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PROJECT REPORT

on

"INTEGRATED SOLID WASTE MANAGEMENT FOR RURAL AREAS USING INTERNET OF THINGS (IOT)"

Submitted in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

CIVIL ENGINEERING

Submitted By

ABHISHEK S	4MN19CV002
CHETHAN N	4MN19CV010
MANOJ KUMAR B M	4MN20CV413
SONA Y R	4MN20CV427

Under the Guidance of

Dr B C NAGENDRA PRASAD

Professor and Head of the department

DEPARTMENT OF CIVIL ENGINEERING

MAHARAJA INSTITUTE OF TECHNOLOGY THANDAVAPURA

Nanjangud Taluk, Mysuru – 571302

MAHARAJA INSTITUTE OF TECHNOLOGY THANDAVAPURA

Nanjangud Taluk, Mysuru - 571302

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE

Certified that the project report entitled "INTEGRATED SOLID WASTE MANAGEMENT FOR RURAL AREAS USING INTERNET OF THINGS (IOT)" carried out by ABHISHEK S 4MN19CV002, CHETHAN N 4MN19CV010, MANOJ KUMAR B M 4MN20CV413, SONA Y R 4MN20CV420 a bonafide students of Maharaja Institute of Technology Thandavapura in partial fulfillment for the award of Bachelor of Engineering in CIVIL ENGINEERING of Visvesvaraya Technological University, Belgaum during the year 2022-2023. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the Departmental library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said degree.

Signature of Guide
Dr. B C Nagendra Prasad
Head of the department
Dept of Civil Engineering

Signature of Project Co-ordinator
Dr. B C Nagendra Prasad
Head of the department
Dept of Civil Engineering

Signature of HOD

Dr. B C Nagendra Prasad
Head of the department
Dept of Civil Engineering

Signature of Principal

Dr. Y T Krishnegowda
Principal
MIT Thandavapura

EXTERNAL VIVA

Name of the examiners — Signature with date

1. ____________ ____________

2. ____________ ____________

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Regards,

ABHISHEK S 4MN19CV002
CHETHAN N 4MN19CV010
MANOJ KUMAR B M 4MN20CV413
SONA Y R 4MN20CV427

DECLARATION BY THE STUDENT

ABHISHEK S 4MN19CV002, CHETHAN N 4MN19CV010, MANOJ KUMAR B M 4MN20CV413, SONA Y R 4MN20CV427, We student of final year Bachelor of Engineering, Department of Civil Engineering, **Maharaja Institute of Technology Thandavapura**, hereby declare that the project work entitled **"INTEGRATED SOLID WASTE MANAGEMENT FOR RURAL AREAS USING INTERNET OF THINGS (IOT)"** has been independently carried out by us under the supervision of my guide **Dr. B C Nagendra Prasad**, Professor and Head of the Department, Department of Civil Engineering and submitted in partial fulfillment of the requirements for the award of **Bachelor of Engineering** in **Civil Engineering** Branch of **Visvesvaraya Technological University, Belagavi** during the academic year **2022-2023**.

We further declare that this project report has not been submitted by us to any other University or Institution either in part or in full for the award of any degree.

Sl. NO.	**NAME**	**USN**	**SIGNATURE**
1	ABHISHEK S	4MN19CV002	
2	CHETHAN N	4MN19CV010	
3	MANOJ KUMAR B M	4MN20CV413	
4	SONA Y R	4MN20CV427	

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INTRODUCTION

1.1 General

Integrated Solid Waste Management (ISWM) represents a contemporary and systematic approach to solid waste management. The U.S. Environmental Protection Agency (EPA) defines ISWM as a complete waste reduction, collection, composting, recycling, and disposal system. An efficient ISWM system considers how to reduce, reuse, recycle, and manage waste to protect human health and the natural environment. It involves evaluating local conditions and needs. Then choosing, mixing and applying the most suitable solid waste management activities according to the condition. With rapid population expansion and constant economic development, waste generation both in residential as well as commercial/industrial areas continues to grow rapidly, putting pressure on society's ability to process and dispose of this material. Also, inappropriately managed solid waste streams can pose a significant risk to health and environmental concerns. Improper waste handling in conjunction with uncontrolled waste dumping can cause a broad range of problems, including polluting water, attracting rodents and insects, as well as increasing floods due to blockage in drains.

As well, it may bring about safety hazards from explosions and fires. Improper solid waste management can also increase greenhouse gas (GHG) emissions, thus contributing to climate change. Having a comprehensive waste management system for efficient waste collection, transportation, and systematic waste disposal—together with activities to reduce waste generation and increase waste recycling—can significantly reduce all these problems. While nothing new, an ISWM approach provides the opportunity to create a suitable combination of existing waste management practices to manage waste most efficiently.

In the year 2000, the management and handling rules of MSW was issued by MoEF. This was to ensure appropriate waste management occurred within India, a further effort was initiated through a recent Published update of draft rules. The implementation of these rules has enabled municipal authorities to create an infrastructure that aids “collection, storage, segregation, transportation, processing and disposal.

Emergent urbanization and changes in the pattern of life, give rise to generation of increasing quantities of wastes and it's now becoming another threat to our already degraded environment. However, in recent years, many programs were undertaken for the control of urbanization gift in the world because the dumping of industrial wastage without proper treatment, responsible for the lowering of a soil fertility, which increases the amassing of essential and nonessential trace metals in the plants. On the other hand, domestic waste management in a soil and aquatic resources are also accountable for the reduced field productivity.

At this time the world is now facing an extreme situation of waste management from both the side i-e from industrialization and municipal waste management especially in a under developing countries. There is a need to address both problems in such a way that there should be resolution which can give proper management of both kind of waste. For this purpose, public awareness about the waste management can play a crucial rule in controlling the waste of both the sides. One of which waste-to-energy technologies have been developed to produce clean energy through the combustion of municipal solid waste in specially designed power plants equipped with the most modern pollution control equipment to clean emissions.

