N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
10°0'0"N
9°58'0"N
Central Vazhappilly
Vyavasaya Park
Janasakthy
Molekkudy
Ilahiya School
M.I.E.T School
Sangamam
Municipal Stadium
Nehru Park
Tharbiyath School
Perumattom
Muvattupuzha Club
Murikkallu
Randarkara
Kacherithazham
Modal High School
Kizhakkekara
Housing Board Colony
East High School
Nellimala
Petta
Kallungalkkudy
Pandarimala
LEGEND
Quantum of Waste in Tonnes
Less than 0.15
0.15 - 0.25
0.25 - 0.35
0.35 - 0.45
More than 0.45
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial

Fig. 2.5.1(c)

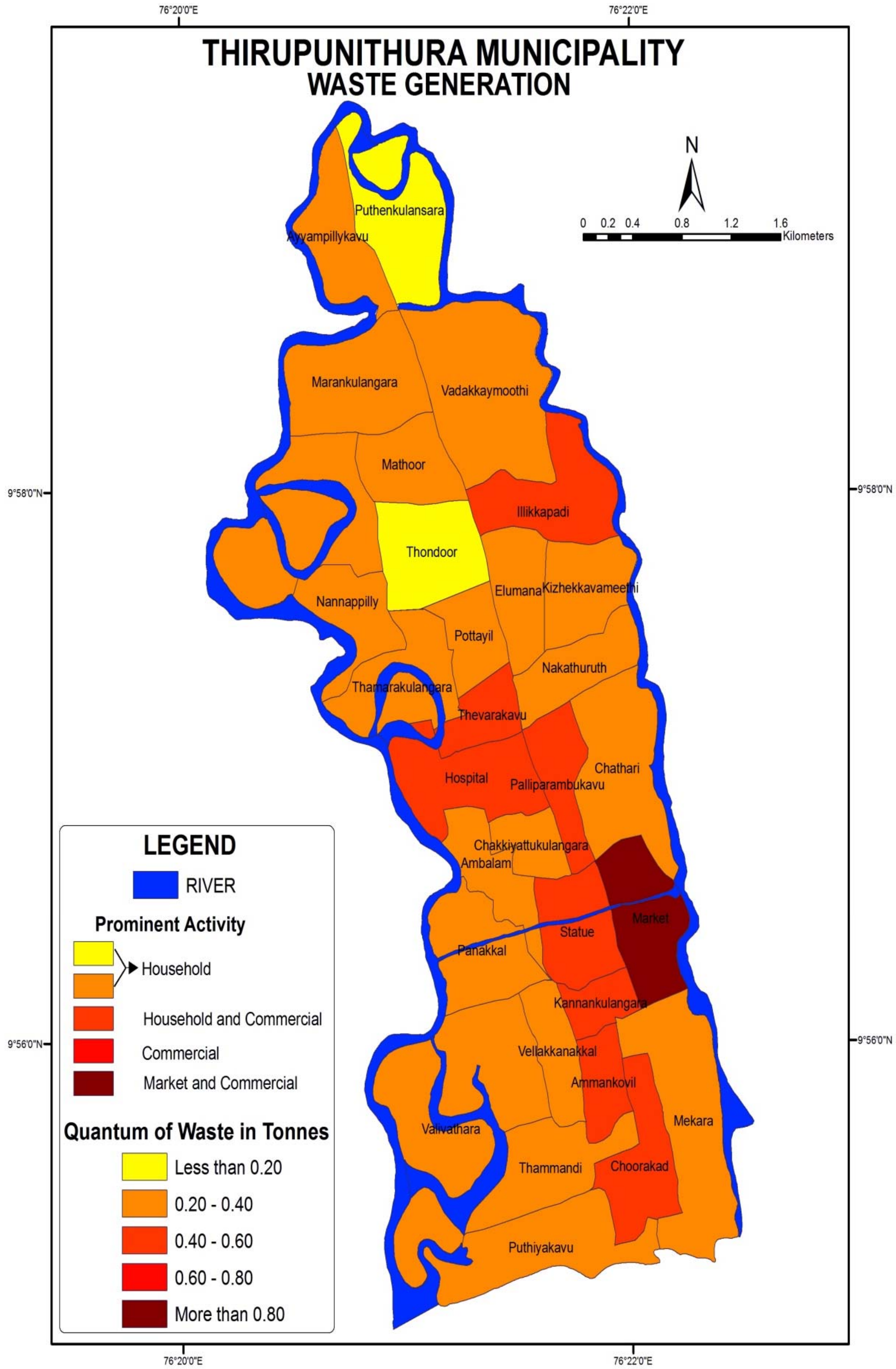

76°20'0"E
76°22'0"E
THIRUPUNITHURA MUNICIPALITY
WASTE GENERATION
N
0 0.2 0.4 0.8 1.2 1.6
Kilometers
Puthenkulansara
Ayyampillykavu
Marankulangara
Vadakkaymoothi
Mathoor
Illikkapadi
Thondoor
Elumana
Kizhekkavameethi
Nannappilly
Pottayil
Nakathuruth
Thamarakulangara
Thevarakavu
Hospital
Palliparambukavu
Chathari
Chakkiyattukulangara
Ambalam
Market
Statue
Panakkal
Kannankulangara
Vellakkanakkal
Ammankovil
Mekara
Valivathara
Thammandi
Choorakad
Puthiyakavu
9°58'0"N
9°56'0"N
LEGEND
RIVER
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
Quantum of Waste in Tonnes
Less than 0.20
0.20 - 0.40
0.40 - 0.60
0.60 - 0.80
More than 0.80

Fig. 2.5.1(d)

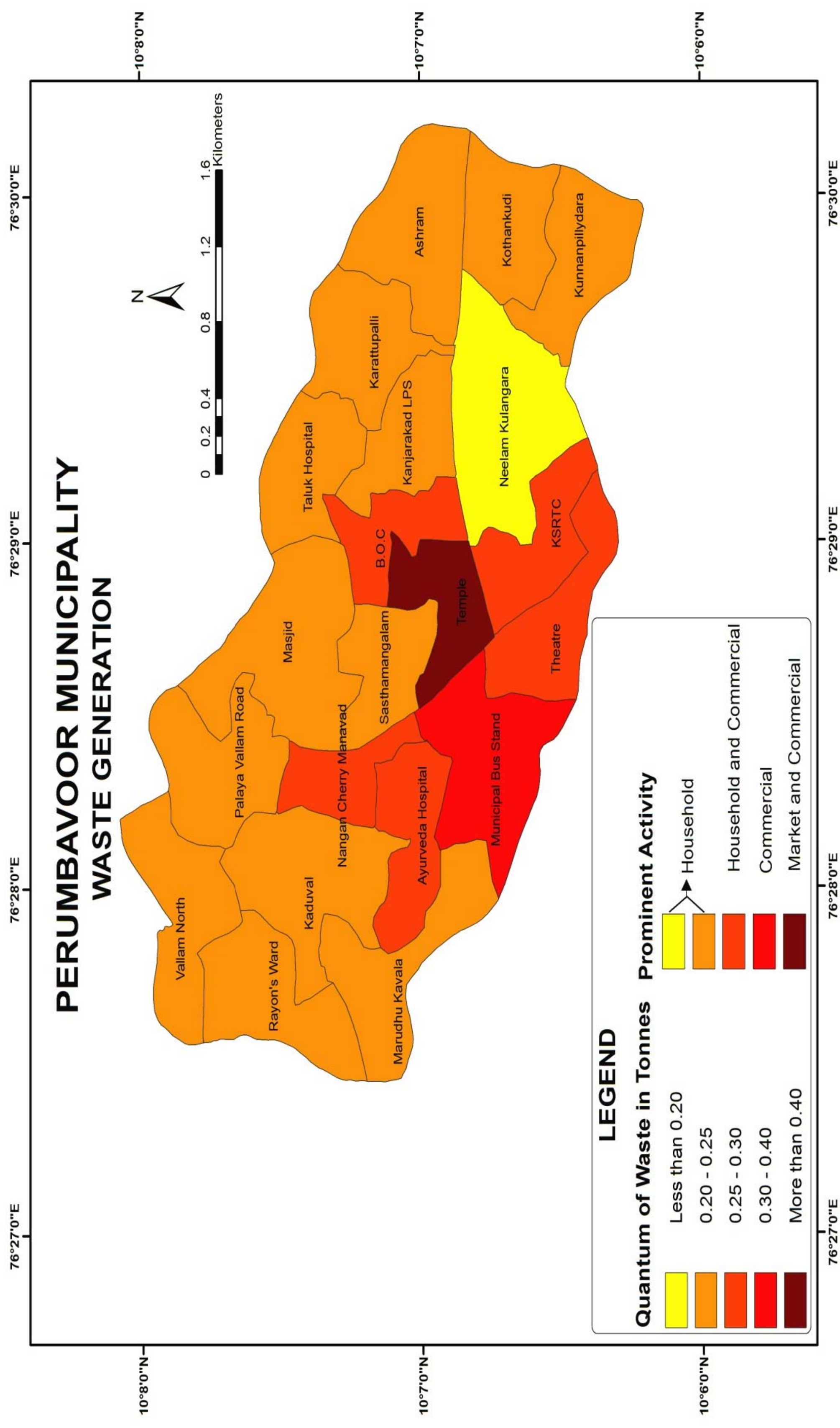

PERUMBAVOOR MUNICIPALITY
WASTE GENERATION
N
0 0.2 0.4 0.8 1.2 1.6 Kilometers
Vallam North
Rayon's Ward
Kaduval
Marudhu Kavala
Palaya Vallam Road
Nangan Cherry Manavad
Ayurveda Hospital
Masjid
Sasthamangalam
Municipal Bus Stand
Temple
B.O.C
Theatre
KSRTC
Taluk Hospital
Kanjarakad LPS
Neelam Kulangara
Karattupalli
Ashram
Kothankudi
Kunnanpillydara
LEGEND
Quantum of Waste in Tonnes
Less than 0.20
0.20 - 0.25
0.25 - 0.30
0.30 - 0.40
More than 0.40
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
76°27'0"E
76°28'0"E
76°29'0"E
76°30'0"E
10°8'0"N
10°7'0"N
10°6'0"N

Fig. 2.5.1(e)

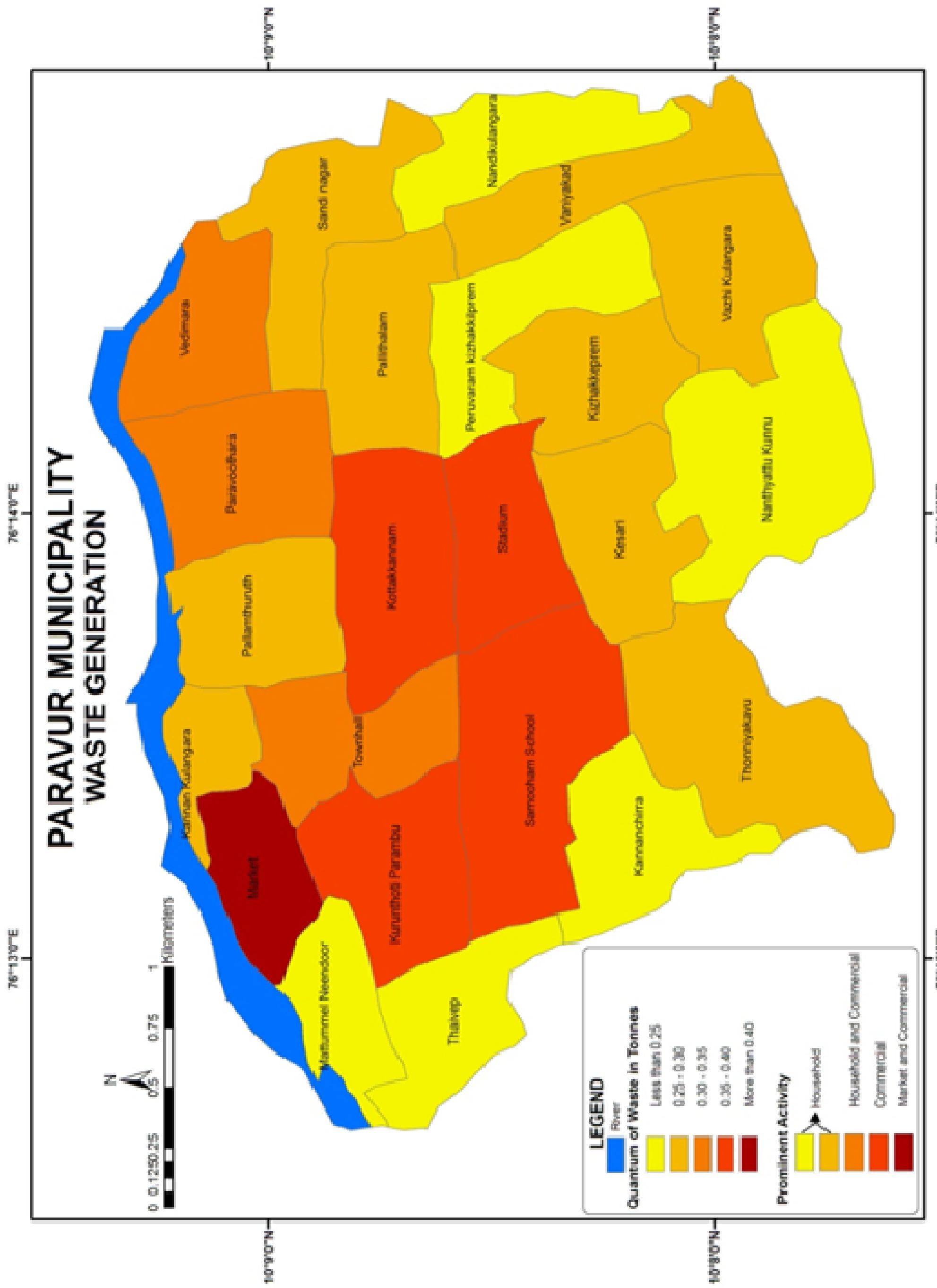

PARAVUR MUNICIPALITY
WASTE GENERATION
LEGEND
River
Quantum of Waste in Tonnes
Less than 0.25
0.25 - 0.30
0.30 - 0.35
0.35 - 0.40
More than 0.40
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
Kilometers
N
Vedimara
Sandi nagar
Nandikulangara
Vaniyakad
Vachi Kulangara
Pallithalam
Peruvaram kizhakkeprem
Kizhakkeprem
Paravoothara
Kottakkavanam
Stadium
Kesari
Nanthyattu Kunnu
Pallamthuruth
Townhall
Samooham School
Thonniyakavu
Kannan Kulangara
Market
Kuruntholi Parambu
Kannanchira
Mattummel Neendoor
Thalayi

Fig. 2.5.1(f)

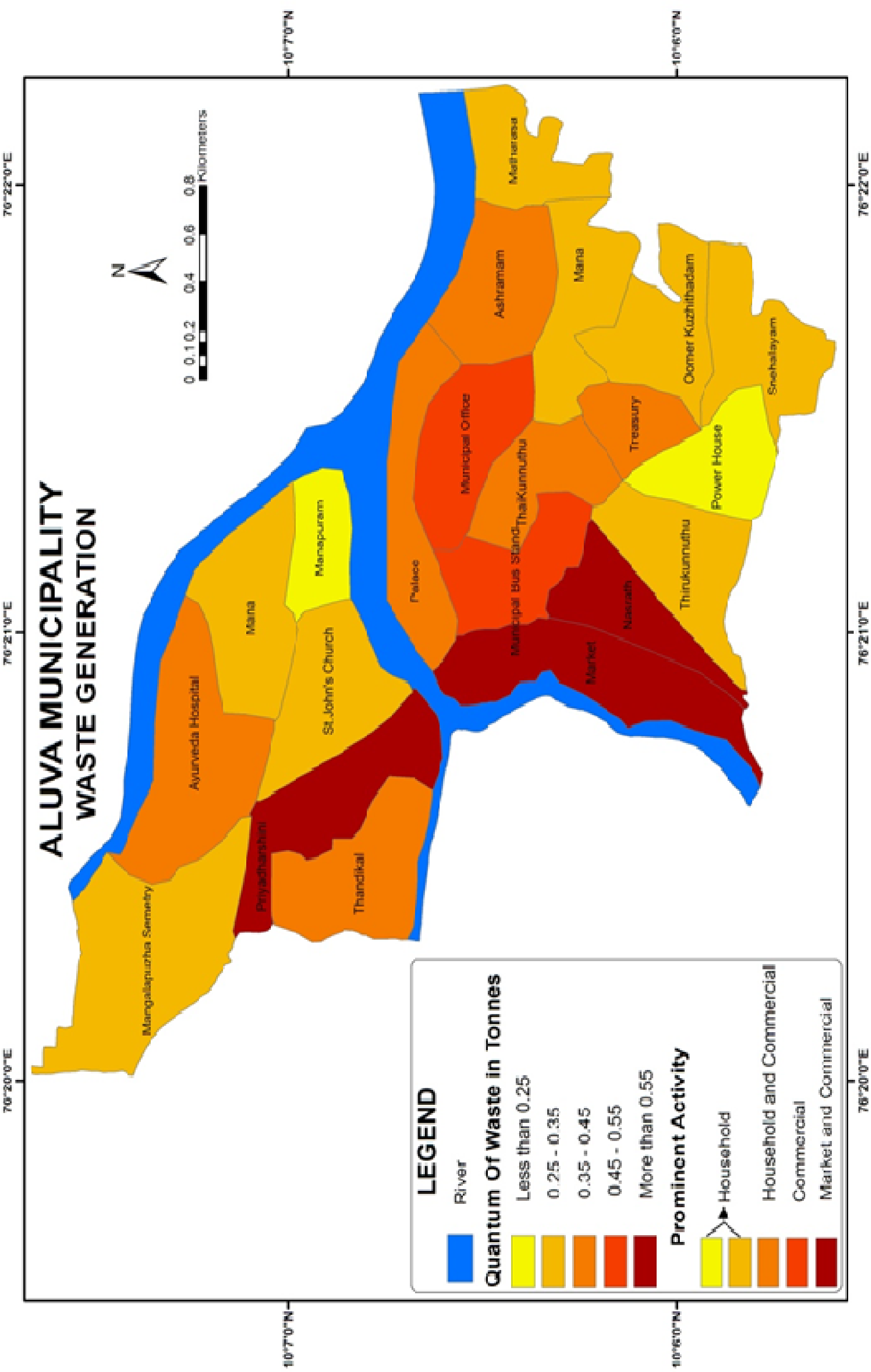

ALUVA MUNICIPALITY
WASTE GENERATION
LEGEND
River
Quantum Of Waste in Tonnes
Less than 0.25
0.25 - 0.35
0.35 - 0.45
0.45 - 0.55
More than 0.55
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
0 0.1 0.2 0.4 0.6 0.8 Kilometers
N
Mangalapuzha Semetry
Ayurveda Hospital
Mana
Manapuram
St.John's Church
Priyadharshini
Thandikal
Palace
Municipal Office
Municipal Bus Stand
ThaiKunnuthu
Market
Nasrath
Thirukunnuthu
Power House
Treasury
Ashramam
Mana
Matharasa
Oomer Kuzhithadam
Snehallayam
76°20'0"E
76°21'0"E
76°22'0"E
10°7'0"N
10°6'0"N

Fig. 2.5.1(g)

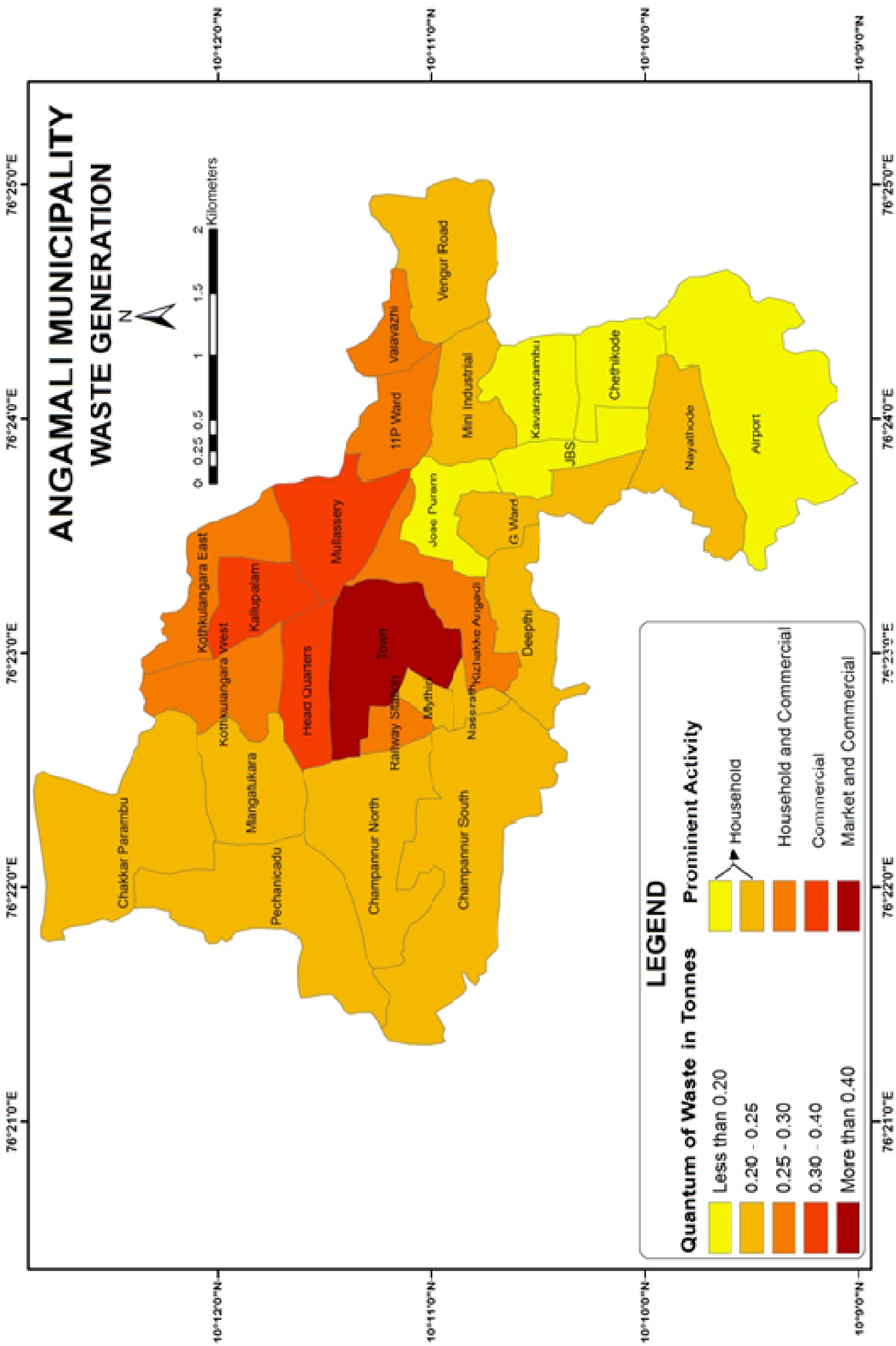

ANGAMALI MUNICIPALITY
WASTE GENERATION
N
0 0.25 0.5 1 1.5 2 Kilometers
Chakkar Parambu
Pechanicadu
Mangatukara
Kothkulangara West
Kothkulangara East
Kallupalam
Head Quarters
Mullassery
Town
Railway Station
Mythri
Champannur North
Champannur South
Nassrath
Kizhakke Angadi
Deepthi
G Ward
Jose Puram
11P Ward
Valavazhi
Vengur Road
Mini Industrial
Kavaraparambu
JBS
Chethikode
Nayathode
Airport
LEGEND
Quantum of Waste in Tonnes
Less than 0.20
0.20 - 0.25
0.25 - 0.30
0.30 - 0.40
More than 0.40
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
76°21'0"E
76°22'0"E
76°23'0"E
76°24'0"E
76°25'0"E
10°9'0"N
10°10'0"N
10°11'0"N
10°12'0"N

Fig. 2.5.1(h)

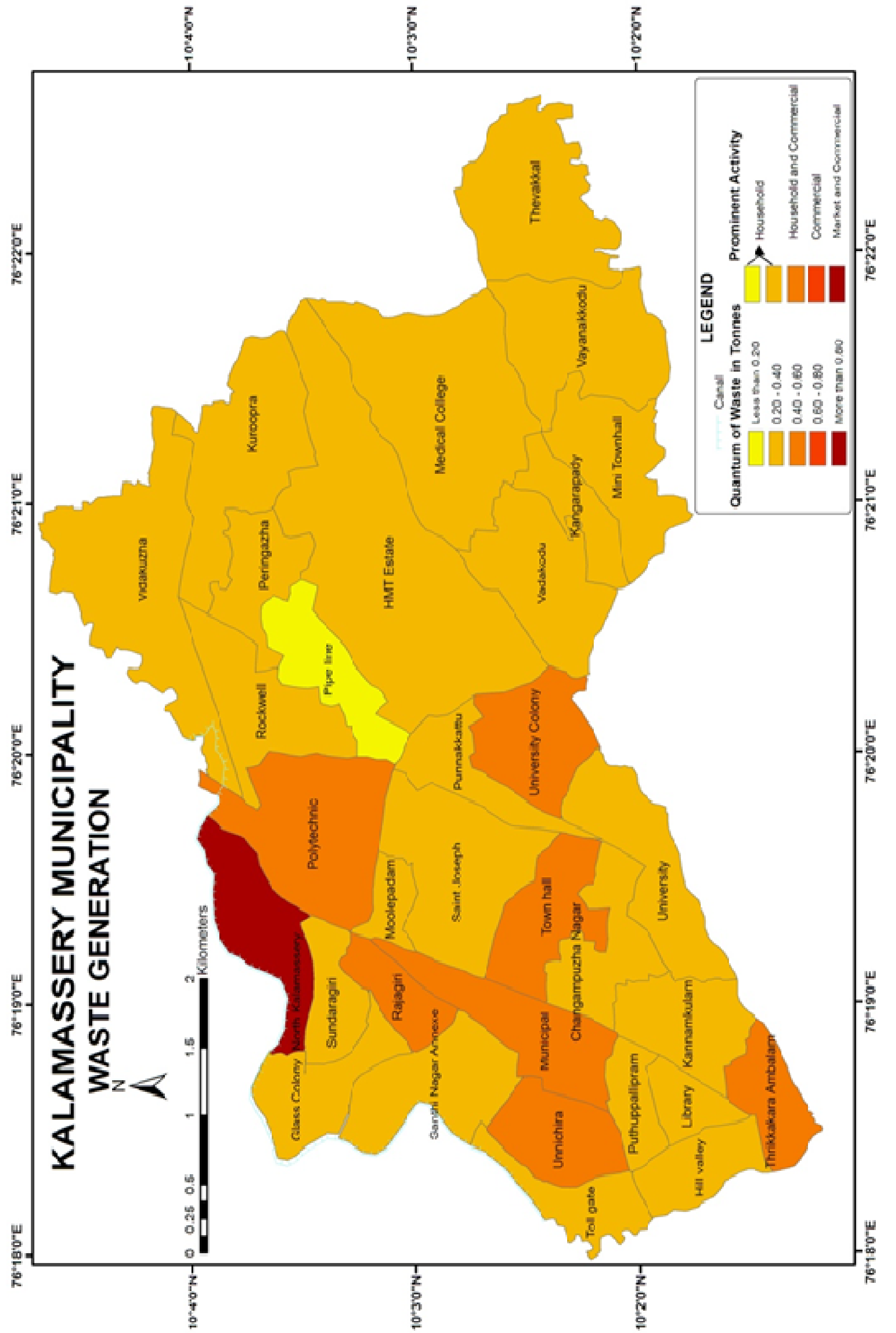

KALAMASSERY MUNICIPALITY
WASTE GENERATION
N
Kilometers
0 0.25 0.5 1 1.5 2
LEGEND
Canal
Quantum of Waste in Tonnes
Less than 0.20
0.20 - 0.40
0.40 - 0.60
0.60 - 0.80
More than 0.80
Prominent Activity
Household
Household and Commercial
Commercial
Market and Commercial
Vidakuzha
Kuroopra
Peringazha
Rockwell
Pipe line
HMT Estate
Medical College
Thevakkal
Vayanakkodu
Kangarapady
Mini Townhall
Vadakodu
University Colony
Punnakkattu
Polytechnic
North Kalamassery
Sundaragiri
Glass Colony
Mookepadam
Saint Joseph
Town hall
Changampuzha Nagar
University
Rajagiri
Santhi Nagar Annexe
Municipal
Kannamkulam
Puthuppallipram
Library
Unnichira
Thrikkakara Ambalam
Hill valley
Toll gate
76°18'0"E
76°19'0"E
76°20'0"E
76°21'0"E
76°22'0"E
10°4'0"N
10°3'0"N
10°2'0"N

Fig. 2.5.1(i)

The problems related to solid waste generation and its disposal are acutely felt along the narrow lanes where slums are located. Lack of essential infrastructure for solid waste clearance in these regions is the main cause of the problem. In the absence of solid waste clearance infrastructure, waste reaches the open ground, roadsides and water ways. The slums are one of the important contributors to surface water pollution in city. The issue of night soil is also a contribution of slum dwellers as they do not have the essential infrastructure within the residential region. The waste generation of household activity relationship states that higher the generation rate more acute is the problem related to solid waste in the concerned ward.

- **Generation of waste through commercial activities**

The commercial activities in city consist of wholesale and retail markets catering to the consumption needs of population. The waste generated by this activity is referred to as commercial waste. The category of mixed activities in map has been grouped under commercial sector for the study purpose. The mixed activities include commercial, industrial institutional and residential sectors. Waste generated by commercial establishments, such as shops, restaurants and offices are collected together with household waste. The wastes generated from shops and commercial establishments are mainly recyclable in nature.

Due to the nature of their operations, restaurants typically generate solid wastes such as paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes and hazardous wastes. Some restaurants in the study area can decrease their waste through recycling and waste reduction programs as shown in Appendix-10.

Institutional waste is the waste generated by schools, leisure facilities, hospitals (excluding clinical waste), etc. This is often included within the commercial waste category. A comparison of wastes generated in rural and urban areas shown no significant differences in the composition of the commercial waste generated. However, the quantity of commercial waste is as comparatively high in densely populated urban areas.

