University of Mumbai

Academic Planning and Development Section
No. APD/ICD/2019-20/762
17th March, 2020

Sub : Minor Research Grant Project 2019-20

Sir/Madam,

I am directed to inform you that the said proposal has been considered by the University and the research grant as quoted above is sanctioned to the researcher.

The sanctioned amount will be disbursed in two installments. The first installment of 40% of the sanctioned amount will be disbursed within the month of March. The remaining 60% amount will be disbursed up to 31st December, 2020.

The researcher is expected to spend 60% amount initially from his/her own resources to carry out the work.

Further, I am to inform you that the researcher will have to utilize the 40% sanctioned amount on or before 31st March, 2020 and submit original bills/vouchers of the expenditure along with Utilization Certificate duly certified by the Principal/Director/Head/Institute/University Department/College to the Accounts Section of the University.

Please note that 60% balance amount, out of sanctioned grant will be released after Poster Presentation & final approval of the committee. Therefore you need to submit of utilization certificate after presentation of your research including bills/vouchers/receipts in original through University Account Section.

The report of the research work carried out by the concerned researcher will have to be submitted to the University on or before 31st December, 2020.

The Principal/Head of the Institute are requested to inform the researcher accordingly and arrange to forward his/her undertaking immediately to enable this office to release first installment of the research grant.

Yours faithfully,

Deepak V. More
Assistant Registrar
(APD Section)

300	Jigna Ankur Vyas	The Kandivli Education Society's Bhanumati Kishandas Shroff of Arts and Maganlal Hargovinddas Shroff College of Commerce	38000
301	Amandeep Singh S.S. Manku	Bunts Sangha Mumbai¿½s Anna Leela College of Commerce & Economics and Shobha Jayaram Shetty College for BMS	30000
302	J GUNASUNDARI	Vidyalankar Institute of Technology	25000
303	Shaikh Irshad Wajid Ali	Shurparaka Educational Medical Trusts Moinuddin B Harris College Of Arts and A. E. Kalsekar College Of Commerce and Management	27000
304	Dr Sunita Prashant Tidke	Prahladrai Dalmia Lions College of Commerce and Economics	25000
305	Mr.Ameya M. Rane	The Kandivli Education Society's Bhanumati Kishandas Shroff of Arts and Maganlal Hargovinddas Shroff College of Commerce	30000
306	Mrs. Saba Ibrahim Shaha	K.M.S.P. Mandal's Sant Rawool Maharaj Mahavidyalaya	25000
307	Dr. Neelam. M. Salim Shaikh	Vidya Prasarak Mandal's K.G.Joshi College of Arts & N.G.Bedekar College of Commerce	46000
308	Navsin Mistry	The Mogaveera Vyavasthapaka Mandali M.V. Mandali College of Commerce & Science Mogaveera Bhavan Veera Desai Road Andheri (West) Mumbai â€" 400 058.	48000
309	Ms.Rakhi P. Madnani	Shri Vile Parle Kelvani Mandal`s Mithibai College of Arts Chauhan Institute of Science and Amrutben Jivanlal College of Commerce and Economics	40000
310	Mr. Gawde Vijay Maruti Subhadra	Vidyalankar School of Information Technology	28000
311	Jetho Purswani	Shri Sindh Thakurnath College of Arts & Commerce (S.S.T.)	30000
312	Parag Bharat Thakkar	H.R.College of Commerce & Economics	35000
313	Mr. NITIN BHASKAR PAGI	Vidya Prasarak Mandal's K.G.Joshi College of Arts & N.G.Bedekar College of Commerce	25000
314	Fatema H Fanuswala	Jai Hind College Basantsing Institute of Science and J.T.Lalvani College of Commerce & Shaila Gopal Raheja College of Management	32000
315	DR. shiva motiram padme	Prahladrai Dalmia Lions College of Commerce and Economics	33000
316	Ms. Reshma Narendrakumar Jaisinghani	Jai Hind College Basantsing Institute of Science and J.T.Lalvani College of Commerce & Shaila Gopal Raheja College of Management	27000
317	Dr. (CA) Gajanan Pandit Wader	Mahatma Education Societys Pillais College of Arts Commerce & Science (Id: C-33961)	38000
318	Mr. NITIN R. Wadhvinde	Vidya Prasarak Mandal's K.G.Joshi College of Arts & N.G.Bedekar College of Commerce	35000
319	Dr. Simmi Singh	Kamaladevi College of Arts, Commerce & Science	27000
320	Shaikh Taufiq Khalil	Dhirajlal Talakchand Sankalchand Shah College of Commerce, Kurar Village Rd, Malad, Kurar Village, Malad East, Mumbai, Maharashtra 400097	25000
321	CA Ajinkya Rajiv Pilankar	R.P.Gogate College, Ratnagiri	22000
322	Swaroop Laxman Ghaisas	R. P. Gogate College, Ratnagiri	25000
323	Meenal Gajanan Khandake	R. P. Gogate College, Ratnagiri	27000
324	Ms. Gajra Namraya Navinchand	Ram Sheth Thakur College of Commerce	22000

19.20

Prahladrai Dalmia Lions College of Commerce & Economics

ISO 9001:2015 Certified

Ref. No.: PDLC/342

Date: 30/9/19

To,
The Assistant Registrar,
APD Section,
Room No.132,First Floor,
University Main Building,
University of Mumbai, Fort Campus
Mumbai-400 032.

मुंबई विद्यापीठ
साभार पोच
आवक/आयसीडी/ईसीडी/
30/9/19
आवक विभाग

Sub: - Minor Research Project

Dear Sir,

We are forwarding herewith the Minor Research Proposal to be undertaken by Dr. Sunita Prashant Tidke for your kind approval and sanction.

The title of the project is, "Commercial Aspects of Waste Management".

Looking forward to your kind cooperation and sanction of the above mentioned project.

Thanking you,

Yours faithfully

Dr. N.N. Pandey

Principal

[redacted]

Prahladrai Dalmia Lions College of Commerce & Economics

ISO 9001:2015 Certified

Ref. No.: PDLC/842

Date: 28 SEP 2019

ANNEXURE- II

Certified that

I. The University / College is approved under Section 2 (f) and 12- B of the UGC Act

II. The institute welcomes participation of **Prof. / Dr. Sunita Tidke** as the Principal Investigator in the Proposed Minor Research Project entitled **Commercial Aspects of Waste Management**. And she will assume full responsibility for implementing the project.

III. The above research project / part of project is not funded by any other funding agency.

IV. The grant-in-aid received for the Research Project will be used to meet the expenditure of the project and the period for which the project has been sanctioned.

V. Institute undertakes the financial and other management responsibilities of the Project and undertake to submit Grant Utilization Certificate and Project Report to the University.

VI. The Institution will provide in-house equipments and basic infrastructure and other required facilities like administrative facilities to the investigator.

Seal of Institution

Signature
Head of Institute

[redacted]

Sunder Nagar, Swami Vivekanand Road, Malad (West), Mumbai - 400064.
Tel.: +91 22 2972 5792 ◆ 2873 2270 ◆ E-mail: dalmialionscollege@gmail.com
Website: www.dalmialionscollege.ac.in

[redacted]

1. Mr. Games, Pl. do the needful.
2. Copy to Prof. Sunita Tidke.
6/09/2021

304

University of Mumbai

Research Project No : 304

NAME OF THE RESEARCHER : Dr Sunita Prashant Tidke
LECTURE IN : Accountancy
AMOUNT SANCTIONED : Rs- 25000/-
CO-INVESTIGATOR :

Ref No. AAMS/ICD/106 of 2021
23rd July, 2021

To,

Prahladrai Dalmia Lions College of Commerce and Economics, Sundar Nagar, S.V.Road, Malad (West), Mumbai - 400 064

Sub: - **Minor Research Grant Project.**

Sir/Madam,

I am directed to inform you that the said proposal has been considered by the University and the research grant as quoted above is sanctioned to the researcher.

The sanctioned amount will be disbursed in two installments. The first installment of 70% of the sanctioned amount will be disbursed within the month of August. The remaining 30% amount will be disbursed up to 31st December, 2021.

The researcher is expected to spend 30% amount initially from his/her own resources to carry out the work.

Further, I am to inform you that the researcher will have to utilize the 100% sanctioned amount on or before 31st December, 2021 and submit original bills/vouchers of the expenditure alongwith Utilization Certificate duly certified by the Principal/ Director/ Head/Institute/University Department of the College to The Deputy Registrar, Accounts Section, Mahatma Phule Bhavan, Vidyanagari, Kalina Campus, University of Mumbai, Mumbai - 400 098 .