Other waste management includes recycling of waste into fertilizers for use agriculture which is a common practice of waste management. The recycling of hazardous industrial wastes into fertilizers introduces several dozen toxic metals and chemicals into the nation's farm, lawn and garden soils, including such well-known toxic substances as lead and mercury. Many crops and plants extract these toxic metals from the soil, increasing the chance of impacts on human health as crops and plants enter the food supply chain. The report based on the use of recycle fertilizers from waste in agriculture industry represent the highly toxic substances found by testing fertilizers, as well as the strict regulations needed to protect humans and the environment from these toxic hazards.

Between 1990 and 1995, 600 companies from 44 different states sent 270 million pounds of toxic waste to farms and fertilizer companies across the country. The steel industry provided 30% of this waste. Used for its high levels of zinc, which is an essential nutrient for plant growth, steel industry wastes can include lead, arsenic, cadmium, chromium, nickel and dioxin, among other toxic substances. Although the industrial facilities that generate these toxic wastes report the amount of chemicals they transfer offsite to the U.S. Environmental Protection Agency's (U.S. EPA) Toxics Release Inventory 50 Integrated Waste Management – Volume II every year, they only report the total amount of a given chemical contained in wastes transferred over the course of a year, making it difficult to determine the chemical make-up of a given waste shipment. With little monitoring of the toxics contained in fertilizers and fertilizer labels that do not list toxic substances, our food supply and our health are at risk.

Solid waste represents a growing challenge at the global level that, when not adequately managed, poses risks to the environment and human health. The matter is particularly critical in low- and middle-income countries (LMICs); indeed, such areas often face more economic and technical hurdles than industrialised countries. Moreover, people living in rural areas often encounter additional challenges making solid waste more difficult to manage. Notwithstanding, modern products and, consequently, new waste fractions have reached rural areas over the years. Indeed, plastic and e-waste can be found in such contexts. Unfortunately, people from rural areas often lack the proper awareness and tools to manage solid waste appropriately and turn to dangerous practices such as open burning or waste dumping.

Although some rural communities have been trying to make resources from waste, recover precious flows and increase their revenues, they have been using polluting practices in many cases. In addition, it was estimated that total greenhouse gas (GHG) emissions from solid waste contribute approximately 5% of overall GHG emissions into the atmosphere, making the sector crucial in fighting climate change through appropriate practices. On the other hand, solid waste disposal sites worldwide are vulnerable to emerging phenomena related to climate change, such as increased rainfall and wind speed. Furthermore, not negligible differences persist between rural areas of low- and highincome countries, starting with road infrastructures being usually worse in LMICs, making their rural communities more isolated.

In addition, waste characteristics are significantly different and solid waste management (SWM) practices are weaker. Han et al.found a linear relationship between the domestic waste generation rate and the gross national income per capita in rural areas; however, the study had a very low correlation, More recently, Gómez-Sanabria et al. projected municipal solid waste (MSW) generation until 2050 in each continent, both in urban and rural areas. The authors assumed different scenarios based on the Shared Socioeconomic Pathways. As expected, MSW generation in rural areas was always the lowest. However, it is necessary to underscore that an estimated 45% of the world population was living in rural areas in 2018, representing about two-thirds of the people in LMICs. Notwithstanding, challenges affecting SWM in rural communities of LMICs often represent an underrated topic.

In many cases, authors have focused more on managing the organic fraction of solid waste. In addition, their results showed that an improved waste treatment increased the net profit, i.e., composting and other waste recycling practices resulted in more sustainability than landfilling from an economic perspective. The results can be integrated with the findings of Araya-Cordova etc all, who recently highlighted how efficient policy to support recycling programs can be crucial for the most vulnerable population, especially those in rural areas.

1.2 SOURCES OF SOLID WASTE

The sources of solid waste include residential, commercial, institutional, and industrial activities. Certain types of wastes that cause immediate danger to exposed individuals or environments are classified as hazardous; these are discussed in the article hazardous-waste management. All non hazardous solid waste from a community that requires collection and transport to a processing or disposal site is called refuse or municipal solid waste (MSW). Refuse includes garbage and rubbish. Garbage is mostly decomposable food waste rubbish is mostly dry material such as glass, paper, cloth, or wood. Garbage is highly putrescible or decomposable, whereas rubbish is not. Trash is rubbish that includes bulky items such as old refrigerators, couches, or large tree stumps. Trash requires special collection and handling.

Table 1.1 Source of solid waste

SOURCES	TYPICAL WASTE GENERATOR	TYPES OF SOLID WASTE
Residential	Single and multi family dwelling.	Foodwaste .paper, cardboard, Plastic, textile, glass,leather,yard waste,wood,glass,metals,ashes, special waste.
Commercial	Stores , hotels, resturants Markets, office buildings Etc	Paper, cardboard, plastic, wood, food waste, glass, metals, special waste, hazardous etc
Industrial	Light and heavy manufacturing ,fabrication ,construction sites ,power and chemical plants.	Same as commercial.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

1.3 Solid waste management in India

On that results in urban flooding, Sub sequently the micro-plastic intermixes with water polluting the rivers and oceans. Current studies have demonstrated that the presence of micro-plastic causes disturbances in the aqua life (primarily the food chain) and ultimately leading to global warming. Consequently, reported as the primary reason for the extinction of various indigenous species on the planet Earth (United Nations, 1992). As per the report published in UNPD, the world produces around 300 million tonnes of plastic waste, only 9% of the generated plastic waste is recycled, ~14% collected for recycling while the rest reaches the ocean annually .