Elamakkara South, Devamkulangara, Ayyappen *kavu*, Kathre *kadavu*, *Elamkulam*, Giri Nagar, Ravipuram, Amaravathi, Fort Kochi and *Karippalam* wards of Cochin Corporation generated 3.0 – 4.0 tonnes of waste per day. Market cum commercial activities are prominent in Mamangalam, Vennala, *Palarivattom*, Chakkara *parambu*, *Karanekotam*, *Kaloor*, Ernakulam North, Ernakulam central, Ernakulam south, *Panampilly nagar*, *Karuvelipady*, *Kochangadi* and Mattancherry wards and they generated more than 4.0 tonnes of waste per day (See in fig. 2.5.1(j). *Ambalaparambu* ward of Kothamangalam municipality generated 0.4 - 0.5 tonnes of waste per day as commercial activities are prominent here. Market cum commercial activities are prominent in Makkathundu and Kothamangalam wards and they generated more than 0.5 tonnes of waste per day. (See fig.2.5.1(k)). In Municipal stadium, Nehru Park and *Kacherithazham* wards of Muvattupuzha municipality generated 0.35 – 0.45 tonnes of waste per day from commercial activities. Market cum commercial activities are prominent in *Tharbiyath* school ward and so generated more than 0.45 tonnes of waste per day. (See in fig.2.5.1(l)). There is no prominent commercial activity in Thirupunithura municipality. Market cum commercial activities are prominent in market ward. It generated more than 0.80 tonnes of waste per day. (See fig. 2.5.1(m)). The municipal bus stand ward in Perumbavoor municipality generated 0.30 – 0.40 tonnes of waste per day from commercial activities. Market cum commercial activities are prominent in Temple ward. So it generated more than 0.40 tonnes of waste per day. (See fig. 2.5.1(n)). *Kurunthoti Parambu*, Samooham School, Stadium and *kottakkannam* wards of Paravur municipality generated 0.35 – 0.40 tonnes of waste per day from commercial activities. Market cum commercial activities are prominent in

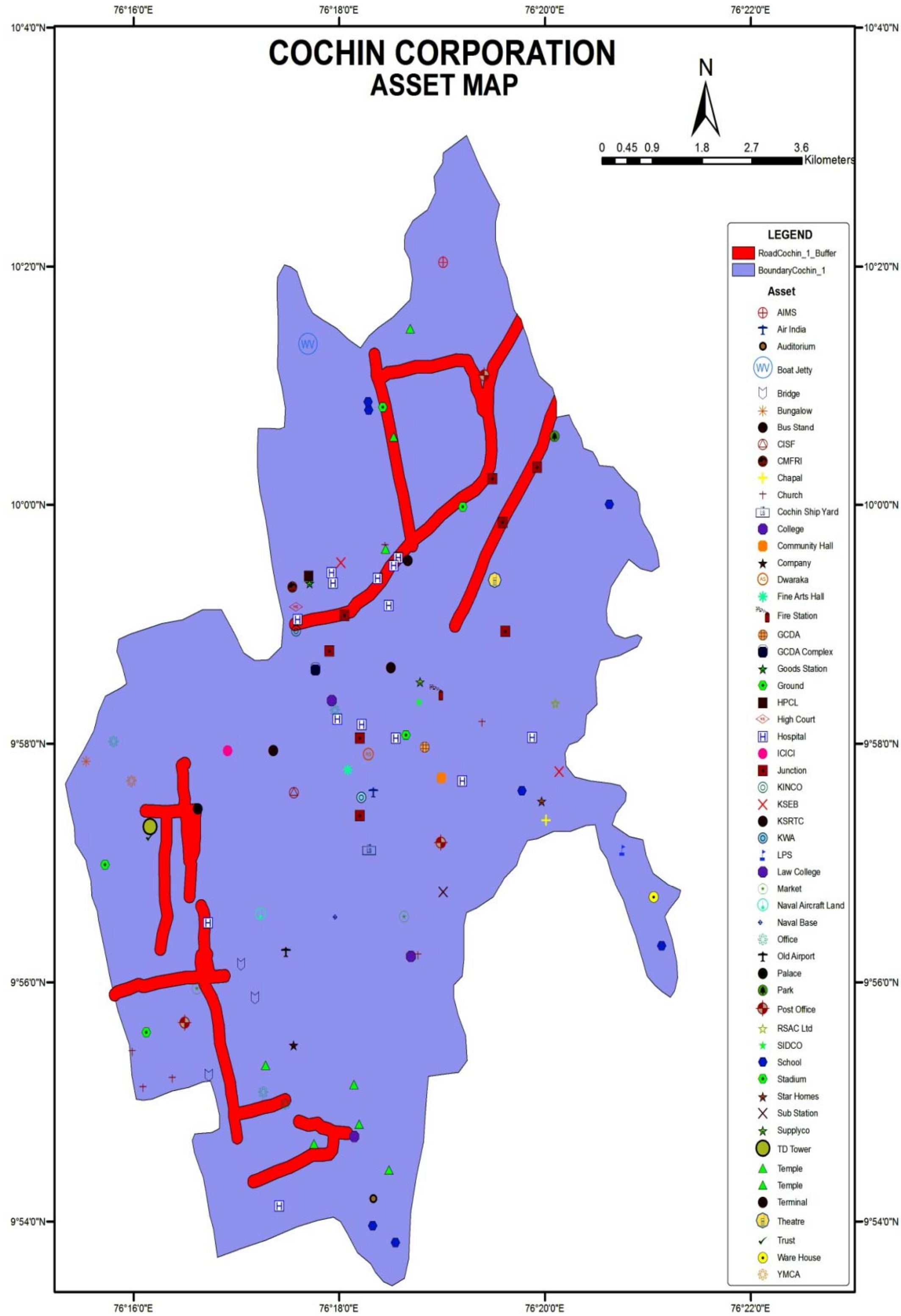
Market ward. It generated more than 0.40 tonnes of waste per day. (See fig. 2.5.1(o)). The municipal office and municipal bus stand wards in Aluva municipality generated 0.45 – 0.55 tonnes of waste per day from commercial activities. Market cum commercial activities are prominent in Priyadharshini, Market and Nasrath wards and so they generated more than 0.55 tonnes of waste per day. (See fig. 2.5.1(p)). *Kallupalam*, Head quarters and *Mullassery* wards of Angamaly municipality generated 0.3 – 0.4 tonnes of waste per day from commercial activities. Market cum commercial activities are prominent in Town ward and so it generated more than 0.40 tonnes of waste per day (See fig. 2.5.1(q)). Market cum commercial activities are prominent in North Kalamassery ward and they generated more than 0.80 tonnes of waste per day. (See fig.2.5.1(r))

- **Generation of waste through household and commercial activities**

Waste generated through households and commercial activities are discussed here. *Thammanam, Chalikkavattam, Ponnurunni* east, Vytila, Kadavanthara, *Kacherippadi, Tharebhagam, Thoppampodi, Chullikkal, Chakkamattam, Panayapilly, Eraveli and Kalvathi* wards of Cochin Corporation have high concentration of activities generated 2.0 – 3.0 tonnes of waste per day. In Kothamangalam municipality, household cum commercial activities are prominent in *Millumpady, Thonikandam, Kattattukulam, Ayankavu, T.B.Kunnu, Mathirapilly, Chirapady* and *Karukadom* west wards. They generated 0.30 – 0.40 tonnes of waste per day. The household cum commercial activities are prominent in Ilahiya school, Model high school and Muvattupuzha club wards of Muvattupuzha municipality generated 0.25 – 0.35 tonnes of waste per day. *Illikkapadi, Thevarakavu*, Hospital, *Palliparambukavu*, Statue, Kannankulangara, *Ammankovil* and Choorakad wards of Thirupunithura municipality generated 0.40 – 0.60 tonnes of waste per day from both household and commercial activities. *Nangan Cherry Manavad*, Ayurveda Hospital, Theatre, KSRTC and B.O.C wards of Perumbavoor municipality generated 0.25 – 0.30 tonnes of waste per day from household and commercial activities. The Townhall, *Paravoothara* and Vedimara wards in Paravur municipality generated 0.30 – 0.35 tonnes of waste per day from household and commercial activities. Ayurveda Hospital, Thandikal, Palace, Ashramam, *Thaikunnuthu* and Treasury wards of Aluva municipality generated 0.35 – 0.45 tonnes of waste per day from household cum commercial activities. The wards of *Kothkulangara*, Railway station, *Kizhakke Angadi*, 11 P and *Valavazhi* in Angamaly municipality generated 0.25 – 0.30 tonnes of waste per day from household and commercial activities. Household and commercial activities are prominent in Polytechnic, Rajagiri, *Unnichira*, Municipal, Townhall, University colony and Thrikkakara *Ambalam* wards of Kalamassery municipality generated 0.40 – 0.60 tonnes of waste per day.

- **Generation of waste through market and commercial activities**

Market and commercial activities generated more than 4 tonnes per day in the respective wards of Cochin Corporation and more than 0.5 tonnes per day per ward in the municipalities. The vegetable shops/markets generate large quantities of degradable waste including dried plantain leaves used for wrapping agricultural goods. Waste from markets in Cochin Corporation is removed for scientific treatment. Vegetable wastes from market in Paravur municipality are used for composting. The entire commercial and market wastes are collected and segregated in the processing yard to produce compost in Muvattupuzha municipality.



COCHIN CORPORATION
ASSET MAP
N
0 0.45 0.9 1.8 2.7 3.6
Kilometers
76°16'0"E
76°18'0"E
76°20'0"E
76°22'0"E
10°4'0"N
10°2'0"N
10°0'0"N
9°58'0"N
9°56'0"N
9°54'0"N
LEGEND
RoadCochin_1_Buffer
BoundaryCochin_1
Asset
AIMS
Air India
Auditorium
Boat Jetty
Bridge
Bungalow
Bus Stand
CISF
CMFRI
Chapal
Church
Cochin Ship Yard
College
Community Hall
Company
Dwaraka
Fine Arts Hall
Fire Station
GCDA
GCDA Complex
Goods Station
Ground
HPCL
High Court
Hospital
ICICI
Junction
KINCO
KSEB
KSRTC
KWA
LPS
Law College
Market
Naval Aircraft Land
Naval Base
Office
Old Airport
Palace
Park
Post Office
RSAC Ltd
SIDCO
School
Stadium
Star Homes
Sub Station
Supplyco
TD Tower
Temple
Temple
Terminal
Theatre
Trust
Ware House
YMCA

Fig. 2.5.1(j)

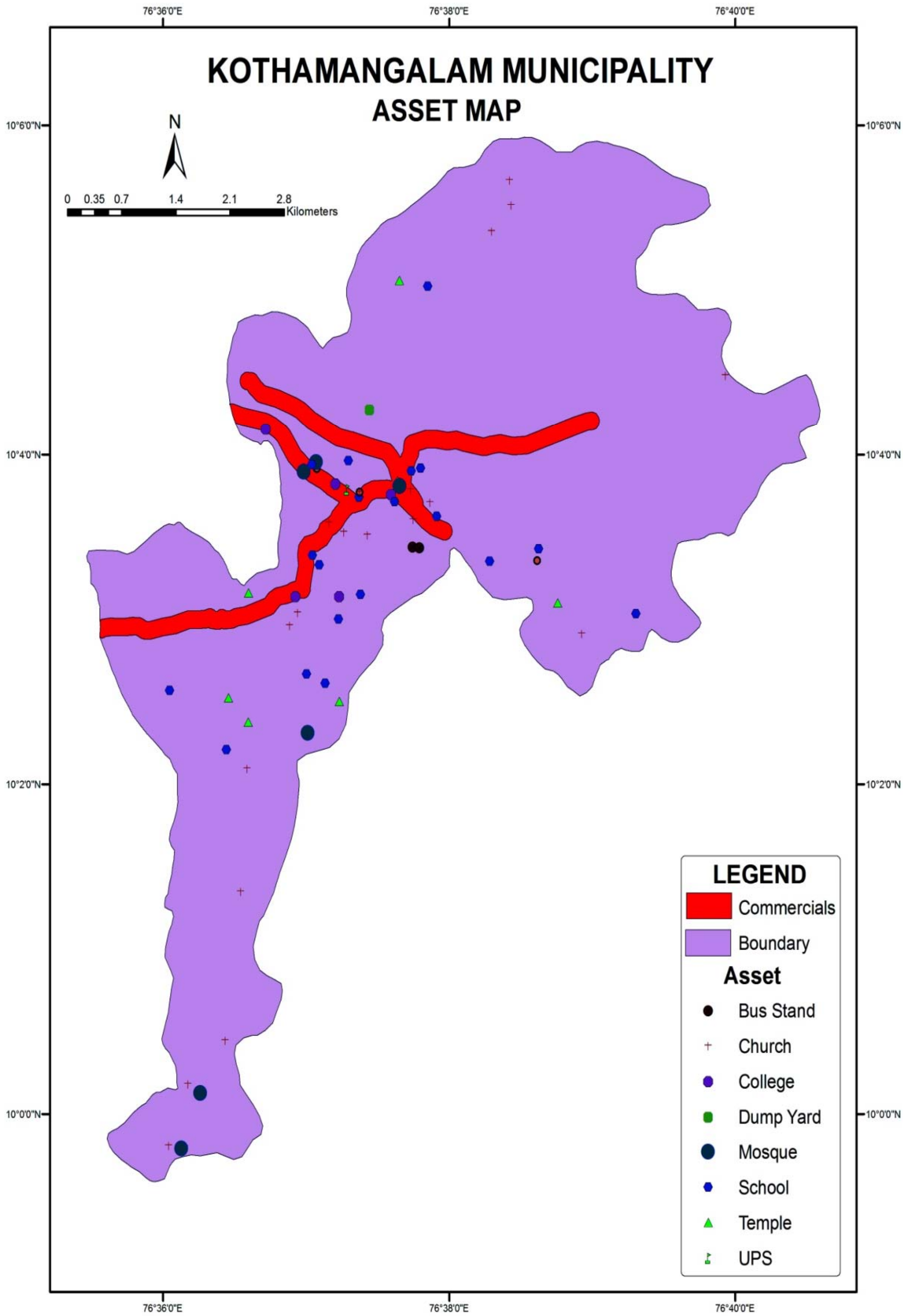

KOTHAMANGALAM MUNICIPALITY
ASSET MAP
N
0 0.35 0.7 1.4 2.1 2.8
Kilometers
76°36'0"E
76°38'0"E
76°40'0"E
10°6'0"N
10°4'0"N
10°2'0"N
10°0'0"N
LEGEND
Commercials
Boundary
Asset
Bus Stand
Church
College
Dump Yard
Mosque
School
Temple
UPS

Fig. 2.5.1(k)

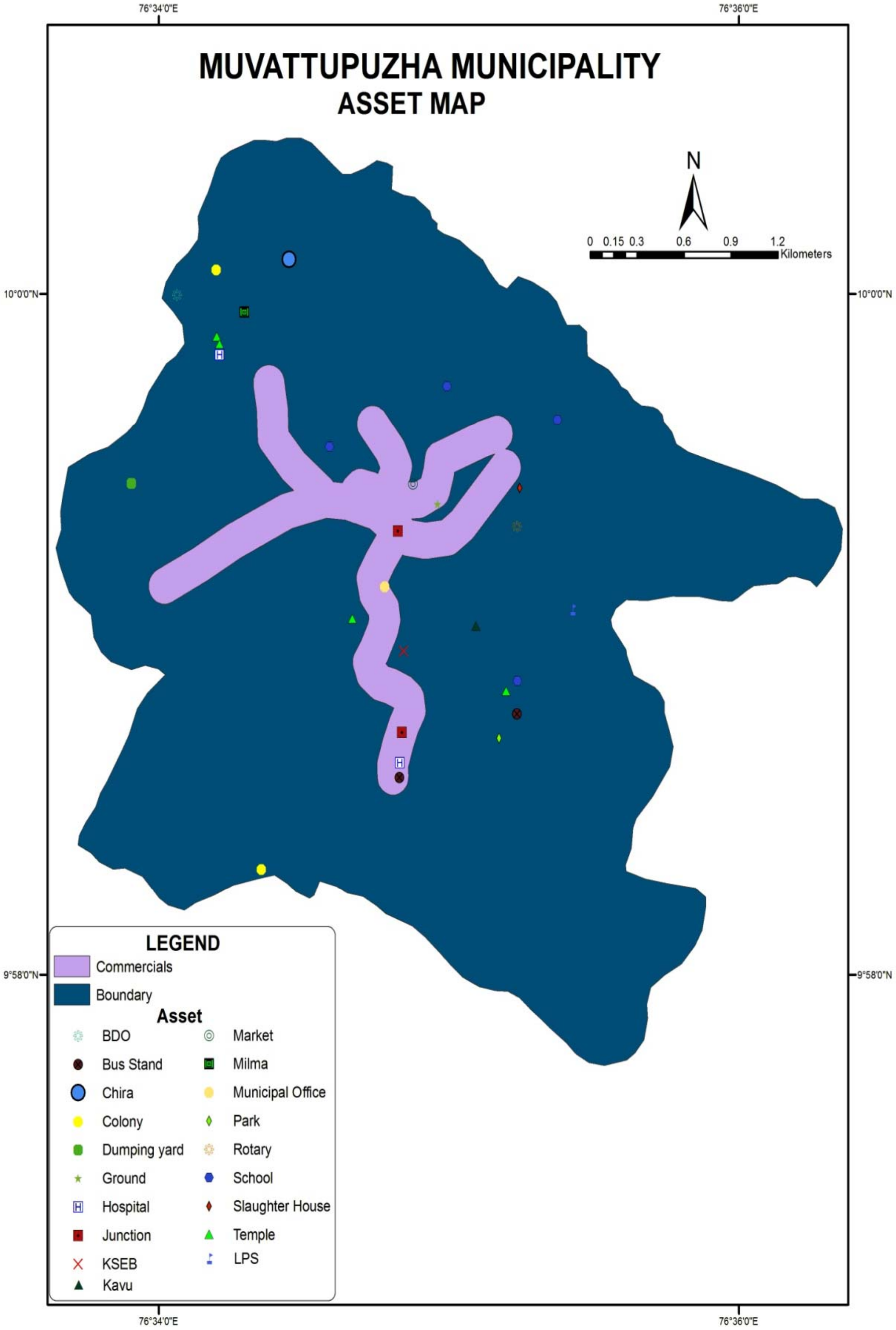

76°34'0"E
76°36'0"E
MUVATTUPUZHA MUNICIPALITY
ASSET MAP
N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
10°0'0"N
9°58'0"N
LEGEND
Commercials
Boundary
Asset
BDO
Bus Stand
Chira
Colony
Dumping yard
Ground
Hospital
Junction
KSEB
Kavu
Market
Milma
Municipal Office
Park
Rotary
School
Slaughter House
Temple
LPS

Fig. 2.5.1(l)

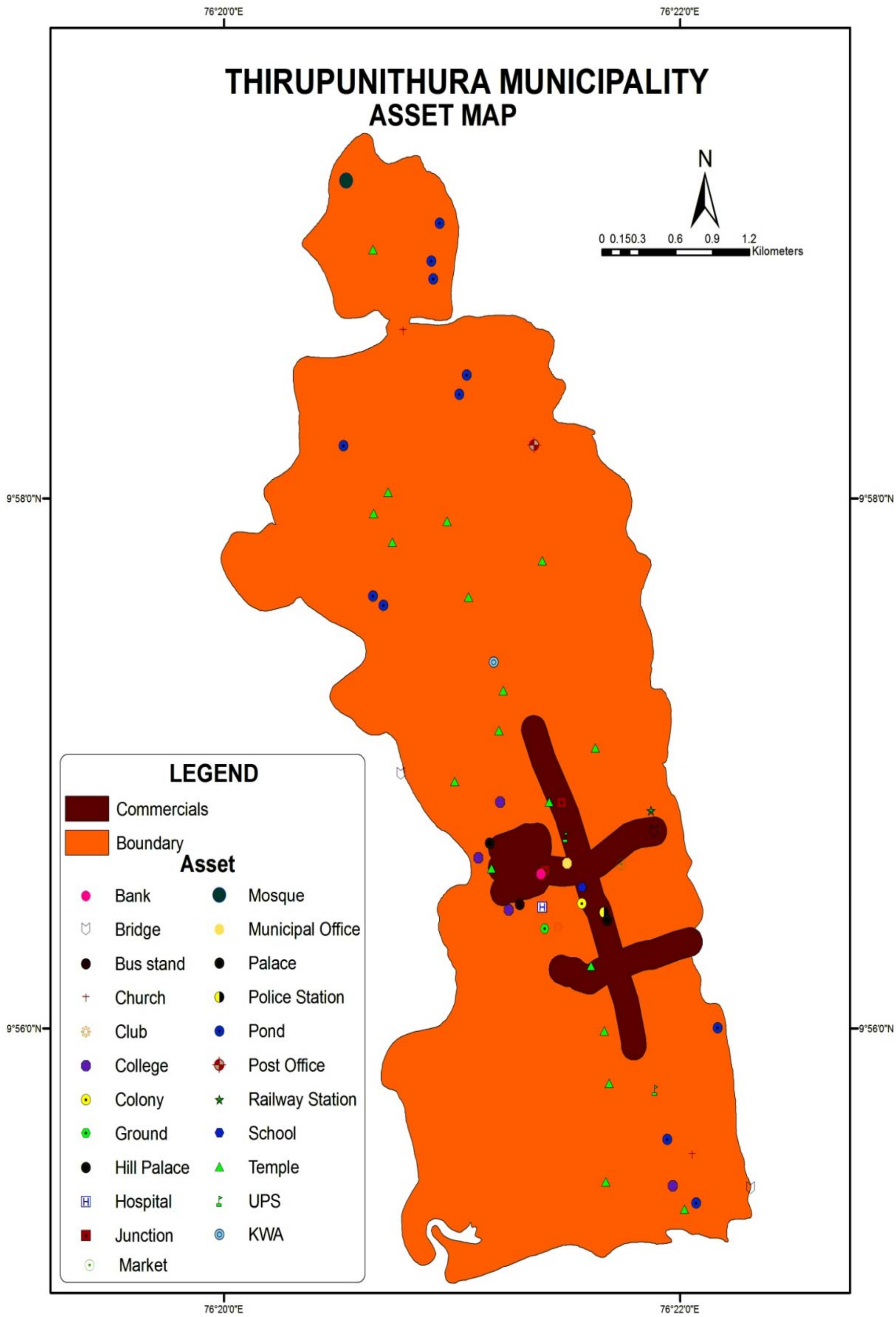

76°20'0"E
76°22'0"E
THIRUPUNITHURA MUNICIPALITY
ASSET MAP
N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
9°58'0"N
9°56'0"N
LEGEND
Commercials
Boundary
Asset
Bank
Bridge
Bus stand
Church
Club
College
Colony
Ground
Hill Palace
Hospital
Junction
Market
Mosque
Municipal Office
Palace
Police Station
Pond
Post Office
Railway Station
School
Temple
UPS
KWA

Fig. 2.5.1(m)

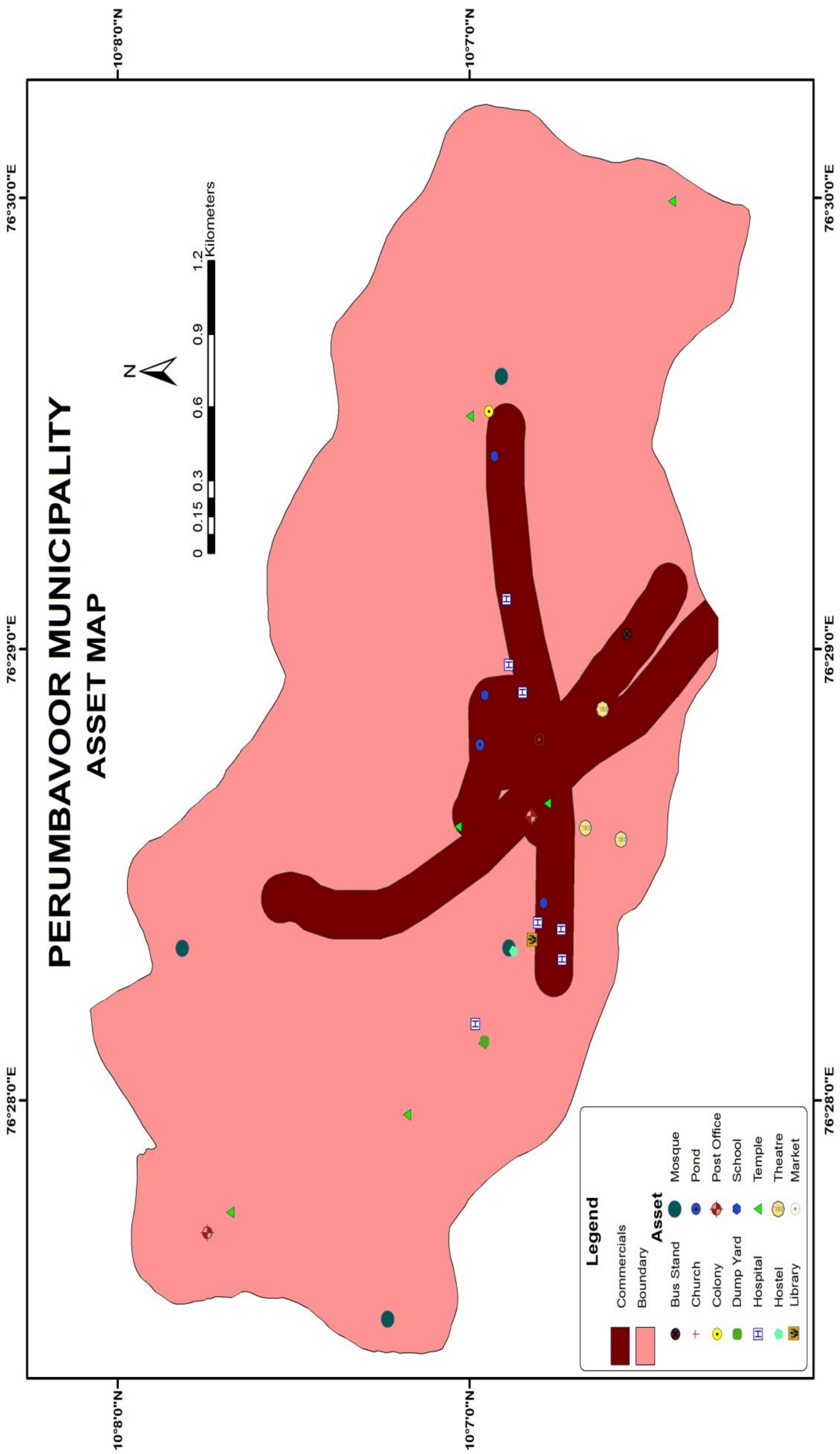

PERUMBAVOOR MUNICIPALITY
ASSET MAP
N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
76°28'0"E
76°29'0"E
76°30'0"E
10°8'0"N
10°7'0"N
Legend
Commercials
Boundary
Asset
Bus Stand
Church
Colony
Dump Yard
Hospital
Hostel
Library
Mosque
Pond
Post Office
School
Temple
Theatre
Market

Fig. 2.5.1(n)


PARAVUR MUNICIPALITY
ASSET MAP
Kilometers
0 0.1250.25 0.5 0.75 1
N
76°13'0"E
76°14'0"E
76°15'0"E
10°9'0"N
10°8'0"N
LEGEND
Commercials
Boundary
Asset
Anganwadi
Bank
Bridge
Bus Stand
Church
College
Colony
Dumping ground
Fire Station
Fish Market
Health Centre
Hospital
Junction
Kuzham
LPS
Library
Mosque
Municipal Office
Office
Orphanage
Park
Police Quarters
Police Station
Post Office
SNDP
School
Telephone Exchange
Temple
Theatre
UPS
Vidyalayam
Water Tank
Market

Fig. 2.5.1(o)

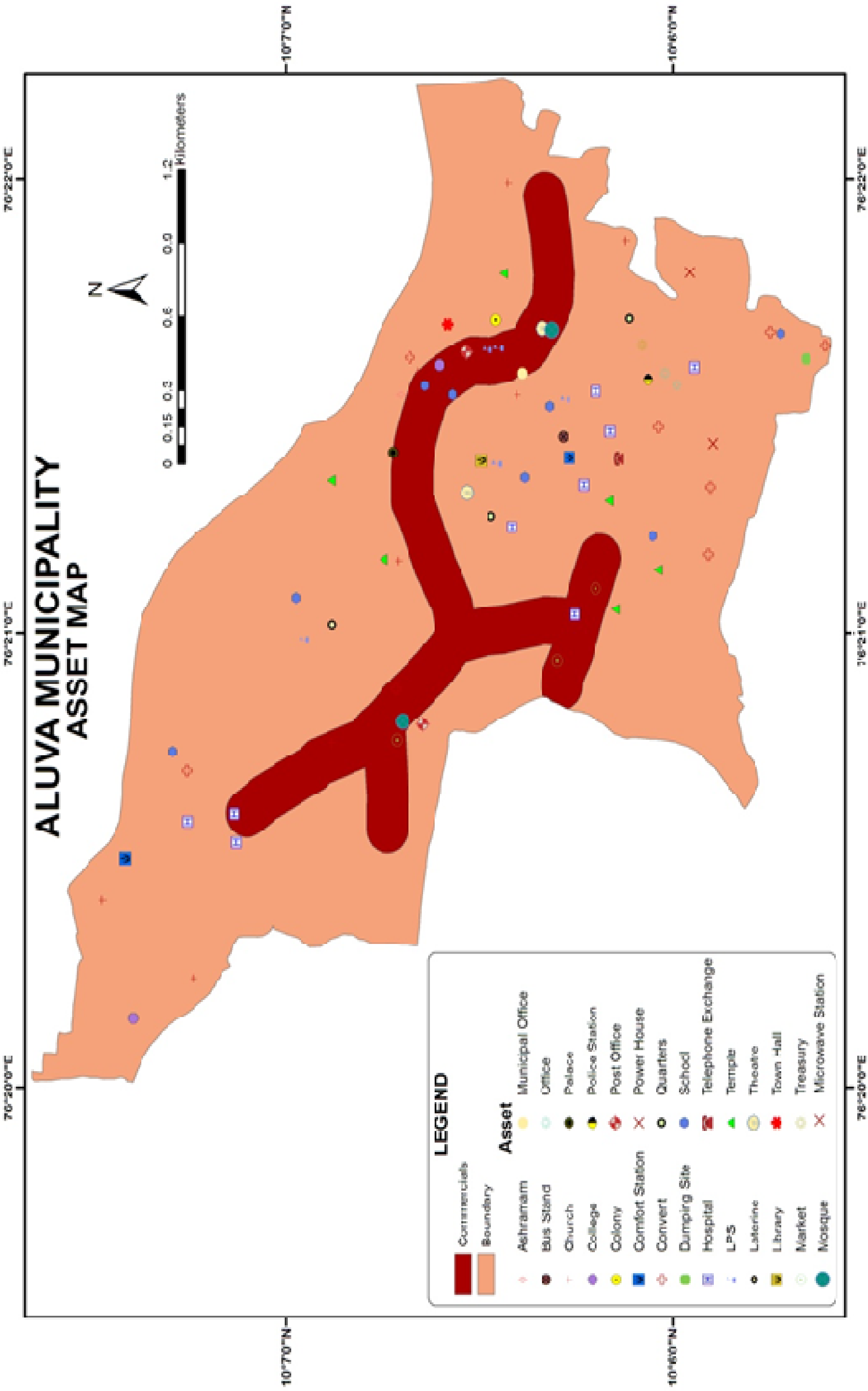

ALUVA MUNICIPALITY
ASSET MAP
N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
76°22'0"E
76°21'0"E
76°20'0"E
10°7'0"N
10°6'0"N
LEGEND
Commercials
Boundary
Asset
Ashramam
Bus Stand
Church
College
Colony
Comfort Station
Convent
Dumping Site
Hospital
LPS
Laterine
Library
Market
Mosque
Municipal Office
Office
Palace
Police Station
Post Office
Power House
Quarters
School
Telephone Exchange
Temple
Theatre
Town Hall
Treasury
Microwave Station

Fig. 2.5.1(p)