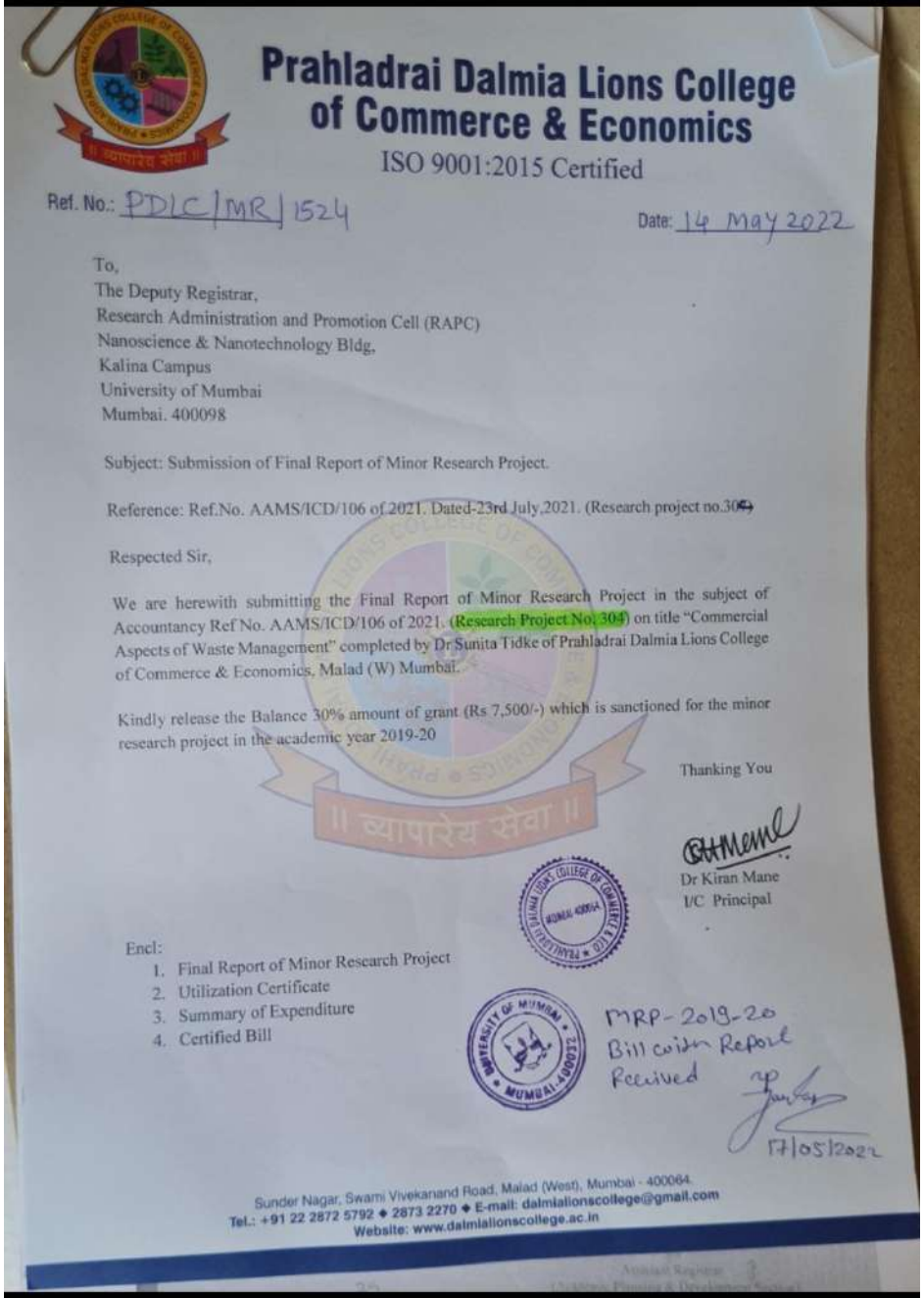
The report of the research work carried out by the concerned researcher will have to be submitted to the University on or before 31st December, 2021.

The Principal/Head of the Institute are requested to inform the researcher accordingly and arrange to forward his/her undertaking immediately to enable this office to release first installment of the research grant.

Yours faithfully,

Assistant Registrar
(Academic Planning & Development Section)

39
15 SEP 2021



Prahladrai Dalmia Lions College of Commerce & Economics

ISO 9001:2015 Certified

Ref. No.: PDLC/MR/1524 Date: 14 May 2022

To,
The Deputy Registrar,
Research Administration and Promotion Cell (RAPC)
Nanoscience & Nanotechnology Bldg,
Kalina Campus
University of Mumbai
Mumbai. 400098

Subject: Submission of Final Report of Minor Research Project.

Reference: Ref.No. AAMS/ICD/106 of 2021. Dated-23rd July,2021. (Research project no.304)

Respected Sir,

We are herewith submitting the Final Report of Minor Research Project in the subject of Accountancy Ref No. AAMS/ICD/106 of 2021. (Research Project No. 304) on title "Commercial Aspects of Waste Management" completed by Dr Sunita Tidke of Prahladrai Dalmia Lions College of Commerce & Economics, Malad (W) Mumbai.

Kindly release the Balance 30% amount of grant (Rs 7,500/-) which is sanctioned for the minor research project in the academic year 2019-20

Thanking You

Dr Kiran Mane
I/C Principal

Encl:
1. Final Report of Minor Research Project
2. Utilization Certificate
3. Summary of Expenditure
4. Certified Bill

MRP-2019-20
Bill with Report
Received
17/05/2022

Sunder Nagar, Swami Vivekanand Road, Malad (West), Mumbai - 400064.
Tel.: +91 22 2872 5792 ◆ 2873 2270 ◆ E-mail: dalmialionscollege@gmail.com
Website: www.dalmialionscollege.ac.in

No date information

0e825adb-fb4f-4d69-8aaf-b34c5d9523df

1. Utilisation Certificate for Total/ Utilized Grant

It is Certified that the grant of **Rs. 25,000/- (Rupees Twenty Five Thousand only)** sanctioned to Dr Sunita Tidke by University of Mumbai vide their Letter No. Ref No AAMS/ICD/106 of 2021 dated 23rd July 2021 towards Minor Research Project (Research Project No :304) has been fully utilised for the purpose for which it has been sanctioned and in accordance with the terms and conditions laid down by the University.

If a result of check or audit objection, some irregularity is noticed at a laterstage action will be taken to refund or regularize the objected amount.

Total actual Expenditure incurred for this project is of **Rs.29,492/-(Rupees *Twenty Nine Thousand Four Hundred Ninety Two only)***

nature of the Principal	Signature of the Principal	Signature of the CA
with Seal	Investigator	with Seal & Reg. No

PRAHLADRAI DALMIA LIONS COLLEGE OF COMMERCE & ECO. MUMBAI-400064.

N.K. Mittal & Associates MUMBAI F.R. No: 113281W Chartered Accountants

M No: 190961.

UDIN: 22190961AIEYQZ7611.

Date: 29/04/22

MINOR RESEARCH PROJECT REPORT

Project title

"A STUDY ON COMMERCIAL ASPECTS OF WASTE MANAGEMENT"

Ref. No. AAMS/ICD/106 of 2021. (Research Project No.304)

Submitted To

Research Administration & Promotion Cell (RAPC)
Nano Science & Nano Technology, Kalina Campus,
University of Mumbai, 400098

Submitted by

Dr. Sunita Prashant Tidke
(PhD, M.Com M.A (Eco),M.ED,LLB)
Assistant Professor, Department of Accountancy
Principal Investigator

Prahladrai Dalmia Lions College of Commerce & Economics,Malad(w)Mumbai.

Year : 2020-2021

ACKNOWLEDGEMENT

The present study is an outcome of constant support, co-operation, scholarly guidance and immense encouragement provided by my principal Dr Kiran Mane. I express my deep sense of gratitude to him for his invaluable advice and patience in reading, correcting and suggesting necessary points on the drafts of the project and, more importantly for her generosity which I have received throughout my complete research work as it is due to him, that I am able to successfully complete this study.

I am indebted for the kind help and support extended by all the librarians and the support staff of the various libraries I have visited. I express my deep sense of gratitude to my family and friends whose good wishes and moral support has made it possible for me to complete this study.

Last but not the least I would like to thank one and all who have directly or indirectly been helpful in my study.

Dr Sunita Tidke
Principal Investigator

DECLARATION

I hereby declare and certify that, the Minor Research Project entitled "A Study on Commercial Aspects of Waste Management" Ref. No. AAMS/ICD/106 of 2021. (Research Project No.304) is a bonafide record of research work carried out by me during the year 2019 to 2021. Further certify that the work presented in the report is original and carried out according to the plan in the proposal and guidelines of the University of Mumbai.

Dr Sunita Tidke
Principal Investigator

CERTIFICATE

Dr Sunita Tidke Assistant Professor Department of Accountancy of Prahladrai Dalmia Lions College of Commerce & Economics, Malad (W) Mumbai., has undertaken and completed the Minor Research Project work on titled **"A Study on Commercial Aspects of Waste Management"** The Minor Research was approved by University of Mumbai in 2019-2020. With reference to circular number AAMS/ICD/106 dated 23rd July, 2021. I am submitting Minor Research Projects on 17.05.2022 to the Deputy Registrar, Accounts Section, Mahatma Phule Bhavan, Vidyanagari, Kalina campus, University of Mumbai, Mumbai-400098. This is bonafied project work and the information presented is True & Original to the best of our knowledge and belief.

Dr Sunita Tidke
Principal Investigator

Dr Kiran Mane
I/C Principal

INDEX

Commercial Aspects of Waste Management

ABSTRACT

Waste is a significant source of short-lived climate pollutants. As the third largest man-made source of methane, waste contributes to climate change and ozone pollution. Open waste burning and the use of polluting collection vehicles emit black carbon, a key component of particulate matter (PM2.5) air pollution. When unsustainably managed, waste is also a breeding ground for toxins and microbes that contaminate the air, soil, and water. The proper management, separation and treatment of waste is important to reduce its impact on the climate and people. Pune is one of the few cities in India working to treat all the waste it generates. To help achieve this the city has come up with an innovative strategy: It has placed a group of marginalized women at the forefront of a campaign to clean the city. This research aims to examine the different commercial opportunities offered by waste management, as well as the operation and profitability of current businesses in Pune and Mumbai.

Keywords: Waste Management, Climate, commercial opportunities

S

INTRODUCTION

Human activities generate waste materials that are often discarded because they are considered useless. These wastes are normally solid, and the world waste suggest that the material is useless and unwanted. However, many of these waste materials can be reused, and thus they can become a resource for industrial production or energy generation, if managed properly. Waste management has become one of the most significant problems of our time because Human's way of life produces enormous amounts of waste, and most people wants to preserve their lifestyle, while also protect the environment and public health. Industry, private citizens, and state legislatures are searching for means to reduce the growing amount of waste that people's homes and business discard and no reuse it or dispose of it safely and economically.

Most human activities produce waste, which is unavoidable. Economic development and rising living standards in Asia and the Pacific have resulted in an increase in the quantity and complexity of waste generated, while industrial diversification and the provision of expanded health-care facilities have added substantial quantities of industrial hazardous waste and biomedical waste to the waste stream, potentially posing serious environmental and human health risks. The chapter examines trash generation, treatment, disposal, and management, which offers significant issues to both high- and low-income countries in the region.

According to the Basel Convention, "waste" is defined as materials that are not primary products and for which the first user has no further use in terms of production, transformation, or consumption and wishes to dispose of. Wastes are produced as a result of the extraction of raw materials, the processing of raw materials into intermediate and final goods, the consumption of final products and other human activities. At the point of generation, residuals are recycled or reused. Waste management is the collection, transportation, processing or disposal of waste items, as well as their management and monitoring. Waste management is a procedure for reducing the impact of waste on human health, the environment and natural resources.

The process of waste management is usually carried out by the waste generator or by an entity that is in the business of collecting waste and disposing of it after treatment. The trash managed by the generator is a cost to the generator, whereas the waste managed by the service provider is an income. The practices of waste management in developed and developing countries, urban and rural locations, and residential and industrial producers may differ. The municipal

government is normally in charge of non-hazardous household and institutional trash management. The generator is responsible for the management of non-hazardous commercial and industrial waste, which is subject to local, national, and international regulations.