Another issue related to MSWM is the generation of hazardous chemical wastes by cities such as hospitals and industries leads to breathing problems and premature deaths .In recent years, India has become the emerging recycling market; however, recycling has not done as per the prescribed marks (Bhattacharya et al., 2018). Improper management MSWs at landfills sites often attracts animals, rodents, mosquitoes, vultures, and scavengers which could cause health issues and even death to front line workers and waste pickers.

Nevertheless, a few cities in India such as Surat, Alleppy, Bobbili, Panji, and Pune have showcased the positive intent towards SWM strategies selection which have discussed in the present study. It has also been observed that the municipalities are focusing mainly on the collection part, but advance treatment is missing. However, this also needs further up-gradation to eliminate the MSWM issue. The resourceful material recovery has been a challenge,that could be achieved by the help of the informal sector into the main streamline of the MSWM process. However, this idea can only be fulfilled with support and funding from the government agencies, public awareness, participation, and to eliminate the social taboos. The mentioned above under one umbrella could contribute in a step towards to clean sustainable cities.

Hence, the present study is a comprehensive review carried out the all possible strategies from past to future pertaining to MSWM, also addressing the challenges and potentials opportunities for the future urban cities of India.

1.4 Integrated solid waste management for rural areas

The domestic waste generated in rural households of India is increasingly becoming an Issue of serious concern. Though, solid waste generated in rural areas is predominantly Organic and biodegradable, it is becoming a major problem as the waste generated is not Segregated in-situ and is of the order of 0.3 to 0.4 million metric tons per day, as reported The Ministry of Drinking Water and Sanitation (MDWS), Government of India. Inconsiderate littering causes poor environmental sanitation resulting in unhealthy quality of living. Therefore, domestic-refuse should be handled responsibly. In order to manage Waste in a desirable way, there should be a functional waste management system in place. Without a functional waste collection and disposal system at the Panchayat level it is arbitrary to hold individual households responsible, or blame them of irresponsibility.

The Government of India (GoI) as well as many State governments are looking up to Gram Panchayats to come up with a working system to manage solid waste in rural areas. This handbook provides lessons from ‘good practices in solid waste management’, Presented as a step by step guide. It will help formulate models and systems for solid Waste management (SWM) that can serve as practicable system for Gram Panchayats to take up for implementation.

The purpose of this handbook is not merely adding to the existing knowledge on SWM, but to provide practicable ideas for implementation. We must admit the fact that ‘some’ Gram Panchayats have been successful in managing Solid waste, while ‘many others’ have had a short stint and faded away. The NIRD&PR Took up the task of collecting and coming up with an array of practicable models of solid Waste management, which GPs can choose from, and take up appropriately for Implementation.

CHAPTER-2

LITERATURE REVIEW

2.1 General

Solid waste management is extremely important in your community mainly because it will prevent your household from experiencing the hazardous outcomes of solid waste material. By getting rid of most of these waste matter properly, you can actually protect your loved ones along with the environment. This means that your young ones along with your grandchildren are able to experience the good thing about nature. Possessing a community that understands this importance can unite as one in preserving the environment inside your city. Since this is not simply for you personally, but also for the next generation as well. The entire process involves basic steps like collecting, sorting, treating, recycling and if possible, providing a source of energy and resources, the latter being a potential economic benefit if utilised effectively. Besides that, in a country like India which has a major livelihood crunch for an ever-growing population, following a proper waste management process creates many jobs. Not to mention the overall jump in the quality of life index that one sees when proper hygiene is ensured and not impaired by health risks as a result of illegal dumping and inadequate garbage collection. Where sustainability angle makes a major difference is, in the environmental impact of it all. Following a sustainable waste management process improves the air and water quality and reduces greenhouse gas emissions. When we reduce the food waste, we also reduce the heavy environmental cost of producing more.

2.2 Earlier Studies

2.2.1 Dr Sindhu J Nair et al., 2005 studied the review of solid waste management practice in India. Since solid waste management consist of lots of waste such as industrial, agricultural, municipal, transport, etc. here in this paper, we focus on municipal waste generated across the country and there treatment in order to conserve environment. As municipal waste is one of the major environment Problems of Indian cities. UN effective management leads to hazardous inhabitant. An attempt has been made to provide Comprehensive review the characteristics, generation, collection and transportation, disposal and treatment technologies of MSW Practiced in India is stated here and discussed.

2.2.2 Ashish Jain et al., 2005 studied the waste characteristics, techniques, adverse environmental impacts, health risks, poor waste management practices and also Problems associated with the solid waste management system at the municipal Level.The findings from this study indicates failure of the existing facilities due to Lack of concern, high volume of waste generation, deficient collection space, Delayed sanctioning of new landfill sites and a number of open-dump sites Which generate fires. The innuendos of the waste management practices in the City are discussed.

2.2.3 Manabhanjan sahu et al., 2006 studied the era of urbanization and globalization accompanied with the population explosion in Developing and underdeveloped countries, the waste management is major social and Environmental challenge. Hence the solid waste management is the basic issue we are concerned of among all the urban and rural waste outputs. In the event of the visionary goal of Swatch Bharat Mission, by govt. of India, we are still under the influence of poverty, infrastructure Insufficiency accompanied with rapid population growth and rapid rural urban migration. In Case of developed countries, they have successfully addressed the issue, while in case of Developing countries the situation is more critical. Hence India is not an exception from having.The issues of solid waste management, and there are multiple reasons for this. The study aims to carry out an analysis on the waste management practices and to develop integrated waste Management model for Berhampur city and for the similar environment.\

2.2.4 Dr R.K.Pandit et al., 2007 studied the solid waste management approach in India is Extremely inefficient, using old and obsolete system, Technology for storage collection processing, treatment and Disposal. There is no formal organized system of segregation of biodegradable and non biodegradable solid waste. The Recovery and recycling of waste is only done by scavengers and scrap dealers which is highly hazardous to those which are involved in this job.