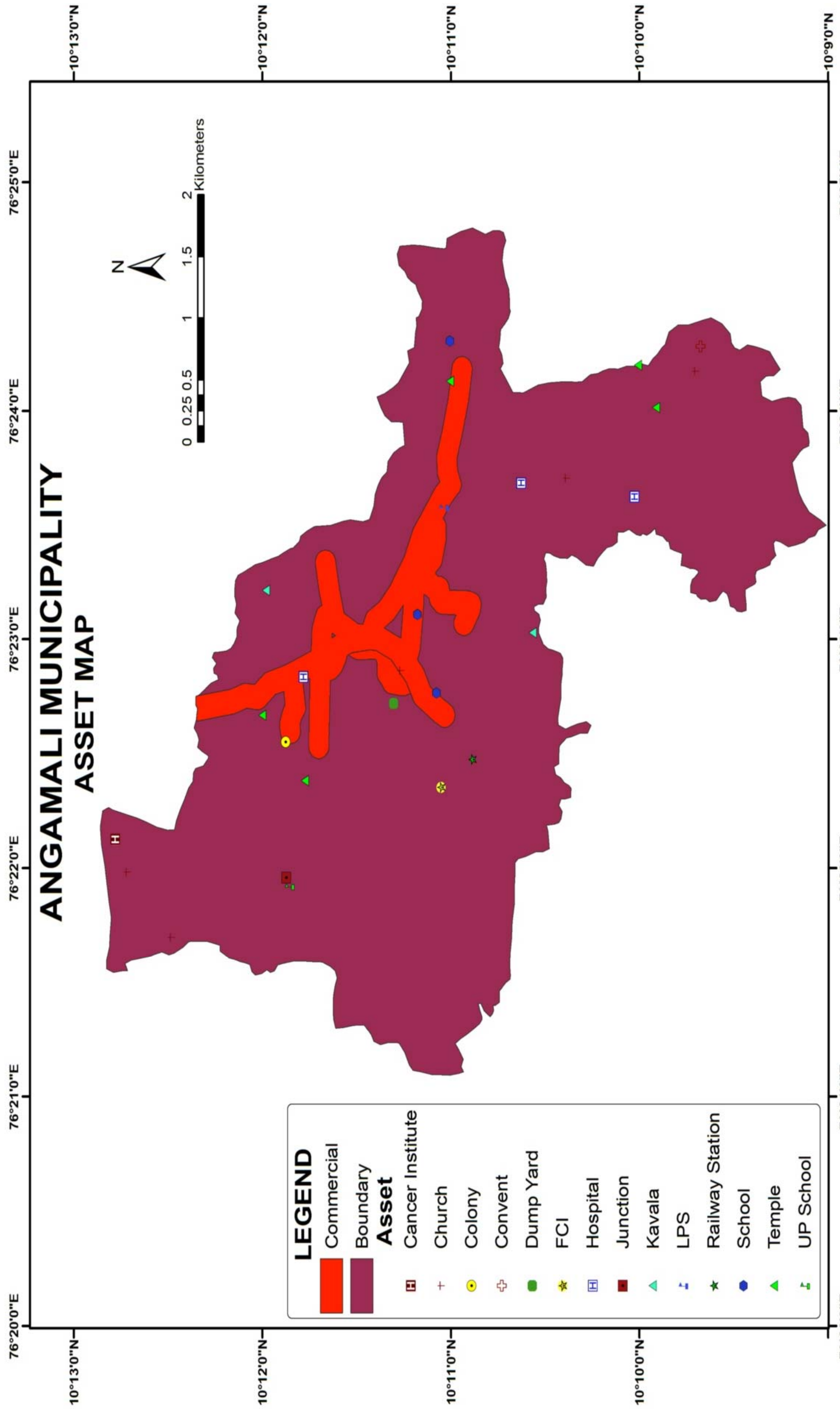

ANGAMALI MUNICIPALITY
ASSET MAP
N
0 0.25 0.5 1 1.5 2 Kilometers
LEGEND
Commercial
Boundary
Asset
Cancer Institute
Church
Colony
Convent
Dump Yard
FCI
Hospital
Junction
Kavala
LPS
Railway Station
School
Temple
UP School
76°20'0"E
76°21'0"E
76°22'0"E
76°23'0"E
76°24'0"E
76°25'0"E
10°9'0"N
10°10'0"N
10°11'0"N
10°12'0"N
10°13'0"N

Fig. 2.5.1(q)

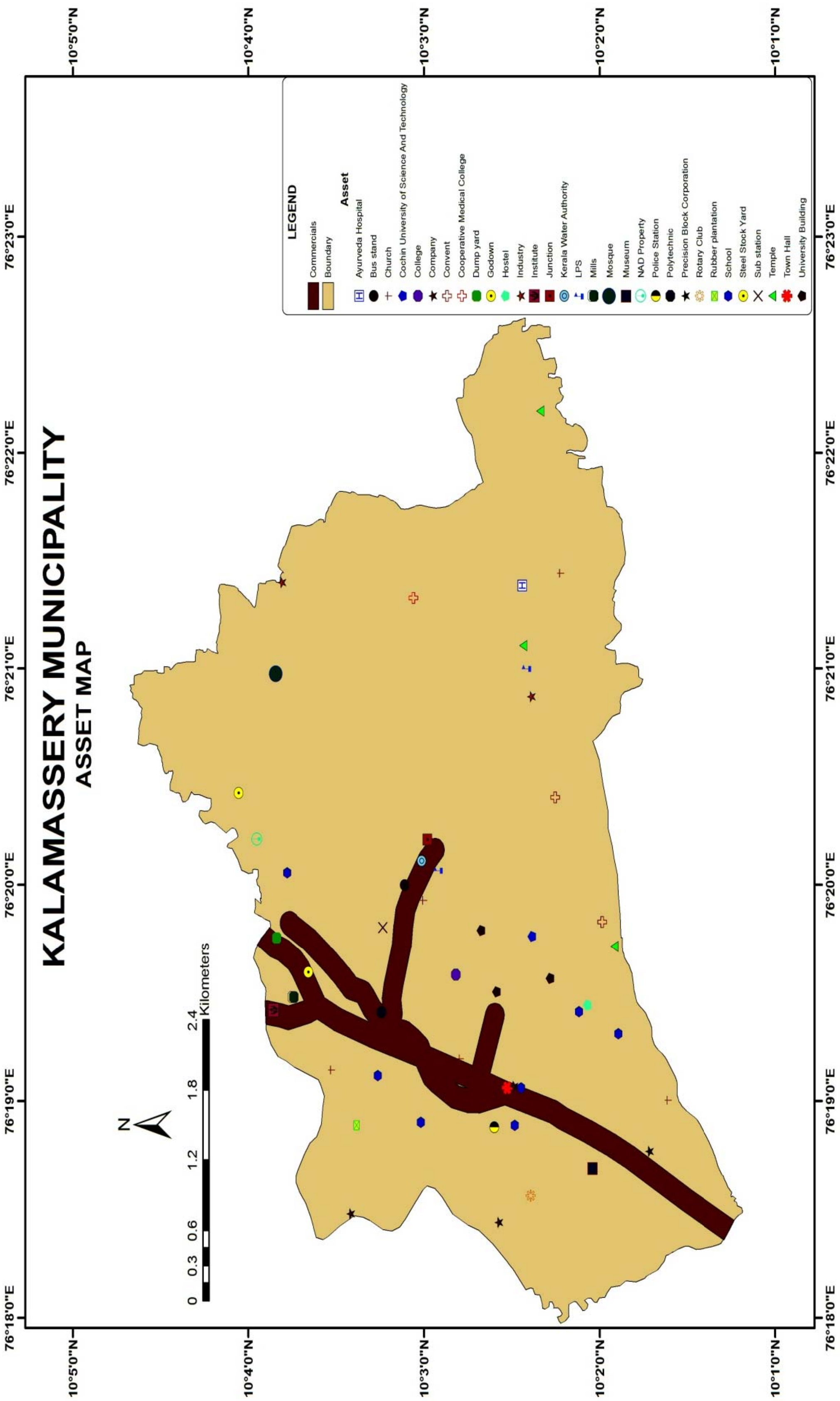

KALAMASSERY MUNICIPALITY
ASSET MAP
LEGEND
Commercials
Boundary
Asset
Ayurveda Hospital
Bus stand
Church
Cochin University of Science And Technology
College
Company
Convent
Cooperative Medical College
Dump yard
Godown
Hostel
Industry
Institute
Junction
Kerala Water Authority
LPS
Mills
Mosque
Museum
NAD Property
Police Station
Polytechnic
Precision Block Corporation
Rotary Club
Rubber plantation
School
Steel Stock Yard
Sub station
Temple
Town Hall
University Building
0 0.3 0.6 1.2 1.8 2.4 Kilometers
N
76°18'0"E
76°19'0"E
76°20'0"E
76°21'0"E
76°22'0"E
76°23'0"E
10°1'0"N
10°2'0"N
10°3'0"N
10°4'0"N
10°5'0"N

Fig. 2.5.1(r)

- **Generation of waste through industrial activities**

The study has taken into consideration only the waste generated by the red industries (the most polluting ones) in Ernakulam. Ernakulam generated 41506 MTA of hazardous waste from industries with landfillable wastes of 14531 MTA, Recyclable waste of 18718 MTA and Incinerable waste of 190 MTA. The most polluting industrial groups within the city are oil refineries, which are producing alkaline, BOD waste, Combustion products, emulsions, hydrocarbons, mucaptans, minerals, acid minerals, phenol, sulphides, sulphur, tar as waste products. The electroplating industries generate pollutants like alkali, boron, cadmium, chromium, copper, detergent, fluoride, iron, nickel, organic complex agents, cyanide, phosphates, silver, sulphate etc. These hazardous wastes pose a severe threat to environment because of the toxicity. These are a danger to the existing environment and its resources. The effect of such a type of waste generation is adverse on the ecosystem and human health. The various hazardous waste producing units in Ernakulam are described in Appendix-11.

- **Other activities -Bio medical waste generation**

Even though, these are insignificant in terms of distribution of activity, this point source generates waste. The infectious waste generated by this activity is hazardous in nature.

The other activities include vacant land and water bodies. The role of these activities in generation pattern of solid waste is insignificant.

2.6 Biomedical waste

Bio-medical waste includes all the waste generated by health care establishments, research facilities and laboratories including minor or scattered sources, i.e. health care taken in the home dialysis, insulin injection etc. General health care waste includes 75 -90% which is the non risk waste comparable to domestic waste. Various sources of biomedical wastes are administrative functions, housekeeping functions, maintenance of health care premises and hazardous health care waste of 10 -35% which is the health care risk waste (Glenn and Garwal, 1999). These wastes now threatens the public since, the health care foundations are situated in heart of city and therefore medical waste, if not properly managed can cause dangerous infection and posses a potential threat to the surrounding environment, persons handling it and to the public. Health and environmental effects, uncertainty regarding regulations and negative perceptions by waste handles are some important concerns in health care waste management in a country (Freeman, 1998). The bio-medical waste generation rate is the study of waste generated by medical centres to the total number of bed availability. The percentage of composition of each item has been estimated as 0.5 percent of pathological waste, 10 percent of infectious waste, 50 percent of general waste, 30 percent of kitchen waste and 9.5 percent of packaging waste (Central Pollution Control Board). It shows that the estimate of waste generated/bed/day is 0.105 kg of infectious waste and 0.895 kg of non infectious waste.

The study has been carried out for the biomedical waste and its generation rate. The biomedical waste generation rate is the study of waste generated by medical centres to the total number of bed availability. The higher rates signify the acuteness of problems in terms of people's susceptibility to infectious. (See table 2.6(a)). The bio medical waste generation in private hospitals is represented in fig 2.6(a).

Table 2.6(a): Bio-medical waste – Private hospitals/Dispensary

Sl.No.	Name of the municipality/corporation	No.of Hospitals	No.of beds	Infectious waste Kg /day	Non infectious waste kg/day
1	Perumbavoor	21+9+9+0	502+9+0+0=511	53.655	457.345
2	Muvattupuzha	32+25+15+0	512+0+0+0=512	53.76	458.24
3	Kothamangalam	23+0+11+0	645+0+0+0=645	67.725	577.275
4	Paravoor	20+22+14+0	328+41+0+0=369	38.745	330.255
5	Thrippunithura	23+14+14+0	44+26+0+0=70	7.35	62.65
6	Kalamassery	0+0+4+0	0+0+0+0	0	0
7	Aluva	37+14+15+0	478+48+0+0=526	55.23	470.77
8	Angamaly	24+10+9+0	1760+0+0+0=1760	184.80	1575.20
9	Kochi Corporation	210+70+76+0	397+84+0+0=481	50.505	430.495
	Total	721	4874	511.77	4362.23

Allopathy+Ayurveda+Homeopathy+Veterinary+Others(LMTC,RAIC,CSO,AD, IPD,LAB, VPC, ETC.

(Source – Kerala State Statistics and Economics Department)

Fig.2.6(a) Bio Medical Waste Generation in Private Hospitals

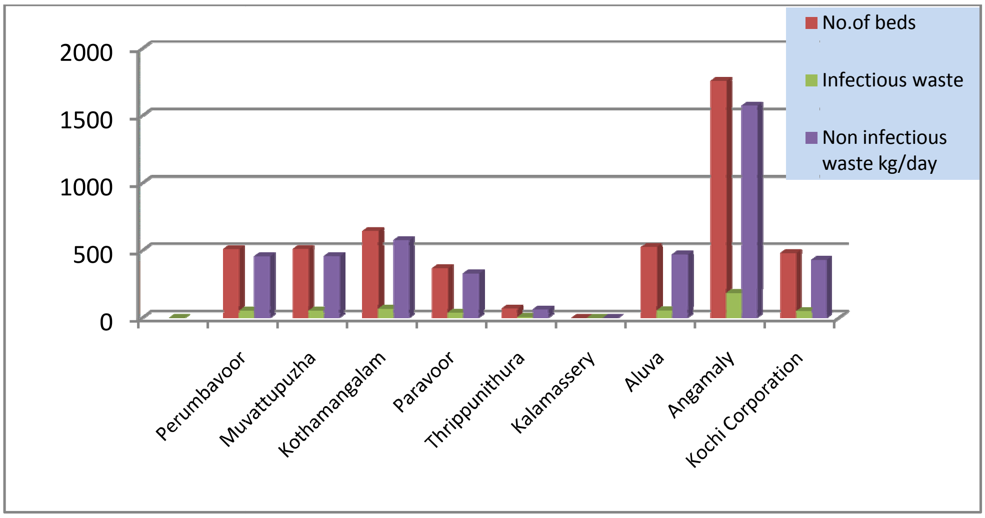


Table 2.6(b) furnishes information regarding bio-medical waste generated in government hospitals and dispensaries. It is diagrammatically represented in fig. 2.6(b).

Table 2.6(b): Bio-medical waste – Government Hospitals/Dispensaries

Sl.No.	Name of the municipality/corporation	No. of hospitals	No. of beds	Infectious waste kg/day	Non-infectious waste kg/day
1	Perumbavoor	1+0+0+1+0	216+30+0+0=246	25.83	220.17
2	Muvattupuzha	1+1+1+0+4	266+0+10+0=270	28.98	241.65
3	Kothamangalam	0+0+0+1+0	-	-	-
4	Paravoor	1+1+1+0+4	152+30+25+0=207	21.735	24.165
5	Thrippunithura	3+1+0+1+0	146+109+0+0=255	26.775	228.225
6	Kalamassery	0+1+0+1+0	0+1+0+0=1	0.105	0.895
7	Aluva	1+1+0+1+4	217+20+0+0=237	24.885	212.115
8	Angamaly	0+0+0+1+2	-	-	-
9	Kochi Corporation	7+6+1+3+5	1495+60+25+0= 1580	165.90	1414.10
	Total	56	2796	294.21	2341.32

(Source – Kerala State Statistics and Economics Department)

Fig. 2.6(b) Bio Medical Waste Generation in Government Hospitals

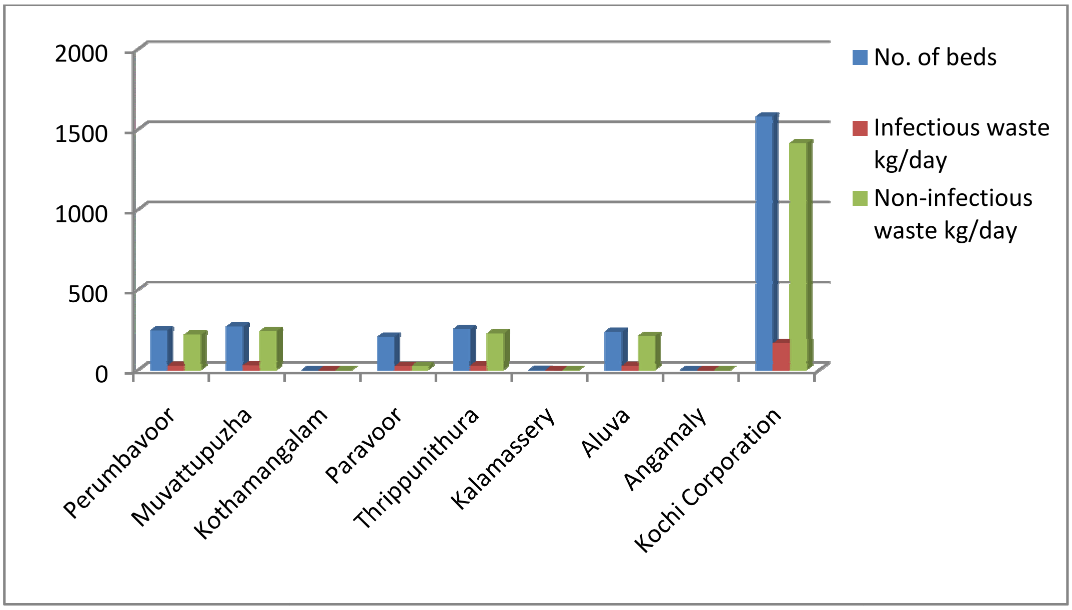


Table 2.6(c) gives information with respect to bio-medical waste generated in health centres and ICDP sub centre.

Table 2.6(c): Bio-medical waste – Health centre/ICDP sub centre

Sl.No	Name of the municipality/corporation	No.of Hospitals	No. of beds	Infectious waste Kg/day	Non-infectious waste kg/day
1	Perumbavoor	0	0	-	-
2	Muvattupuzha	0	0	-	-
3	Kothamangalam	3	0	-	-
4	Paravoor	0	0	-	-
5	Thrippunithura	1	0	-	-
6	Kalamassery	1	0	-	-
7	Aluva	1	0	-	-
8	Angamaly	1	41	4.305	36.695
9	Kochi Corporation	1	0	-	-
	Total	8	41	4.305	36.695

(Source – Kerala State Statistics and Economics Department)

Therefore the total biomedical waste generated in the city is 7550.53kg/day with non infectious waste of 6740.245kg/day and infectious waste of 810.285kg/day.

2.7 Quality of municipal solid waste

The physical characteristics of solid wastes vary widely based on socio-economic, cultural and climatic conditions. The study on physical qualities of solid waste like bulk density, its moisture content etc., help to identify solid waste management practices like disposal, recycling and other processing methods. Information on the chemical composition of solid wastes is important in evaluating processing and recovery options. In addition, the study helps in adopting and utilizing proper equipment and techniques for collection and transportation. The chemical characteristics like pH, chemical constituents like carbon content and N, P, K micronutrients of municipal solid waste help the decision maker to select proper waste management technology.

2.7.1 Physical composition of municipal solid waste

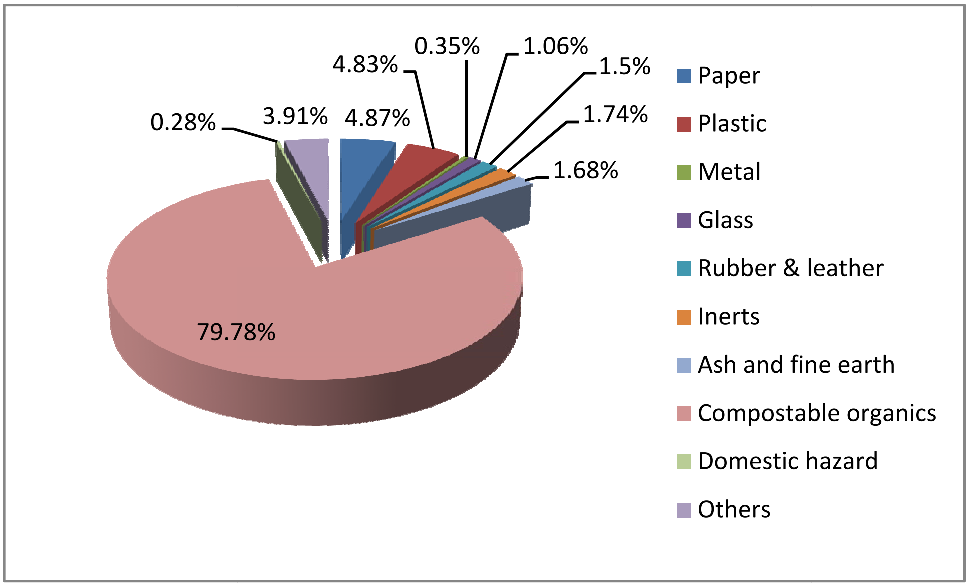
The physical composition of municipal solid waste is important for deciding the prime management actions namely the reduction, reuse and recycling of waste. The physical components are represented in the table 2.7.1 and are presented diagrammatically in fig. 2.7.1.

Table 2.7.1: Physical composition of municipal solid waste

Type of municipal solid waste	Percentage of municipal solid waste
Paper	4.87
Plastic	4.83
Metal	0.35
Glass	1.06
Rubber & leather	1.50
Inerts	1.74
Ash and fine earth	1.68
Compostable organics	79.78
Domestic hazard	0.28
Others	3.91
Total	100

Source: Kerala State Urban Development Programme, 2007

Fig. 2.7.1 Composition of municipal solid waste



2.7.2 Chemical characteristics of municipal solid waste

The chemical characterization of waste is important to understand the utilization as well as the pollution potential of solid waste. According to Kerala State Urban Development Programme report the chemical characteristics of municipal solid waste in Kochi are as follows; density-267.81kg/m3, moisture content-55.29%, calorific value-1759K.cal/kg, pH-7.46, C-26.39%, N-1.25%, C/N-21.11%, P as P2O5-129.25%. The heavy metal content of municipal solid waste contains Ar-5.72Mg/kg, Ni-4.49ppm, Cd-0.38ppm, Pb-2.48ppm, Cu-47.53ppm, Zn-98.98ppm and Hg <0.1Mg/kg.

2.8 Limitation of the study

The information was collected from different sources and tried to incorporate in the GIS data base. The limitations are discussed below; the maps available from the Corporation and municipalities were old enough and do not have the information about the later date and changes.

Commercial and institutional solid wastes are important contributors to the waste handled by Corporation and municipalities. With the exception of hospital wastes, little compositional data are available. There can be an analysis of physical and chemical characteristics of waste generated in the city. Since commercial and institutional wastes are often collected with domestic refuse by municipal agencies, such information would require special sampling and analysis efforts. This could help in analyzing the waste generation situation in a precise manner. Such tests have not been extensively conducted.

2.9 Conclusion

This chapter is an effort to understand the waste generation pattern of eight municipalities and one Corporation in Ernakulam district. The solid waste generation is the product of various human activities. These activities are identified as the residential, commercial, industrial, institutional and biomedical etc. based on Pollution control authority.

The city generates approximately 382.89 tonnes of residential and commercial solid wastes per day. Besides the above activities another important waste generating sector is the bio-medical unit. These are the medical treatment and health centres generating hazardous waste in the city. The total amount of waste generated by this activity is 7550.53kg/day.

The residential waste which contributes the maximum waste generation of 2.0 tonnes per day per ward in Cochin Corporation and 0.2 to 0.4 tonnes per day per ward in other municipalities is the result of household with higher paying abilities living in the city centre generated more waste when compared to others.

The commercial activities contribute to the maximum waste generation in comparison to other activities is a result of man's day to day domestic and commercial chores. The prominent commercial activities in a ward of Cochin Corporation generate more than 4 tonnes of waste per day and a ward in municipalities generate between 0.3 to 0.8 tonnes of waste per day.

The industrial and biomedical units in city contribute to the hazardous waste generation. Among the industries the most polluting ones are oil refineries, electroplating and service stations. The waste generated by these industries is toxic and hazardous in character. Ernakulam generated 41506 MTA of hazardous waste from industries. However, no proper disposal techniques are available for the industrial waste generation in the city. In the case of hazardous waste management with the initiative of the Kerala State Industrial Development Corporation and the Industries Department, the

Government is planning to have a common facility at a central place in the State.

Another type of hazardous waste generated in city is by bio-medical activity. Some of the waste generated by medical centres in the city is infectious in nature. The waste requires a safe mode of disposal, with least or minimum exposure to people. At present the waste are collected by Indian Medical Association from the hospitals by conservancy staff to the treatment plant in Palaghad.

The generated ArcGIS maps give efficient information concerning static and dynamic parameters of the municipal solid waste management problem such as the generation rate of municipal solid waste in different wards and their attributes. This analysis of solid waste generation helps to understand the acuteness of solid waste problem faced by the city. Such type and quantity analysis helps to lay out an efficient management infrastructure for the clearance, transportation and disposal of solid waste which is discussed in the chapter III.

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Chapter - III

SOLID WASTE MANAGEMENT

3.1 Introduction

In the last chapter we have discussed the process and extent of solid waste generation. In this chapter it is proposed to discuss management of solid waste. Waste materials generated by activities connected with market, agriculture, industry and households have become a major public health hazard. Hence solid waste management has become a matter of prime concern. Directives of the Supreme Court and consequent enactment of Municipal Solid Waste (Management and Handling) Rules, 2000 in Kerala have added urgency to the issue. Management of waste involves purposeful and systematic control of generation, storage, collection, transportation, processing and disposal of solid waste.

3.2 Solid Waste Problems in Indian cities

Rapid population growth, urbanization and industrial growth have led to severe problems of waste management in Indian cities. These developments will have serious implications with regard to the performance of municipal governments in the provision of municipal services (Singh, 1999). Also increased economic activities and technological developments have led to generation of huge quantity of solid waste in urban areas. (Trehan, 1992). Generally municipal corporations and municipalities collect solid waste through various modes of transportation like handcarts, animal-driven carts, rickshaws, etc. and street sweeping is carried out manually. Disposal of wastes in an unhygienic way as open dumping has become a common practice and such dumping areas have become breeding grounds of pathogenic microbes and their vectors (Jha, 1998). Extensive use of open dumping by urban and local self government institutions prompted The Hindu to characterize urban India as a site of rotting garbage (The Hindu, Survey of Environment, 1995). This highlights the need for correct planning and managing of solid waste practices. Moreover, efficiency improvements in solid waste management practices will help to minimize hazardous environmental impacts. Unplanned and unscientific management of solid wastes by municipalities can lead to outbreaks of epidemics of plague, cholera, malaria and that will result in high death tolls (Sudhir et al 1996). But most of the municipalities, barring a few progressive ones, are unable to provide the desirable level of conservancy services because they are afflicted with a number of problems (Mazumdar, 1996).

Research study carried out by solid waste management cell of the All India Institute of Local Self Government indicates that big cities spend approximately Rs.1000/- to Rs.1,400/- per tonne on city solid waste management. This means that at the national level Rs.10 crore to Rs.12 crore are being spent every day on management of municipal solid wastes (Sneha Palnitkar et al, 2004). Except in the metropolitan cities, solid waste management is the responsibility of a health officer who is assisted by the engineering department engaged in transportation work. The activity is mostly labour intensive, and 2-3 workers are provided per 1000 residents. The municipal agencies spend 5-25% of their budget on solid waste management, which is accounted to Rs. 75 - Rs. 250 per capita per year (Kumar and Gaikwad, 2004). Despite the huge amount of public money going into waste management sector, the state of solid waste management in most of the Indian cities is unsatisfactory.

This study is confined to Ernakulam District in Kerala. Solid waste management is in a pathetic state here. This results in ecological problems of flood, water logging, mosquito menace, sanitation and environmental hazards and health related problems. The pressure on infrastructural facilities and core sector services is severely felt in municipalities and panchayats. Except in Kochi Corporation, the problem is similar in all the municipalities. Although the mean per capita waste generation is estimated as 450 grams per day (gpd) a good portion of household waste is disposed of in individual compound yard itself (Reghunadanan, 2004). Methods of vermicomposting and biogas production are practiced in outlying areas where household land extent is comparatively more. The waste generated from Kochi Corporation is collected for treatment at Brahmapuram treatment plant. In two municipal areas viz., Kalamassery and Paravur door-to-door collection is done from a central area. The operation and maintenance cost in such cases is being recovered from beneficiaries. No systematic solid waste management practices have been carried out to dispose the quantum of solid wastes generated in municipalities in Ernakulam. Hence this chapter aims at a detailed evaluation of manpower requirements for collection, transportation and routing of vehicles for safe disposal of solid waste in the city.

3.3 Data Sources and Methodology

1. This study is conducted to assess the present solid waste management practices in Ernakulam. The study revolves around evaluation of facilities connected with collection, transportation, storage and disposal of solid wastes collected from different parts of Ernakulam District.
2. The information regarding collection and transportation of wastes has been accessed from Kochi Corporation and the nearby Municipalities, viz; Kalamassery, Thirupunithura, Aluva, Paravur, Angamaly, Perumbavoor, Kothamangalam and Muvattupuzha.

3. The existing standard of the management systems are analyzed and their efficiency measured using simple statistical, mathematical and cartographic techniques.
4. The study relating to number of heavy vehicles that are covered with nets while carrying the wastes to the disposing areas is assessed through observation for a week at all municipal landfills during morning shift.
5. A brief reference has been made to privatization of solid waste management in the city.
6. An optimum level of requirement of infrastructure for Kochi Corporation and all municipalities in Ernakulam district are developed based on norms set by the State Pollution Control Board and the Ministry of Environment and Forest. In the optimum level study, the required demand for sanitary workers is assessed using following criteria, (a) The total number of sanitary workers required is computed on the basis of 2 - 2.5 workers per 1000 population. (b) The workers capacity to collect individually and with the help of cart cycles of 60-65 kilogram capacity is assessed.
7. The vehicular requirement of different capacity to collect wastes from community to landfill sites are studied based on existing vehicles and required number, the surplus and deficit regions are identified.
8. At present both heavy and light vehicles are used by the Corporation and the municipalities. The route map for Kalamassery municipality has been used to study the comparison of total distances travelled by waste collection vehicles to cover the existing routes and new routes. The route chart for vehicles to collect waste from communities has been based on optimum distance and time to cover all collection points.

3.4 Solid Waste Management in Ernakulam

Table 3.4 provides information regarding solid waste management in Ernakulam district.

Table 3.4: Performance rate of Sanitary Workers in Ernakulam

Name of Municipality/Corporation	No.of Workers	Waste disposal per day in tones	Per head clearance Collection/day/tonnes
Perumbavoor	40	6	0.15
Angamaly	19	4	0.210
Aluva	27	16	0.592
Paravur	49	7.5	0.15
Cochin	920	140.5	0.152
Kalamassery	44	3	0.068
Thrippunithura	15	12	0.800
Muvattupuzha	23	5	0.217
Kothamangalam	28	7.5	0.267
Total	1165	201.5	0.172

Source: The Corporation and Municipalities.

Each worker approximately has a per head collection of 0.172 tonnes of solid waste per shift. The average collection and disposal per day for the study area is approximately 201.5 tonnes.