Solid, liquid, and gaseous wastes are classified according to their physical state. Municipal wastes, hazardous wastes, medical wastes, and radioactive wastes are the four types of solid waste. Planning, financing, construction, and operation of facilities for trash collection, transportation, recycling, and final disposal are all part of solid waste management. Waste might be thought of as a demon with many heads. When we attempt to handle one of the difficulties, many others emerge, creating a vicious spiral. At times, it appears that the situation may spiral out of control, and we will be unable to address the waste problem.

However, deliberate action can address the waste problem; actions should be performed in a methodological and regular manner and solutions that are both sustainable and environmentally friendly should be employed.

To comprehend and effectively handle the problem of waste management, we must first define waste. "Waste are materials that are not prime products (that is, things produced for the market)," according to the United Nations Statistics Division (UNSD). In India, our current garbage disposal procedures and mentality are to simply dispose of the rubbish. Improper garbage disposal not only creates pollution, but also has an impact on groundwater and wildlife, as well as many diseases and a high environmental and economic cost.

We need to use scientific, long-term, environmentally friendly, and cost-effective solutions. The activities and actions necessary to manage garbage from its inception to its final disposal are referred to as waste management (or waste disposal). This involves garbage collection, transportation, treatment and disposal, as well as waste management process monitoring and control. Solid, liquid and gaseous wastes all have different disposal and management strategies. Industrial, biological, and domestic garbage are all dealt with via waste management. Waste can, in some situations, be harmful to human health. Human action generates waste. The waste management generator has no longer use for it in terms of production, transformation or consumption, and wishes to dispose of it.

Waste management is a big issue in many of our country's urban areas, such as Pune and Mumbai (waste collection or dumping area). Effective sustainable waste management is a major difficulty in cities that are already dealing with resource limitation, such as limited land space and a high population density. Thousands of tons of municipal solid garbage are generated daily due to the high population density.

Countries (developed and developing countries), regions (urban and rural areas), and the residential and industrial sectors can all take different approaches.

OBJECTIVES

1. To Identify the generation of waste and its impact in India, especially Pune and Mumbai
2. To study different types of waste generated in India
3. To examine the current waste management practices and waste disposal options
4. To Understand the economics of waste management and its commercial aspects

RESEARCH METHODOLOGY

The data is collected from primary and secondary source by visiting Pune and Mumbai landfills. The secondary data is collected from newspapers, contacting the chain of people involved in waste management and by reading research papers available on the internet. Environment report and transportation report has provided data input for the study.

SECTION I : GENERATION, CHARACTERISTICS AND TYPES OF WASTE

The creation of robust and cost-effective solid waste management plans requires a thorough understanding of the quantities and characteristics of the trash being generated.

Although waste quantification and characterization form the foundation for management and intervention in some of the region's more developed countries, systematic waste surveying is given little priority elsewhere, and the quantities, characteristics, seasonal variations, and future trends of waste generation are poorly understood. Despite the lack of comprehensive or reliable data, several broad trends and common components can be discerned at the country level.

In comparison to the developing countries in the region, developed regions generate far more waste per capita. However, managing even tiny amounts of trash can be difficult in some situations.

Small populations and limited economic activity, for example, have ensured that comparatively little amounts of waste are generated in small areas of India like Jaipur and Indore. However, because to their small land areas and lack of disposal choices, many of these towns, particularly small atoll cities like Bikaner and Bhavnagar, suffer significant waste management difficulties.

Throughout the region, the principal sources of solid waste are residential households and the agricultural, commercial, construction, industrial and institutional sectors. For the purposes of this review these sources are defined as giving rise to five major categories of waste:

1. Municipal Solid Waste

Households, offices, hotels, stores, schools, and other institutions generate municipal solid waste (MSW). Food waste, paper, plastic, rags, metal, and glass are the most common components, though demolition and construction debris, as well as small quantities of hazardous waste such as electric light bulbs, batteries, automotive parts, and discarded medicines and chemicals, are frequently included in collected waste. Generation rates for MSW vary from city to city and from season to season and have a strong correlation with levels of economic development and activity. The Asian and Pacific Region presently produces 1.5

million tonnes of MSW per day, which is predicted to more than double by 2025. (World Bank 1999). The current waste generation estimate is likely to be conservative; actual levels are likely to be more than double this amount.

The composition of municipal solid trash varies greatly across the region, with some middle and low-income countries producing waste that contains over 70% organic content and a moisture content of over 50%. Some municipal authorities include building and demolition trash and industrial garbage as part of the municipal waste stream, whilst others do not.

Climate and fuel use are two factors that influence inter-urban disparities.

In squatter districts of many Asian and Pacific cities, where "wrap and throw" sanitation is practiced or bucket latrines are emptied into waste containers, the proportion of human faces in MSW is high.

The latter is typical in many cities in the region (such as mumbai, outskirts of Pune, Calcutta), where sewerage systems are inadequate.

Plastic products have become an important element of our daily lives, which has prompted increased production. 70 percent of this output is discarded. Pune Municipal Corporation has undertaken - Preparation of a Plastic Waste Management Plan for the city in accordance with Plastic Waste Management Rules 2016 based on the principle of 'Extended Producers Responsibility' to address this problem and make Pune a plastic waste free city or zero plastic waste city (i.e.no plastic to land).

200 material recovery centres held consultative seminars with stakeholders to reduce, reuse, recycle, and recover 170 to 180 MT of plastic trash per day PET bottle crusher machines were installed at 20 areas with heavy pedestrian traffic.

Because of improved hygiene awareness and the availability of sanitary napkins and diapers, their use has increased, as has the problem of scientific disposal. PMC contacted the manufacturers of these items and requested that they offer separate, easily identifiable bags in which to dispose of the discarded items. PMC pushed Swachh to produce paper bags for the purpose and advocated their use after receiving a negative response from them. A procedure for scientific disposal of the waste was also established. There are three locations throughout the city. Each station disposes of 600 to 900 sanitary napkins every day in a methodical manner. Working women's hostels, red light zones, girls' hostels, and large residential societies are among the areas of attention for a collection, transportation, and disposal system.

Extension of these services to 15 additional places across the city is proposed.

2. Industrial Solid Waste

In the west of India, as everywhere, industrial solid waste includes a diverse spectrum of materials with variable levels of environmental toxicity. Paper, packaging materials, food waste, oils, solvents, resins, paints and sludges, glass, ceramics, stones, metals, plastics, rubber, leather, wood, fabric, straw, abrasives, and other items fall into this category. The lack of a regularly updated and structured database on industrial solid waste, as with municipal solid waste, means that the exact rates of generation are generally unknown.

Industrial solid waste generation differs not only between developed and developing countries, but also between developing and developed countries.

However, based on a regional average ratio, the region's industrial solid waste generation amounts to 1900 million tonnes per year. This number is likely to rise significantly, and at current rates of growth, it will more than double in less than 20 years. Because many countries' existing industrial solid waste collection, processing, and disposal systems are woefully inadequate, such incremental development will pose significant issues.

Industrial Units, particularly small-scale enterprises, in the Pimpri-Chinchwad-Bhosari industrial area appear to be polluting the air, water, and soil, despite the Maharashtra Industrial Development Corporation (MIDC) and Maharashtra Pollution Control Board (MPCB) apparently turning a blind eye. The industrial units allege that they are powerless since no government agency has ensured that basic services are available in the area. Outside the industrial plants in the Bhosari industrial region, blocked nullahs with stagnant chemical waste were a regular sight. Some of the units had small man-made ponds outside their doors. Untreated chemical waste is dumped here, and environmental activists claim that it pollutes the soil as it percolates through it. In the Bhosari, Chinchwad, Indrayani Nagar, and Landewadi regions, piles of hazardous industrial trash — including cloth, polythene bags, and sacks saturated in chemical waste — were apparent on every length of the road. Every other nullah in the industrial region was either half-built or appeared to be far from finished. Around 75% of industries in the Pimpri-Chinchwad-Bhosari industrial area, according to Suvarna Fibrotech, employ chemicals and subsequently dump the untreated waste in open nullahs.

During various phases of processing, electroplating units, as well as units engaged in manufacturing polyester resins, leather, painting, or dye, require chemicals. Because wastewater treatment plants are expensive, small-scale enterprises cannot afford them. Instead, the government should establish a centralized wastewater treatment plant to address the issue. Despite the fact that the industrial sector is under its control, the civic body is not responsible for it.

The MIDC and the MPCB are responsible for controlling pollution in the industrial sector. The PCMC has already instructed the MIDC and MPCB to begin the process of establishing a unified effluent treatment plant. They have also been advised to make sure the existing nullahs are connected to our nearest sewage treatment plant.

3. Bio-Medical and Agricultural Waste

The number of hospitals and health-care facilities in Mumbai and Pune has been growing to fulfill the growing population's medical and health-care needs. Although city planners have long considered the provision of medical and health care institutions and services, they, and even municipal waste management authorities, have paid little attention to the wastes generated by these facilities, which can be hazardous to human health and the environment, until recently. However, in recent years, there has been growing worry about the potential for infection spread and environmental contamination as a result of inappropriate handling and management of clinical and biomedical waste. While regulatory programs and guidelines have been implemented to control waste from such organizations. Guidelines and laws have been established in order to ensure proper disposal of waste. Bio medical waste should not be mixed with other wastes. Such waste has to be segregated at the point of generation itself prior to its storage, transportation, treatment and disposal. The containers should be labelled. For the container to be transported from the premises of generation of waste-to-waste treatment plant outside the premises it shall be labelled as prescribed in schedule III of this Act. Untreated bio-medical waste should not be kept stored beyond 48 hours provided, if necessary, permission has been obtained to store beyond the period specified in this Act. An Annual report in Form 11 be submitted on or before every January 31 providing information about the categories and quantity of Bio-medical waste handled in the previous year. This will help the authorities to send the information to Central Pollution Control Board by 31st March every year. Record relating to generation, Technical Guide on Auditing Waste Management 56 collection,

reception, storage, transportation, treatment, disposal and/or any form of handling of bio-medical waste in accordance with the rules and guidelines issued. Record so maintained are subject to inspection and verification by prescribed authority at any time.

The aim of these Rules is to ensure that bio-medical wastes are safely disposed of. Bio-medical waste can be defined as any waste or by product generated during treatment, immunization and treatment of human beings or animals or in research activities. Schedule I of the Rules, differentiates biological wastes into different categories like microbiological and biotechnological, human anatomical, animal anatomical, discarded medicines, chemical related waste, etc.