2.2.5 Dr. Rudra Rameshwar et al., 2007 studied the municipal solid waste plan formulated by the government of Punjab is highly ambitious, but the work carried out is very less. Only four clusters have got environment clearances. While the Green tech fuel processing plant was completed in 2 years. This plant can serve as ideal plant to all the processing plants is Punjab. As Punjab generates large amounts of solid waste these processing Plants can add up to its revenue. The processing plants under public private partnership will also Harness the power scenario of the Punjab. The products of processing plant such as refused devried Fuel (RDF), Vermicompost and recycling of paper products will ensure the sustainable growth of the state.

2.2.6 Giovanni Vinti **et al., 2007** studied Solid waste management (SWM) in rural areas of many low-and middle-income countries (LMICs) represents a critical and underrated topic. However, almost half of the world's population still lives in rural areas and an adequate SWM is crucial in reducing environmental and health threats. A lack of knowledge and appropriate tools often leads to inappropriate practices such as waste dumping and uncontrolled burning. However, appropriate methods can transform waste into resources and even guarantee a revenue source. This manuscript provides an overview of the state of the knowledge characterising SWM in rural communities of LMICs, analysing common practices and principal issues. Different solid waste fractions are considered. Virtuous approaches are presented, taking into account recent sustainable solutions. Considering that a relevant part of the world population is still living in rural areas, the benefits associated with an appropriate SWM may be enormous. Such activities may improve local conditions from social, environmental and health perspectives; furthermore, they may have a global impact on facing climate change and environmental pollution.

2.2.7 Rafia Azmat et al., 2008 studied Today's industrial world has contaminated our soil, sediments and aquatic resources with hazardous material. Metal water is often resulting of industrial activities, such as mining, refining, and electroplating, Hg, Pb, As, Cd and Cr are often prevalent at highly contaminated sites. Therefore it is our responsibility to check and develop the low cost techniques to remove the toxic metals by methylation, complexation or changes in valance state from the environments for humanity. Domestic waste is generated as consequences of household activities such as the cleaning, cooking, repairing empty containers, packaging, huge use of plastic carry bags. Many times these waste gets mixed with biomedical waste from hospitals and clinics. There is no system of segregation of organic, inorganic and recyclable wastes at the household level. Improper handling and management of domestic waste from households are causing adverse effect on the public at large scale and this deteriorates the environment. Segregation of this different type of waste is essential for safety of the environment because the improper management and lack of disposal technique of the domestic waste pollutes to the environment. It affects the aquatic resources. It also changes the physical, chemical and biological properties of the water bodies.

2.2.8 Ankur Rajpal et al., 2008 studied based on the observations, more than 90% of the total generated waste in the villages of District Haridwar was cattle dung, and the rest 5-10% was household waste containing 70-80% biodegradable portion. The major waste management problem in rural setup is the lack of source separation and proper disposal strategy as generally. The household waste is dumped outside the houses and across the road. Due to the lack of garbage collection facilities, the majority of rural residents are not following the recommended waste separation and disposal practices. This solid waste produces odour and anaesthetic look and ultimately pollute the river Ganga during the rainy season. Hence, it has to be appropriately managed at the household level by collecting dry and wet waste separately to reduce the public health risk. Composting organic (biodegradable) household waste with animal waste is the best option, which can be used as a fertilizer in agriculture. The dry fraction (nonbiodegradable) can be transferred to waste to energy facilities in nearby areas. General public awareness is a must in the success of any public project for implementing a waste management strategy. The municipality and village panchayat should organize social and environmental awareness programs for rural waste utilization in agriculture.

2.2.9 Dr Raveesh Agarwal et al., 2008 studied the adequately to say that we require a more stringent integrated and strategic waste prevention framework to effectively address wastage related issues. There is an urgent need to build upon existing systems instead of attempting to replace them blindly with models from developed countries. To prevent any epidemic and to make each city a healthy city-economically and environmentally, there is an urgent need for a well-defined strategic waste management plan and a strong implementation of the same in India. To achieve financial sustainability, socio-economic and environmental goals in the field of waste management, there is a need to systematically analyze the strengths and weaknesses of the community as well as the municipal corporation, based on which an effective waste management system can be evolved with the participation of various stakeholders in India. The public apathy can be altered by awareness building campaigns and educational measures. Sensitization of the community is also essential to achieve the above objectives and we need to act and act fast as every city in India is already a hotbed of many contagious diseases, most of which are caused by ineffective waste management.

2.2.10 Derek Hondo et al., 2009 briefly studied that effective solid waste management is critical for achieving sustainable development in municipalities. In the last half century, urban cities around the world have grown significantly, and experts forecast that this trend will continue into the future. Increased populations coupled with rapid urban buildup put enormous stress on municipalities, especially in developing countries. Without proper solid waste management services and practices, there is little chance of achieving the related Sustainable Development Goals (SDGs). This policy brief looks at the problem of rampant solid waste production, both in the global context and in developing Asia, in particular. One of the precursors to developing more advanced waste management systems is in the adoption of waste separation practices. Waste separation, when implemented properly can lead to improved recycling and ultimately help societies shift from linear consumption patterns to a more circular economy, promoting the principles of reducing, reusing, and recycling (3Rs) and reducing overall waste.