3.5 Transfer and transportation of waste

Basically, two important types of vehicles are used for transfer and transportation of wastes. These are tractor with 1 tonne capacity and vehicles having a capacity of 4 to 4.5 tonnes. All vehicles have well defined routes and schedules. The major problems faced by many municipalities and the corporation is narrow lanes and congested living. The high density of living and waste generation and its disposal pose a threat to health and hygiene in the concerned areas. The waste uncleared that remains for days generates disease causing vectors and pathogens. That also produces bad odour. Therefore inaccessibility is also one of the important reasons of ineffective solid waste clearance in Ernakulam. Such a situation increases work load of sanitary workers. Besides the light and heavy vehicles an auto rickshaw is used for collection and disposal of waste. The heavy vehicles transport waste collected from collection points to processing yard in Kochi Corporation and landfills. The tractor has a carrying capacity of 1 tonne and the lorries 4 tonnes - 4.5 tonnes. The total number of vehicles deployed for waste disposal is considered for this study are listed in table 3.5.

Table 3.5: Deployment of Vehicles

Name of Municipality/Corporation	No.of Vehicles	Tones Cleared
Perumbavoor	2 tractors (each 1 ton capacity)	6.0
Angamaly	1 tractor (1 ton capacity) and 1 lorry (4-4.5 tones capacity)	4.0
Aluva	2 tractors and 1 lorry	16.0
Paravur	2 tractors and 1 lorry	7.5
Cochin	53 lorries	250
Kalamassery	2 tractors and 1 lorry	3.0
Thrippunithura	2 tractors and 1 lorry	12.0
Muvattupuzha	4 tractors	5.0
Kothamangalam	2 tractors	7.5

Source: The Corporation and Municipalities.

Lorries are deployed two times a day. They collect wastes from selected locations. Municipalities use lorries more intensively without transfer stations. Kochi Corporation lorries collect wastes from transfer stations to take to the treatment plant located at Brahmapuram.

One of the problems associated with transportation of waste by vehicles is that the waste remains exposed during transportation to landfills and so dry waste often gets spilt on both sides of the road when wind blows. In order to avoid such situation, the Corporation is proposing to use fish net to cover wastes during transportation. But in all the municipalities waste is transported without any such cover. The study pertains to safety standards maintained by solid waste transporting vehicles during transportation of solid waste to the landfills. Transportation of wastes without any cover often proves to be hazardous.

The next level of service provided by management authority for clearance of solid waste is temporary storage facility. The temporary storage sites are called transfer stations.

3.6 Transfer stations

Transfer stations are temporary storage points of waste within zonal limits. An attempt has been made to describe the existing transfer stations and their conditions. The light vehicles unload waste collected from different sources in transfer stations. The quantum of solid wastes transferred to transfer stations can be assessed by taking the number of vehicles deployed and the collection process. Vehicles are deployed to collect solid wastes only during morning and the solid waste so collected is dumped temporarily at the transfer stations. The waste from transfer station is carried to landfills by heavy vehicles.

Since the transfer stations cause inconveniences to the public, there must be certain accepted criteria in setting up. The transfer stations that now exist are of different types. They are listed below;

a) Short-range transfer stations consisting of level sites and split level sites. The level sites transfer stations are usually affected by manually unloading containers and vehicles.

b) The split level sites are those from where small vehicles unload waste directly into large vehicles.

c) The third type of transfer stations serves the population of a particular region. The transfer stations are in the form of buildings with boundary having adequate safe storage capacity. Such transfer stations have to satisfy the following conditions.

   i. A cemented ground floor, for dumping and transfer of waste.

   ii. Building for office and stores, locker, shower, toilets and other basic facilities.

The existing transfer station (circle office) in Kochi Corporation resembles the third type. The waste deposited in transfer station is required to be removed within 48 hours. But such regulations are often violated and wastes remain in transfer stations for a longer period and that makes unhealthy environment in and around the area.

The transfer stations in Kochi Corporation are located at circle office. There are around 21 transfer stations (circle office) in Kochi Corporation. But the municipalities do not have any transfer stations. So they directly transport the waste to the dumping area.

All transfer stations in Kochi Corporation remain as dumping spots for days. This has created environmental problems and became production chamber of disease causing vectors, flies and mosquitoes. The life of nearby residents has become extremely difficult. The movement of vehicles to and out of the stations often create traffic problems.

The waste collected from transfer stations is transported to the treatment plant located at Brahmapuram. The existing system of transportation of solid waste requires a substantial improvement both in terms of manpower and technical support. An important step taken in this context is privatization of solid waste, with respect to collection, transportation and disposal.

3.7 Management of hazardous waste

The hazardous wastes generated in the city are of two types – the industrial waste and bio medical waste. Both require special type of collection and disposal techniques.

The biomedical waste generated can be categorized as infectious and non infectious wastes. The non infectious wastes can be disposed directly. However, infectious type requires a special treatment as well as different mode of disposal. The most commonly used way of disposing infectious bio medical waste is incineration. But installation of incinerators pose problems such as

i. Space: The hospitals should have adequate space to install incinerators within the hospital compound or nearby area.

ii. Location: It should be centrally located for easy access from different points. The location should be less inhabited as the operation can cause public nuisance and noise.

iii. Quantity: Except for a few hospitals the amount of waste generated is very little, and therefore, individual installation is not economical

iv. High cost of installation

v. Operational and maintenance problem.

Installation of incinerators is highly capital intensive programme and so there must be collective effort to establish incinerator for treatment of bio-medical wastes. At present almost all the biomedical wastes generated in the city are collected by the Indian Medical Association's agency from hospitals with a nominal fee and are treated at Palaghad biomedical waste treatment plant.

3.8 Required optimum infrastructure

This study is an attempt to find out the required level of infrastructure for eliminating the problems connected with waste management in the city. The focus is mainly on clearance of waste generated in the city. The study evaluates the following factors

i. Solid waste generation by different municipalities and corporation.

ii. The basic infrastructure requirement for collection, storage, transportation and clearance of waste.

3.8.1 Sanitary conservancy Requirement

Under this head, the existing layout of the sanitary conservancy staff for street clearance and cleaning are discussed. The present study is developed on the norms laid down by the Central Pollution Control Board for number of sanitary workers required for a particular region (2 to 2.5 workers per 1000 population). If similar norms are adopted for the study area, the municipality wise requirement of sanitary workers is listed in table.3.8.1.

Table 3.8.1: A comparison of required manpower to the existing manpower

Name of Municipality/Corporation	Population	Required manpower	Existing manpower	Percentage of deficit
Perumbavoor	26547	66	40	39.39
Angamaly	33409	83	19	77.10
Aluva	24110	60	27	55.00
Paravur	30059	75	49	53.06
Cochin	595575	1488	920	38.17
Kalamassery	63116	157	44	71.97
Thrippunithura	59884	149	15	89.93
Muvattupuzha	29246	73	23	68.49
Kothamangalam	37173	92	28	69.56
Total	899119	2243	1165	48.06

Source: The Corporation and Municipalities

3.8.2 Optimum Clearance by Sanitary Workers

Average clearance (1kg/worker)

Pick up by cycle carts of 60kg capacity (1 cart/2 workers)

Table 3.8.2

Name of Municipality/Corporation	Pick up by hand in tonnes	Pick up by cycle carts of 60kg capacity in tonnes
Perumbavoor	0.066	1.98
Angamaly	0.083	2.49
Aluva	0.060	1.80
Paravur	0.075	2.25
Cochin	1.48	44.4
Kalamassery	0.157	4.71
Thrippunithura	0.149	4.47
Muvattupuzha	0.073	2.19
Kothamangalam	0.092	2.76

Source: The Corporation and Municipalities

The total conservancy requirement includes street cleaners, collectors, drivers, helpers and others working at transfer stations and disposal sites.

The cycle cart improves pick up efficiency. The carts follow door to door collection of waste at a particular time and schedule. The kudumbasree practices door to door collection of waste. Such a facility allows increase in the number of trips compared to hand pickup method. In Perumbavoor municipality the pickup efficiency increased as much as 1.98 tonnes per day by two sanitary workers per trip, using cycle carts compared to hand collection of 0.066 tonnes. In Angamaly municipality, the efficiency increased from 0.083 to 2.49 tonnes. In the case of Paravur municipality the efficiency increased from 2.25 tonnes per day by two sanitary workers per trip using cycle carts compared to hand collection of 0.075 tonnes. In

Cochin, the efficiency increased from 0.157 to 4.71 tonnes with that of pick by hand in tonnes to pick up by cycle carts. In Kalamassery municipality the efficiency of clearance increased from 0.157 to 4.71 tonnes. The efficiency of clearance increased from 0.149 to 4.47 tonnes in Thriuppunithura municipality. In Muvattupuzha municipality the clearance efficiency increased from 0.073 to 2.19 tonnes. Similarly, the efficiency increased from 0.092 to 2.76 tonnes in Kothamangalam municipality.

3.8.3 Refuse collection vehicles

Refuse collection vehicle is the process of transferring solid waste from storage receptacle to place of disposal. Essentially, this involves employing storage containers into vehicle in which wastes are transported. The norms listed in table 3.8.3(a) are applicable to vehicles of all types.

Table 3.8.3(a): Carrying capacity –Vehicle

Haulage (Physical Distance)	Trips	Carrying Capacity Tonnes
8000-10000 sq.km	4	4-5
10000-20000sq.km	5	5-6
More than 20000 sq.km	6	6-7

Source: S.K.Sharma – Solid Waste Management and Environment Cleanliness (1990)

The type of vehicles (capacity) required and number of trips and haulage to be undertaken are decided by major factors such as the amount of waste generation and total population of the area. Table 3.8.3(b) gives a general idea regarding density and carrying capacity (tonnes/day) requirement.

Table 3.8.3(b): Requirement of vehicles (4 – 5 tonnes capacity)

Name of the municipality/Corporation	Total waste generation in tonnes	Required number of vehicles
Perumbavoor	11.8	3
Angamaly	12.59	3
Aluva	17.0	4
paravur	12.6	3
Cochin	255	64
kalamassery	23.2	6
Thrippunithura	23.3	6
Muvattupuzha	12.9	3
kothamangalam	14.5	4
Total	382.89	96

Source: The Corporation and Municipalities

The other various requirements for transportation of waste include

a) The load or waste should be covered during transportation. This is imperative for motor vehicles travelling at a speed of 30 kilometer/hour or more. This is not that important for slow moving vehicles.

b) The loading height of vehicles receiving the contents of manually emptied containers should not exceed 1.6m.

c) Unless the load is carried in portable containers, the body of the vehicle should have hand operated or power operated tipping gear or a power operated ejection plate.

d) The transfer of waste from a primary collection vehicle to the larger one should never involve dumping the load on the ground and both vehicle designs should take this into account.

3.9 Optimum waste collection programme

The frequency of waste collection depends on quantity of waste generated by a particular dwelling. The season also influences the frequency, eg. rainy seasons in Ernakulam retards daily pickup. Proper planning is required to establish an optimum collection system with charted routes, properly trained manpower and above all maintenance of proper and efficient sanitary standards, which protect the environment. The refuse collection programme takes into consideration (a) Man power requirement and (b) Vehicle requirement for transportation of waste.

3.10 Optimum waste collection route chart–Kalamassery municipality

An effective management practice involves a schematic and strategic distribution of collection points, so that it serves all possible lanes and streets in the city. It should be located in points easily accessible to different types of vehicles used for solid waste management. Based on existing infrastructure facilities for management of solid waste in each municipality, a path optimization for solid waste collection programme has been charted for kalamassery municipality. The municipality has residential, commercial and industrial region.

The study is conducted to chalk out an optimum refuse collection programme for the Kalamassery municipality. The study analyzed the existing route and collection system of solid waste disposal and then tried to find out the optimum path for transportation of waste with existing facilities using network analysis in Geographical Information System (GIS). The path optimization was calculated based on time and distance.

Table 3.10: Comparison of Existing and Optimized route

Sl.No	Days	Total Distance Traveled by Truck in Meters		Total Time Taken by Truck in Hours	
		Existing	Optimized	Existing	Optimized
1	Monday-route-1	9342	8032	2 Hours 31minutes	2 Hours 20 minutes
2	Monday-route-2	11055	10046	2 Hours 27minutes	2 Hours 17minutes
3	Tuesday-route-1	6778	6403	1 Hour 26 minutes	1 Hour 22 minutes
4	Tuesday-route-2	12359	10797	2 Hours 37minutes	2 Hours 28 minutes
5	Wednesday-route-1	7501	6980	1 Hour 51 minutes	1 Hour 45minutes
6	Wednesday-route-2	11734	10979	2 Hours 31minutes	2 Hours 23 minutes
7	Thursday-route-1	13835	12375	3 Hours 9 minutes	3 Hours 6 minutes
8	Thursday-route-2	12617	11558	3 Hours 34 minutes	3 Hours 23 minutes
9	Friday-route-1	19495	18217	3 Hours 51 minutes	3 Hours 34 minutes
10	Friday-route-2	10766	10356	3 Hours 37 minutes	3 Hours 28 minutes
11	Saturday-route-1	9296	8137	2 Hours 33 minutes	2 Hours 21minutes
12	Saturday-route-2	11498	10829	2 Hours 29 minutes	2 Hours 38 minutes
13	Sunday-route-1	4336	3219	1 Hour 49 minutes	1 Hour 30 minutes
14	Sunday-route-2	8120	7141	1 Hour 35 minutes	1 Hour 25 minutes

Both distance and time criteria were used to generate new routes for Kalamassery municipality. Based on distance criteria, the total distance travelled by vehicles was taken into account to decide new routes. Here, the collection schedule was fixed based on density of population, land use patterns like residential, commercial, institutional and industrial and accordingly barriers were given to find optimum route. Based on time criteria, the total time taken by vehicles to cover particular distance was considered for generation of new routes. Here collection points were considered as stops and collection time from each collection point as well as the running time of vehicle from municipal office to dumping site was calculated as total time taken by each vehicle.

Using existing infrastructure facilities in Kalamassery municipality 14 new routes were generated for 2 waste collection vehicles by considering municipal office as starting point and dumping site as destination point. The vehicles collect the waste from collection points or community bins located at different parts of municipality and transported to dumping yard. The exercise is a small workout on distribution of collection points and collection of waste from various collection points by optimum time and distance. Similar efforts should be carried out for other municipalities. The solid waste clearance service should always be an effort towards zero waste management. It should include not only complete clearance and disposal but also salvaging of waste as much as possible. Recycling and reuse of waste is an important method of waste reduction. The practice of recycling is a prevailing managed economical activity in the city which is examined in this study.

3.11 Conclusion

Solid waste management covers collection, transportation and disposal of waste in an available eco friendly environment. The Indian cities are not able to cater to day to day increase in quantity of solid waste generation. The study area shows a deficit in many areas of management techniques (collection, transportation, processing and disposal). The problem arises right from the point where waste comes out of community to roads. The first problem witnessed is scattering of garbage on road sides. Such a scene is aesthetically and environmentally degrading in region.

The inadequacy of sanitary workers complicates the management of waste disposal. The percentage deficit of manpower is 39.39 per cent in Perumbavoor municipality, 77.10 per cent in Angamaly, 55.00 per cent in Aluva, 53.06 per cent in Paravur, 38.17 per cent in cochin, 71.97 per cent in kalamassery, 89.93 per cent in Thriuppunithura, 68.49 per cent in Muvattupuzha and 69.56 per cent in Kothamangalam municipality.

The garbage is handpicked or using basket and is transported to dumping yard. The vehicles have a scheduled route from where waste is collected. These vehicles do not cover narrow lanes and streets and so the sanitary workers must do the work in such areas also. The lanes and streets are often seen with uncleared solid waste for a number of days. The number of vehicles and trips available are not sufficient for eliminating the problems connected with waste management. There is absolute requirement for additional number of vehicles for the efficient coverage of the regions which are described in the optimum infrastructure requirement for the city.

The transfer stations or collection points are environmentally degrading. This temporary collection points facilitate vehicles to unload solid waste. The waste should be moved from there within 48 hours of arrival to landfill sites. In many cases waste has not been cleared for days. The collection point creates unhealthy environment especially for people residing nearby. The waste from collection point is removed by vehicles and transported to landfills. The study area has inadequate number of vehicles. The need is only to change vehicle pick up schedule so as to have a complete waste collection structure.

The fresh water sources in and around Ernakulam are polluted due to illegal dumping of solid waste and untreated sewage in to water course.

Industries should properly treat the waste according to Pollution control Board norms before discharging it into water course. Often bio-medical wastes are mixed with municipal solid waste. So there is a need for a common incinerator for treatment of biomedical waste in Ernakulam region.

The optimum waste collection infrastructure aims at establishing the required level of services for collection and transportation of solid waste in the city. The structure proposed requires a total manpower of 2243 for solid waste clearance while there is only 1165 manpower at present. This shows a deficit of 48.06 per cent in manpower.

The study shows that clearance efficiency among sanitary workers can be improved by using cycle carts for collecting waste through door to door operation. The carts have carrying capacity of wastes of 60 kg/shift. The usage of carts enhances the pickup efficiency up to 67.05tonnes per day by two sanitary workers per trip.

The vehicular requirement study reveals some deficit in vehicles. For efficient collection Perumbavoor needs 3 vehicles with 4tonnes -5 tonnes capacity. The requirement of vehicles with similar capacity in other areas are Angamaly 3, Aluva 4, Paravur 3, Cochin 64, kalamassery 6, Thriuppunithura 6, muvattupuzha 3 and Kothamangalam 4. The deficiency in the number of vehicles can be made up to some extent by rescheduling the trips.

The path optimization exercise (as in table 3.10) reveals that the collection efficiency of wastes can be increased by covering maximum collection points and reducing travel time by using the shortest path. A comparison of total distance traveled by vehicles through the existing routes and the proposed new routes shows that the total distance traveled by vehicles through new routes will be covered in 13.663 km. This will reduce clearing time by 3 hours. Similar studies can be extended to other municipalities to enhance the efficiency in waste collection and disposal.

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Chapter - IV

WASTE RECOVERY IN ERNAKULAM

4.1 Introduction

The third chapter discussed the present status of solid waste management. It is proposed to assess the waste recovery in the present chapter. Nearly all human activities leave behind some kind of waste. The activities like residential, commercial, institutional, industrial etc. generate waste of different types in different quantities. In recent years, the quantity of waste generated by these activities has reached a significant proportion and its disposal has become an increasingly difficult problem. In most of the Indian cities waste is collected and transported to landfills for final disposal. An efficient management practice considers not only environmental safe disposal of waste but also salvaging of those materials from waste that could be used in one form or the other. The process of salvaging materials from waste is called resource recovery from waste. Resource recovery from waste is an important method of waste reduction process. Given the existence of well-established informal and private sector systems of waste trading, it might seem that a city like Ernakulam is in no need of any intervention to support waste reduction. It should be remembered, however, that Ernakulam, like so many of the thousands of cities in the developing world, is under great pressures of modernization and change. It is a city that is officially unaware of its traditions of waste recycling. Even though the municipalities have a relatively small amount of waste to deal with daily, they are not able to handle that efficiently.

The technology options available for processing Municipal Solid Waste (MSW) are based on either bio conversion or thermal conversion (Diaz et al., 2002; Benedict et al., 1988; Corey, 1969; Tchobanoglous, 2003; UNEP, 2005; Salvato, 1992). The bio- conversion process is applicable to the organic fraction of wastes, to form compost or to generate biogas such as methane (waste to energy) and residual sludge (manure). Various technologies are available for composting such as aerobic, anaerobic and vermi-composting. The thermal conversion technologies are incineration with or without heat recovery, pyrolysis and gasification, plasma pyrolysis and pelletization or production of Refuse Derived Fuel (RDF). This chapter has brief account of these technologies which is essential for evaluating their efficiency, applicability and impacts.

Waste can become wealth if properly managed. One of the important steps emphasized in zero waste management is reduction of waste through resource recovery (fig 4.2). Recovery of waste can be achieved through processes like reuse, recycle, conversion to other forms etc. Reuse includes using waste as fertilizer. Recycling turns waste materials into valuable resources. It also generates a host of financial, social and environmental benefits. Recycling involves collection, sorting and processing waste into new products. Upon recycling, waste becomes an “asset” and its value increases. It reduces and relieves the ecological burden from the earth’s ecosystem and significantly enlarges the earth’s “carrying capacity” (Sinha, 1996). Another way of recovering resources from waste is its conversion. Conversion is often associated with organic waste like vegetable or animal matter or organically decomposable materials. It is a process based on anaerobic digestion of organic matter in which microorganisms break down biodegradable material in the absence of oxygen. It produces methane and carbon dioxide rich biogas suitable for energy production.

4.2 Waste Reduction Process

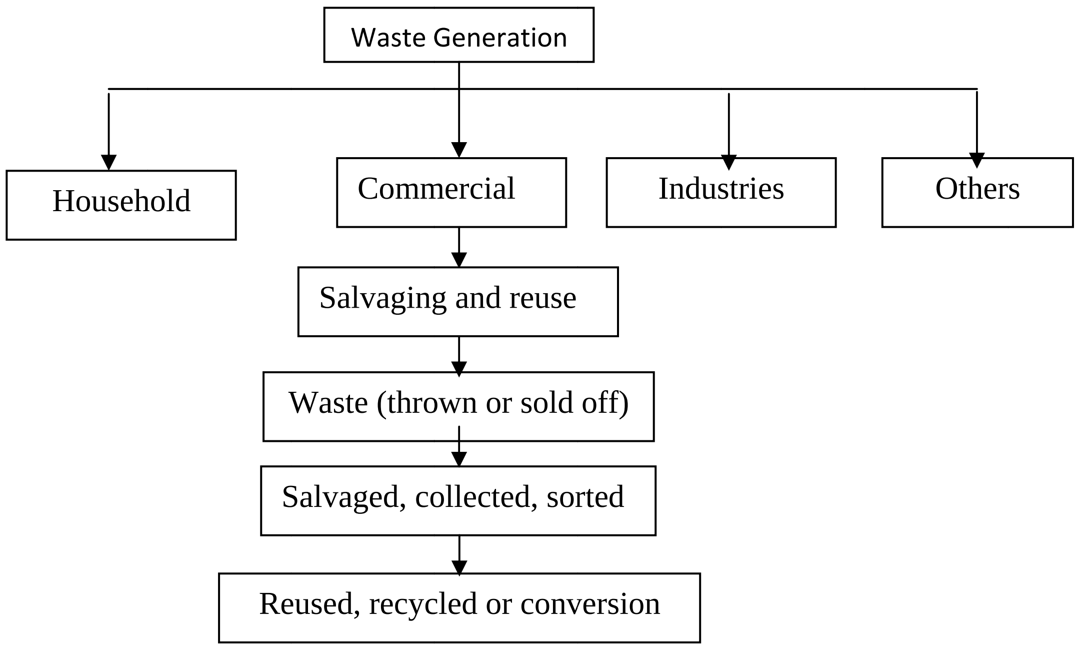

Fig.4.2

4.3 Waste reduction

These materials can be converted into manure, fuel, pellets etc. All these activities are important methods for waste reduction. If properly managed they can reduce pressure of waste on landfills to a great extent.

Process of reduction of waste occurs at two levels – reduction at source and reduction through salvaging of materials from waste that is thrown off. Source reduction encourages and prevents generation of waste in the first place. So it should be the most preferred method of waste management. The second method is salvaging products from waste and converting them into reusable materials. The present study emphasizes these two levels for waste reduction in the study area, Ernakulam.

4.4 Resource Recovery process

International bodies and environmental movements now place emphasis on recycling as part of an environmental ethic for resource conservation and waste reduction (World Commission on Environment & Development, 1987, pp.253-255). Most of the materials recovered through recycling are traded through informal trading system like Waste pickers, waste buyers, small waste-trading shops, larger dealers, wholesalers and recycling enterprises (Furedy, 1990, pp.18-19). In spite of increase in waste materials the waste buyers believe that the trade in this has become more competitive recently. In addition, the waste buyers operate under the typical handicaps of informal work and enterprises (Samal 1990).

The activity of resource recovery in Ernakulam is supported by a small community of rag pickers, retail and wholesale dealers and recycling units. The present study briefly highlights the resource recovery at household level and the activity of rag picking community in resource salvaging. The methodology used to study the resource recovery process in the study area is listed below.

4.5 Data sources and methodology

The study is based on primary and secondary data. The study assumes that each household generates an average amount of recoverable materials from waste per month (limitation). Data for the study were collected as follows

- The secondary data were collected from Cochin Corporation and Kalamassery, Aluva, Angamaly, Paravur, Thiruppunithura, Perumbavoor, Muvattupuzha and Kothamangalam municipalities.
- The primary data were collected from 25 units comprising of retail and whole sale dealers from different parts of the city. This

information is used to arrive at average generation of recoverable waste from households in each municipality and the Corporation.

- The average renewable waste generated per month is multiplied by the household data for each municipality and the Corporation to get an estimated amount of resource recovered from waste.
- Resource recovery rate of organic waste and its cost benefits are calculated based on the information collected from Cochin Corporation.
- Data collected from 30 households who were using biogas plants with kitchen waste as feeding materials relate to Kalamassery municipality.

4.6 Recoverable waste –Households

The materials that are recovered for reuse and recycling from the households are plastic, paper (news papers, magazines, etc.) metal and glass. These materials are considered as waste by households but are retained for selling. They are sold to retail or whole sale dealers.

The approximate amount of waste recovered from households in each municipality and the Corporation is the average recovery per household. The average generation per household is as follows.

Newspaper, Magazines and Books – 5 kg/ 3 months/ household

Plastics – 1 kg/ 3 months/ household

Metals – 1kg/3months/household

Glass 1.5kg/3 months/household.

Table 4.6(a): Households material recovery/3 months

Name of the Municipality/Corporation	Paper Tonnes	Plastic Tonnes	Metal Tonnes	Glass Tonnes
Perumbavoor	30.32	6.06	6.06	9.09
Angamaly	37.78	7.56	7.56	11.33
Aluva	26.67	5.33	5.33	7.99
Paravur	34.17	6.83	6.83	10.25
Kochi	658.46	131.69	131.69	197.53
Kalamassery	71.03	14.20	14.20	21.30
Thrippunithura	69.62	13.92	13.92	20.88
Muvattupuzha	32.57	6.51	6.51	9.76
Kothamangalam	40.93	8.19	8.19	12.27
Total	1001.55	200.29	200.29	300.40

Source: Survey data

Fig.4.6(a) explains the householders material recovery per 3 months in the Ernakulam district.

Fig.4.6(a) Households material recovery per 3 months

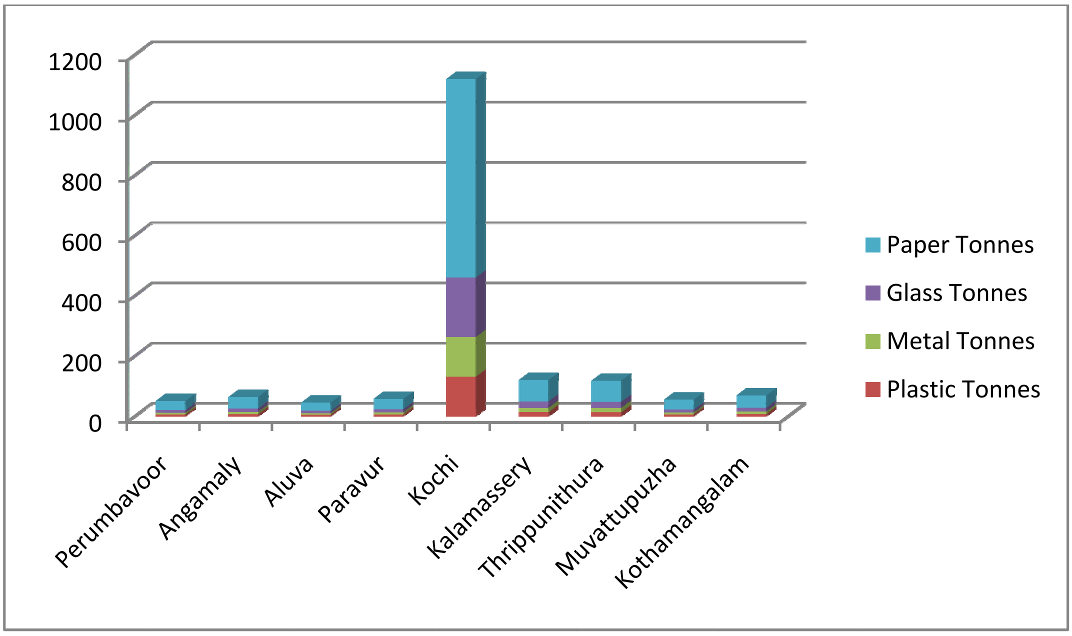

Table 4.6(b): Earnings per household through material recovery in lakhs (Average earnings/3months)

Name of the municipality/Corporation	Average earnings/3 months
Perumbavoor	3.81
Angamaly	4.71
Aluva	3.24
Paravur	7.50
Kochi	82.90
Kalamassery	8.91
Thrippunithura	8.67
Muvattupuzha	4.01
Kothamangalam	5.11
Total	128.86

(Calculated based on the price list given by waste dealers)

Source: Survey data

Fig.4.6(b) Earnings in lakhs per 3 months

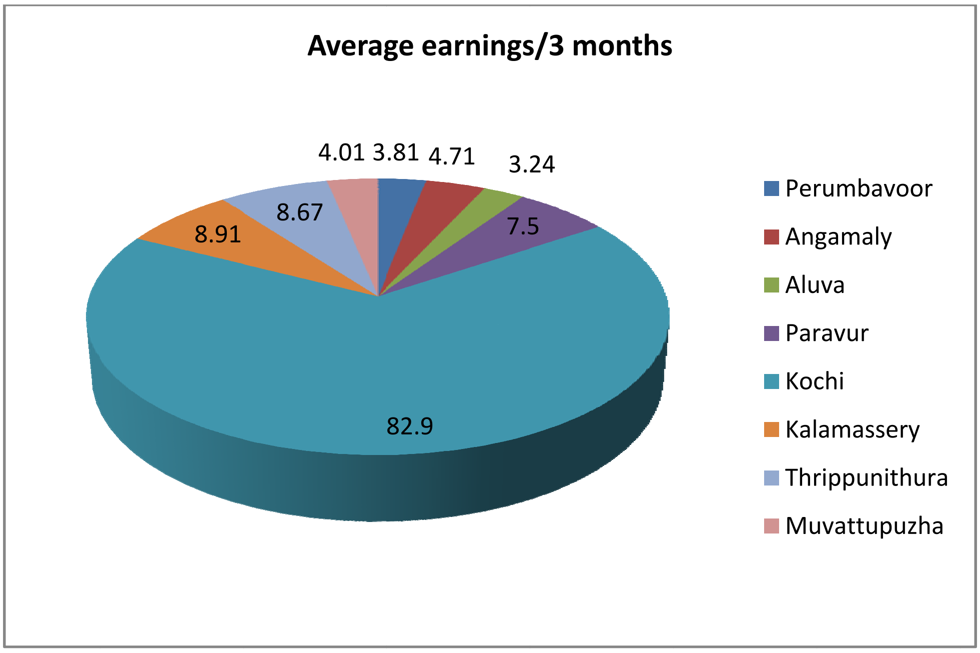

Table 4.6(c): Waste bought and sold by dealers

Materials	Quantity Kg/day	Buying price Rs./kg	Selling Price Rs./kg
Paper	15	5	6
Plastics	5	8	10
Metals	5	15	20
Glass	25-50 bottles	2/bottle	3/bottle

On an average they have the profit margin of more than 20 percentage.