The BMW Rules apply to various institutions like nursing homes, animal houses, veterinary homes, blood banks, dispensaries, pathological laboratories, etc. The BMW Rules prohibit mixing of biological wastes with any other type of wastes. The general rule provided is that bio-medical wastes can't be kept stored beyond the period of 48 hours without being treated. Rule 8 (1) requires every occupier or any institution which is dealing with biological waste to take an authorization form the State Pollution Control Board. Further, according to Rule 5 (2), all institutions covered under the rules are to mandatorily set up treatment facilities like microwave system, autoclave, etc.

4. Hazardous Waste

With rapid development in agriculture, industry, commerce, hospital and health-care facilities, the Asian and Pacific Region is consuming significant quantities of toxic chemicals and producing a large amount of hazardous waste. Currently, there are about 110000 types of toxic chemicals commercially available. Each year, another 1000 new chemicals are added to the market for industrial and other uses. The availability of robust data on the generation of hazardous waste for the Asian and Pacific Region is limited by the reliability of information on the quantities and types of hazardous waste produced at the country level. This is due to a variety of reasons, including the lack of qualified personnel to undertake the necessary assessment, the reluctance of industries to provide process information (including waste arising data) and a poor appreciation of the extent to which generated waste is hazardous. Where data is available, significant difficulties are encountered in seeking to draw international comparisons due to differences in classification and definition of hazardous waste from country to country within in the region. Most hazardous waste is the by-product of a broad spectrum of

industrial, agricultural and manufacturing processes, nuclear establishments, hospitals and health-care facilities. Primarily, high-volume generators of industrial hazardous waste are the chemical, petrochemical, petroleum, metals, wood treatment, pulp and paper, leather, textiles and energy production plants (coal-fired and nuclear power plants and petroleum production plants). Small- and medium-sized industries that generate hazardous waste include auto and equipment repair shops, electroplating and metal finishing shops, textile factories, hospital and health-care centres, dry cleaners and pesticide users. The principal types of hazardous waste generated in the Asian and Pacific Region, include waste solvents, chlorine bearing waste and pesticide organophosphate-herbicide-urea-fungicide bearing waste. In particular, solvents are extensively used in the region and, as a consequence, large quantities of waste solvents are produced. The types, quantities and sources of hazardous waste vary significantly from country to country and are influenced by the extent and diversity of industrial activity.

5. E-waste and Radioactive Waste

Any activity related to the nuclear fuel cycle, that produces or uses radioactive materials generates radio-active waste. The management of radiation emitting radioactive material is a matter of concern and is what sets nuclear wastes apart. Public acceptance of nuclear energy largely depends on the public assurance for safe management of radioactive wastes. Not all nuclear wastes are particularly hazardous or difficult to manage as compared to other toxic industrial wastes.

Safe management of radioactive waste has been accorded high priority right from the inception of our nuclear energy program. In accordance with international guidelines, a coherent comprehensive and consistent set of principles and standards are being practiced all over the world for waste management system. Radioactive waste would be managed in a manner so as not to cause any undue radiation risk to the workers, the public (present as well as future generation) and the environment.

Management of these wastes covers the entire range of activities right from handling, treatment, conditioning, transport, storage and disposal. The recent technological developments in India realize the recovery of valuable radionuclide from radioactive waste for societal application besides ensuring the highest level of safety in the management of radioactive waste. Safe

management of radioactive waste has been accorded high priority right from the inception of our nuclear energy program. As a result of rugged design with 'defence in depth' concept, well established practices and safety review by independent agency, an excellent track record for safe management of radioactive waste in India has been demonstrated for more than five decades. Consistent efforts in R&D have enabled indigenous development of novel processes and technologies in the field of management of radioactive waste and their deployment to realise the waste volume minimization, effective isolation of radionuclide in engineered matrix, minimization of discharges and extracting wealth from waste by separating useful radionuclide from radioactive waste for societal applications.

Such developments enable the country to be front-runner in the field of radioactive waste management in the world. Maharashtra state is number one in e-waste production in India. Mumbai city is a financial and cultural capital of India. It generates more employment opportunities and attracts skilled labour force across the country. Due to high density of population, skilled labour force and technological innovations, electronic waste is growing fast in city. According to Central pollution control board (CPCB), Mumbai is at top in order to generate e-waste in the country.

The Mumbai metropolitan region will generate 2.92 lakh ton e-waste's in 2020. It means e-waste is continuously rising with alarming rate in region. At present, e-waste disposal is mixed with solid waste. It is posing a greater threat for environmental degradation and the effects are much more than they are estimated. E-waste that is land filled pollutes water, soil and air. E-waste contaminates rivers, wells and other water resources in the region. The air gets pollute due to emission of gases and burning of e-waste. The fertility of land declines due to e-waste landfill. Effects of e-waste on human health are widely observed. E-waste of chemicals such as lead, mercury, copper found in computer screens and televisions are poisonous. It can lead to fatal diseases like cancer, kidney failure, thyroid, hormone disruption and damage.

Most of the informal units are responsible for e-waste collection, segregation and disposal. Nearly 95 percent of the e-waste in region is processed by the informal sector. Women and children are collecting the e-waste in the metropolitan region. Women and children are less educated and they do not have much knowledge of e-waste. They collect e-waste and sell it to the retailer. In replace of that, they get few amounts of money which is used for daily livelihood. Waste pickers are from poorer section of society therefore they can afford to work at lower wage. They do not get any medical allowance or compensation for injury. They are also not

aware of such rights. They do not prefer to wear masks and hand gloves while handling e-waste. They are at high health risk due to exposure to dangerous and slow poisoning chemicals. But lower labour cost, high unemployment rate, migration and lack of protest are the reasons of the waste pickers working for e-waste collection. Electronic waste which is commonly referred as “e-waste” is the new by-product of the InfoTech society. It is a physical waste in the form of old discarded, end of life electronics.

Alternatively, it can be defined as “E-waste is electronic waste. It includes a broad and growing range of electronic devices from large household appliances such as refrigerators, air conditioners, cellular phones, computers and other electronic goods”. Similarly, e-waste can be defined as the result when consumer, business and household devices are disposed or sent for re-cycling example, television, computers, audio-equipment’s , VCR,DVD, telephone, Fax, Xerox machines, wireless devices, video games, other household electronic equipment’s. All the above definitions explain about electronic goods which are used and discarded when new electronic goods are bought.

SECTION II : Current Waste Management Practices and Waste Management Disposal

India is turning into one big garbage dump. The problem is assuming gigantic proportions and the numbers are staggering. Urban India is the world's 3rd largest garbage generator and by 2050 waste is expected to rise to 436 million tons up. Out of the total municipal waste collected, 94% is dumped on land and 5% is composted.

When it comes to waste management in India, nothing is quite right. Central Pollution Control Board in its report which was released in 2009 indicates that around 62 million tons of solid waste is produced in our country every year, of which less than 20% or only 12 million tons are treated. This essentially means that the remaining 52 million tons of waste remain 'untreated' and contaminate land or make its way into rivers, lakes and wetlands. last year, The Central Pollution Control Board (CPCB) has issued statutory notices to municipal commissioners of 184 towns to ensure proper management of domestic sewage and solid waste. But no serious action has been taken till now. Another major issue is the overflowing landfills – there is literally no space to accommodate fresh garbage waste. An expert at the Centre of Science and Environment says, instead of constructing new landfill sites, the government should be really looking into innovative methods to dispose and recycle its waste. The reason why most landfill sites are over-flowing is because the current waste disposal system is flawed.

In Pune city, the rag pickers collect solid waste from homes and streets. Street sweepers also collect waste while sweeping various streets. Rag pickers visit every day to different households and collect waste and segregate it. These waste pickers consist of male, female and children of different age groups. The waste pickers are poor and they do not have access to the water supply, health care and sanitation. They carry big bags which have huge weight and consist of iron plates, plastic bags and bottles on their heads or on their backs. The waste collection from the big bins in the street is hazardous task. Some of the women end up with factures from falling while entering in big bins or uneven surface. There is no transport facility for carrying the big bags of solid waste. Most of the waste picker women complaint of back bone pain. During monsoon, waste pickers come into electricity contact with bare electric wires. It causes causality to them. If rag pickers get injured by accidents and burns and admitted in any public health care hospital then they do not get the adequate health treatment. Usually, health staff of hospitals ignores rag pickers during treatment.

Pune Municipal Corporation collects solid waste and transport up to the disposal site. Regularly funds are allotted for solid waste management in municipal corporation area. Therefore, Municipal Corporation claims for necessary infrastructure for collection, storage, segregation, transportation, processing and disposal. In Pune Municipal Corporation, whole responsibility of solid waste management is given to health department. The medical officer of health department of the municipal corporation is responsible for solid waste management. Therefore, health department is accountable for collection, storage, segregation, transportation, processing and disposal of solid waste.

The solid waste collection and transport is managed through a team of workers and a fleet of vehicles and dumper placers. Health department employ sanitary inspectors for solid waste management. Municipal Corporation is employing more than two thousand sweepers. The solid waste is also collected through rag pickers. There are more than four thousand rag pickers appointed by the municipal corporation for segregation. They are appointed for the five Ghantagadis in city. But not all rag pickers are employee of the municipal corporation and no regular payment is given to them.

They carry door to door collection in municipal corporation area. Most of the households pay them Rs.10 per month which is depending on their service and area. Municipal Corporation is extending their services such as waste storage and segregation to all 18 ghantagadies in city. But it will be additional economic burden on Municipal Corporation. At present in Pune Municipal Corporation, there is no specific organizational structure for solid waste storage, collection, segregation etc. The Pune Municipal Corporation has a decentralized pattern of solid waste segregation and disposal at it sources. Dry waste is collected by the rag pickers and other NGOs for recycling. Primary collection means collection from source or roadside dustbins. The secondary waste collection means designated ramps at strategic locations. The primary and secondary arrangements overlap in Pune city. There is no clear distinction between primary and secondary collection points. There are few primary collection points in PMC. These primary points are in form of bins provided on the roadsides. Households and other waste generators put their solid waste at street corners and local open spaces where ever it is possible. In city, dust bins are overburdened of daily solid waste. These points are collection points depending on secondary and primary collection point.

Pune Municipal Corporation has put five areas for door-to-door collection where rag pickers collect waste from individual households. The PMC has provided 84 dumper placer vehicles

containers with about 1.0 to 1.5 tonnes of refuse–carrying capacity each. They are used for collection and transport of solid waste from the collection points to the disposal sites. There are two JCB loaders meant for loading waste from open secondary collection points.