2.2.11 Priyabrata Banerjeeet et al., 2009 studied Human civilization consciously or unconsciously is on the verge of generating a tremendous amount of solid wastes that consequence in serious health-related issues. ‘Prevention is better than cure’ is a very popular adage; abided by it here too prevention of these practices is superior to curing the detrimental effect on living system and environment. However, this can only be feasible by proper system of waste management and most significantly public awareness. Waste management not only deals with its treatment and disposal; it is a whole system that incorporates reduction of waste generation, collection, segregation and proper transportation to its corresponding recycling hub. Disposal of solid waste with conventional way is not so effective in reducing its noxious effect. As a consequence, for biodegradable

Solid Waste Management in India: A Brief Review 1047 waste, composting is a very useful method since here the residual part can be further used as fertilizer. Some disposal methods like gasification, pyrolysis, RDF can minimize the solid waste volume and its lethal effect. These methods are very efficient for generating fuel, for instance syn gas which can be a prominent source of energy in the recent future. Our research on different technologies such as plasma arc pyrolysis or autoclaving for safe disposal of solid waste is under active progress.

2.2.12 Ruchira Totade et al., 2009 studied and examined the objectives the waste management of Nagpur city. Nagpur is one of the largest market place in India with population of 24, 05, 665 NMC has divided Nagpur in total of 10 zones for proper administration. Due to factors like industrialization and urbanisation it is the fastestgrowing city leading to increase in waste generation. This present case study aims to analyse current MSW management practices and its status and it also discusses the issues related with collection, transportation, treatment and disposal. The goal of this study is to help in minimizing the waste generation and to reduce its impact on humans. It also suggests ways to improve the administration of NMC

2.2.13 Puneet Juneja et al., 2010 studied the municipal solid waste plan formulated by the government of Punjab is highly ambitious, but the work carried out is very less. Only four clusters have got environment clearances. While the green tech fuel processing plant was completed in 2 years. This plant can serve as ideal plant to all the processing plants is Punjab. As Punjab generates large amounts of solid waste these processing plants can add up to its revenue. The processing plants under public private partnership will also harness the power scenario of the Punjab. The products of processing plant such as refused devried fuel (RDF), Vermicompost and recycling of paper products will ensure the sustainable growth of the state.

2.2.14 David Haynes et al., 2010 They studied Poor municipal solid waste management is a major threat to sustainable development in the Pacific Island Countries and Territories, with potentially negative consequences on public health, environmental quality, water resources, fisheries, agriculture, tourism, trade and other areas of national development. Waste management in the Pacific Islands region is currently undergoing a transformation, which began in the early to mid 2000s with consistent support from several donors. Even with the progress being made through regional initiatives and national programs, solid and hazardous waste management remains an ongoing and escalating priority problem for the region. This chapter provides a regional overview of solid waste management in the Pacific Islands region.

2.2.15 P Somani et al., 2010 studied the blooming of industrialization and urbanization are directly corelated with increased solid waste generation. Every year India faces a massive challenge as it deals with municipal solid waste equating to approximately 62 million tonnes including E-waste, plastic and medical waste. This has mounted and stands as a budding hazard to public and environmental health. Within India solid waste management predominantly adheres to sustainable development. The waste management rules are generally framed and handled through the Ministry of Environment and Forest (MoEF); however, compliance varies among states. In this article we are describing the present status, challenges and implementation followed in the waste reduction processes including segregation/ collection, recycling, energy recovery (composting, bio methanation, and bioremediation), land filling of household and industrial waste; its impact on the environment. This review concludes with some simple and effective international trends in waste management, with a vision of improving in current Indian systems.

2.2.16 Hossein Asefi et al., 2011 studied about Sustainability and integration concepts are explored to evaluate the effectiveness of advanced models in achieving sustainable MSW management practices. Papers published are categorized into three main classes with respect to the methods applied to evaluate the operational efficiency and performance of IMSW systems. These include System Assessment (SA), Multi-Criteria Decision Making (MCDM) and Operation Research (OR) techniques. Each class is then analyzed by reviewing the key studies as the representatives of the class and potential improvements are suggested to achieve a sustainable Integrated Solid Waste Management (ISWM) system.

2.2.17 Martin Murphy et al., 2011 studied the data relate to ongoing noncompliance with the EU Nitrates Directive among farmers in Ireland. We compiled more than 1.2 million records from disparate administrative data, then employed multi-level statistical analysis to model regulatory breaches. The novel statistical associations generated shed light on possible reasons for noncompliance and allow us to predict violations more accurately than a regulatory rule of thumb previously used to target a behavioural ‘nudge’. By quantifying variation in likely rates of false positives and false negatives, the models can be used to improve the efficiency of the behavioural intervention. The work illustrates how big data can combine with behavioural interventions to support better environmental enforcement.

2.2.18 Balakrishna Kempegowda., 2012 studied the on a real-time soil monitoring for the agriculture farmlands to provide optimal and integrated data collections. Real- time monitoring provides reliable, timely information of crop and soil status plays an important role in the decision making in the crop production improvement. Agriculture depends on many parameters as inter and intra variabilitys of plants to give better yields such as soil parameters, climatic parameters so on. Here the system is designed to collect the data set for major parameters such as temperature, humidity, soil pH, soil moisture, light intensity and carbon-dioxide of the fields. The system consists of an ATmega 328 microcontroller, DHT11 Sensor, soil hygrometer, light intensity sensor, soil pH sensor, MQ-135 sensor and DC motor. Data sets collected were used for the analysis of selection of crops and their vulnerabilities for regulating the irrigation parameters which will be of help in the agricultural practices, it will make easy way for farmers to take decision on planting a crops, watering and fertilizing them by avoiding the interference of hydro geologists and soil scientists by giving precaution. The obtained results were compared with the standardized optimum values for the particular crops and based on the differences inputs for the crops are varied. The automated watering helps the crops to get flow of water to fields based on the parameters, which is controlled by the DC motor. Multi sensor implementation for acquiring primary parameters essential for plant growth is the main aim of the paper. Easily available sensors were a motivation for the development of this project.