Source: Survey data

Besides recovery at household level, waste is also recovered from community bins, transfer stations and land fill sites by rag pickers.

4.7 Waste recovery by rag pickers

The rag pickers play a very important role in the recovery process of solid waste. Solid Waste is recovered at 3 stages by rag pickers from the disposed waste. Three groups of rag pickers can be identified based on collection, they are as follows.

- Primary collectors i.e. rag pickers collecting from community bins and the road sides, where the waste is discarded.
- Secondary collectors i.e. rag pickers collecting from transfer stations.
- Tertiary collectors i.e. pickers from the landfills.

The average amount of waste recovered by rag pickers per day from dumpsite is in table 4.7.

Table 4.7: Waste recovery by rag pickers in collection points (bins) and dumpsites.

Materials	Quantity	Selling Price
Paper	1kg/day	Rs.2/kg
Plastics	3kg/day	Rs.8/kg
Metals	1kg/week	Rs.15/kg
Glass	1kg/week	Rs.10/kg

Source: Survey data

Rag pickers who collect wastes from streets earn rupees 8/kg/day from plastic, rupees 2/kg/day from paper, rupees 15/kg/week from metals and rupees10/kg/week from glass. The waste collected is sold either to retailers or whole salers.

4.8 Waste dealers and recycling units

The reusable waste materials collected by the door-to-door waste collectors as well as street and dumpsite rag pickers sell to middlemen, who, in turn, sell them to small recycling units. Waste recycling involves sorting, cleaning and processing of solid waste. The various recyclable materials from municipal solid waste in the study areas are discussed below.

4.8.1 Plastics

Waste dealers cater to the demands of recycling units located in the same region. The plastic items used for recycling are bottles, scraps, containers, buckets, toys, polythene and PVC. There are well developed plastic recycling establishments in the city. The recycling units practice simple techniques of melting the plastic and molding it to new materials which the market can absorb. Some of the units convert the plastic into pellets and transport them to the units where they are molded into new products.

4.8.2 Paper

Paper recycling is an inter district and interstate activity. Besides recycling, paper is also sold for reuse.

4.8.3 Metals

Most of the metal items include containers, utensils and parts of machines. These are usually sold for reuse. Other than reuse these are transported to other states for recycling purpose. The scrap merchants segregate all types of waste and send them for recycling units to Edayar (Iron & Steel Recyling Units), Perumbavoor (Plastic Recycling Units), Mettur, Salem (Iron & Steel Recycling Units), etc.

4.8.4 Glass

There are no glass manufacturing units in the city. The glass recovered from waste is transported mainly to other states.

4.9 Organic waste recovery in Ernakulam

The potentiality of organic waste is many. It can be processed and converted to manure or fuel pellets. The study of the nature of organic waste reveals that the fuel pellets have a calorific value of 3200 kilo calories per kg. With additives the value increases to 4000 calories per kg. Around 500 tonnes of organic waste can be converted to 100 tonnes of fuel pellets (Source:CMDA). Efforts have been made to convert organic waste to fuel pellets in cities like Baroda and Bangalore. In Ernakulam discussions are going on between the government and private organizations to set up pellets producing plants in Brahmapuram waste processing yard. It is a high capital intensive investment project. The establishment of such a project is an effective way of controlling solid waste pollution.

Another important way of utilizing organic waste is to convert it into manure. The Cochin Corporation is playing an important role in processing organic waste into manure. The technology used is simple. The process is called composting. Another technology is vermicomposting. The earthworms are used to convert the organic waste to manures. Many of the residential colonies in the Corporation and the Municipal areas are using this method to convert the organic waste into manure at the household level. Also the residential associations in the Cochin Corporation dug up ecobins for collection of organic waste generated by residential colonies and its conversion to manure. These associations practice segregation of waste into organic and recyclable and reusable waste. However, these activity are restricted to a very few areas within the city. The regions (Cochin Corporation) process the organic waste for manure production, while a large quantity of organic waste generated by other municipalities is left unutilized at the dumpsites.

4.9.1 Cost and economic return of resource recovery in Ernakulam

Households in the Cochin Corporation mostly segregate the organic waste and that is collected by the Corporation workers and transported to Brahmapuram processing plant. A nominal fee of Rs.30/- per household is charged for this. The Cochin Corporation collected 100-150 tonnes/day of biodegradable waste and processed that into compost (45-50 tonnes/day). They had a tie up with Fertilizers And Chemicals Travancore (FACT) for marketing the manure at (Rs.2/- per kg) produced from biodegradable waste. Earnings from organic compost of Cochin Corporation is estimated to be Rs.90000 to Rs.100000/day (Source: Cochin Corporation). Apart from that some households in the localities converted organic waste into compost at source and saved rupees thirty per month the collection fee charged by the Corporation.

4.9.2 Material recovery rate

The percentage of waste stream recovered as usable secondary materials.

$$\text{Material recovery rate \%} = 100\% \times \frac{\text{Amount of recyclable materials leaving the system}}{\text{Total amount of waste entering waste management system}}$$

Organic material recovery rate in Cochin Corporation

Total collected waste	= 255 tonnes/day
Quantity of organic waste recovered for compost	= 100 tonnes/day
Organic material recovery rate in %	$= \frac{100\% \times 100}{255}$ = 39.21%
Production of compost from 100 tonnes of organic waste	= 45tonnes of compost
Cost of compost	= Rs.2/kg
Economic return from compost	= Rs.90000/day

Ernakulam district generated a total waste of 382.89 tonnes per day (Table 2.5). From that 305.50 tonnes of compostable organic waste is recovered per day (as per Table 2.7.1). It has the potential of producing 137.475 tonnes of compost/day. It can be sold at the rate of Rs.2/kg. On the basis of this the Corporation and municipalities in Ernakulam district can earn Rs.274950/- per day. However, a substantial amount or recyclable items such as plastic, glass, paper and metal along with household appliances are also disposed off along with the regular garbage in the municipalities. In some parts of the city, households make compost and biogas from organic waste.

In October 2000, the Ministry of Environment and Forest notified the Municipal Solid Waste (Management and Handling) Rules which require that all the cities should set up suitable waste treatment and disposal facilities by 31st December 2001. The local bodies find it hard to acquire land, machinery, manpower and technology. This big challenge made them to find various solutions that include waste recovery and generation of energy from waste. Accordingly, organic waste are to be converted into compost and biogas in the Corporation and municipalities. Some municipalities are trying to produce bricks and fencing poles from plastics with the help of National Small Industries Corporation. From one tonne of plastic wastes it is supposed to produce 1000 bricks (Source:Kodungallur municipality)

Production of bricks/tiles from 1 tonne of plastic waste = 8000 bricks

(Size of the brick = 16inchX9inchX8inch)

Cost of brick/tile = Rs.20/brick/tile

Production cost of 1 brick/tile = Rs.8/-

Total production cost for making 8000 bricks/tiles from 1 tonne of plastic waste

(8000XRs.8) = Rs.64000/-

Market price for 8000 bricks/tiles(8000XRs.20) = Rs.160000/-

Revenue from bricks/tiles using plastic waste (Rs.160000-Rs.64000)

= Rs.96000/- per tonne

(Ernakulam generated 382.89 tonnes of solid waste per day (table 2.3). This includes the plastic waste of 4.83% (table 2.7) which amount to 18.49tonnes of waste per day.)

Economic return from 18.49 tonnes of plastic waste = Rs.17,75,040/-per day.

Therefore, the economic return from plastic waste for Ernakulam = Rs.64, 78, 89,600 per annum.

An attempt has been made to study the feasibility for setting up of family type biogas plants in the study area to reduce waste at source. The Asian Business Group has developed a new technology to treat the organic waste using bio technology method. The plant can be tailor made that depends upon the requirement of household. The total cost of the plant varies from Rs.9,000 to Rs.44,000. The details are presented in table 4.9.2.

4.9.2 Cost and benefits of biogas plant

Sl.No.	Description	Amount
1	Cost of construction of 1m³ biogas plant	Rs.9000.00
2	Operating cost (Repairs and Maintenance assumed at 3% of construction cost on a per annum basis)	Rs.270.00
3	Annual cost on capital - Interest on capital investment @12%	Rs.1080.00
4	Depreciation @4% per annum	Rs.360.00
5	Total annual cost (Operating cost + Interest + Depreciation)	Rs.1710.00
6	Annual gas production and replacement value of biogas plant Total gas production/annum (365 x 0.250)	91.25kg
7	Assuming 12 LPG cylinders will be required for a household per annum (12 x300=3600) Replacement of biogas/annum (3600-1710) By using biogas, household can save Rs.1890/- per annum	Rs.1890

The main advantage of using organic waste as a feed for biogas plant is that its calorific value is higher when compared to dung or excreta (www.arti-india.org). Households make biogas from organic waste can save Rs.1890/- per annum.

4.10 Biogas plant Impact Assessment

Biogas is a product of anaerobic fermentation of organic matters and consists of around 60-70% methane, 30-40% carbon dioxide. The input material for the biogas materials for biogas digesters are the wastes that are found locally such as animal dung, agricultural residues and leaf litters from forests. The residues are introduced into a closed digester, where without the presence of free oxygen, the responsible microorganisms work successively to convert complex organic matter in to CH4, CO2, H2, H2S (Ramachandra, 2003).

According to the Appropriate Rural Technology Institute (ARTI) in Pune, the family size biogas plant has the potential to reduce the waste at source which can be fed with household organic waste. Users apply 1kg of organic waste daily and add 10 litres of water. In return the plant will produce around 250g of methane per day, enough to cook a full meal for a family of five. The gas could also be fed into a generator to provide around 1 kWh of electricity. One of the main advantages of using organic waste as the feedstock compared with dung or excreta is that its calorific value is considerably higher (www.arti-india.org). The various strengths and weaknesses of biogas using household waste in the study area is discussed in the following paragraphs.

4.10.1 Use of feed in biogas plant

Organic waste is the most significant source of biofeed. Other feeds have been used and these include cow dung, fish waste and organic wastewater. Any fermentable wastewater is put into the plant.

Table 4.10.1

Feed materials in biogas plant	No.of respondents	Percentage
Kitchen waste	21	70
Cowdung	6	20
Night-soil	3	10
Total	30	100

Source: Survey data

Chi-Square value is 14.60, degrees of freedom is 2 and p-value is <0.01

Seventy percent of the respondents are using only kitchen waste as feed material and 20% of the respondents use cowdung along with the kitchen waste and 10% of the respondents connect biogas plant to the septic tank. Table 4.10.1 shows that significantly higher number of respondents uses kitchen waste as feed material in biogas plant.

4.10.2 Daily availability of biogas

On an average, a house requires 4 to 5 hours biogas flame or fire in the oven. Users made an observation that they do not cook continuously with biogas and if cooked continuously, the gas will not be sufficient for entire cooking. They allow a gap of 10 to 15 minutes in between two cooking sessions. This type of management ensures that all cooking needs can be met from biogas.

Table 4.10.2

Daily availability of biogas	No.of respondents	Percentage
Up to 1 hour	17	56.67
1-2 hours	8	26.67
Above 2 hours	5	16.66
Total	30	100

Source: Survey data

Chi-Square value is 7.800, degrees of freedom is 2 and p-value is <0.05

Table 4.10.2 shows that significantly higher number of respondents (56.67%) reported biogas availability is only upto 1 hour.

4.10.3 Details of LPG savings due to usage of biogas

However, households did not have any clear idea on this as no measurement has been done or observations made on this.

Table 4.10.3

LPG savings due to usage of biogas	No.of respondents	Percentage
Up to 25 %	12	40
25 – 50 %	15	50
Above 50%	3	10
Total	30	100

Source: Survey data

Chi-Square value 7.800, degrees of freedom is 2 and p-value is <0.05

Table 4.10.3 reveals that significantly higher number of respondents reported upto 50% savings in LPG.

4.10.4 Management of biogas for domestic purpose

Wide variety of items are cooked using biogas. In a general sense, all food items that require short duration cooking have been shifted to biogas. Women using biogas have been unanimous that in a day, several small cooking sessions occur. Most of the cooking is short duration cooking. Biogas is idealy designed to that.

Table 4.10.4

Management of biogas for domestic purpose	No.of respondents	Percentage
Tea/Coffee	6	20
Boiling water	8	26.67
Cooking rice	11	36.67
Others	5	16.66
Total	30	100

Source: Survey data

Chi-Square value is 2.799, degrees of freedom is 3 and p-value is >0.05

There is no significant difference between the respondents with respect to management of biogas.

4.10.5 Impact of biogas on home garden

All adopters of biogas plant follow the practice of applying bio-slurry for their Home garden. Everyone had positive trust in the effectiveness of applying slurry. The yield and productivity have enhanced since the practice of application of slurry began and the instances of diseases have reduced.

Table 4.10.5

Impact of biogas on home garden	No.of respondents	Percentage
Vegetables	4	13.33
Banana	13	43.34
Flower and growtons	4	13.33
Others	9	30
Total	30	100

Source: Survey data

Chi-Square value is 7.599, degrees of freedom is 3 and p-value is >0.05

There is no significant difference of respondents with respect to impact of biogas on home garden.

4.10.6 Impact of biogas as energy source on households

Around 37 percent (36.67%) of the respondents answered that the impact of biogas as an energy source on households is significant. Forty percent of the respondents partially used and 23.33% scarcely used.

Table 4.10.6

Impact of biogas as energy source on households	No.of respondents	Percentage
Most significantly used	11	36.67
Partially used	12	40
Very little	7	23.33
Total	30	100

Source: Survey data

Chi-Square value is 1.40, degrees of freedom is 2 and p-value is <0.05. There is no significant difference among the respondents with respect to impact of biogas as energy source in households.

4.10.7 Influence of biogas on waste disposal

Cleanliness in the kitchen and environmental upgradation is another important benefit of biogas. While precise quantitative measurement in respect of these aspects is not possible, the user households have a positive feeling of realization of these benefits.

Table 4.10.7

Influence of biogas on waste disposal	No.of respondents	Percentage
Reduced pollution	5	16.67
Reduced fuel expenses	19	63.33
Reduced fuel expenses & pollution	6	20
Total	30	100

Source: Survey data

Chi-Square value is 12.2, degrees of freedom is 2 and p-value is <0.01. Significantly higher respondents (63.33%) have reported that the biogas on waste disposal has reduced fuel expenses.

4.10.8 Gender sensitivity of biogas plant operation

Biogas is definitely an advantage as far as women are concerned. Atleast some of them had an apprehension whether this facility will increase their work burden. However, out of experience, now women say that their work burden has not increased, because of adopting biogas. Men and women share the responsibility of mixing organic waste and feeding the same into the plant.

Table 4.10.8

Gender sensitivity of biogas operation	No.of respondents	Percentage
Male	7	23.33
Female	18	60
Husband & Wife	5	16.67
Total	30	100

Source: Survey data

Chi-Square value is 9.80, degrees of freedom is 2 and p-value is <0.01

Female sex is more sensitive to use of biogas than male. Sixty percent of the households answered that women have operated biogas plant, while 16.67% households answered that both men and women have operated biogas plants.

4.10.9 Rate of satisfaction among biogas users

Forty percent of the biogas plant owners are very satisfied and 26.67%, are satisfied about the performance of the plant. But 33.33% are dissatisfied about the performance of biogas plants.

Table 4.10.9

Rate of satisfaction among users	No.of respondents	Percentage
Very satisfied	12	40
Satisfied	8	26.67
Dis satisfied	10	33.33
Total	30	100

Source: Survey data

Chi-Square value is 0.80, degrees of freedom is 2 and p-value is <0.05

There is no significant difference among users with respect to rate of satisfaction.

4.10.10 Reason for dissatisfaction

Households often face shortage of kitchen waste to feed the biogas plant. That reduces the quantity of gas generation. The Plant owners recognize that the plant is working satisfactorily by seeing outflow of slurry or the generation of gas and its availability in the kitchen.

Table 4.10.10

Reason for dissatisfaction	No.of respondents	Percentage
Inadequate quantity of waste	5	50
Inadequate quantity of gas generation	2	20
Construction fault	1	10
Other reasons	2	20
Total	10	100

Source: Survey data

The reasons for dissatisfaction are largely due to inadequate quantity of biofeed (50% of the respondents) and hence reduced gas generation.

4.11 Limitations of the study

This study on recoverable waste generation by households is completely based on average waste generation data. It is also based on the assumption that all the households generated the average amount of recoverable waste.

4.12 Conclusion

The problems related to solid waste can be reduced to a great extent if a proper management system is practiced. An efficient management system not only takes into consideration environmentally safe disposal, but also salvaging of resources from waste. The reduction, reuse and recycling of waste are very efficient way of waste management. These techniques not only reduce the waste production, but also initiate reuse of the materials considered waste. Waste reaching the landfills is also reduced by a great quantity by practicing salvaging of resource from waste.

The potential of recovery of waste material in Ernakulam is: paper - 1001.55 tonnes, plastic-200.29 tonnes, metal-200.29 tonnes and glass-300.40

tonnes from households/3 months in all the municipalities and the Corporation. This results in an average earnings of Rs.128.86 lakhs during the reference period.

Waste bought and sold by the dealers generates a profit margin of more than 20%. Similarly, on an average the rag pickers collect waste from streets are plastic Rs.8/kg/day, paper Rs.2/kg/day, metals Rs. 15/kg/week and glass Rs.10/kg/week. The waste collected is sold to retail and whole sales.

Most of the metal items include containers, utensils and parts of machines which are usually sold for reuse. Other than reuse these are transported to other states for recycling purpose. The scrap merchants segregate all types of waste and send it for recycling units to Edayar (Iron & Steel Recyling Units), Perumbavoor (Plastic Recycling Units), Mettur, Salem (Iron & Steel Recycling Units), etc.

Since solid waste management involves the entire population, full cooperation from the public is to be ensured. Public awareness is essential to accept their role in terms of following the rules meticulously and payment of necessary taxes and service charges. Along with that public should initiate waste reduction at source. Though there are lot of activities in India in the field of source reduction, an important such activities are production of compost and biogas.

The organic waste recovery rate in Cochin Corporation is 39 per cent. Households in the Cochin Corporation segregate the organic wastes which are collected and transported by the Corporation workers to Brahmapuram processing plant. It produces compost with an average of 45-50 tonnes per day. The compost is marketed by FACT at the rate of Rs.2/kg. Thus the organic waste recovery earns Rs.90,000 to Rs.1,00,000 per day. It shows that Ernakulam has the potential of producing 137.475 tonnes of compost per day. It can earn revenue of Rs.2,74,950/- per day through organic waste recovery.

The disposal of plastic waste along with the municipal solid waste is the main problem for the urban local bodies. Recycling of plastic waste can resolve the issue. The study shows that Ernakulam generated 18.49 tonnes of plastic waste per day. It has the potential of producing brick/tiles from plastic waste and can earn revenue of Rs.17,75,040/- per day. It is experienced that bricks made from plastic waste improves the life of building and particularly the requirement of materials like sand, cement and aggregates is very much less when compared to other construction. This recyclable activities can minimize any harmful impact on environment especially to reduce the sand mining.

Some of the households in Ernakulam district produce biogas from kitchen waste. The replacement value of biogas for LPG is worked out to be Rs.1890/- per household per annum. Biogas plants provide several benefits. Organic waste is the most significant source of biofeed. By using kitchen waste as feed materials for biogas, 56.67% of the respondents get biogas only up to 1 hour. The study reveals that up to 50% savings in LPG is possible by using biogas. However, households did not have any clear idea on this as no measurement has been done or observations on this aspect. Cleanliness in the kitchen and environmental upgradation is an important benefit of biogas production. The user households have a positive feeling of realization of these benefits. More than 63% have reported that the biogas has reduced fuel expenses and 20% of the respondents reported that it reduced environmental pollution. Biogas is definitely an advantage as far as women are concerned. Female sex is more sensitive in operating of biogas than males. Forty percent of the biogas plant owners are very satisfied and 26.67%, satisfied. But 33.33% are dissatisfied about the performance of biogas plants. The reasons for dissatisfaction are due to inadequate waste quantity and thus reduce gas generation. This apart, society enjoys certain benefits in terms of environmental upgradation i.e. cleanliness in the absence of littered solid waste here and there, conservation of land, water and air to maintain ecological balance etc.

Unfortunately, in Ernakulam the municipalities are not involved in waste recycling activity. The resource recovery practice is privately aided by community recycling units distributed within and outside the city. These units have been able to generate a demand resulting in employment opportunity for many as rag pickers. The waste is also recovered from the household level by the retail and whole sale units within the city. These small chains of activities are good source of resources recovery in the city. But the fact that large quantities of resources are lying unutilized in the landfills. Cochin Corporation took the initiative in separation of the organic waste and process into manure. A few households in Ernakulam segregate the organic waste and process them into manure and energy by using vermicompost and biogas technology.

The enhancement of separation can not only serve economic and social goals but also allows more effective use of the residual organic and inert wastes to achieve maximum recycling.

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Chapter - V

SOCIO-ECONOMIC ASPECTS OF RESOURCE RECOVERY

5.1 Introduction

After studying the potential economic benefits from the adoption of resource recovery practices at the household level, it is considered necessary to find out the socio-economic conditions of their resource recovery pattern with respect to solid waste management. The conditions like their education, status and income could affect their recovery pattern. In 1992 the United Nations Conference on the Environment and Development (UNCED) recommended various activities like preventing and minimizing waste production, reusing or recycling waste to the extent possible, treating waste by safe and environmentally-sound methods and disposing of the final residues by landfill in confined and carefully designed sites for effective solid waste management (Prüss et al., 1999). Various criteria to measure an effective solid waste management program are frequency of collection, method of disposal, location of disposal site, environmental acceptability of disposal system, and the level of satisfaction of the customers (Davis and Cornwell, 1998). These measures have a direct impact on socioeconomic conditions of the people practicing resource recovery in cities.

5.2 Socio-economic aspects of resource recovery – In Indian cities

In India, recycling and reuse is practiced effectively reducing the per capita waste generation. Various kinds of resource recovery activities like composting and recycling are practiced in India. According to a recent estimate, urban solid waste in India generally contains up to 20 per cent of recyclable matter, whereas the compostable material may constitute around 40 - 50 per cent, the rest being stones, dust etc, (GOI, 1998). Likewise, Ernakulam has a high potential of recycling scrap metals, rubber, plastic and glass as every 3 months. About Rs. 128.86 lakh worth of recyclable household materials are wasted (chapter II). Recycling has in some parts of Ernakulam, especially the Cochin Corporation received a strong participation of the local people due to the value of the materials. The level in which recyclables are segregated manually at source is astonishing. The reduction of waste arriving at the disposal site might be accounted for 40%. Also the quality and quantity of municipal solid waste generated by a particular community will vary according to their socio-economic status, cultural habits, urban structure, population and commercial activities. Hence the present study analyzes the socio economic aspects of resource recovery with respect to the municipal solid waste management in the study area.

5.3 Data sources and Methodology

The total number of houses in the Aluva municipality is 5333. Thirty houses were numbered and identified. Out of these, 10 were selected using lottery method from each group of wards with prominent household activity, prominent household and commercial activity and prominent commercial activity. The sample taken from other municipalities in each region as proportionate to Aluva municipality are represented in table 5.3.

Table 5.3

Name of municipality/corporation	Total number of households	Sample taken
Perumbavoor	6063	34
Angamaly	7556	43
Aluva	5333	30
Paravur	6834	38
Kochi	131692	740
Kalamassery	14206	80
Thirppunithura	13925	78
Muvattupuzha	6513	37
Kothamangalam	8186	46
Total	200308	1126

Source: Kerala State Statistics and Economics Department

The survey was conducted using a structured questionnaire containing questions concerning the solid waste disposal, and types of solid waste disposed, adequacy of the current waste management system and method of reducing the waste at source, local environmental conditions, and activities to improve the current resource recovery state. The objective of the survey was to gain knowledge regarding the local peoples' opinions on solid waste management at the ward level. This survey also helped to assess the community's participation in the current solid waste management program. The primary data were collected from 1126 respondents. The data so collected are compiled and statistically analyzed using correlation and Chi-square tests. The results of the statistical analysis of the data are summarized below:

5.3.1 Number of members in a family

Size of the family affects generation of solid waste. Generally, larger the family size more the solid waste generation. (See table 5.3.1)

Table 5.3.1

No. of persons	No. of respondents	Percentage of respondents
0-2	100	8.88
3-4	629	55.86
More than 4	397	35.26
Total	1126	100.00

Source: Survey data

Fig. 5.3.1 Family size

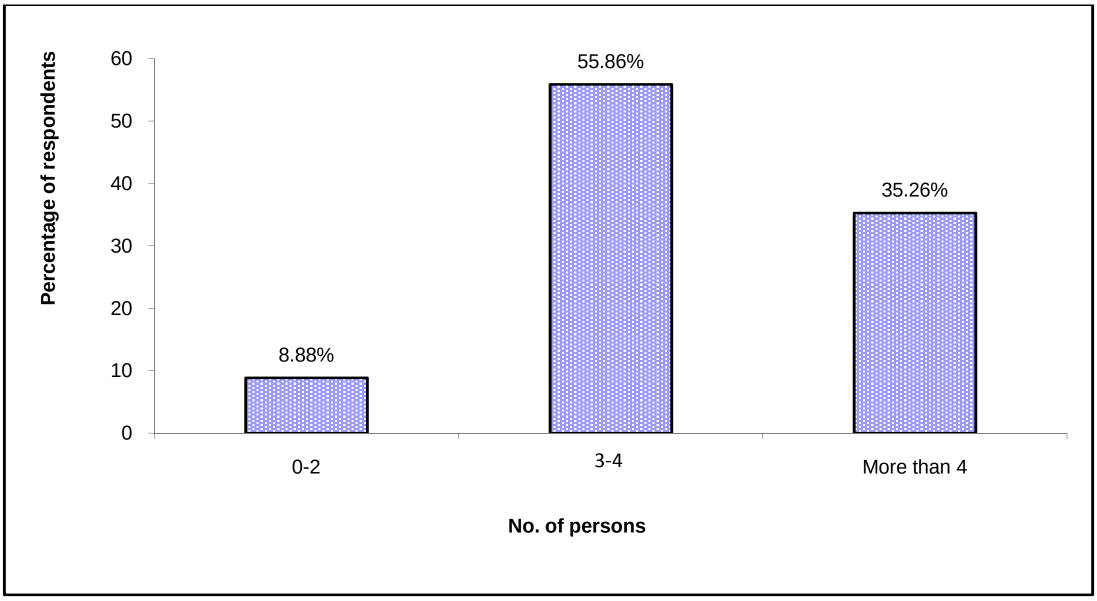


Fig. 5.3.1 explains that majority of the respondents had 2 to 4 members (55.86%) in their families. In the case of 35.25 percent respondents had more than 4 members in their families and 8.88% of the respondents had only up to 2 members in their families.

5.3.2 Income

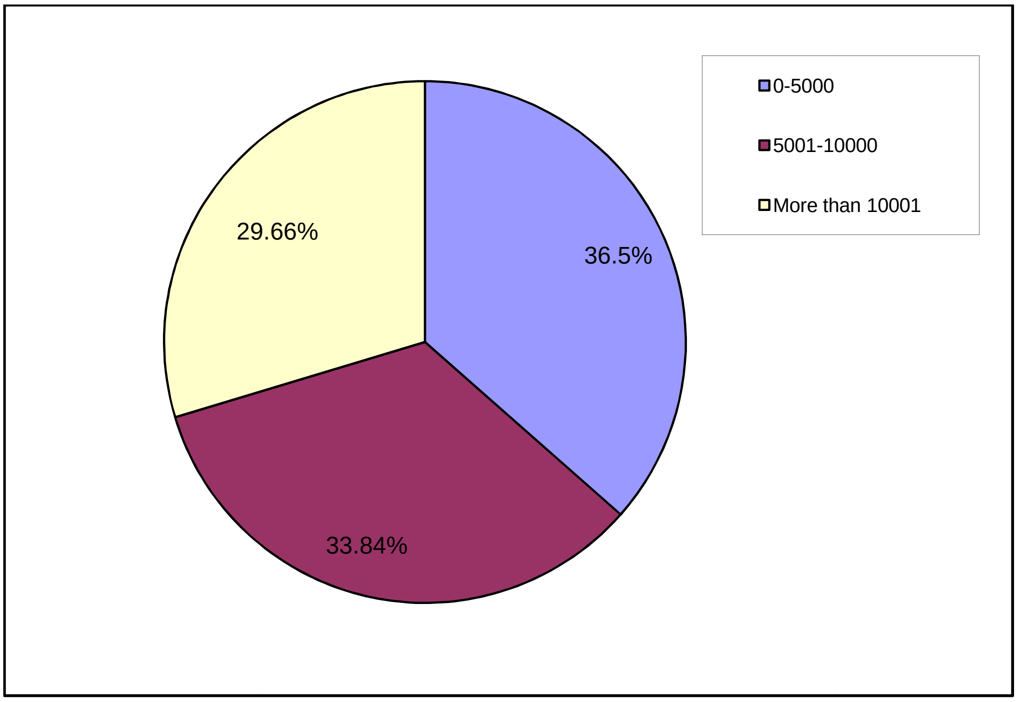
Here family income includes the total monthly income of the respondents and their family members from all sources. The respondents were asked to state their monthly income from all sources. The responses of the respondents were categorized as given in table 5.3.2.

Table 5.3.2 Income level

Income level (monthly)	No.of respondents	Percentage of respondents
0-5000	411	36.50
5001-10000	381	33.84
More than 10001	334	29.66
Total	1126	100

Source: Survey data

Fig.5.3.2 Income level



Source: Survey data

Majority of the respondent's (36.5%) monthly income was less than Rs.5000. Around 34% respondents had monthly income between Rs.5000 to Rs.10000 and around 29.66%, of the respondents more than Rs.10000 per month. This is explained in fig.5.3.2.

5.3.3 Household waste generation

Solid waste generation largely depends on the level of economic development, density of population, size of the urban habitation and the consumption rate. The data on quantity of solid waste generated by the households per day is presented in table 5.3.3.