There are 2690 bins and they are insufficient therefore at source segregation and recycling is encouraged. Municipal Corporation is employing NGO'S for solid waste segregation at source and at disposal sites by using the services of more than 4000 rag pickers (PMC 2006). PMC has shifted the dumping ground from Kothrud to Urali Devachi in 1999. It is located 25 kilometre away from city.

The area of dumping ground is 43 acres. The second future land fill waste disposal site is located at Yewalewadi of 17.5 acres. The plan is to develop Urali Devachi 120 acres for waste processing and disposal facility. The funds are received from government of India under the scheme of Airfield town's project. The Pune Municipal Corporation has adopted the decentralized system of waste disposal at local level. The wet waste can be disposed by vermiculture.

Waste Disposal Options

Final destination of solid waste in India is disposal. Most urban solid waste in Indian cities and towns is landfilled and dumped. A wide range of disposal options in many developing countries is available and some of them are listed below:

1. **Non-engineered disposal**

This is the most common method of disposal in low-income countries, which have no control, or with only slight or moderate controls. They tend to remain for longer time and environmental degradation could be high, include mosquito, rodent and fly breeding, air, and water pollution, and degrading of the land. In many Indian cities, open, uncontrolled, and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation. More than 90% of Solid waste in cities and towns are directly disposed of on land in an unsatisfactory manner.

2. **Sanitary Land filling**

Sanitary landfill is a fully engineered disposal option, which avoids harmful effects of uncontrolled dumping by spreading, compacting and covering the wasteland that has been

carefully engineered before use. Through proper site selection, preparation and management, operators can minimize the effects of leachates (polluted water which flows from a landfill) and gas production both in the present and in the future. In this process the waste is disposed and is covered with a layer of soil.

The compact layer of soil restricts continued access to the waste by insects, rodents and other animals. It also isolates the refuse, minimizing the amount of surface water entering into and gas escaping from the waste (Turk, 1970). Sanitary Landfilling is a necessary component of solid waste management, since all other options produce some residue that must be disposed of through landfilling. However, it appears that landfilling would continue to be the most widely adopted practice in India in the coming few years, during which certain improvements will have to be made to ensure the Sanitary landfilling.

3. Composting

Composting is a biological process of decomposition carried out under controlled conditions of ventilation, temperature, moisture and organisms in the waste themselves that convert waste into humus-like material by acting on the organic portion of the solid waste. If carried out effectively, the final product is stable, odour-free, does not attract flies and is a good soil conditioner. Composting is considered when biodegradable waste is available in considerable fraction in the waste stream and there is use or market for compost.

This is a popular technique in Europe and Asia, where intense farming creates a demand for the compost (Schneider, 1970). Centralized composting plant for sector may only be undertaken if adequate skilled manpower and equipment are available, hence at household level and small level composting practices could be effective which needs the people's awareness.

Many large-scale compost plants with capacities of ranging from 150 to 300 tonnes/day were set up in the cities of Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur and Kanpur during 1975-1980 (Sharolyn et al., 2008). Now, about 9% of solid waste is treated by composting. After composting the final product obtained is called compost, which has very high agricultural value. It is used as fertilizer, and it is non-odorous and free of pathogens.

4. Incineration

In Incineration combustible waste is burned at temperatures high enough (900-1000 0C) to consume all combustible material, leaving only ash and non-combustible to dispose off in a landfill. Under ideal conditions, incineration may reduce the volume of waste by 75% to 95%. Incineration may be used as a disposal option, only when land filling is not possible, and the waste composition is of high combustible (i.e self-sustaining combustible matter which saves the energy needed to maintain the combustion) paper or plastics. It requires an appropriate technology, infrastructure, and skilled manpower to operate and maintain the plant.

In Indian cities, Incineration is generally limited to hospital and other biological wastes. This may be due to the high organic material (40-60%), high moisture contact (40-60%) and low calorific value content (800-1100Kcal/Kg) in solid waste. Incineration of urban waste is not a clean process. It may produce air pollution and toxic ash.

For example, incineration in the United States apparently is a significant source of environmental dioxin, a carcinogenic toxin and a controversy over incineration has resulted. Smokestacks from incinerators may emit oxides of nitrogen and sulphur that lead to acid rain; heavy metals such as lead, cadmium, and mercury; and carbon dioxide that is related to global warming. In modern incineration facilities, smokestacks are fitted with special devices to trap pollutants, but the process of pollutant abatement is expensive.

5. Pyrolysis

In Pyrolysis, the chemical constituents and chemical energy of some organic wastes is recovered by destructive distillation of the solid waste. It is a form of incineration that chemically decomposes organic materials at high temperature in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs.

If volatile or semi-volatile materials are present in the waste, thermal desorption will also occur. Organic materials are transformed into gases, small quantities of liquid, and a solid residue containing carbon and ash. The off-gases may also be treated in a secondary thermal oxidation unit. Particulate removal equipment is also required. Several types of pyrolysis units are available, including the rotary kiln, rotary hearth furnace, or fluidized bed furnace. These

units are similar to incinerators except that they operate at lower temperatures and with less air supply.

6. Vermicomposting

Municipal solid waste is highly organic in nature, so vermicomposting has become an appropriate alternative for the safe, hygienic and cost-effective disposal of it. In this method earthworms feed on the organic matter present in the solid waste and convert into casting (ejected matter) rich in plant nutrients. Vermicomposting has been used in various cities of India like Hyderabad, Bangalore, Mumbai and Faridabad. Experiments on developing household vermicomposting kits have also been conducted.

7. Reuse and Recycling of waste materials

Recycling is the reprocessing of discarded materials into new useful product. The process of reusing of cans can save money. Recycling of paper will reduce of cutting of tress. Reuse of metals will reduce the mining activities. In India about 40-80% of plastic waste is recycled compared to 10-15% in the developed nations of the world.

However, the recovery rate of paper was 14% of the total paper consumption in 1991, while the global recovery rate was higher at 37%. During most of human history, the approach to waste management in many cultures and civilizations was the recovery of materials. Only around the turn of the twentieth century the emphasis shifted from recovery to disposal.

During the nineteenth century there were pioneering efforts in England to minimize wastes as a way to improve industrial competitiveness. Waste management in developing countries like India, must emphasize and be linked to the creation of jobs, poverty alleviation and community participation. There is increasing evidence that community-based approaches to waste management can promote a more sustainable development. Grassroots efforts can be more successful than top-down programs created by bureaucrats or experts with little or no community participation.

To minimize the solid waste generation, adopt the policy of 4R's.

The policy of 4R's

Refuse

Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.

Reuse

Do not throw away the soft drink cans or the bottles; cover them with homemade paper or paint on them and use them as pencil stands or small vases.

Recycle

Use shopping bags made of cloth or jute, which can be used over and over again. Segregate waste to make sure that it is collected and taken for recycling.

Reduce

Reduce the generation of unnecessary waste, e.g carry your own shopping bag when you go to the market and put all your purchases directly into it.

SECTION III : The Economics of Waste Management

Waste management services first arose with the aim of protecting public health. With regard to waste collection, the value of the service is in the removal of the materials from the place of generation. Clients of the service tend to be willing to pay for removal of their waste. The resulting direct Service Payment relationship helps to create a favourable economic platform for the provision and progressive extension/improvement of current services.

Waste treatment and disposal services are, however, different. Service-Payment relationships between the client and the service provider are indirect, i.e the client does not 'see' the service that they receive, with the effect that the service is often under-valued and under-provided unless policy and legislative instruments are in place to ensure service provision. The quality of disposal services is almost entirely driven by environmental legislation. When left to market forces, the quality of disposal tends to remain very low.

This is due to the cost of long term or cumulative environmental (and indirect health) impacts not being reflected in market prices, unless, there is some form of regulation or policy driver. The disposal service is a net financial cost activity which the customers of the service often regard as 'out of sight and out of mind'.

Under pure market conditions, the economic viability of recycling and treatment is driven by the market value of the materials extracted from the waste stream; either for re-use, recycling, composting or conversion to energy. The market can be relied upon to deliver a certain level of recycling and treatment, mainly for higher value materials such as ferrous and non-ferrous metals, glass, certain plastics and pure organics/biodegradables. Experiences from industrialised countries that have succeeded in establishing higher treatment intensity, and diverting larger percentages of municipal waste away from landfill, demonstrate that policy instruments are required to shape the market conditions on the ground.

Higher intensity of treatment is driven by a combination of the policy (regulatory, financial, economic) framework, coupled with the specific local market influencing factors. The basic costs of waste management under the 'Business as Usual' (BAU) scenario increase as waste collection coverage extends and legally compliant landfill is ensured.

At the same time improved cost control and revenue collection improve financial management and enable a cost efficient high quality services. There is a demand for collection service and usually people are willing to pay something for removal.

Therefore, collecting revenues from the public in the form of user charges, tax is possible and sometimes reaches full cost recovery. For low-income citizens, where affordability is an issue, public funds are allocated due to public health issues that may arise in case the service is not available. There is a demand for recovery driven from the intrinsic value of the discarded materials. As the city will move from a linear collection- transport – landfilling to a multi-dimensional waste management system that includes treatment, revenue streams will diversify. Revenues for waste treatment are usually derived from various sources, including commercial revenues from the sale of recovered materials and energy.

Those activities that are not demand driven and need an environmental policy push and revenues from subsidies or other public funds. Such is the case for the recovery of certain waste streams and for the disposal of refuse.

Economic costs and benefits of waste management

Advanced waste treatment is generally more expensive than landfilling when considering the financial costs of the service only. However, when considering the wider economic costs and benefits from a societal standpoint, the advanced treatment options become more favourable than just landfill. Internationally, there have been numerous efforts to monetize the negative environmental and health impacts of landfilling and other, less environmentally friendly methods of disposal that do not respect the norms of sanitary landfilling.

These studies are usually location specific, but they all monetize negative impacts, such as air, water and soil pollution, health impacts of pollution, climate change impact, nuisance caused by odour and the negative landscape impact. It should also be pointed out that much of the available evidence is for small island states, where estimation is easier, but where the impacts may be more pronounced due to scarce land and high dependence on certain resources, and the small population may result in a higher cost per capita.

However, on the basis of the best estimates here, comparing the incremental costs of proper waste management of Rs. 500-700 with a likely cost of inaction of perhaps Rs. 5000-10000 per capita, it is reasonable to conclude that it is much cheaper for society as a whole to manage its waste NOW in an environmentally sound manner than to carry on dumping.