2.2.19 Kadir Canda., 2012 studied the solid waste collection systems have become extremely important in relation to recycling and hygiene issues. Local governments have a responsibility to utilize the least costly and most sanitary types of such systems. However, when current practices are examined, it can be seen that, even in developed countries, waste collection is often carried out in an unhealthy and inefficient way, thus indicating the need for smart system solutions. With the approach used, the smart waste collection system presented in this study applies technology that can solve the problems of the developed world efficiently, with the least cost and damage to the environment and in a way that is healthy, hygienic and fits in with modern city design. This system was developed by combining current technological advances and communications technology with knowledge gathered from years of experience in the field of solid waste collection. System trials were carried out in an area with a population of 50,000, and the components of the system and the waste collection algorithm used in the project were optimized. According to the observations and surveys with the people, this proposed system was found to be satisfactory. Although different approaches can be found in the literature, the one presented here is quite economical. At the end of the analyses, it was demonstrated that the proposed system would cost 50–80 % less than the existing system. After completion of the initial test setup of the system, it has been redesigned to be suitable for installation in larger cities.

2.2.20 Aliq UZ Zaman et al., 2013 studied the Waste management systems are involved with different multi-disciplinary factors; therefore, trends in the development of waste treatment technologies have been led by various social, economic and environmental drivers in Sweden. Identifying development drivers is important to understand, plan for design new system in the waste management sector. Society is very dynamic in nature; understanding the interrelationship of different drivers are important for predicting and understanding the emerging waste treatment technologies. Dry composting, pyrolysis-gasification, plasma arc and anaerobic digestion have been identified as potential emerging waste treatment technologies in Sweden. However, the development of waste technologies also involves other externalities like shifting personal and social viewpoints on waste such as ‘waste’ to ‘resource’. Currently, a number of studies have been conducted by different researchers on the ‘zero waste’ (Zaman and Lehmann 2011) concept. Therefore, waste avoidance and reduction technology is considered to be the prime challenge rather than the development of new waste treatment technology. Extended producer responsibility as well as consumer accountability are gaining importance since both are the key drivers for the development of sustainable waste management systems. Therefore, further studies could be done to explore possibilities of consumer accountability in consumption and generation of waste and in product stewardship and sustainable development.

2.2.21 Chettiyappan Visvanatha et al., 2013 studied the Rapid waste generation along with urbanization and population growth creates critical concerns on municipal solid waste (MSW) management strategies. Generally, improper waste management generates numerous problems including environmental pollution, degradation of sanitation, unhygienic living conditions, etc. Proper MSW management such as source reduction, recycling, and composting are presently practiced in most developing countries in Asia. However, the existing management was not able to tackle huge amount of waste which has been resorted only to dispose in open dumps or unsanitary landfills. Importantly, MSW characteristics in most Asian countries is known for its high organic and moisture content, and low calorific value which makes it unsuitable for direct landfill disposal and incineration because of potential emissions (Visvanathan et al. 2004). Recently, increased environmental awareness and concern over direct landfilling issues have stimulated new approaches for organic fraction of MSW treatment prior disposal. In this regard, aerobic and anaerobic biological processes are considered as useful pre-treatment technologies for volume reduction and waste stabilization prior to landfilling. The importance of anaerobic digestion for organic waste treatment is a growing interest towards sustainable MSW management and able to support for alternative renewable energy resources. The process involves the conversion of waste biodegradable fraction into biogas and stable residue that can be used as fertilizer or compost. Anaerobic biodegradation proceeds in the absence of oxygen and produce byproducts after a series of metabolic interactions among various groups of microorganisms.

2.2.22 Fengming Tao et al., 2014 studied the MSW collection and transportation are important in investment costs, operational costs and environmental impact. Intelligent technologies, like radio-frequency identification (RFID), Global Positioning System (GPS) and geographic information system (GIS) technology have been applied to waste collection routing model. In this article, in order to implement sorted waste collection with the application of smart waste bins, the CCMCEVRP is introduced, and the experiment results indicate the benefits of using multi-compartment EVs for minimising the collecting cost. This study represents an important contribution in the first phase of MSW. And there are some suggestions for environment departments in city governments. First, environment departments might introduce some relevant policies to raise citizens' awareness of waste sorting, in the meantime, accelerate the application of smart waste bins to raise the efficiency of the waste management system. Second, both from the perspective of environmental and economic aspect, the application of multicompartment EVs according to the different waste sorting policies in different cities should be increased as soon as possible. Third, the bureau of urban planning needs to speed up the construction of infrastructure related to multi-compartment EVs, such as construction and maintenance of recharging stations, which will be beneficial to promote the use of multi-compartment EVs. Consequently, there appears an important research area where the effective layout model of recharging stations in the VRP of EVs could be combined with their route recharging modes.

2.2.23 Alaki-issi Massimapatam., 2014 studied the objective of this study was to estimate the quantities of GHGs emitted during composting. It appears that there was a reduction in CO2, CH4 and NO2 emissions of 76.89% in 2018 against 75.53% in 2019.These reduction percentages are slightly higher than the overall reduction percentage of 2013 to 2017 estimated at 74.28%. Composting therefore avoided the potential for anthropogenic global warming. This reduction is significant for the Emission Reduction Certification (CER) process which can allow Togo to access climate finance for developing countries. The quantification of GHG emissions attributable to waste management will serve as a guide for communities and companies in charge of the sector. The results obtained could be improved by a study envisaged over a longer time series to serve as a reference for the emission measurement, reporting and verification (MRV) system. A natural ventilation composting method is proposed to further reduce emissions.