Table 5.3.3

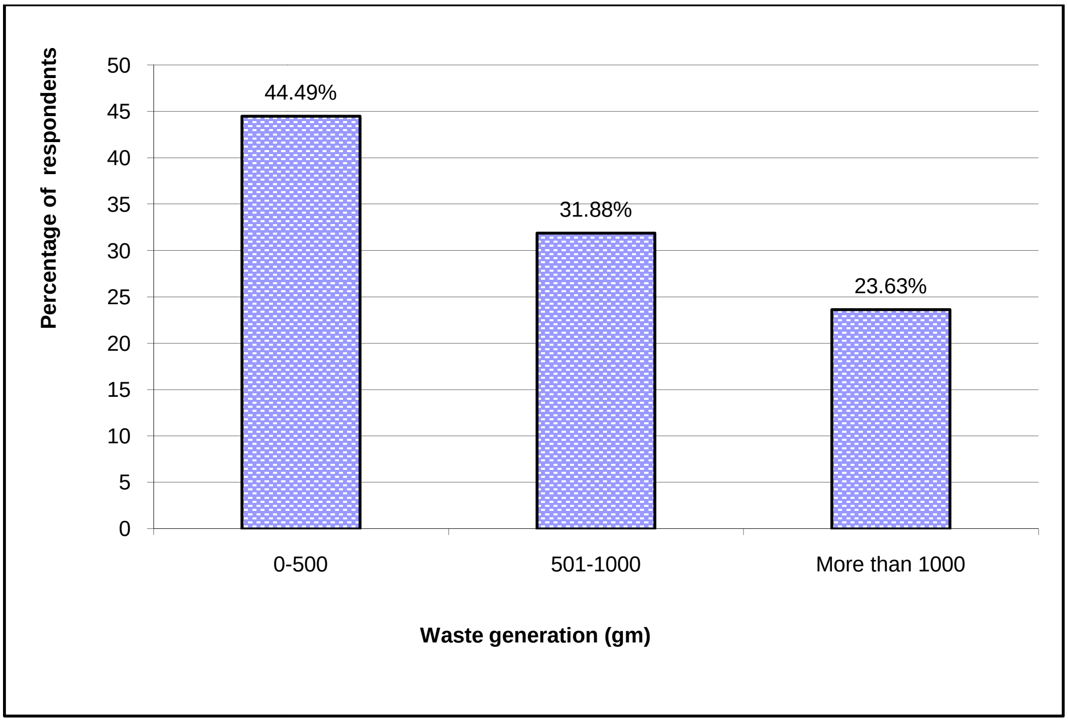
Waste generation (gm)	No.of respondents	Percentage of respondents
0-500	501	44.49
501-1000	359	31.88
More than 1000	266	23.63
Total	1126	100

Source: Survey data

Chi-Square value is 74.70, degrees of freedom is 2 and p-value is <0.001

Table 5.3.3 reveals that 44.40 percent of the respondents' families generated waste up to 500 gms per day, 31.88 percent, between 501 to 1000 gms and 23.63 percent, more than 1000 gms per day. It is represented diagrammatically in fig. 5.3.3.

Fig.5.3.3 Rate of household waste generation



Solid waste generation, as already stated, is the consequence of production and consumption activities in the economy which has some influence on the income of the household. The estimated coefficient of correlation between waste generation and income of the respondents is 0.877 and that is highly significant ($p<0.001$). The positive correlation coefficient indicates that waste generation is an increasing function of income. This implies that as income increases waste generation also will increase.

5.3.4 Waste generation and family size

The mean waste generation of family size is given in table 5.3.4

Table 5.3.4

Family size	Mean waste generation in gram
1	625
2	692.31
3	870.37
4	1003.09
5	1012.82
6	1059.52

Source: Survey data

The coefficient of correlation between waste generation and family size is positive and significant at 5% level. It indicates that the waste generation increases with family size.

5.3.5 Education of household

Education of the household here means the formal education received by the respondents in schools and in colleges. Education helps an individual to acquire knowledge and skill and that gives shape and direction to the thinking process. It is believed that the educational status of family members plays an important role in generating awareness about environmental issues. Table 5.3.5 presents information regarding the educational status of the respondent's.

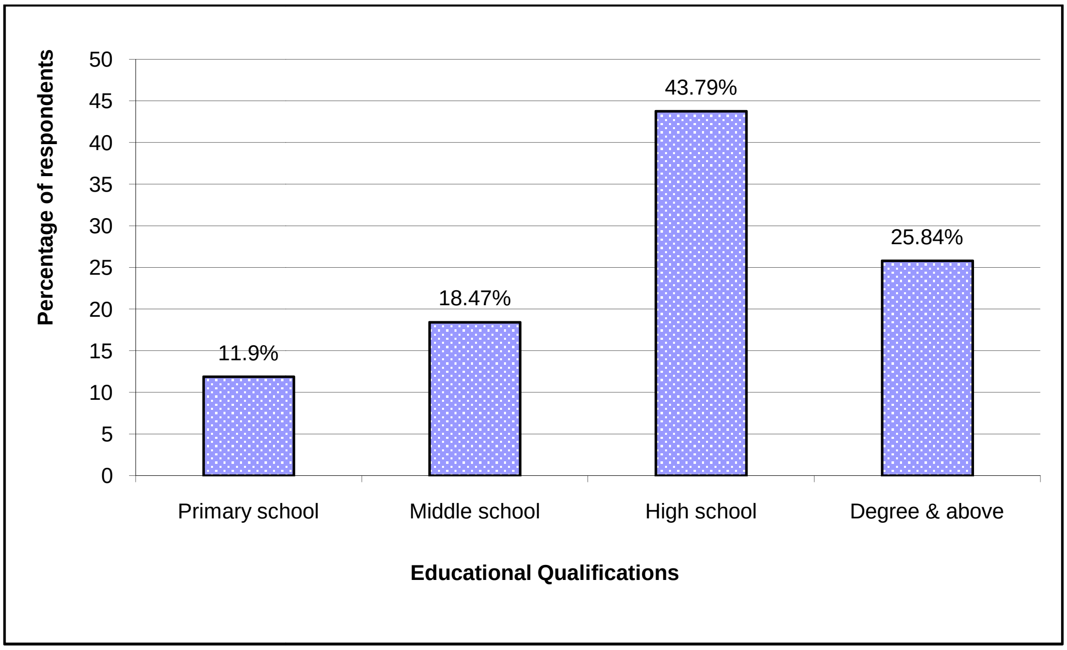
Table 5.3.5

Educational Qualifications	No.of respondents	Percentage of respondents
Primary school	134	11.90
Middle school	208	18.47
High school	493	43.79
Degree & above	291	25.84
Total		100

Source: Survey data

Table 5.3.5 reveals that majority of the respondents (43.79%) have completed high school and 25.84%, degree. More than 18% respondents have studied up to middle school and 11.90%, primary school. Also the fig. 5.3.5 explains the level of education of the households.

Fig.5.3.5 Education of household



5.3.6 Environmental pollution disturbances in residential area

It is often seen that perceptions of people with respect to consequences of pollution are not the same. This can be seen from the information provided in Table 5.3.6

Table 5.3.6

Experience of environmental pollution	No.of respondents	Percentage of respondents
Experience of environmental pollution	342	30.37
No Experience of environmental pollution	784	69.63
Total	1126	100

Source: Survey data

Chi-Square value is 17.503, degrees of freedom is 1and p-value is <0.001

Table 5.3.6 reveals that a significantly higher number of respondents (69.63%) reported that they have not experienced any environmental pollution. Only 30.37% of the respondents revealed that they have experienced pollution.

5.3.7 Method of waste disposal

The method of waste disposal is presented in table 5.3.7.

Table 5.3.7

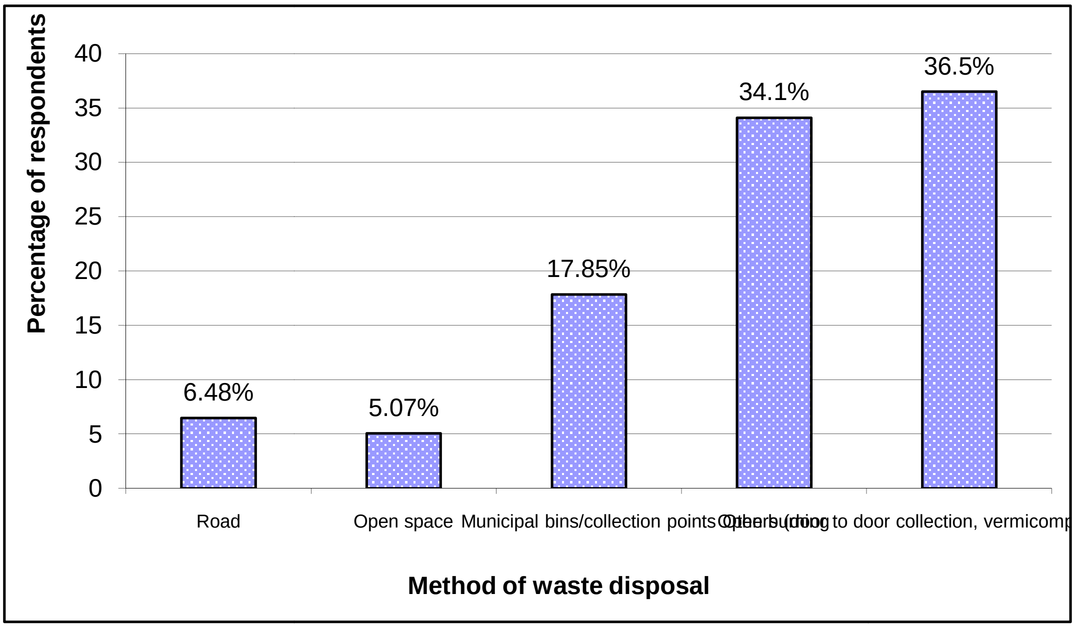
Method of waste disposal	No.of respondents	Percentage of respondents
Road	73	6.48
Open space	57	5.07
Municipal bins/collection points	201	17.85
Open burning	384	34.10
Others (door to door collection, vermicomposting, biogas)	411	36.50
Total	1126	100

Source: Survey data

Chi-Square value is 504.007, degrees of freedom is 4 and p-value is <0.001

Table 5.3.7 reveals that about 5.07 percent of the households dispose their solid waste in the open space and 6.48%, on the road side. Only 17.85 per cent of the respondents disposed their solid waste in municipal bins/collection points, while 34.10 per cent, burn their solid waste in the open. Others (36.50%) resort to door to door collection, for vermicomposting and or making biogas. And fig. 5.3.7 shows various methods of waste disposal.

Fig. 5.3.7 Method of disposal practices



5.3.8 Segregation of waste at home

Table 5.3.8 presents information regarding segregation of waste at home.

Table 5.3.8

Segregation of waste at home	No.of respondents	Percentage of respondents
Segregation of waste	742	65.90
No Segregation of waste	384	34.10
Total	1126	100

Source: Survey data

Chi-Square value is 113.822, degrees of freedom is 1 and p-value is <0.001

The data indicate that higher number of respondents (65.90%) were in favour of segregation of waste at home. The remaining 34.10% were not interested in segregation because of lack of time or because of lack of awareness about the importance for segregation.

5.3.9 Method of reducing waste

Table 5.3.9 reveals information regarding methods of reducing waste. Usable items like cloth bags, glass bottles, and metal containers are recovered by the households and they sell them to the waste collectors at nominal amounts or in exchange of some material. This helps in reducing the quantity of waste generated. Percentage of respondents with respect to the methods of reducing waste is represented in fig. 5.3.9.

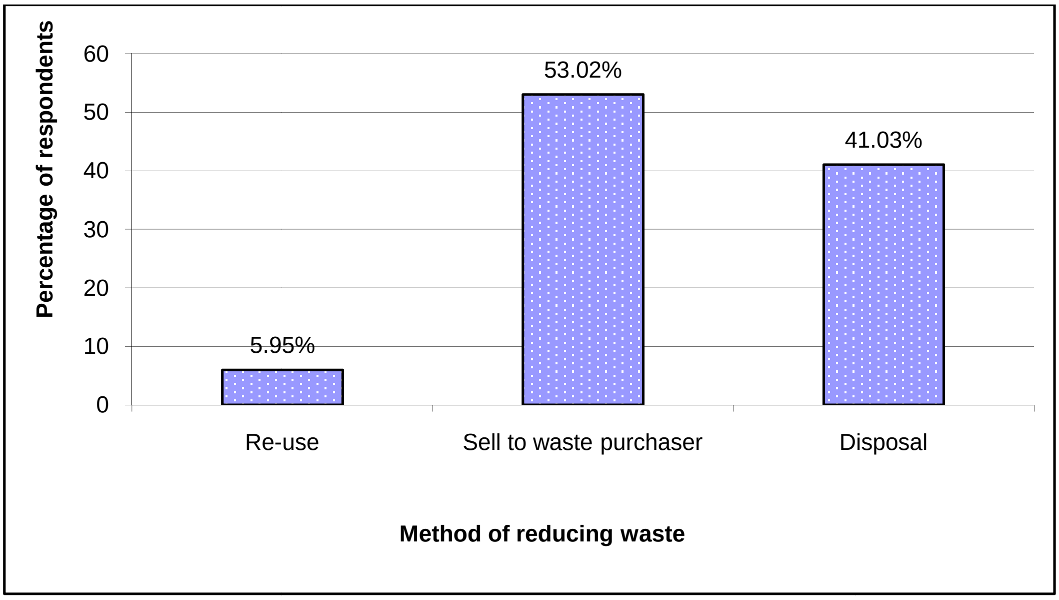
Table 5.3.9

Method of reducing waste	No.of respondents	Percentage of respondents
Re-use	67	5.95
Sell to waste purchaser	597	53.02
Disposal	462	41.03
Total	1126	100

Source: Survey data

Chi-Square value is 404.222, degrees of freedom is 2 and p-value is <0.001

Fig. 5.3.9 Methods of reducing waste



5.3.10 Awareness on household hazardous waste

Household solid waste contains both hazardous and nonhazardous components. Households knowingly or unknowingly mixed the hazardous waste with other solid waste. These hazardous wastes pose many serious health threats to the communities. Table 5.3.10 indicates the awareness on household hazardous waste.

Table 5.3.10

Awareness on household hazardous waste	No.of respondents	Percentage of respondents
Aware of household hazardous waste	592	52.58
Non Awareness of household hazardous waste	222	19.72
May be	312	27.70
	1126	100

Source: Survey data

Chi-Square value is 188.403, degrees of freedom is 2 and p-value is <0.001

Fig. 5.3.10 Awareness on household hazardous waste

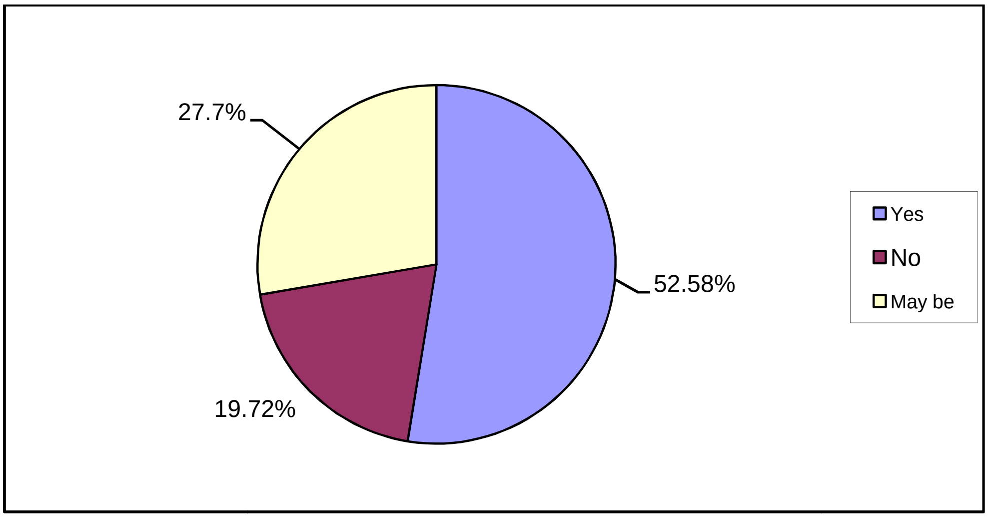


Table 5.3.10 reveals that 52.58 percent of the respondents have awareness on household hazardous waste and 19.72% do not have any

awareness regarding the hazardous nature of household waste. The rest (27.70%) are not sure about such things. This is diagrammatically represented in fig. 5.3.10.

5.3.11 Disposal of household hazardous waste

The respondents were asked about the disposal of household hazardous waste. The responses of the respondents are presented in table 5.3.11.

Table 5.3.11

Disposal of household hazardous waste	No.of respondents	Percentage of respondents
Separate	258	22.91
Mixed	868	77.09
Total	1126	100

Source: Survey data

Chi-Square value is 330.462, degrees of freedom is 1 and p-value is <0.001

Table 5.3.11 shows that most of the respondents (77.09%) disposed hazardous waste in mixed form due to lack of space or ignorance. Around 23% of the respondents disposed the waste in segregated form.

5.3.12 Acceptance of services on solid waste management by municipalities/Corporation to public

The collection, transportation and disposal of solid waste are done by the local bodies in cities and towns. Municipalities and the Corporation are responsible for the clearance of solid waste in the study area. The respondents were requested to reveal the services they get from municipalities or the Corporation in disposing their solid waste. The information provided by the respondents on this matter is presented in table 5.3.12.

Table 5.3.12

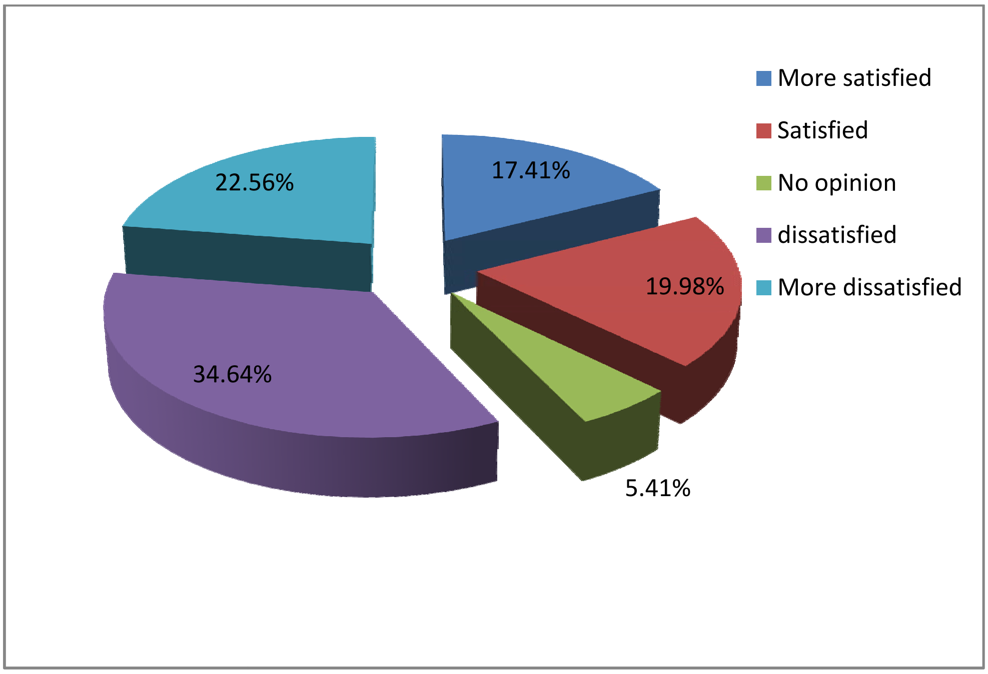
Public acceptance of municipal services	No.of respondents	Percentage of respondents
More satisfied	196	17.41
Satisfied	225	19.98
No opinion	61	5.41
dissatisfied	390	34.64
More dissatisfied	254	22.56
Total	1126	100

Source: Survey data

Chi-Square value is 247.792, degrees of freedom is 4 and p-value is <0.001

Table 5.3.12 reveals that 37.39 percent of the respondents are satisfied by the services rendered by the municipalities and the Corporation while 57.20 percent are not satisfied. About 5.41% of the respondents are indifferent on this aspect. It is represented diagrammatically in fig.5.3.12.

Fig.5.3.12 Public acceptance of municipal services



5.3.13 Willingness to pay for pollution free environment

Households were asked if they would be willing to pay some price for regular collection of garbage. The information on this is presented in table 5.3.13.

Table 5.3.13

Willingness to pay	No.of respondents	Percentage of respondents
Willingness to pay	852	75.67
Not Willingness to pay	274	24.33
Total	1126	100

Source: Survey data

Chi-Square value is 296.700, degrees of freedom is 1 and p-value is <0.001

Table 5.3.13 reveals that 75.67% of the households are willing to contribute towards garbage disposal program, while the rest (24.33%) were not.

5.3.14 Whom to tackle the waste problem

The respondents were required to identify the agency or agencies responsible for tackling the waste problem. The information provided by the respondents are presented in table 5.3.14.

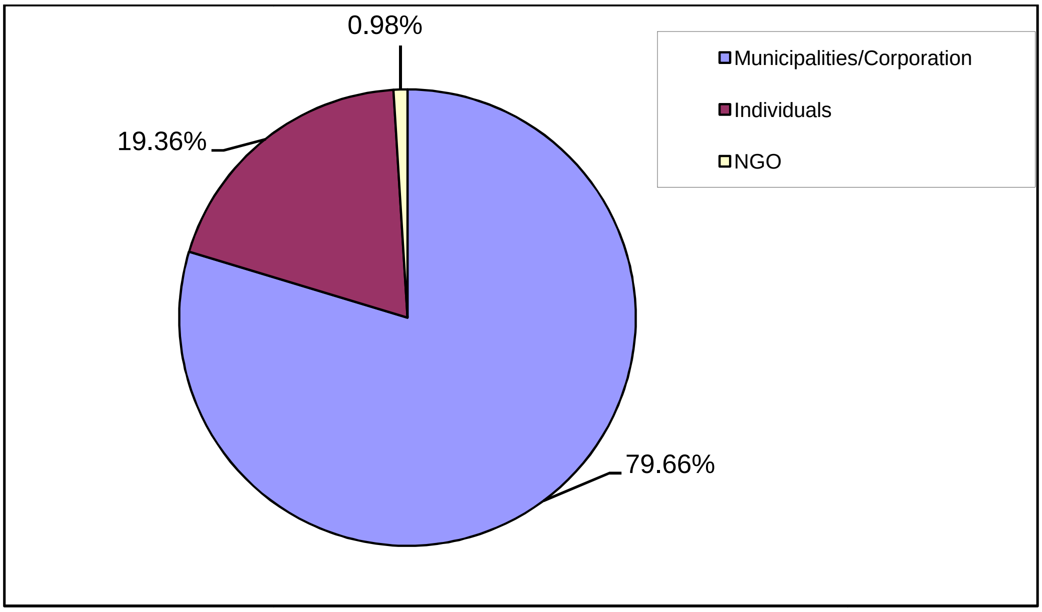
Table 5.3.14

Responsibility for tackling waste problem	No.of respondents	Percentage of respondents
Municipalities/Corporation	897	79.66
Individuals	218	19.36
NGO	11	0.98
Total	1126	100

Source: Survey data

Chi-Square value is 1145.535, degrees of freedom is 2 and p-value is <0.001

Table 5.3.14 indicates that 79.66 percent were of the opinion that the Municipalities and Corporation are responsible for tackling the waste disposal problem. More than 19 percent of the respondents hold the view that individuals themselves are responsible for tackling the problem while 0.98% was of the opinion that NGOs are responsible for tackling the waste problem. Fig. 5.3.14 explains the responsibility for tackling waste problem.



5.4 Limitations of the study

Some error might have occurred in the survey and with respect to the sample selected. Only a small sample was selected from a large population. In order to accurately measure waste generation by household, the researcher should have gathered information from the households. But that was not possible because of time and resource constraints.

5.5 Conclusion

As generators of solid waste, the public must be aware of the hazards posed by ineffective management of the waste. Household solid waste contains both hazardous and nonhazardous components, which are disposed together with other municipal solid waste or buried. Hazardous wastes pose many serious health problems. Resource recovery helps in reducing the hazardous problems of solid waste. The recovery of the usable materials like cloth bags, glass bottles, and metal containers occurs at the household level by the waste collectors who generally pay a nominal amount for the material or provide some useful material in exchange. The socio economic study revealed some idea about the waste generation and the citizen's attitude in dealing with the recyclable waste. The observations made by the respondents show that there is a positive contribution from the public in resource recovery system.

The study indicates that the size of the family affects the generation of solid waste. The coefficient of correlation between waste generation and family size is positive and significant at 5% level. Besides these higher number of households reported that the waste generation varies between 0-500gm. The coefficient of correlation between waste generation and income of the respondents worked out to be 0.877 which is highly significant ($p<0.001$). It is also realized that educational status of family members plays an important role in determining the way one gathers information about environmental pollution, and the perceptions of people on the consequences of pollution are not the same. The individuals differ in their perceptions according to their period of stay, income, literacy, etc. The data show that 69.63% of respondents have not experienced any environmental pollution. Access to safe disposal facilities is limited for the great majority of households, and this circumstance results in indiscriminate disposal practices, improper burning, and burying of solid waste. The result of the study shows that there is significant difference in the method of waste disposal. Majority of the respondents reported that they used road sides and open space for waste disposal.

Segregation of waste is mandatory in Cochin Corporation and 65.90% of respondents were in favour of segregation of waste at the source itself.

Only lesser number of households cited cost as a reason for not segregating waste.

The resource recovery at household level influences the waste collectors who buy the waste at nominal rates or providing some materials in exchange. The study indicates that significantly higher numbers of respondents are in favour of selling waste. The private businessmen who buy waste help to reduce the workload of the municipalities and the Corporation.

Hazardous waste generated in households pose severe health problems. Most of the respondents (52.58%) are aware of this. But even, then they disposed hazardous wastes along with other solid wastes due to lack of space and or lack of awareness about scientific methods.

Solid waste management services are rendered by the local bodies. But low infrastructural facilities and financial constraints hamper the municipalities and the corporation in providing the required service. This causes dissatisfaction among the public. The public prefer door to door collection of solid waste to keep the streets and drains clean.

The study also revealed that 75.67 percent of the households are willing to contribute to the solid waste management for having a pollution free environment. This aspect must be kept in mind by the authorities in planning the process of waste management. Without public cooperation, no scheme of solid waste management programs will be successful.

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Chapter - VI

PERCEPTION OF PEOPLE LIVING NEAR DUMPING YARD

6.1 Introduction

We have discussed the socio-economic aspects of solid waste management particularly with reference to resource recovery in the last chapter. Now it is required to study the environmental perception of the people living near the dumping yard. Environmental perception has been defined as the process of taking cognizance of a sensible or a quasi-sensible object, or the process of becoming aware of something. Thus environmental perception is the process of taking cognizance of the environment. Individuals and groups of people relate to environment through their perception. Their decisions and actions are influenced by perception of internal link within a problem rather than externally defined objects (Whyte, 1977). It is also based on traditions, customs, myths, awareness and stage of socio- cultural development. Environmental perception is based on custom, culture, faith, objectives and experience and differs from person to person. Environmental perception plays the most significant role in management of environment especially in solid waste management. Perception constitutes a value system that constraints planning and purification. Thus the solution to environmental problems must be based on a clear perception of them.

6.2 Environmental aspects of municipal solid waste dumping yard

In India, most of the municipal solid waste is dumped in a mixed form in an unscientific manner on open waste land or low lying areas which do not meet the norms of disposal specified in the Municipal Solid Waste Rules.

These dumping grounds affect the environment by air, water and soil pollution (R.K.Sinha, 2000).

Concentration of pollutants varies from season to season depending on ambient temperature and precipitation. They are emitted all over the ground haphazardly and this phenomenon is more significant in summer. During monsoon, it gets settled with precipitation and the effect is not very significant. The contaminant concentrations tend to decrease, during the post monsoon season and increase, during the pre monsoon season in most of the samples (Mohan et.al.2009). Leachate collected from the site showed the presence of heavy metals. The quantity of leachate will be more in Kerala due to heavy rainfall. It is the state where large numbers of wells are used for drawing ground water for domestic purposes as well as for agricultural use. The use of such polluted water will affect adversely the health of the people and as well as crops. Once the ground water is polluted it may take decades to attain the normal condition. Also the decomposition of solid waste, when dumped into the dump-yards without any treatment, gives rise to generation of methane, which is a greenhouse gas responsible for global warming, climate change and related impacts.

6.3 Health aspects of municipal solid waste dumping yard

These open dumping areas can create health problems by reducing oxygen content in the air. If oxygen content in the air is reduced from 21% to 17% asphyxiation can occur. Such low oxygen levels are possible if landfill gas accumulates to a ratio of 1:4 in air (Wilhelm, 1989). Generation of anaerobic gases in open dumping areas create bad odour and that results in a variety of diseases. A critical review of the North American literature indicated that headaches, wheezing, sleepiness, narcotic symptoms and mood disorders occur among residents living proximal to a landfill (Croen, 1998). Vector-related diseases remain an important public health threat throughout developing countries. The dengue vector mosquito that spreads dengu fever favors small, clean water pools for breeding in containers, tires, and tin cans found in waste piles (Listorti, 1996). Domestic animals (e.g., cows, goats, pigs, chicken, and horses) are present at most of the open dumps in these countries. Such animals are prone to infection. Wastes from slaughterhouses are often indiscriminately discharged to the same open dumps as municipal solid wastes, raising concern about diseases such as mad cow diseases being spread when animals eat the infected flesh of other animals (Cowell, 1996).

Improper disposal of municipal solid waste at the dumping sites attracts rodents, flies, etc. Apart from this, open dumping of wastes create unhygienic conditions and that is a case of persistent complaints from people residing near such areas. The public perception of environmental pollution among different culture groups brings out the importance of perception surveys in cognition of problems and approaches to their solution (Karan, 1977).

Hence this chapter aims at a detailed survey on perceptions of people living near the processing yard of the Cochin Corporation and the municipalities viz; Kalamassery, Thirupunithura, Paravur, Angamaly, Perumbavoor, Kothamangalam and Muvattupuzha.

6.4 Data sources and methodology

- The percieived consequences of environmental and health impacts have been assessed in respect of factors such as physical health, mental health, income, habits and social values.
- The cartographic techniques and the GIS tools have been used to represent the dumping sites data.
- The 240 respondents who are living near the dumpsite at the distance of <500m are selected from the study area of Cochin Corporation and

the municipalities viz., Kalamassery, Thirupunithura, Paravur, Angamaly, Perumbavoor, Kothamangalam and Muvattupuzha. At the time of data collection, the Aluva municipality had no dumpsite. It disposed and transported the waste to Tamil Nadu through a private agency. Thus 30 respondents from each municipality and corporation are selected randomly to a total of 240.

- The data has been collected from 240 respondents with the help of an interview schedule, specially constructed for the purpose of this study through review of literature, discussion with the municipal workers and advisors.
- The interview schedule has been designed in such a way which included questions to measure the environmental perception of the respondents living near dumpsite and perception of consequences of environmental pollution due to solid waste dumping site.
- The data collected through personal interview schedule were coded, transferred on the data sheet and tabulated in respect of frequencies. The data were analyzed with the help of statistical tools such as frequency distribution, Percentage, Mean and Chi-square.

6.5 Environmental and Health impacts of dumping yard

The various factors responsible for environmental and health impacts are discussed below

6.5.1 Family Income

Family income includes the total monthly income of the respondents and family members from all the sources. The respondents were asked to state their monthly income through all sources. The responses of the respondents were categorized in table 6.5.1.

Table 6.5.1: Income of the household

Income level	No.of respondents	Percentage
Less than 5000	117	48.75
5000-10000	84	35.00
More than 10000	39	16.25
Total	240	100

Source: Survey data

Majority of the respondent's monthly income was less than Rs.5000 (48.75%) followed by respondents with monthly income between Rs.5001 to Rs.10000 (35%) and 16.25% of respondents with the monthly income of more than Rs.10000.

6.5.2 Duration of stay in the Locality

This refers to the time period for which the respondent and their family members have been residing in the locality. The period of stay was recorded in years. This is shown in table 6.5.2.

Table 6.5.2: Duration of stay

Duration of stay	No.of respondents	Percentage
Less than 5 years	83	34.58
5-10 years	112	46.67
More than 10 years	45	18.75
Total	240	100

Source: Survey data

Majority of the respondents (46.67%) were staying near the dumpsite for 5 to 10 years and 34.58% for less than 5 years. The rest of the respondents were staying near the dumpsite for more than 10 years.