Besides pollution control and public health benefits proper waste management can bring lots of benefits environmentally and economically.

1. **Increased resource security**

   After a century of steady decline, resource prices in real terms doubled between 2000 and 2010. With continued price volatility, developing indigenous supplies of secondary raw materials from recycling makes good sense, particularly in rapidly industrialising countries. For example, e-waste comprises a richer 'ore' for many scarce and critical metals than the natural ores mined for the virgin raw materials.

2. **New Jobs**

   Environmentally sound waste management, the recycling of dry and organic materials and energy recovery from wastes all represent 'new' green industrial sectors with the potential for substantial job creation. UK employment in the sector, for example, increased by 50% between 1993 and 2013. The wider 'circular economy' holds further promise: the McKinsey report estimates the potential to create between 9 and 25 million new jobs worldwide.

3. **Reduction in GHG emissions from waste management**

   The Intergovernmental Panel for Climate Change reports that MSW accounts for approximately 3% of total Greenhouse Gas (GHG) emissions, mainly as methane. Efforts in high-income countries to divert biodegradable municipal waste from landfill represent a significant contribution to early progress on GHG mitigation.

4. **Energy recovery by using waste to generate energy often together with sparing other precious resources**

   Through conventional and advanced and waste-to-energy technologies, co-incineration and anaerobic digestion technology. For example, waste to energy plants in China are both reducing fossil fuel use and are known to prevent deforestation, wood being a common source of fuel in rural China.

Costs and revenue of waste management

Investment Cost

When planning waste management improvements, municipalities need to think of investment costs immediately and source the financing. If improvements are small, the costs will be reasonable and rather easy to estimate, including equipment that the municipality itself is familiar with such as compactor trucks, containers needed for collection or equipment needed for the day-to-day operation of the landfill.

When a more significant change is planned, such as introduction of transfer station, reshaping the disposal site and introducing new modern disposal practices, leachate treatment, collection of gas and treatment technologies, careful planning is needed and expertise needs to be brought in as municipalities may not be familiar with the new investments. During the planning phase and the project development phase, a series of costs will occur as listed in Table below.

Cost Category	**Notes**
Feasibility Study and Technical Design	5 to 10% of the total investment costs. The most expensive phase is the detailed technical design.
Permitting (including Environmental Impact Assessment (EIA) and technical documentation needed for permitting, site selection and specialist studies)	3 to 5% of the total investment cost, depending on the difficulty of procedures and compliance.
Market Research	Regularly part of the feasibility study. This merits special attention. Market research may be omitted at times for waste management tenders by public authorities, but is crucially important especially if waste treatment is planned that will produce various marketable outputs.
Setting up the Financing Scheme	Often the source of financing is a combination of public funds, different

	donors and development banks and private funds. Putting together options for the financing scheme becomes part of the feasibility study.
Contracting and Negotiations	In case the investments are going to be delivered by a third party, other than the municipality, i.e. for the construction of a new landfill site, contracting and negotiation become part of the transaction costs.
Construction Supervision	Along with the construction, contracting a separate construction supervision contract is needed to monitor and control the construction works. This may be tendered and allocated together with the detailed design.
Stakeholder engagement and customer satisfaction	The long process of stakeholder engagement and customer satisfaction starts at an early planning and design phase. For a system to work, the communities need to embrace it, approve it and be able to work with it. The engagement process and the customer satisfaction studies will take up time and resources.

The most important cost categories are mentioned and may be used as a checklist to verify if all costs were included when considering AWT investments.

Typical Investment cost structure

Investment Phase	**Description and Notes**
Land and Acquisition	Planning of waste management facilities can be a significant cost; however industrial land is relatively cheap.
Site Infrastructure	• Paved areas, concrete works

	• Civil works and construction work • Water supply, access to utilities • Effluent disposal/storing facilities • Road infrastructure
Supporting infrastructure	• Buildings • Weighbridges • Offices • Fencing and Security systems
Equipment	Equipment needs depend on the type of investment. Typical equipment that will be necessary for most waste management systems include compactor trucks, excavators, compactors, various vessels, sieves, separators, loaders, conveyors, temperature monitoring and control and in some cases odour control equipment, blowers, fans and filters, to name a few. Some of the equipment is locally produced and available, whilst other equipment needs to be purchased from outside the country.
Regulatory compliance	Includes all necessary permits and approvals.

Operational costs

Bookkeeping and budgets maintain information about operating costs. Some difficulties may arise in discovering these costs as municipal waste budgets may not be clearly demarcated or 'ring fenced'; further more cost data may only be available to operators who might wish to keep these data private. Costs of different utilities or service elements are often aggregated, and recorded in different departments of the municipality.

This situation fosters uncertainty in decision making and sends incoherent signals to the private sector, thus creating a market barrier for the development of AWT. A typical operating cost structure of waste management includes direct labour, fuel, utilities, supplies and mechanical maintenance and repair costs. Operation costs include costs that are not always immediately

obvious and may be hidden in other budget lines, or may be part of an overall overhead that is not attributed to waste management.

Examples of these costs include; obtaining permits, planning for waste management, preparing tenders and contracting, management of operators and monitoring and quality control. Customer relations and satisfaction surveys, awareness raising, insurance, taxes and cost of financing sometimes fall under this category.

Below table lists typical cost categories in operation

Operational phase	**Description and notes**
Examples of direct costs • Labour • Fuel • Energy and Utilities • Maintenance and Repairs • Replacement costs • Disposal of Rejects • Feedstock Costs • Additives and Consumables	Labour costs include normal salaries and wages, bonuses, overtime costs, allowances, fringe benefits and social contributions, etc. Some technologies may have the need for highly specialized personnel; various technologies can include phases/departments that can be either labour intensive or fully mechanized, depending on local factors. Typical labour requirements may include heavy equipment operators, maintenance personnel, instrumentation/ computer operators, administrative support and management.
Some hidden costs of operations • Overhead (office supply, communication, etc.) • Advertising, promotion, awareness raising • Taxes and Insurance • Monitoring and reporting to environmental and public health agencies • Intervening in case of emergencies, such as fires at the disposal site or equipment failure due to rainy season • Capacity building	Overhead costs and so called recurring hidden costs are part of operation and often left unaccounted for. This list shows the cost categories and budget lines that belong to operation costs but sometimes get lost in other municipal budget lines. Private operators do not always incur all of these costs. Depending on the service contract between municipality and operator, these may be with the municipality or the operator.

Costs associated with the client function of the municipality • Contracting out services to operators • Monitoring of service performance • Administering fines • Controlling and managing revenue collection	The municipality as the authority responsible for waste management needs to ensure a good quality service to the citizens, keeping the city clean and protecting public health and the environment. No matter if the waste management service delivery is outsourced to private contractors or is carried out directly to the municipality, the municipality will always need to act as a "client" monitoring the quality of service. There are costs associated with these functions as well.

Operation costs are not as obvious as capital costs but need the same attention for informed decision-making, ensuring that the chosen technology can be sustained by revenues and gate fees. Costs related to more ad-hoc activities, such as clean-up of illegal dumps or debris after a storm or flood, extinguishing landfill fires or closing old landfills sometimes also fall into the category of "forgotten or hidden" costs. Calculation of costs based on activity, separated for each individual component of the service – such as street sweeping, waste collection, waste transport, recycling operations, landfill operations, billing – is considered good practice and will help pin-pointing and correcting potential inefficiencies.

Revenues

Revenues may comprise local taxes or fees for waste management services, revenue from the sale of materials or energy recovered, gate fees at treatment plants or disposal sites, or transfers from local or national budgets. Other, less significant, financing sources include income from permits, the occasional renting of assets, profit sharing deals (fees from concession), sale of space for advertisement on containers and litter bins or littering fines. Once current costs and revenues are understood the process of forecasting future revenues and expenditures may commence. Forecasts of future revenues are required to set user fees. Different revenue collection mechanisms are possible, including a tax, a user charge or combination of both. Changes proposed in the revenue structures or revenue collection methods usually need to be gradually introduced, coupled with improvements of the service and awareness raising campaigns in order to ensure social acceptance.

Sources of revenue are listed below

Operational phase	Description and notes
Non –tariff revenues • Avoided costs if commercial entities are not included • Avoided costs if recyclables are extracted from the waste stream at no cost to the municipality • Offering service to larger waste generator at higher cost • Collecting gate fees at disposal site or treatment site paid directly by commercial agents bringing their own waste in the facility • Sale of recyclables • Sale of compost • Sale of energy • Sale of Refused Derive Fuel	Understanding and maximizing non-tariff revenues will help with both cost recovery and affordability of the waste management system. Often the first and most easy thing to do is to avoid certain costs. Costs may be avoided if commercial entities are expected to bring in their own waste to treatment facilities. Costs may also be saved in the informal sector extracts valuable materials at the point of generation since those materials need not be handled in the system operated by the municipality. However, the municipality may decide not to avoid costs, but to extend its service to include large generators and manage the recyclables themselves. If done efficiently these systems may bring extra revenues to the municipality. It is often the case that in trying to introduce a collection of recyclables where there is a thriving informal sector increases in fact the costs for the municipality, as extra effort will need to be put into competing for the valuable material streams. Cooperation with the existing systems is therefore adviseable.
User charges/tariffs	User charges are established based on the revenue requirement that is still needed after the non-tariff revenues have been discounted from the total costs. Here the dual constraint of cost-recovery and affordability play an important role, one driving the user charges/ tariffs up, the other pulling them down.

User charges, gate fees and billing procedures

Establishing user charges and gate fees involves the calculation of the revenue requirement and then this is spread over the tonnes handled to calculate gate fees and the number of service users to calculate user charges/ tariffs.

Gate fee at disposal

Establishing a gate fee for disposal is a good practice that is likely to encourage recycling, given that a reasonable control of illegal dumping is carried out by the environmental authorities and the municipality.

The gate fee at disposal will be paid by the service operator be it a private company, a public company or a different kind of organization. This will then become their cost and will be charged to the user. This way the user charge includes the full cost of waste management, including the gate fee of the disposal site or any treatment site that is part of the waste management system.

User Charges, Tariffs

Methodologies for establishing these charges are usually set at national or municipal and respect a set of principles. The principles usualy used to design tariff setting methodologies include:

1. Cost recovery
2. Affordability
3. Equity and fairness
4. Polluter pays
5. Behaviour change

The exercise of establishing the so-called macro-tariff at cost recovery, is very similar to establishing to the gate fee at cost recovery at a disposal site or treatment facility.