2.2.24 N.Cobo et al., 2015 studied the different kinds of assays have been proposed by a number of authors to characterize waste degradability in old landfills. In this paper, the techniques used for sample extraction and conservation are summarized together with those used for laboratory analyses. Since there is not standardized methodology yet, some assays are performed in a different way by each author. BMP, the test that most directly characterizes waste biodegradation stability in landfills, is precisely one of the tests that more variability presents in different laboratories. For this reason among others, several authors try to relate the obtained BMP results to other assays. Since the results published by diverse authors have been obtained by using different methodologies, no generalizable conclusions can be drawn from the available information in this regard. However, analysing the published data, an approach to BMP based on its relation to the VS content, CEL, HEM and their rate to the LIG content of waste have been proposed in this paper. For a specific material, VS, CEL, CEL+HEM and (CEL+HEM)/LIG can be employed as indicators of the degradation state, since they all diminish when the degradation state is higher. However, only CEL and CEL+HEM contents permit to compare the biodegradability of different materials. Accepting the same accessibility conditions to the compounds, the same linear relation between these parameters and BMP should be applicable to different kinds of waste.

2.2.25 R.A.Joshi et al., 2015 studied on gained result of calculations show that in both cases either with addition or without addition of temperature the solid waste can be treated and digested in such kinds of landfill which have been shown as a module, but the process of minimization of the organic municipal solid waste is happening more rapidly when heat increase involved in the process, calculated weight of the total waste showed that only (0.5 %) of the total weight remained after storing the waste in the module for (17) days and heated frequently each (24 hrs) once, while (40.71 %) of the waste remained without addition of temperature, this shows that degradation of the solid municipal organic waste has more affinity toward decaying and digestion when the landfills temperature is higher than surrounding environment.

2.2.26 G.A Kristanto et al., 2016 studied on degradation of organic content in waste significantly increased due to the effect of the addition of enzyme cellulase on leachate recirculation investigated by a degradation process of cellulose, lignin and volatile solid content in waste as well as settlement of waste in landfill bioreactor. Stabilization of landfill review by the decreasing rate constant of the cellulose and lignin ratio parameter was more rapidly achieved by enzyme addition compared to control. It is important to identify the optimal quantity of the enzyme cellulase to enhance stabilization and improve the efficiency of the operation in landfill.

2.2.27 J.N.Alfred et al., 2017 studied the field capacity parameter of solid waste is essential for calculating the amount of leachate that will be generated by a landfill. Therefore, its accurate determination requires the application of a relative methodology. The moisture content and the dry field density of the solid waste increased with increasing depth whereas the higher the dry field density, the lower the field capacity and vice versa. This is consistent with the result reported in the literature for municipal solid waste by Jorge et al. (1999), field capacity show decreasing trend with depth. The Optimum Field Capacity was found to be 0.38L/kg which indicate the water holding capacity of the waste. This project suggested that, the results can be extrapolated to other landfills with similar characteristics, thus making it possible to design the dimensions of the devices required to control the production of leachate with greater accuracy. The methodology should be able to simulate different depths of any given landfill, and monitor the variation of field capacity under such circumstances. It is essential to standardize a methodology for the determination of actual field capacity because that is the only way to compare results obtained in different parts of the globe. It is highly advisable to perform this type of test at different times of the year, and running several series tests in each season, in order to find representative average values. The experiment should also be repeated using a larger quantity of solid waste and using larger lysimeters. This is the only way to increase the accuracy of the results, because there would be more control over variables such as drained water and the characteristics of the solid waste.

2.2.28 John J., 2017 studied onThe BMP results, along with CH4 generation rates determined, confirm the high biodegradability and biogas potential of MSW disposed of in a tropical landfill in Colombia, characterized by high contents of both readily and moderately degradable materials typical for developing countries. The BMP of the FW was relatively high in comparison to that reported for fresh MSW and even OFMSW. In contrast, the BMP for EW was nearly onequarter of that measured for FW but falls within the range reported for landfilled wastes of similar age and even older. These results also indicate that, given the MSW characteristics and the environmental conditions of landfills in tropical developing countries, the application of enhanced landfill management strategies has the potential to accelerate waste degradation, a key aspect towards improving biogas utilization and the lifespan of final disposal sites in developing countries.

2.2.29 Perboyre Alcantara et al., 2018 studied onThis work approaches the evolution of the settlements in experimental landfills considering the influence of climatic conditions, the composition of the municipal solid wastes and the evolution of the biodegradation process. For that, two simulated landfills were built with a volume of 10 m3 approximately. The experiments, monitored in field conditions, were built in the Muribeca Solid Waste Landfill, in the Metro politan Area of Recife (PE), Brazil. The settlements were measured using leaning plates on the top of the layer of wastes and through magnetic disks. Besides settlements were evaluated other parameters such as tempera ture, biogas composition and concentration of microorganisms.

2.2.30 Mani Vannan et al., 2018 studied the Investigation gives the data about how much of quantity and characteristics of solid waste generated on daily basis. It will find out the biodegradable and nonbiodegradable fraction and how the biodegradable will be used for bioenergy source and converted into bioorganic fertilizer. Uses of 5R project (Recycle, Reduce, Reuse, Refuse and Recover) will be increased. Awareness campaigns need to be conducted for the peoples so that the corporation burden regarding the proper segregation of waste will be reduced. House to House collection of Solid waste method should be more organized by using the methods like collection of daily waste by using proper scheduling and trimmings. Maintaining proper recycling units will save valuable raw materials and resources waste management systems will upgrade the living and the working condition of the waste pickers and other marginalized groups.