6.5.3 Household solid waste storage practices

Home storage of solid waste is a common practice among households in Ernakulam. Many households store waste in open containers ranging from baskets to plastic bags. This is highly unhygienic as over 70 percent of household solid waste generates organic matter which decomposes rapidly and produces bad odour. Again, organic waste, when stored in open containers for long periods, breed disease-carrying vectors like rodents and insects and attracts flies into household kitchens.

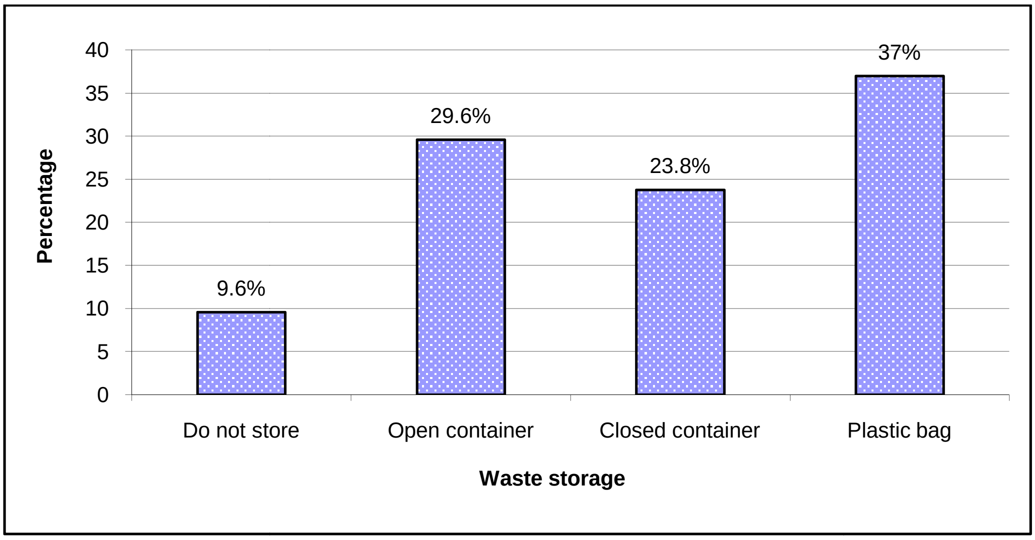
Table 6.5.3: Waste storage practices

Waste storage	No.of respondents	Percentage
Do not store	23	9.6
Open container	71	29.6
Closed container	57	23.8
Plastic bag	89	37.0
Total	240	100

Source: Survey data

Significantly large number of respondents (37.0%) reported that they used to store waste in plastic bags. These wastes are then disposed indiscriminately. (Chi-square value – 38.951, degrees of freedom – 3 and p value < 0.001). Fig. 6.1 shows different waste strorage practices of the respondents.

Fig. 6.5.3 Household solid waste storage practices



6.5.4 Impact of solid waste storage practices in home

It was already pointed out that household solid waste stored in open attracted flies and they enter kitchens. These houseflies are vectors of various infectious diseases. They transmit diseases through food contamination either by direct contact with food or through their droppings. The high incidence of diarrhea among children is related to food contamination caused by flies.

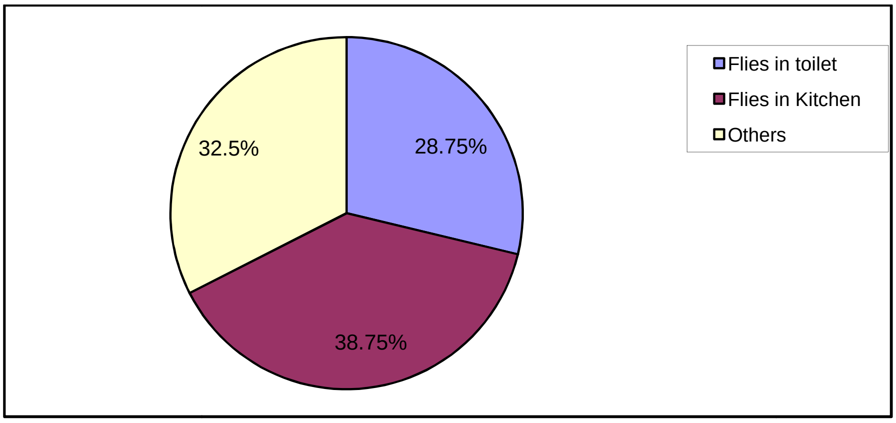
Table 6.5.4: Disturbance of flies

Presence of flies	No.of respondents	Percentage
Flies in toilet	69	28.75
Flies in Kitchen	93	38.75
Others	78	32.50
Total	240	100

Source: Survey data

Table 6.5.4 shows that significantly higher number of respondents (38.75%) reported about the presence of flies in their Kitchens (Chi-square value – 7.676, degrees of freedom – 2 and p value < 0.05). Fig. 6.5.4 explains the presense of flies in the respondents' houses.

Fig. 6.5.4 Presence of flies



6.5.5 Water related environmental pollution

Water pollution refers to the deterioration in chemical, physical and biological properties of water caused mainly by human activities. Water pollution causes harmful effects on human and aquatic bodies. Most of the rivers, lakes and reservoirs in Kerala are polluted and so water from these sources is not safe for human consumption. Water pollution is the most important cause of public health problems both in urban and rural areas.

Table 6.5.5: Impact on water quality

Change of water colours in wells	No.of respondents	Percentage
Yes	32	33.33
No	64	66.67
Total	96	100

Source: Survey data

(Total no.of respondents having well: 96)

In spite of the above situation a large number of respondents (66.67%) did not point out this aspect. They did not report any change in the colour of water. (Chi-square value – 10.667, degrees of freedom – 1and p value < 0.01). This paradox may be due to the fact that during monsoon season the pollutants get settled in water and so the adverse effect is not very significant.

6.5.6 Air related environmental pollution

Air pollution refers to those conditions in which the general atmosphere contains substances in concentrations which are harmful to man or his environment (Gilpin, 1976) or which interferes directly or indirectly with man's comfort, safety or health. Air pollution is one of the commonest forms of environmental deterioration. The dust in air pollution causes respiratory diseases. Other diseases include pneumonomiosis, silicosis and asbestosis, which are caused by inhalation of dust. Eye ailments include cataract, conjunctivitis, corneal ulcers, and squint trachomia.

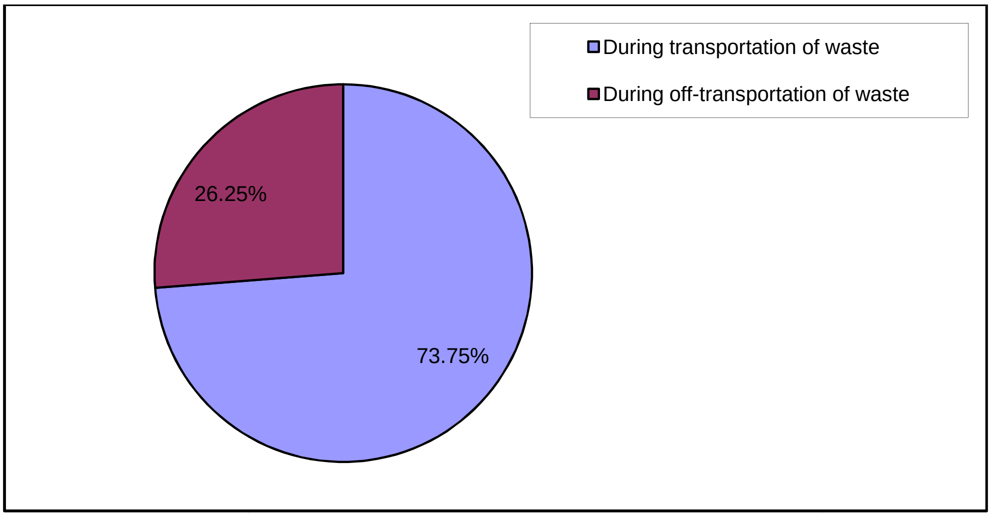
Table 6.5.6: Impact on air

Air pollution	No.of respondents	Percentage
During transportation of waste	177	73.75
During off-transportation of waste	63	26.25
Total	240	100

Source: Survey data

Air pollution is significantly high during transportation of waste (Chi-square value – 54.15, degrees of freedom – 1 and p value < 0.001). The table shows that 73.75% respondents are affected by odour during transportation of waste through their lane. This is represented diagrammatically in fig. 6.5.6

Fig. 6.5.6 Impact on air



6.5.7 Impact of solid waste on health

Landfills often give rise to health concerns in the community. An increased prevalence of self-reported health symptoms such as fatigue, sleepiness, and headaches among residents near waste sites has consistently been reported.

Table 6.5.7: Solid waste related diseases

Solid waste related vector borne diseases	No.of respondents	Percentage
Chikunkunya once in a year	60	25
Frequent head ache, vomiting, etc.	81	33.75
Others (Malaria, Dengu, Fever, Loose motion)	99	41.25
Total	240	100

Source: Survey data

Frequent head ache, vomiting, Malaria, dengu fever and loose motion were reported by significantly higher number of respondents (Chi-square value – 9.526, degrees of freedom – 2 and p value < 0.01). The table 6.5.7 shows that 41.25% of the respondents were affected by Malaria, Dengu, Fever and loose motion, 33.75%, by frequent head ache and vomiting and 25%, by chikunkunya once in a year.

6.5.8 Household perception on impact of solid waste dumping site

According to household perception study the current waste management service is inadequate. The previous study (Chapter V) suggests that a large percentage of households are willing to contribute to an improved solid waste management program in Ernakulam. Recycling and composting are also viable options for Ernakulam to reduce the amount of solid waste that is currently being disposed of at the dump yard.

Table 6.5.8 presents information regarding perception of the respondents with respect to solid waste pollution.

Table 6.5.8: Solid waste pollution

Solid waste pollution	No.of respondents	Percentage
No problem	16	6.67
Problem	161	67.08
Major problem	63	26.25
Total	240	100

Source: Survey data

Significantly higher number of respondents view (Table 6.5.8) that solid waste pollution as a serious problem for them (Chi-square value – 136.856, degrees of freedom – 2 and p value < 0.001).

6.5.9 Willingness to accept to stay near dump site

The environmental quality is a major determinant of property value at any location. Waste dumpsites affect property values negatively. Properties located nearer to, waste dumpsite will have lower value than identical ones located further away from such sites. The reason is that poor quality of the surrounding areas of dump sites create social cost to the residents. As such, residents will have to spend substantial amount of their income in offsetting the social cost. This is true of tenants and that will be reflected in low rents of properties located closer to the waste dumpsites

Table 6.5.9 presents information regarding willingness of respondents to stay near the dump sites.

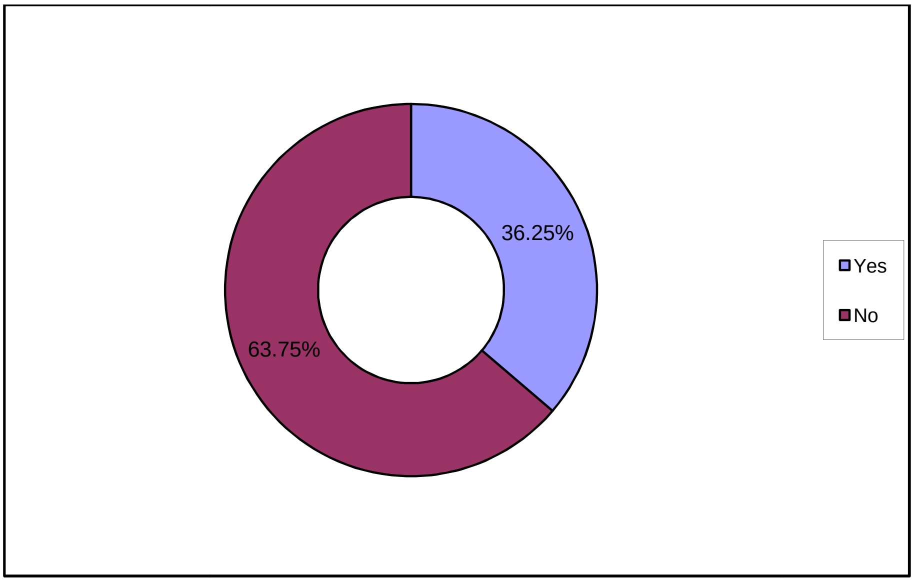
Table 6.5.9: Willingness to accept

Willingness to accept	No.of respondents	Percentage
Yes	87	36.25
No	153	63.75
Total	240	100

Source: Survey data

Table 6.5.9 reveals that significantly higher number of respondents are not willing to stay near dump sites (Chi-square value – 18.150, degrees of freedom – 1 and p value < 0.001). This is because of the reason mentioned earlier. The Fig. 6.5.9 shows the willingness of the respondents to stay near the dump site.

Fig. 6.5.9 Willingness to accept



6.6 Limitation

This study is confined to problems relating to municipal solid waste only.

6.7 Conclusion

The study reported here demonstrated the problems of municipal solid waste practices and the associated environmental and health problems.

Most of the households store their waste in open containers (29.6%) ranging from baskets to plastic bags (37%), making home storage unhygienic. Access to safe disposal facilities is limited for the great majority of households, and this circumstance results in indiscriminate disposal practices, improper burning, and burying of solid waste. Improving access to safe disposal facilities, in addition to conducting awareness campaigns on the health impacts of poor sanitation, will help alleviate the problems of improper waste disposal and eventually improve the quality of the environment in the city.

Due to chemical reactions below the ground, obnoxious gases and chemicals emit throughout the year. However it is intensified during summer and affects the human health, damage sensitive equipments like computers, electronic devices etc. The results regarding water pollution arrived from data shows that 66.67% of the respondents do not have colour change in well water. The separation or recycling of materials with high contents of heavy metals or organic contaminants decreases the concentration of these pollutants in the remaining MSW stream, thereby reducing the emissions from the dumping yard.

Air pollution during transportation of solid waste is significantly high. Most of the respondents (73.75%) are affected by odour while during transportation of waste through their lane. The urban local bodies can take steps to remove and transport the solid waste at least within two days from the collection bin. This will reduce further decomposition of waste in collection bin and consequently the odour during transportation of waste.

Landfills often give rise to health concerns in the community. The study reveals that 41.25% of the respondents are affected by Malaria, Dengu, Fever and loose motion, 33.75% of the respondents are affected by frequent head ache and vomiting and 25% of the respondents are affected by chikunkunya once in a year. The water borne diseases, such as cholera, typhoid, diarrhea, dysentery, malaria and intestinal worms claim a heavy toll of life. This is mainly because of breeding of flies in stagnant water pools, waste tyres, coconut shells, etc. Fresh water mosquito spreads dengu fever and chikungunya while malarial and filarial vectors breed in stagnant water in canals. Thus the health department in all the municipalities concentrates on mosquito eradication by intensifying vector control activities so that chikungunya does not spread to more places.

Deteriorating environmental quality is a major cause of high incidences of infectious and parasitic diseases. An increased prevalence of self-reported health symptoms such as fatigue, sleepiness, and headaches among residents near waste sites have consistently been reported. The treatment of waste at source and elimination of breeding grounds of mosquitoes will reduce the health related problems of solid waste.

It is found that many residents continue to stay near the dump sites as they have no other alternative or because of sentiments connected with ancestral property. Significantly higher number of respondents (63.75%) expressed that they are not willing to stay near dump site. Willingness to pay for reducing impacts of pollution from dump sites is relatively low.

The study shows that public attitudes to specific waste management facilities are so strongly negative. About 67.8% of the respondents complained about the solid waste pollution and think that the current waste management service is inadequate.

Recycling of waste into useful resources will create jobs for recyclers and will improve the environment. Metals such as aluminium can be recovered from solid waste that can be and sold to small-scale recyclers who can produce valuable items such as lamps and cooking utensils using the same. Organic waste can be composted and used as fertilizer in urban farming and help reduce reliance on inorganic fertilizers. If wastes are properly processed then the present and potential dumping sites can be used for better commercial purpose.

Since a sizeable section of the community is willing to assist in local solid waste management programs, the local government must be prepared to collaborate with them in solid waste management.

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Chapter - VII

SUMMARY AND CONCLUSION

Waste management is a critical problem for the local self governments. The unscientific method of dumping waste in open space creates several environmental as well as health problems. Scientific and economic methods of waste management are now available. By making use of these methods waste can be converted into assets. The present study on solid waste management is an attempt to understand and identify the emerging socio-economic and environmental issues with emphasis on solid waste management in Ernakulam district. The issues discussed in the thesis are,

1. Solid waste generation in the corporation and municipalities in Ernakulam district, the units generating waste, the quantum of waste generated by each unit in the study area.
2. Existing and required level of infrastructure facilities for optimum clearance of waste and converting the waste into useable products.
3. The present resource recovery and recycling activities available and the required facilities for profitable and environment friendly methods of waste treatment.
4. Evaluate the effects of resource recovery and solid waste management on the basis of a case study of Ernakulam district.
5. Environmental perception of people living near landfill sites.

7.1 Summary of the findings

Solid waste is generated by various urban activities. The study classified the solid waste generation units in the city. They are residential houses, commercial establishments, motels, hospitals, industrial and bio-medical institutions. The quantum of solid waste generated by residential houses, commercial establishments, motels and institutions in the district is estimated to be 382.89 tonnes per day. The biomedical waste generated is 7.5 tonnes per day. Apart from the solid and biomedical waste generated, around 41506 tonnes of hazardous waste per annum is generated in the district.

7.1.1 Existing facilities for waste clearance

The study highlights the deficiency in the number of sanitary workers and vehicles in each municipality and the corporation. At present Ernakulam district has only 1165 sanitary workers and 71 vehicles for the purpose of waste management. With the present resources available the district can manage only 53% of the solid waste generated in the city.

7.1.2 Required facilities for clearing and converting the waste into salable products

The required number of workers for clearing waste in Ernakulam district is 2243. Altogether the clearance efficiency in Ernakulam increased as much as 67.29 tonnes per day by cycle carts compared with hand collection of 2.243 tonnes.

The study further shows that the required number of vehicles to clear the waste is 96. But only 71vehicles are available. The optimum clearance of solid waste by the required number of vehicles is 382.89 tonnes per day.

7.1.3 The present resource recovery and recycling capacity

The resources recovered from households in the district is around 1001.55 tonnes of paper, 200.29 tonnes of plastics, 300.40 tonnes of glasses during the period of 3 to 4 months. From this, the households can earn around Rs.128.86 lakhs.

Waste dealers in the city earn around Rs.400/- per day. Besides recovery at household level, waste is also recovered from community bins, transfer stations and land fill sites by rag pickers. They earn a minimum of around Rs.50/- per day.

The scrap merchants buy scraps from scrap collectors and after segregation send them for recycling units to Edayar (Iron & Steel Recyling Units), Perumbavoor (Plastic Recycling Units), Mettur, Salem (Iron & Steel Recycling Units), etc.

Households in the Cochin Corporation mostly segregate the organic waste and that is collected by the Corporation workers for transporting to Brahmapuram processing plant.

At present, out of the total waste generated (255tonnes/day) Cochin Corporation’s organic waste recovery rate is only 100 tonnes (39.21 per cent). From 100 tonnes of organic waste collected per day the Cochin Corporation produces 45 tonnes of compost. Cost and economic return of resource recovery shows that the earnings of Cochin Corporation from compost is between Rs.90, 000 to Rs.1, 00,000 per day.

The 382.89 tonnes of waste generated in Ernakulam district has a potential of producing 137.475 tonnes of compost per day and that could earn a revenue of Rs.2, 74,950 per day.

Some municipalities are trying to produce bricks and fencing poles from plastic wastes with the help of National Small Industries Corporation. From one tonne of plastic wastes 1000 bricks can be produced. Ernakulam generates 18.49 tonnes of plastic wastes. This has the potential of producing 1,47,920 bricks and that can earn Rs.17,75,040 per day.

7.1.4 The gap in solid waste management practices

There is lot of gap in solid waste management practices among and between municipalities and the Corporation. Though economically profitable methods of waste management are available, the municipalities and the Corporation are not making use of such facilities. Now some half -hearted methods are used to generate compost or biogas, briquettes. No concerted action is so far been taken by any municipality or the corporation to fully convert the waste into usable and economic assets.

7.1.5 Additional facility required

Lack of proper system of collection, processing and management of solid waste; create serious health and environmental problems in the Corporation and Municipal areas. Such problems arise as waste is thrown into canals, drains and road sides. The efficiency of waste collection is only 53%. This is to be increased to 100 percent. This can be achieved by proper waste management by creating awareness among the public, using waste for biogas production, encouraging segregation of solid waste at the source itself involving public participation, acquisition of modern environment friendly vehicles to carry waste and developing proper processing systems. At present the whole programme of Solid Waste Management for Ernakulam district is proposed to be taken up with Public Private Participation at Brahmapuram. The present Brahmapuram project is exhibiting several problems.

7.1.6 Effects of solid waste management practices

When solid waste is not disposed properly it can have consequences of the environment and its natural vegetation and inhabitants, as well as for public health. Usually proper solid waste management practices are in place, but those standards are not always practiced.

The study reveals that about 5.07 percent of the households dispose their solid waste in the open space and 6.48%, on the road side. Only 17.85 per cent of the respondents disposed their solid waste in municipal bins/collection points, while 34.10 per cent, burn their solid waste in the open. Others (36.50%) resort to door to door collection, for vermicomposting and or making biogas. The irresponsible methods of waste disposal creates negative side effects and often causes serious health problems such as malaria, Dengu fever, influenza, H1N1 fever, Chikunkunya etc. Another major negative impact is water pollution. Drinking water in the area is highly polluted. From the drinking water supplied by the Water authority is highly contaminated. This causes water borne diseases such as loose motion, gastroenteritis, etc.

Air pollution during transportation of solid waste is significantly high. Most of the respondents (73.75%) are affected by bad odour during transportation of waste through their lanes.

7.1.7 Environmental Perception of People Living Near Landfill Sites

The study shows that the entire households living near the dumpsites are highly susceptible to mosquitoes and fly borne diseases. Around 40 percent of the population in the district are affected by one of the above mentioned diseases. They also experiences frequent head ache and vomiting also.

Significantly higher number of respondents (63.75%) expressed that they are not willing to stay near the dump sites. Willingness to pay for reducing impacts of pollution from dump sites is relatively low. About 67.8% of the respondents complained about the solid waste pollution and think that the current waste management service is inadequate.

7.2 Suggestions

The study analyzed the pros and cons of solid waste management in Ernakulam district and suggested that 100 percent efficiency in solid waste management is achievable by creating awareness among the public, using waste for biogas production, encouraging segregation of solid waste at the source itself with public participation and carrying waste in covered vehicles and developing proper processing systems.

7.3 Conclusion

This thesis analyzed waste generation and waste disposal problems in municipalities and Cochin Corporation in Ernakulam district. Then the potential of resource recovery and recycling from biodegradable and non bio-degradable waste is established. The study further focused on the need for segregation of waste at the source as biodegradable and non biodegradable solid waste. The potential of resource recovery is explained in detail through the case study.

The thesis also highlights the economically viable and environmental friendly methods of treatment of waste. But the problem is that concerted and earnest attempts are lacking in making use of such methods. In spite of the health problems faced, people living near the dump sites are forced to stay there either because of their weak economic background or family ties.

The study did not calculate the economic cost of health problems arising out of unscientific and irresponsible methods of waste disposal. There is scope for conducting a full fledged study on this aspect.

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Appendix-1

WASTE GENERATION ACTIVITIES IN COCHIN CORPORATION

Ward No.	Houses	Shops	Hotels/ Restaurants	Institutions	Hospitals	Thattukada	Markets	Total waste Tonnes
1	3200	270	35	8	0	42	1	3.75
2	2000	123	13	0	0	1	1	3
3	1750	66	7	0	1	0	0	3
4	2277	145	9	3	0	3	1	4
5	3492	422	16	5	1	4	1	6
6	1577	121	8	35	1	3	2	3
7	2405	282	9	60	2	4	0	5
8	3105	201	1	3	2	2	1	11
9	1048	137	7	32	1	3	0	3
10	2526	228	2	4	3	2	0	11
11	2450	688	19	2	4	1	2	3
12	2300	460	11	1	1	0	0	2.5
13	2800	160	5	2	0	0	0	1
14	2700	145	5	3	1	0	0	1
15	2100	51	4	3	1	10	1	0.75
16	2250	47	3	3	1	8	0	0.75
17	2100	35	5	3	0	7	1	1
18	2300	51	4	2	1	9	0	1.5
19	2400	106	4	0	1	11	1	2.5
20	2400	104	4	0	0	0	0	1.5
21	2500	127	7	3	1	0	1	1.5
22	2406	149	2	2	1	0	0	3
23	1702	24	0	2	0	0	0	2
24	1584	121	1	2	1	0	1	2
25	1480	58	4	2	0	0	0	3
26	2200	96	11	0	0	0	1	3
27	2100	70	3	3	0	3	0	2.75
28	2600	171	20	4	2	2	1	4
29	5500	37	2	3	0	0	0	1.2
30	1700	117	9	12	2	0	0	0
31	2500	156	2	1	2	0	1	1.5
32	2500	95	4	2	2	0	0	1
33	2820	160	5	1	0	0	0	0.5
34	1670	105	4	2	2	1	0	0.5
35	2110	103	5	4	0	0	0	0.5
36	1650	180	6	4	1	0	0	0.5
37	1660	220	4	3	1	0	0	0.5
38	3000	550	24	75	5	2	1	5
39	2462	94	6	45	1	0	0	4
40	2300	600	21	65	4	3	0	5
41	4000	400	22	54	4	2	0	6
42	3000	650	10	60	3	1	0	5
43	2600	512	13	55	5	4	2	5
44	2485	265	15	5	1	2	1	2.9
45	3000	265	10	50	4	2	0	5
46	1512	215	12	4	0	0	0	2.2
47	1413	115	8	4	1	3	0	2.6

48	3215	225	10	2	4	10	2	2.1
49	1645	242	15	7	2	5	0	2.3
50	2935	238	12	6	3	2	0	2.6
51	2085	158	10	5	6	4	0	2.7
52	2000	260	8	12	3	7	1	4
53	2110	212	16	6	1	5	0	4
54	2650	200	5	4	0	10	0	4
55	3500	165	6	6	0	2	0	3
56	2650	168	8	4	0	0	1	1.1
57	2000	80	4	8	1	1	0	1
58	4500	171	7	1	0	2	0	1.2
59	350	91	7	4	1	3	0	0.7
59	1349	685	42	24	6	10	0	3
60	1385	547	32	14	7	12	0	4.5
61	2350	150	9	5	1	1	1	2
62	2951	190	12	147	4	4	1	4
63	2853	505	26	60	10	9	1	4.5
64	1763	2126	37	7	0	9	0	5.5
64	1100	820	34	300	3	6	0	3
65	1697	1943	36	5	1	7	1	16.5
65	800	452	22	155	1	3	0	1.8
66	2256	328	18	2	1	0	0	4
67	2836	190	11	4	1	0	0	4.5
68	3080	521	31	56	9	4	1	4.5
69	3370	150	6	1	1	0	0	0.6
70	3425	242	11	1	0	0	1	0.6
71	2700	83	5	2	1	4	0	1
Total	175189	20639	841	1484	131	255	31	140.5

Source: Cochin Corporation

APPENDIX-2

Waste generation activities in Thiruppunithura municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	436	44	2	2	-	-	0.350
2	469	20	3	2	-	-	0.400
3	380	10	-	1	-	-	0.300
4	418	128	5	3	-	-	0.400
5	473	56	1	3	2	-	0.450
6	387	85	3	2	-	-	0.400
7	533	21	-	-	-	-	0.400
8	411	39	-	1	-	-	0.350
9	349	74	2	1	2	-	0.250
10	404	59	5	4	1	-	0.350
11	371	106	2	3	-	-	0.400
12	359	24	1	2	-	-	0.325
13	353	78	2	4	1	-	0.400
14	392	139	4	5	-	-	0.450
15	562	22	-	3	-	-	0.400
16	701	15	2	3	-	-	0.600
17	391	126	3	5	-	-	0.400
18	434	183	3	4	-	-	0.550
19	384	106	2	-	-	-	0.300
20	367	197	5	2	2	-	0.600
21	443	112	2	2	2	-	0.600
22	478	25	-	2	2	-	0.300
23	334	9	-	3	3	1	2.000
24	420	120	2	3	3	-	0.400

25	442	16	-	-	-	-	0.350
26	579	17	-	1	1	-	0.500
27	452	52	-	-	-	-	0.450
28	441	48	2	2	2	-	0.400
29	405	35	-	-	-	-	0.350
30	474	20	-	-	-	-	0.450
31	485	47	2	1	1	-	0.400
32	458	18	-	-	-	-	0.350
Total	13985	2051	53	64	22	1	14.625

Source: Thiruppunithura Municipality

APPENDIX-3

Waste generation activities in Kalamassery municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	477	17	-	2	-	-	0.375
2	447	24	-	2	-	-	0.450
3	415	112	3	6	-	-	0.525
4	390	97	2	-	6	1	1.400
5	385	28	-	11	-		0.350
6	396	15	-	13	-	-	0.450
7	428	14	-	3	-	-	0.350
8	486	8	-	6	-	-	0.450
9	396	16	-	5	-	-	0.400
10	348	33	-	2	-	-	0.300
11	289	14	1	2	-	-	0.250
12	497	27	-	4	-	-	0.350
13	445	14	-	3	1	-	0.400
14	468	33	-	5	-	-	0.400
15	420	28	-	5	1	-	0.300
16	449	20	-	3	-	-	0.350
17	381	14	-	4	1	-	0.300
18	335	45	3	5	-	-	0.350
19	485	85	5	4	-	-	0.500
20	398	36	2	5	-	-	0.400
21	400	42	2	8	-	-	0.350
22	424	16	-	2	-	-	0.400
23	563	28	2	6	4	-	0.550
24	451	105	5	1	2	1	1.500
25	449	41	3	3	-	-	0.450

26	388	66	-	3	-	-	0.400
27	390	118	3	4	-	-	0.400
28	478	75	-	2	2	-	0.450
29	465	23	-	3	2	-	0.400
30	404	37	1	4	-	-	0.300
31	486	36	-	5	2	-	0.300
32	544	218	5	2	-	-	0.600
33	429	127	3	2	-	-	0.300
Total	14206	1612	40	135	21	2	15.05

Source: Kalamassery Municipality

APPENDIX-4

Waste generation activities in Aluva municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	307	60	3	5	1	-	0.300
2	229	125	6	7	3	-	0.400
3	306	18	-	6	-	-	0.300
4	251	17	-	2	-	-	0.250
5	263	84	3	6	-	-	0.300
6	183	64	2	3	-	-	0.400
7	242	75	1	11	-	-	0.500
8	203	45	-	6	-	-	0.600
9	188	106	3	12	-	-	0.400
10	299	24	-	5	-	-	0.300
11	221	36	-	7	-	-	0.250
12	231	191	4	3	1	-	0.450
13	309	12	-	2	5	-	0.300
14	316	21	-	3	-	-	0.300
15	276	18	2	3	-	-	0.250
16	333	166	5	6	-	-	0.350
17	194	130	4	3	-	1	2.400

18	232	292	6	4	2	1	4.000
19	147	13	2	4	-	-	0.250
20	339	54	-	-	-	-	0.360
21	264	16	-	1	2	1	1.250
Total	5333	1567	41	99	14	3	13.91