After this point, the municipality needs to make a series of decisions on prioritizing principles. For example South Africa made an important point of making sure that all the citizens benefit of waste management services and decided to provide these free of charge for the poorest segments of society. Other countries or municipalities may decide that everybody who generates waste needs to pay something for waste management services. In this case even the

poorest households need to pay a user charge based on their capacity to pay. Cross-subsidizing is very common, meaning that those service users who generate more waste and are likely to be better off also pay higher tariffs for waste management. When designing a tariffing system, this needs to be done having a correct understanding of the services users in terms of their waste generation patterns, recycling habits, income levels, etc.

Revenue Collection

It is not enough to have user charges/ tariffs established it is also important to collect these revenues. In this sense, the first important issue is to have a service that has a value to the users. People are usually willing to pay for a good waste collection service, but if that service fails and they are left living in dirty, unhealthy environments, then they see no reason to pay. Second, the municipality needs to be able to control the financial flows of the revenues. When the revenue collection function is left to the private operator, several problems occur:

- the private operator has no legal basis to enforce payment

- the private operator is likely to not provide the service to non-payers, thereby causing public health risks and nuisance to all citizens. This will in turn generate a general dissatisfaction with the service and even less users willing to pay

- the municipality has no financial means to control the quality of the services provided since they cannot withhold payment to the operator in case of lack of service or poor service provision

As a conclusion, the best revenue collection system is one in which: - enforcement of payments is possible through administrative or financial penalties - the municipality can control the quality of the services and impose financial penalties on the operator in case of non-performance The most efficient revenue collection methods include the collection of revenues in the form of a property tax or linking the revenue collection and billing procedure to a public utility bill or a widely provided and used service such as phone services. The property tax is efficient because it is collected once a year and thus the administrative cost of revenue collection is low.

However, this constitutes also a drawback for this method, since for poor households paying out a big amount of money once a year is not affordable. Collecting revenues through public utilities has been proven widely successful and cost efficient. There may be issues with the legality of sanctions such as cutting off users from electricity or water supply in case of non-

payment. But if legally possible, such systems yielded high payment rates, in fact payment rates are usually equal to the coverage rate of the service. So, for instance, if the waste user charge is connected to the electricity bill and 90% of the users are using electricity, then the expected payment rate is 90%.

Financial Management

Moving from providing services and budgeting for them yearly to financial management of services involved going through the exercise of understanding costs, understanding revenues and managing both sides of the equation while improving the quality of the services.

Costs and Revenues in improved services

The current waste fees in Pune are deemed affordable and range from 100 to 600 Rupees per household per month. The problem is rather the lack of proper waste collection service, the precarious conditions at the dumpsite. The community awareness raising work carried out by several NGOs, in the wards and sub-wards of the city point to lack of willingness to pay for the service linked to the lack of service quality.

The collection service coverage ranges between an estimated 30 to 45% and the collection of payment is as low as 25%. In these conditions the waste management system is both chronically underfinanced and underperforming. Extending collection system and improving landfilling are immediate goals of the Pune City Council and the 5 district municipalities. Extending collection in a cost-effective manner means that transfer stations will need to be introduced.

The graph that was studied illustrated the cost of direct transfer versus transfer station and long-distance hauling with larger vehicles. In this particular analysis that was studied, the break-even point at which it makes sense to introduce a transfer station is at around 55 kms of distance. Many users in Pune are as far as 80 kms from the landfill, the collection trucks are small and the traffic is heavy. A similar analysis would be needed to analyse the cost efficiency of introducing transfer stations in Pune.

There are cost efficiency considerations in case of treatment and landfilling as well. There are quite significant fixed costs associated with these fixed facilities, meaning that there needs to be a certain quantity of materials handled to make sure that the per tonne cost of treatment or disposal is reasonable. The figure that was studied showed a typical economies of scale curve for a disposal site or a treatment facility, it could be seen that as quantities grow, specific costs decrease and then they level off.

Improving cost efficiency and raising revenues

In brainstorming sessions, municipalities, academia, NGOs of Pune came up with strategies for improving cost efficiency and raising revenues. In analysing the current situation, stakeholders came to the conclusion that low waste management costs signal inefficiencies because there is:

• No monitoring & control of operation included

• Low frequency of collection (1-2 times a week) linked to lack of availability of trucks

• The informal service providers who dump waste illegally

• Illegal dumping by service providers

• No management and no costs at collection points/transfer stations

Several measures to lower current costs and improve cost efficiency were identified in discussions, namely to:

• Introduce transfer stations

• Integrate informal sector and thereby increase recycling, avoiding cost of collection with the recyclables that are extracted from the waste stream at no cost to the municipality

• Plan collection routes and timing to avoid rush hours

• Optimize routing

• Raise awareness of population to increase participation in the system

• Introduce collection points and encourage bring in system

Raising revenues was deemed necessary through both national and local level measures.

• National level, earmark funds for waste management at national and local level

• Product tax/ charges

• Tax second hand imported goods

• Introduce extended producer responsibility

• Earmark part of pollution charges and environmental fines to industry for waste management

• Littering fines and penalties for non-payment:

• Change and adapt procedure of collecting fines, involve community leaders in establishing the ways these can be done. Current procedures are overly burocratic and inefficient

• Earmark fines collected to fund waste management activities

Improving payment rates should be done in parallel to improving service

• Improve payment rates

• Inform people about the service, when to pay, whom to pay to

• Link waste fee to electricity bill, water bill, phone service

• Collect as part of property tax

• Awareness raising

• Improve service (and raise fees in parallel)

• Use indicators, monitoring

• Involve community leaders in monitoring

Other strategies for raising revenues include the following:

• Reduce and reuse (4 Rs)

• Improve recycling to increase sources of revenues for the municipality

• Involve sub-ward leaders better to convince their people to participate in source separation and recycling

• Capacity building of sub-ward leaders

• Financial system for waste management only

• budget for waste management only

• Earmarking revenues

• Contract management

• only pay when waste comes to treatment or disposal site

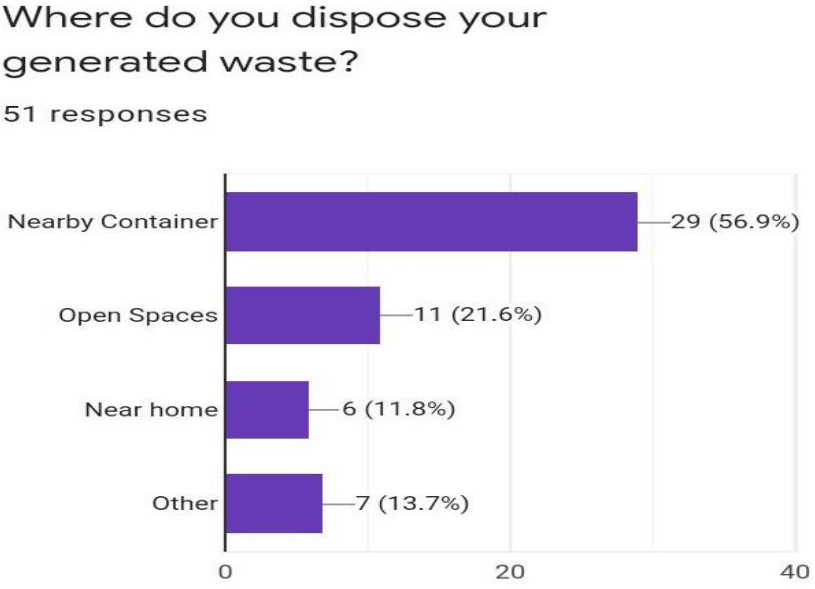
• Permits for businesses

• Include mandatory payment of waste management fees at time of permitting

The workshop results showed that there are a multitude of ideas for both improving cost efficiency and increasing revenues while improving the waste management service.

SECTION IV: Questionnaire

We asked 40 students and people of Pune and Mumbai about their understanding of waste management and its commercial aspects. Following were their answers:Q.1



OPINION	FREQUENCY	PERCENTAGE
Nearby Container	29	56.9%
Open Spaces	11	21.6 %
Near home	6	11.8%
Other	7	13.7%

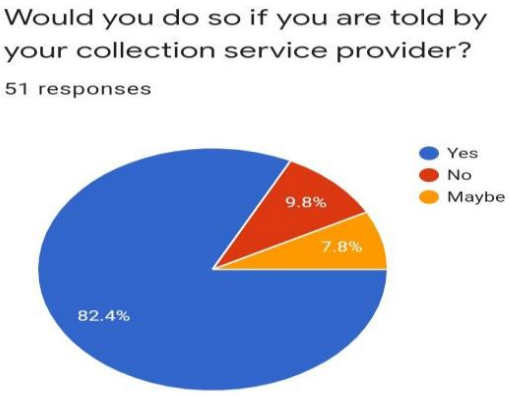
Interpretation:

- 56.9 % respondents dispose their waste nearby container with 29 frequency.
- 21.6 % respondents dispose their waste in open spaces with 11 frequency.
- 11.8 % respondents dispose their waste near home with 6 frequency.
- 13.7 % respondents dispose their waste in other options with 7 frequency.

Comment: -

After taking responses into consideration, it is to be interpreted that maximum people are disposing their waste in nearby container.

Q.2



OPINION	**PERCENTAGE**
YES	82.4 %
NO	9.8%
MAYBE	7.8%

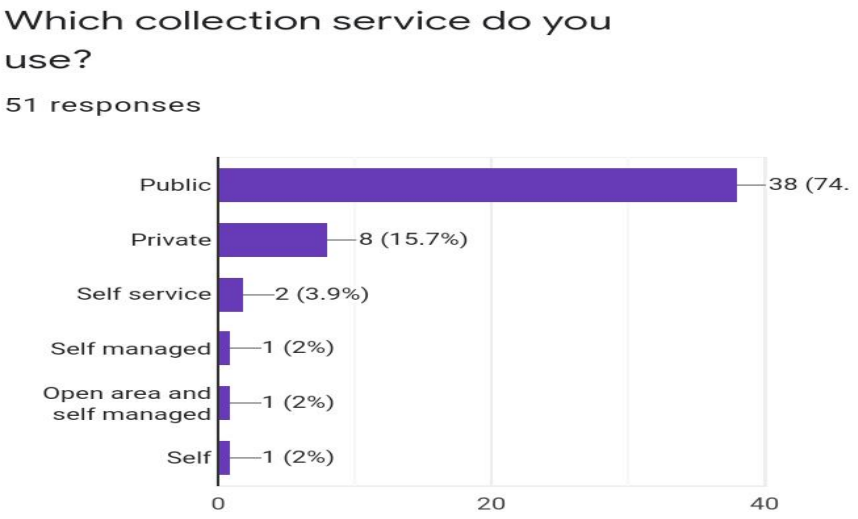
Interpretation:-

- 82.4% respondents will separate their waste at home by responding positively. ie. YES
- 9.8% respondents will not separate their waste at home by responding negatively. ie. NO.
- 25.5% respondents maybe separate their waste at home. ie. MAYBE

Comment: -

After taking responses into consideration, it is to be interpreted that maximum people are willing to separate their waste if asked.