Source: Aluva Municipality

APPENDIX-5

Waste generation activities in Angamaly municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	284	16	-	4	-	-	0.250
2	253	32	1	5	-	-	0.250
3	306	86	3	6	1	-	0.300
4	284	152	4	9	2	-	0.350
5	259	72	2	7	1	-	0.300
6	312	58	-	5	3	-	0.350
7	370	104	3	3	1	-	0.400
8	344	69	1	4	1	-	0.300
9	367	56	2	3	-	-	0.300
10	314	18	-	-	-	-	0.250
11	282	22	-	2	-	-	0.250
12	317	6	-	1	1	-	0.200
13	203	15	1	1	-	-	0.200
14	293	7	-	2	1	-	0.200
15	319	11	-	-	-	-	0.250
16	419	17	2	-	-	-	0.250
17	325	23	2	1	-	-	0.200
18	385	12	1	1	-	-	0.250
19	337	68	1	4	3	-	0.300
20	246	9	-	1	-	1	1.450

21	325	76	2	7	2	-	0.300
22	331	85	1	5	4	-	0.250
23	397	191	4	6	5	-	0.250
24	279	52	1	6	1	-	0.250
Total	7551	1257	31	83	26	1	7.65

Source: Angamaly Municipality

APPENDIX-6

Waste generation activities in Perumbavoor municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	308	56	1	4	-	-	0.300
2	293	73	2	2	2	-	0.300
3	280	55	1	5	1	-	0.300
4	276	38	-	1	-	-	0.270
5	291	136	3	6	2	1	1.300
6	288	86	2	2	1	-	0.350
7	290	85	3	5	3	-	0.250
8	306	18	-	1	-	-	0.250
9	287	12	-	1	-	-	0.250
10	322	56	-	4	1	-	0.300
11	314	87	2	1	-	-	0.300
12	300	27	1	1	-	-	0.250
13	260	52	2	1	-	-	0.270
14	327	182	4	3	2	-	0.350
15	235	60	2	1	-	-	0.315
16	237	72	2	1	-	-	0.400
17	295	81	3	8	2	-	0.400
18	291	95	2	6	2	-	0.300
19	296	162	4	7	2	-	0.300
20	243	32	-	2	-	-	0.300
21	324	103	3	4	2	-	0.300
Total	6063	1568	37	66	20	1	7.355

Source: Perumbavoor Municipality

APPENDIX-7

Waste generation activities in Kothamangalam municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	302	62	3	1	1	-	0.250
2	273	50	4	1	2	-	0.275
3	308	79	2	2	1	-	0.300
4	357	86	2	8	1	-	0.400
5	348	49	-	5	1	-	0.300
6	373	59	-	2	1	-	0.350
7	242	28	-	6	-	-	0.200
8	306	135	5	1	-	-	0.300
9	340	114	4	1	-	-	0.500
10	299	72	2	2	-	-	0.300
11	312	38	-	1	-	-	0.350
12	279	27	-	3	1	-	0.250
13	310	107	6	6	-	-	0.400
14	306	18	1	4	-	-	0.300
15	361	95	2	5	2	1	1.450
16	301	72	2	7	2	-	0.400
17	376	89	2	6	1	-	0.550
18	297	79	2	5	2	-	0.300
19	290	22	1	2	1	-	0.250
20	292	13	-	2	1	-	0.300
21	365	48	3	3	1	-	0.350
22	346	37	1	3	1	-	0.375
23	314	124	4	3	-	-	0.300
24	305	43	-	5	-	-	0.325
25	309	119	5	1	1	-	0.300
26	275	46	-	6	3	-	0.280
Total	8186	1711	51	91	23	1	9.655

Source: Kothamangalam Municipality

APPENDIX-8

Waste generating activities in Muvattupuzha municipality

Ward number	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	341	89	2	2	2	-	0.250
2	251	65	1	-	-	-	0.250
3	286	68	-	3	-	-	0.300
4	261	7	-	5	3	-	0.400
5	312	74	2	2	-	-	0.250
6	281	92	3	3	1	-	0.250
7	248	102	3	4	2	1	1.500
8	298	93	2	2	1	-	0.400
9	295	56	-	-	-	-	0.250
10	238	62	1	-	-	-	0.250
11	283	24	3	3	-	-	0.200
12	264	12	1	4	-	-	0.250
13	256	32	4	2	-	-	0.250
14	262	18	2	-	-	-	0.200
15	299	21	2	-	-	-	0.250
16	249	26	2	-	2	-	0.250
17	295	14	1	-	-	-	0.250
18	347	20	2	4	4	-	0.350
19	321	164	3	5	2	-	0.400
20	239	42	1	1	2	-	0.250
21	294	32	-	2	3	-	0.300
22	295	54	2	6	2	-	0.250
23	298	31	1	4	-	-	0.250
Total	6513	1198	38	52	24	1	7.550

Source: Muvattupuzha Municipality

APPENDIX-9

Waste generation activities in Paravur municipality

Ward No.	No.of Houses	No.of Shops	No.of Hotels/ Restaurants	No.of Institutions	No.of Hospitals	No.of Markets	Total waste in Tonnes
1	301	23	2	1	-	-	0.250
2	288	94	4	7	-	--	0.400
3	325	207	4	8	-	1	1.500
4	273	61	1	5	-	-	0.300
5	291	142	3	7	-	-	0.350
6	255	82	1	4	2	-	0.300
7	298	198	4	12	4	-	0.400
8	292	97	2	7	2	-	0.350
9	323	56	1	5	-	-	0.350
10	309	48	0	6	-	-	0.300
11	310	72	3	1	-	-	0.300
12	314	19	2	8	-	-	0.250
13	283	28	-	-	-	-	0.280
14	268	35	-	-	-	-	0.250
15	274	67	1	5	-	-	0.300
16	284	184	3	-	1	-	0.300
17	307	215	3	3	1	-	0.250
18	294	129	4	5	-	-	0.300
19	321	182	4	7	3	-	0.450
20	389	212	3	6	2	-	0.450
21	288	83	1	8	2	-	0.300
22	261	84	2	4	1	-	0.250
23	286	100	4	9	3	-	0.250
Total	6834	2418	52	118	21	1	8.430

Source: Paravur Municipality

APPENDIX-10

INDUSTRIES PRODUCING HAZARDOUS WASTE IN ERNAKULAM

Sl. No	Product and Name of the Company	Hazardous waste generation	Disposal of Hazardous waste
1	Capcicum, Paprikka, Akay Flavours	used oil – 2 barrels/year	To authorized recycler
2	Relays, CII Guardian	Spent solvents-71 litres/month Empty solvent containers-4 No./year	-
3	Crumb rubber, Crescent crumb rubbers (p) Ltd	Chemical sludge -3 barrels/month	-
4	Electronic components assembly, Crysind Electronics Pvt. Ltd.	Glues, Cements, Adhessive, Residues – 2 kg/week, Spent solvents-1.25lit/week, Used oil-4lit/year and Empty solvent containers-9 barrels/week, Lead -1.2kg/week and Cotton waste-10kg/month	Used oil to authorized recycler.
5	Crumb rubber, Edathala polymers	Used oil – 20 lit/day	To authorized recycler
6	Soft drinks, Elenjickal Beverages, Edathala	Used oil- 400T/year	To authorized recycler
7	Chilled Milk, Ernakulam Regional Co-operative Milk Producers Union Ltd, Muvattupuzha	Used oil-80lit/day	To authorized recycler
8	Inserts, Moulds, Electrodes, FCI Technologies Services Ltd.	Used oil-210lit/month	To authorized recycler
9	Dehydrated Green Pepper, Herbal Isolates.	Used oil-200lit/year	To authorized recycler
10	Servicing of vehicles, Mustang Motors, Geethanjali Junction.	Used oil- 250lit/month	To authorized recycler
11	Vintreous China Sanitary Wares, Muthoot Ceramics, CSEZ.	Spent oil-12MT/year	-
12	Printed circuit board assemblies, Nest Power Electronics.	Waste, Glues and Adhesives-1kg/month Spent solvents-161kg/year Used oil-50lit/year Empty solvent containers-200Nos./year Lead-50kg/month	Used oil to authorized recycler
13	Servicing of vehicles, Penisular Honda	Used oil-14,400lit/year	To authorized recycler
14	Sales and repairing of automobiles, Popular Hyundai, Geethanjali Junction.	Used oil-500lit/month	To authorized recycler
15	PCB Assembly, Electronic subassay, SFO Technologies PVT Ltd (Unit II)	Used oil-20lit/year Sold solder Dross-500kg/year Scrap PCB assay-15kg/year Empty solvent containers-3200kg/year	To authorized recycler

		Used cleaning solution- 15000 lit/year	
16	Nitrogen, Oxygen, Sterling Gases, Ambalamugal.	Used oil-6 barrels/year	To authorized recycler
17	PCB Assy, Electronic Subassay, Sun Fibre Optics (SFO Technologies PVT Ltd Unit 1)	Spent solvents-15,000lit/year Empty solvent containers-500 Nos/year Lead-500kg/year Used oil-20 lit/year.	Used oil to authorized recycler
18	Cable assay, Sun Generic Cables (P) Ltd	Used oil-1lit/month Spent solvents-1.5kg/month Waste glass and adhesives-500gm/month Empty solvent containers-2 Nos/month Lead-200gm/month Contaminated cotton waste -580gm/month	Used oil to authorized recycler
19	Scrap non ferrous metals, A.R.Chockalingam Chettiyar and Sons, Basin Road, Kochi.	Solid Scrap collection and setting	-
20	Dealer in spent catalyst, Aaron International, Azad Mansil, Panayikulam, Aluva	Copper, Zinc and Nickel from fertilizer manufacturing company all over India	Processing and transporting
21	Automobile tyres, Appolo Tyres Ltd, Kalamassery, Ernakulam.	Used oil-1200kg/year	To authorized recycler
22	Curcumin Powder, TPA, Garcina, Cimvogia extract, Ginger dry extract, Arjuna Natural Extracts Ltd, Erumathala P.O.	ETP sludge-50kg/year Used oil-50 lit/year	Used oil to authorized recycler
23	Oleoresin, essential oil, natural colour, AVT Natural Products Ltd, South Vazhakulam, Marampilly P.O., Ernakulam.	ETP sludge-164 tonnes/year Spent iol-1800 lit/year	Secured land fill Used oil to authorized recycler
24	Beacon Power systems, Kalady, Ernakulam	-	-
25	Storage and Supply of petroleum products, Bharat Petroleum Corporation Ltd., Irumpanam.	Oil containing sludge-4000Tonnes/year	To authorized recycler
26	Electricity, Brahmapuram Diesel Power Plant, Brahmapuram.	Oil water sludge-222Tonnes/year Spent oil-15Tonnes/year	To authorized recycler
27	Cloth, Cotton yarn, Chakolas Spinning and Weaving Mills, Kalamassery.	Spent oil-120 lit/year	-
28	Isopropyl alchocol, liquid lenium, CII Guardian International Ltd., Kakkanad, Kochi.	-	-
29	Craft paper, Cochin Kadalas Pvt ltd., Thripunithura, Ernakulam.	Used oil-50kg/year ETP sludge-2400Tonnes/year	To authorized recycler
30	Craft paper, Cochin Kagaz Ltd., Angamaly, Ernakulam.	ETP sludge-3.65 Tonnes/year	To authorized recycler
31	Wet blue hides, Cochin Leathers Pvt.Ltd, Muppathadom, Ernakulam.	ETP sludge-6Tonnes/year	-
32	Cochin Port Trust, Kochi.	Used oil-10000lit/year	-
33	Cochin Shipyard Ltd., Kochi	Oil sludge-110Tonnes/year	-

34	Paints, primers, inks, Colour India Paints and Inks (P) Ltd., Vazhakulam, Ernakulam	ETP sludge-200Tonnes/year	
35	TPA Coagulant, Enviro Design and Equipments, Lissie Junction, Kochi.	Spent acids-50Tonnes/year	-
36	Sterllised flavoured milk, ice cream, Peda, Ghee, Ernakulams Regional Co-operative Milk Producers Union, Edappally, Ernakulam.	Used oil-15lit/year	-
37	Service Station, EVM Automobiles, Sahodaran Ayyappan Road, Vyttila, Kochi.	Waste oil-550lit/year	-
38	FACT-CD, Ambagamugal, Ernakulam.	-	-
39	Electronic connectors, FCI OEN Connectors, Electrogiri, Mulanthuruthy.	ETP sludge-18000lit/year Spent lubricating oil-1000lit/year.	Initial construction for secured landfill
40	Electroplating, Fine Electro plating industries, Perumbavoor.	ETP sludge-91kl/year	-
41	Yarn, G.T.N. Textiles Ltd., Ernakulam	Used engine oil-600lit/year	-
42	Service station, German motors, Thathrikadavu Junction, Cochin.	Used oil-6240lit/year	To authorized recycler
43	Gramox paper &Boards Ltd., Muvattupuzha, Ernakulam.	Used oil, ETP sludge-900lit/year	-
44	HHA Tank Terminal Pvt. Ltd., Ernakulam	Sludge from storage tank-0.001Tonne/year	-
45	Bathing soap, Hindustan Lever Ltd, Tatapuram, Ernakulam.	Spent oil-2Tonnes/year	To authorized recycler
46	Hindustan Organic Chemicals Ltd., Ambalamugal, Ernakulam.	ETP sludge-12Tonnes/year Cumox waste oil-4500Tonnes/year Cumene soot-720m3/year Incinerator ash-1 tonne/year Spent oil-155Tonnes/year Deag benzene-50 Tonnes/year Waste asbestos-1Tonne/year Spent catalyst-80Tonnes/year	-
47	Machine tools, Offset printing, Machine paper cutting, HMT Limited, Ernakulam	Waste oil, Lubricating oil.	-
48	Storage and supply of petroleum products, HPCL, Ernakulam.	Semi solid sludge-10kg	-
49	Storage and supply of furnace oil, HPCL, Kadavanthra	Semi solid sludge	-
50	Storage and supply of petroleum products, Indian Oil Corporation, Irumpanam, Ernakulam.	Waste oil-10000lit/year	-
51	Storage and supply of petroleum products, Indian oil Corporation, Karshaka, Ernakulam.	Waste oil-1600lit/year	-
52	Storage and supply of petroleum products, Indian Oil Corporation, Willington Island, Ernakulam.	Waste oil-2000Tonnes /year	-

53	Service Station, Indus Motors Co.Pvt Ltd., Ernakulam.	Used oil	-
54	Intechs Manufacturers Llimited, Aluva	-	-
55	J & J Bio-tech & Speciality Chemicals (P) Ltd., Erumathala, Aluva	-	-
56	Service station, J.Patel Cars Pvt. Ltd., Maradu, Kochi.	Spent oil-6000lit/year	-
57	Primer, Pine Jar, Wire rope, J.K.Enterprises, Aluva.	Oil sludge-1152Tonnes/year	-
58	Oleoresin,, Extracted residual fatty oil, Kancour flavours & Extracts Ltd., Angamaly	Sludge-600tonnes/year Carbon-11tonnes/year Plate and frame filter-45000m3/year	Secured land fill To authorized recycler
59	KAMCO Power tillers, Kerala Agro Machinery Corporation Ltd., Athani.	Phosphate-1Tonne/year Sludge-8Tonnes/year Paint booth sludge-2 Tonnes/year ETP sludge and used oil-800lit/year.	To authorized recycler
60	Gelatin, Kerala Chemical and Proteins Ltd., Thrikkara	Spent oil-42Tonnes/year Lubricating oil-480lit/year	To authorized recycler
61	Transformer products, Kerala Electricals and Allied Industries, Mamala.	Used transformer oil-19.5kg/year Lubricating oil-5lit/year Cutting oil-10lit/year	-
62	Mango pulp, Fruit Drinks, cartons, Pine apple juice, KHDP Nadukkara Agro Processing, Muvattupuzha.	-	-
63	Kochi Refineries Ltd., Ambalamugal	Oil sludge-180tonnes/year Spent catalyst-90tonnes/year Sludge-15tonnes/year	-
64	Service station, Koyenco Autos(P)Ltd., Padivattom	Used oil-9700lit/year	-
65	Service station, M.G.F.Motors, Edappally	-	-
66	Service station, Marikar Motors Pvt. Ltd., Edappally, Kochi.	Used oil-480lit/year	-
67	Steel ingot, metrola streets Ltd., Moovattupuzha	-	-
68	Service station, MGF Motors Pvt. Ltd., Willington Island, Kochi	Oil filter-600Nos.	-
69	Service station, MGF Pvt. Ltd., Palarivattom, Kochi.	Waste oil	-
70	Bread, Modern Food Industries, Edappally, Ernakulam.	Used oil-60kg/year	-
71	Diesel generator, Muthoot APT Ceramics Ltd., kochi	Spent oil-0.120tonnes/year	To authorized recycler
72	Service station, Muthoot Honda, Kochi	Used oil-550lit/year	-
73	Pine apple juice, Mango pulp, Fruit drinks, Nadukkara Agro processing Co.Ltd., Muvattupuzha.	Lubricating oil-0.2tonnes/year.	-
74	Aluminium vessels, National Aluminium Company, Cochin.	Slag-2tonnes/year	-

75	Service station, National motors, Perumbavoor.	Used oil-600lit/year	-
76	Paint remover, Naval Aircraft Yard, Kochi.	Dasic paint remover residue-1950lit/year	To authorized recycler
77	Service station, Nippon Toyotta, moopen motors Pvt, Ltd.,	Waste oil-2000lit/year	
78	Switches, Potentio Meter, OEN India Ltd., mulanthuruthy.	ETP sludge-14.4 tonnes/year Spent lubricating oil-200lit/year	To authorized recycler
79	LNG Storage, Petronet LNG Limited, Ernakulam	-	-
80	Carbon black, Philips Carbon Black Ltd., Brahmapuram, Ernakulam.	Used Engine oil-10000lit/year Incinerator Ash-30kg/year	-
81	Spice oleo resin, Plant Lipids Pvt.Ltd., Kolencherry.	Used oil, ETP sludge-500lit/year DG set-73tonnes/year	Secured landfill To authorized recycler
82	Service station, Poomkudy Tempo, Ernakulam.	-	-
83	Service station, Popular Mega Motors (P) Ltd., Pathalam, Ernakulam	Used oil-14400lit/year	-
84	Service station, Popular vehicles & Services, Elamakkara, Ernakulam	-	-
85	Hawai sheets, Prakash Rubbers, Kalady, Ernakulam	Residue wax oil-8tonnes/year	-
86	Two wheeler and Three wheeler tyre, Rado Tyres Pvt.Ltd., Nellikkuzhy, Kothamangalam.	Used oil-720lit/year	To authorized recycler
87	Service station, Rajasree Motors Pvt.Ltd., Kundannoor junction, Ernakulam.	Used oil-3600lit/year	-
88	Rubber mat,Sabari Rubber Industries, Kalady, Ernakulam	-	-
89	Work shop for servicing and repairing, Sai Service Station Ltd., Kochi.	Waste oil-2460lit/year	-
90	Electroplating unit, Sree Muruga Electroplating Industries, Edappally, Ernakulam.	ETP sludge-0.6tonnes/year	Provided concrete pit to deposit Hazardous waste.
91	Yarn, Sri Asoka Textiles Ltd., Aluva, Ernakulam.	Used lubricating oil-250lit/year Used oil of DG set-350lit/year	To authorized recycler
92	Printed circuit board, Assemblies computer network products, Sub Fibre Optics Pvt.Ltd, Kakkanad, Kochi.	Solid-0.6	-
93	Spices Olerosin, Spice oil, Natural food colour, Synthite Industrial Chemicals, Ernakulam.	Lubricating oil-300lit/year Spent carbon-15	-
94	Hotel, TAJ Malabar, Cochin.	Used oil-80lit/year	-
95	Cup and mug, Tata Ceramics Ltd., Kakkanad.	Used oil-300tonnes/year.	To authorized recycler
96	Aluminium vessels, Thekkinedath Aluminium Company, N.Parur, Ernakulam.	2tonnes/year	-

97	Service station, Toyota Nippon, Nettoor.	Used oil-20000lit/year	To authorized recycler
98	Traco Cable Company Ltd., Thripunithura, Ernakulam.	Used coolant oil-3200lit/year	-
99	Current transformers, potential transformer, gas circuit breakers, power transformer, Transformer and Electricals Kerala Limited, Angamaly, Ernakulam.	Waste oil-18.9 tonnes/year	-
100	Caustic soda, chlorine, HCL, Travancore Cochin Chemicals Ltd., Udyogamandal.	ETP sludge-161tonnes /year	Secured landfill
101	Service station, TVS Ltd., Kaloor, Kochi.	Used oil-5000tonnes/year	To authorized recycler
102	Service station, TVS Suzuki service station, Janatha junction, Ernakulam.	Used oil-360lit/year	To authorized recycler
103	Dies and moulds, spares for dies and moulds, Tyco Electronics Tools India Ltd., Kakkanad, Ernakulam.	Grinding waste of MS-1200kg/year Spent oil-2000lit/year	To authorized recycler
104	Procaine penicillin, Formamide, Filled injection vials, Vysali Pharmaceuticals, Bulk Drug Plant, Edathala, Ernakulam.	ETP sludge-0.3tonnes/year Spent solvent-50000lit/year Spent lubricating oil-960lit/year	To authorized recycler
105	Ship maintenance, Western marine Engineering, Edakochi, Kochi.	Solid and liquid-7tonnes/ship	-
106	Amusement park, Veega Holidays & Parks Pvt Ltd.	Incinerator ash-1.4tonnes/year	-

Source: Kerala State Pollution Control Board

APPENDIX – 11

Resturants

Sl.No.	Name and Address of the Hotels and restaurants	No.of persons	Quantity of garbage	Disposal
1	Grand Castle, S.A.Road, Panampally Nagar Junction, Kochi-16	-	20kg/day ETP-7kg/day	Biogas plant
2	Hotel Orchid, Grinagar link road, Kadavanthara, Kochi	52	0.5t/year ETP0.5t/year(septic tank)	Dumped in corporation site
3	The old court yard hotel, Princess street Fort Kochi	16	1t/year ETP 0.5t/year	Biogas plant Septic tank
4	Hotel Maria International, A.M.Road, Kothamangalam	50	1t/year ETP 0.5t/year	By municipality Septic tank
5	Gokulam Park, Kaloor, Kochi	100	100kg/day	Biogas Anaerobic digester
6	Matha Tourist Home, A.M.Road, Kothamangalam	-	11.2kg/day	Biogas Anaerobic digester
7	Highland Star Hotels and Resorts Pvt Ltd., Kadavantra, Kochi	-	700t/year along with ETP	Anaerobic digester
8	Time square Hotel, Club road, Ernakulam, Kanayanoor	7	10kg/day	Sale to pig farmers and daily collect by Kudumbasree
9	Indroyal Hotel Pvt Ltd, Chakkaparambu Junction, N.H byepass	-	146t/year ETP36.5t/year	Corporation Digester and dried using filter press.
10	Travancore Court, Wariam Road, Ernakulam	130	50kg/day	Coorporation
11	Casino Hotel, Willington Island, Kochi	-	Non degradable 50kg/day segregated as tins, bottle, glass, paper, plastic and sold for recycling. Biodegradable waste 30kg/day	Sold to piggery.
12	Hotel Cee Cee Tower, Chendamangalam Junction, North paravur	25	10kg/day	Kudumbasree

13	Hotel Hill palace, Refinery Road, Irempanam, Thripunithura, Kanayanoor	25	3kg/day	Local body
14	Hotel Golden Palace, Pulamkulam Road, North Paravur	25	10kg/day	Kudumbasree
15	PVR Tourist Home, Alapatt Regency, Palarivattom, Kanayanoor	45	-	Disposal at St.George farm piggery, Vazhakulam
16	Royal Palace, Aroor Byepass Road, Kundannoor	300	5.6t/day ETP 2t/day	Composting Digester
17	Poovath Hotel, Dutch Cenetry Road, Fort Kochi	15	15kg/day ETP	Corporation Disposed along with solid waste
18	M/S Avenue Centre Hotel, Panampilly Nagar, Kanayanoor	6	-	-
19	Silver Kitchen, Out door catering, Mulanthuruthi, Moovattupuzha.	6	50kg/day	Biogas
20.	Damianz Retreat, Puthenvelikara, Paravur	-	70kg/day ETP 1kg/day	Biogas
21	M/S Devi Taal Resorts Poothotta, Kanayanoor	70	50kg/day	Vermiculture
22	Admiral Plaza Hotel, Safe way properties pve ltd., Palarivattom, Kanayanoor	66	15t/year ETP 3t/year	Corporation Fertilizer
23	Hotel Mermaid, Vytila, Kaniyampuzha Road,	100	65kg/day	Corporation
24	Hotel Pearl Dunes (p) Ltd., Duraisamy Iyer road, Opposite to M.G.Road, Kochi, Kanayanoor	80	50kg/day	Corporation
25	Hotel Rose Residency, Kolencherry, Kunnathunadu	30	100kg/day ETP 1.5kg/day	Anaerobic digester
26	Hotel Seashells, Shanmugam road	24	-	Corporation
27	Hotel White City, South Naluvazhi, Varapuzha Road, North Paravoor	50	5t/year ETP 1t/year	Municipality Fertilizer

28	Casino Hotel, Willington island, Thoppumpady, Kochi.	-	Bio-degradable-30kg/day Non bio degradable-50kg/day	Piggery Sold for recycling
29	Central kitchen catering, Vennala, Medical centre road, Palarivattom, Kanayanoor	25	-	Piggery
30	Hotel sea shells	-	-	Corporation
31	Veg.World restaurant, M.G.Road, Fotofast, Padma Kochi.	35	10-15kgs food remains 1-2kg vegetables	Corporation
32	Vigneswara Caterers, Ponnurunni, Thonnurukandiyil, Kanayanoor.	-	10kg/day	Corporation
33	M/S Killian Eco Tourism (P) ltd. Santa Cruz Basalica Junction, Fort Kochi.	-	Garbage-15kg/day ETP10kg/day	Municipality
34	Resort Project, Puthuvyppu, Heritage Hotel Resort, Kochi.	52	20kg/day	Local bodies
35	Holiday Hotel, Munamban Road, Cherai Po., Kochi taluck	-	Garbage-60kg/day ETP-1kg/day	Pig farmers Sludge drying bed
36	Hotel Luciya, Stadium Road, Kochi, Kanayannur	-	Garbage 20kg/day	Pig farmers
37	Back water Hotel and Restaurant, Silver west, Silver sand island, Cochin, Kanayanoor	400	180kg/day ETP	Aerobic composting Co-composting
38	Park Residency, Kakkanad, Near Civil station,	70	Garbage-100kg/day	-
39	Grand Hotel, M.G.Road, Kanayanoor.	150	Garbage	Pig farm
40	Hotel Aramanu, M/S Kamyakum Hotels (P) ltd, Manjapra po., Aluva Taluk.	-	-	-
41	Quality Airport Hotels and Flight Services (P) ltd., Near Cochin International airport, Nedumbassery, Angamaly	30	Garbage-8T/year ETP-3T/day	-
42	Hotel Mermaide, Vytila	100	Garbage-65kg/day	Corporation
43	Choice Towers, Residence	-	250kg/day	Conservative system

	Society, M.G.Road, Kanayanoor.			
44	Pathrose Issac & Sons, Near Ernakulam Medical Centre, Palarivattom.	50	Garbage 45kg/day ETP 40kg/day	Corporation Septic tank
45	Hotel Rennaisance, Palarivattom, Kanayanoor	-	50kg/day	Corporation

Source: Kerala State Pollution Control Board

APPENDIX-12

QUESTIONAIRE

1. Name of the Respondents
2. Address
3. No.of members
4. Income
5. Religion
6. Nature of residence
7. Live stock

   a.Yes □ No □

8. Environmental pollution disturbance

   a. Air □ b. Water □ c. Land □ d. Noise □

9. Total waste generation

   a.0-500 Gm □ b.< 1000 □ c. >1000□

10. Method of waste disposal

    a. Road □ b. Open space □ c. Municipal dust bins □

    d. Drains □ e. Open burnings □ f. Others □

11. Importance for pollution free environment

    a.Yes □ No □

12. Awareness on recycling

    a.Yes □ No □

13. Segregation of waste at home

    a.Yes □ No □

14. Method of reducing daily waste

a. Sell to waste purchasers □ b.Throw away □ c. Reuse □

15. Disposal of biodegradable waste

a. Dumping □ b. Compost □

c. Vermicompost □ d. Biogas □

16. Outcomes

a. Cost saving □ b. Time saving □ c. Easy disposal □

d. Not better □ e. Fuel saving □

17. Type of exposure living near landfill

a. Ingestion □ b. Inhalation □ c. Skin contact □

d. Fire or explosion □ e. Health problems □ f. Mortality □

g. Cancer □ h.Infectious disease □ i.Birth defects □

j. Symptoms □ k. Asthma □ l. Abnormal liver function □

m. Body burden □

18. Tackle of waste problem

a. Corporation □ b. NGO □

c. Residents assosciation□ d. Individuals □

19. Awareness on hazardous waste disposal

a. Yes □ b. No □ c. May be □

20. Education of household head

a. Primary □ b. Middle School □ d. High School

c. Degree and above □

21. Disposal of hazardous waste materials

a. Separately □ b. Mixed with other wastes □

22. Rate of satisfaction among biogas users

a. Very satisfied □ b. Satisfied □ c. Not satisfied □

23. Construction fault

a. Inadequate quantity of gas generation □

b. Reason for dissatisfaction □ c. Inadequate quantity of waste □

d . Other reasons □

24. Use of feed in biogas plant

a. Kitchen waste □ b. Cow dung □ c. Night soil □

25. Impact of biogas as energy source on households

a. Very little □ b. Partially used □ c. Most significantly used □

26. Daily availability of biogas

a. Up to 1 hour □ b. 1-2 hour □ c. 2-3 hour □ d. above 3 hours □

27. Details of LPG savings due to usage of biogas

a. Above 50% □ b. 25-50% □ c. Up to 25% □

28. Management of biogas for domestic purpose

a. Tea/coffee □ b. Boiling water □ c. Cooking rice □ d. Others □

29. Impact of biogas on home garden

a. Vegetables □ b. Banana □ c. Flowers and growtons □

30. Gender sensitivity of biogas plant operation

a. Male □ b. Female □ c. Servant □ d. Husband and wife □

31. Influence of biogas on waste disposal

a.Reduced fuel expenses and pollution □

a. Reduced fuel expenses □ b. Reduced pollution □

Questionnaire: Perception of people living near dumping yard

1. Name of the respondent
2. Address
3. Family income
4. Duration of the stay in the locality

   a. <5 years □ b.5-10 years □ c.>10 years □

5. Household waste storage practices

   a. Open container □ b. Closed container □ c. Plastic bag □

   d. Do not store □

6. Impact of solid waste storage practices in home

   a. Disturbances of flies in toilet □ b. flies in kitchen □ c. others □

7. Water related environmental problems near dump site

   a. Change of water colours in wells □ b. no change □

8. Air related environmental problems

   a. During transportation of waste □

   b. During off transportation of waste □

9. Impact of solid waste on health

   a.Chikunkunya once in a year □

   b. Frequent head ache and vomiting □

   c. Others □

10. Household perception on impact of solid waste dumping site

    a. No problem □ b. Problem □ c. Major problem □

11. Willingness to accept to stay near dump site

    a.Yes □ b.No □