Q.3



OPINION	FREQUENCY	PERCENTAGE
Public	38	74 %
Private	8	15.7 %
Self service	2	3.9 %
Self-managed	1	2 %
Open area and self-managed	1	2 %
Self	1	2 %

Interpretation

- 74 % respondents use Public service for waste collection.
- 15.7 % respondents use Private service for waste collection.
- 3.9 % respondents use self-service for waste collection.
- 2% respondents use self-management for waste collection.
- 2% respondents use open area and self-management for waste collection.
- 2% respondents use self-management for waste collection.

Comment: -

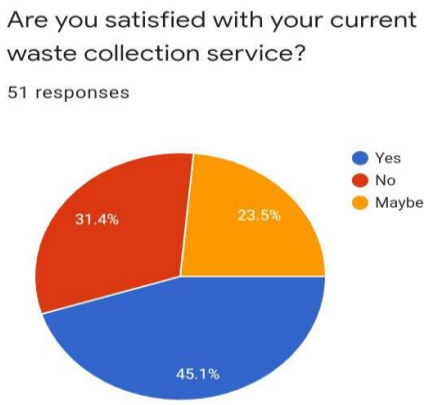
After taking responses into consideration, it is to be interpreted that maximum people are using public service for collection of waste.

Q.4

OPINION	PERCENTAGE
YES	45.1 %
NO	31.4%
MAYBE	23.5%

Interpretation:-

- 45.1 % respondents are satisfied with their waste collection service.



- 31.4 % respondents are not satisfied with their waste collection service.
- 23.5 % respondents are neutral with their waste collection service.

Comment: -

After taking responses into consideration, it is to be interpreted that maximum people are satisfied with their waste collection services by responding in positive (YES).

Waste-to-energy in India

The problems associated with improper waste disposal could be significantly mitigated by requiring material recovery. Source separation of inert and high moisture content fractions would maximize the potential for thermal recovery and other treatment options in India. The waste processed in thermal recovery is residual waste that remains after all commercially viable recyclable materials have been extracted.

Waste-to-energy technologies produce energy, recover materials and free land that would otherwise be used for dumping. The composition of residual waste is important for energy recovery and waste composition is changing in India, with the amount of high calorific waste generally increasing. A significant increase in the use of waste-to-energy technologies has been proposed, but this depends on location, climate, demographics and other socioeconomic factors.

The most widely used waste-to-energy technology for residual waste uses combustion to provide combined heat and power. Adopting maximum recycling with waste-to-energy in an integrated waste management system would significantly reduce dumping in India. Waste-to-energy technologies are available that can process unsegregated low-calorific value waste, and industry is keen to exploit these technologies in India.

Several waste-to-energy projects using combustion of un-segregated low-calorific value waste are currently being developed. Alternative thermal treatment processes to combustion include gasification, pyrolysis, production of refuse derived fuel and gas-plasma technology.

Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India. However, the track record of waste-to-energy in India highlights some of the difficulties. Most facilities have not worked effectively due to various operational and design problems. For example, the first large-scale MSW incinerator built at Timarpur,

New Delhi in 1987 had a capacity to process 300 tonnes per day and cost Rs. 250 million (US$ 5.7 million).

The plant failed because of poor waste segregation, seasonal variations in waste composition and properties, inappropriate technology selection and operational and maintenance issues. Despite this experience, waste-to-energy will have a key role in future waste management in India.

Barriers to improved waste management in India

The current status of SWM in India is poor because the best and most appropriate methods from waste collection to disposal are not being used. There is a lack of training in SWM and the availability of qualified waste management professionals is limited. There is also a lack of accountability in current SWM systems throughout India.

Municipal authorities are responsible for managing MSW in India but have budgets that are insufficient to cover the costs associated with developing proper waste collection, storage, treatment and disposal. The lack of strategic MSW plans, waste collection/segregation and a government finance regulatory framework are major barriers to achieving effective SWM in India.

Limited environmental awareness combined with low motivation has inhibited innovation and the adoption of new technologies that could transform waste management in India. Public attitudes to waste are also a major barrier to improving SWM in India.

Changes required to improve waste management in India

Core to the vision for waste management in India is the use of wastes as resources with increased value extraction, recycling, recovery, and reuse. ULBs need to be responsible for waste management, with the ULB Commissioner and Chairman directly responsible for performance of waste management systems. Waste management needs to be regarded throughout Indian society as an essential service requiring sustainable financing. The case presented to a ULB for a properly funded system must demonstrate the advantages of sound investment in waste management.

A strong and independent authority is needed to regulate waste management if SWM is to improve in India. Without clear regulation and enforcement, improvements will not happen. Strong waste regulations can drive innovation. The waste management sector needs to include attractive and profitable businesses with clear performance requirements imposed by the ULB, with financial penalties applied when waste management services are not working effectively.

Finance for waste management companies and funding for infrastructure must be raised from waste producers through a waste tax. An average charge of 1 rupee per person per day would generate close to 50 000 crores annually, and this level of funding would probably be sufficient to provide effective waste management throughout India.

Information on future quantities and characterization of wastes is essential as this determines the appropriateness of different waste management and treatment options. State-level procurement of equipment and vehicles is necessary for primary and secondary collection with effective systems for monitoring collection, transport, and disposal.

Littering and waste in streets is a major problem in India that has serious impacts on public health. Nagpur has introduced a system for sweeping roads in which every employee sweeps a fixed road length. The **Swatchata Doot Aplya Dari** (sanitary worker at your doorstep) scheme of the Centre for Development Communication was selected as an example of good practice by UN HABITAT in 2007.

Waste management must involve waste segregation at source to allow much more efficient value extraction and recycling. Separating dry (inorganic) and wet (biodegradable) waste would have significant benefits and should be the responsibility of the waste producer.

Long-term waste management planning requires visionary project development by ULBs, the private sector and NGOs. The roles and responsibilities to deliver sustainable systems need to be defined, with monitoring and evaluation to monitor progress. Experiences should be shared between different regions of India and different social groups. There are a number of research institutes, organizations, NGOs and private sector companies working on a holistic approach to SWM, and future waste management in India must involve extensive involvement of the informal sector throughout the system.

There is a need to develop training and capacity building at every level. All Indian school children should understand the importance of waste management, the effects of poor waste

management on the environment and public health, and the role and responsibilities of each individual in the waste management system. This will develop responsible citizens who regard waste as a resource opportunity.

Conclusion

Population growth and particularly the development of megacities is making SWM in India a major problem. The current situation is that India relies on inadequate waste infrastructure, the informal sector and waste dumping. There are major issues associated with public participation in waste management and there is generally a lack of responsibility towards waste in the community. There is a need to cultivate community awareness and change the attitude of people towards waste, as this is fundamental to developing proper and sustainable waste management systems. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities. India faces challenges related to waste policy, waste technology selection and the availability of appropriately trained people in the waste management sector. Until these fundamental requirements are met, India will continue to suffer from poor waste management and the associated impacts on public health and the environment.

Proper waste management is the key - Effective waste management is clearly the need of the hour, but getting it right remains a challenge. The Government's Swachh Bharat Abhiyan, which aims for 'Clean India' by 2019, has been a step in the right direction. Solid waste management is a crucial component of the ambitious mission and among its other objectives, Swachh Bharat Abhiyan wants to introduce scientific municipal solid waste management practices, enable private sector participation in the sanitation sector, and change people's attitudes to sanitation.

Since Prime Minister Narendra Modi launched the mission in 2014, over 42,000 wards across India have achieved 100 percent door-to-door waste collection, while more than 31 lakh individual toilets and 1,15,786 community and public toilets have been constructed. Over 164,000 metric tons of waste was composted in 2016 alone.

The mission has also given fillip to innovative practices in waste management such as waste-to-energy. Six waste-to-energy plants have already been commissioned across the country. Current production, as per the Swachh Bharat Abhiyan statistics, is 88.4 MW. Some of the other innovative technologies include plasma gasification, biphasic bio methanation and bio-stabilisation.

While the mission has tasted success and provided the required impetus to find solutions for India's solid waste management (SWM) woes, a lot still needs to be done.

Corporates collaborate to contribute- The waste management challenge is too big for the government alone to solve and its consequences are faced by the communities. It is the need of the hour for businesses to be involved and think about how they can collaborate and contribute. On one hand, corporates implement various measures to reduce, reuse and recycle waste at their manufacturing plants.

And on the other hand, they believe that waste management is related to various dimensions of the overall environment and needs greater engagement with the community. Thus, they adopt a public-private partnership (PPP) approach to handle solid waste management. One effective way to promote the cause of cleanliness is through the CSR programmes.

The Mahindra Group, for example, follows a zero-waste philosophy. Through radical resource efficiency, it ensures waste is managed at every stage in the hierarchy. The Group has also successfully implemented energy self-reliance at the Mahindra World City in Chennai. Shuttle buses and streetlights at Mahindra World City are powered by CNG which is produced at a bio-CNG plant. The group is also piloting GSM-enabled, solar-powered garbage compaction bins. These not only signal for a pickup when they are full, but also optimise the route of the waste collection vehicle.

This is where entities such as corporate houses and non-profit organisations, with the support of the government, play an important role. The non-profit organisation trains poor women in collection, handling, segregation and transportation of waste, compost pit management, biogas plant management and gardening. This ties in with a three-pronged strategy: ensuring employability, creating a greener India and innovating for green eco-friendly products. The aim is to create enough potential through skilling, for people to find employment, wherever they want to.

Being equipped with the right skill set can enhance employment opportunities for waste workers. And as India's waste generation is set to rocket, streamlining waste management to generate employment will further benefit India's economy.

Effective solid waste management is not just the responsibility of individual stakeholders. It is a collaborative effort with integrated systems and a sense of ownership from every stakeholder.

Making waste management a business can surely be painful but can also prove to be rewarding for the world as a whole and future generations.

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