2.3 Solid Waste Collection:

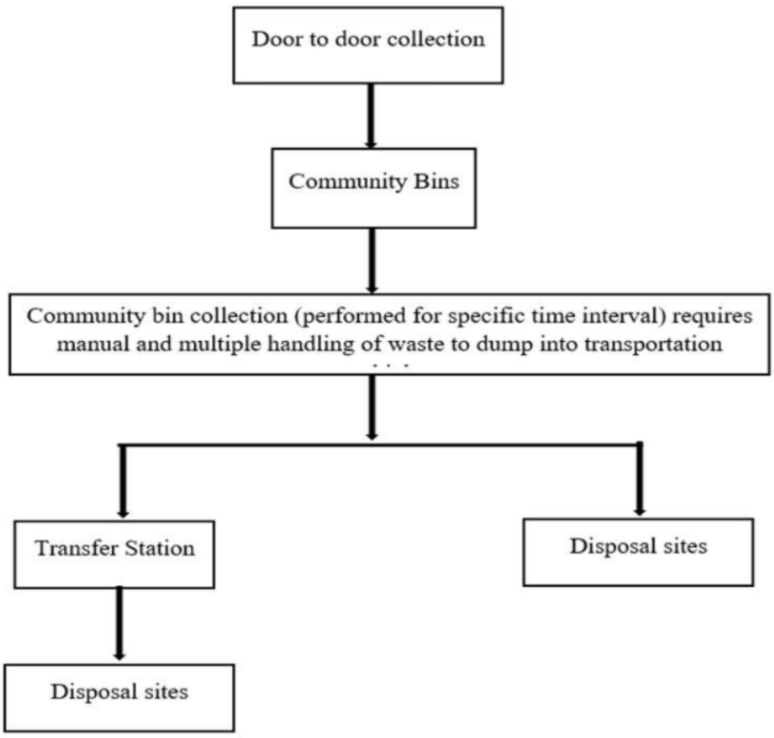


Figure2.1: Flow chart illustrating collection of solid waste

2.3.1 Integration of waste management:

Integrated waste management is a framework for the design and development of modern waste management and disposal systems and the study and optimization of current waste disposal systems. Within this definition it is important to examine all technological and non-technical elements of management schemes together [8]. Currently, with the introduction of new legislation, laws, and waste management sector as an enterprise, nontechnical elements like public involvement and awareness are necessary and essential to the successful adoption of many recycling and recovery schemes. A classic example is the general resistance to incineration services around the world largely due to the perception that incinerators are the origin to dioxins, which also underlines the efficiency of incinerators in reducing waste quantity and waste disposal levels. Therefore, in managing pollutants reaching the atmosphere, advances in emissions abatement mechanisms and gasification techniques.

More critically, for the effective implementation of the new waste treatment systems, engaging the public in such reviews and informing them about the needs and concerns of waste treatment and disposal in a specific region or country. Today, cooperation between the state, business, and informal sectors is apparent, and it is optimal to coordinate environmental education and public participation for successful implementation through one of these networks .As stated earlier, the Planet's carrying capacity is continuously threatened as the environmental protection is paying the price for economic activities. Therefore, resources are rising while competition is growing with the environment and consumption being changed. As the new waste management elite maintains, the first step to achieving waste reduction is citizen engagement and improving their view, whereas recycling and reuse often need technical assistance. Energy and nutrient regeneration are focused on science though their adoption may be a target of NIMBY syndrome if not properly tackled.

Modern integrated waste disposal is thus the need for time, whereas sustainability needs to be incorporated into all materials, taking into account the material supply and demand. It's unavoidable that waste is tool now and it's the duty of people if people use it. As is obvious from past experience, if people really find the Planet as "our home" it is not convenient, but not difficult.

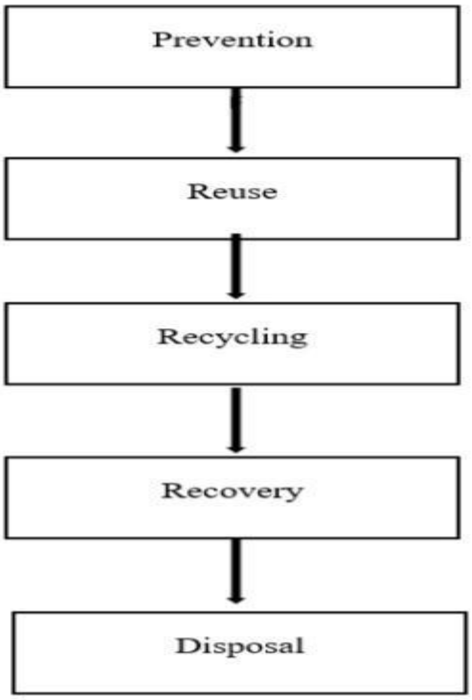


Figure 2.2: Block Diagram illustrating solid waste management

2.3.2 Steps to improve SWM in India.

India requires a dedicated powerful, independent governance to take control and improve waste management. Clear rules and administration only can achieve development and innovation in SWM. Waste management companies would benefit from financial support and sponsorship for better infrastructure obtained from producers of the waste and applying waste tax charges. For example, 1 rupee collected from each individual daily would equate to approximately 50000 crores annually and provide funds towards effective waste management around India. To aid crucial primary and secondary collection, there is a need for governmental investment in vehicles and equipment with plausible systems in place relating to collection, transport, disposal and management.

This would include better organization of separating from waste recyclable materials like inorganic dry waste and biodegradable wet waste, noting materials of value chargeable to the waste producer. In India, all children in schools should be educated on the importance of waste management, their impacts upon the environmental and health, simultaneously promoting individual responsibilities to control waste management in educational systems. Literature is being used within the modern world as a method of educating students and should be utilized in an effective manner to provide lasting knowledge which constitutes to the development of responsible citizens. Through this, students will find prospective resources in waste. Segregation and recycling initiatives can create enhanced employment options in waste management. This will enable the poorer people in India to be self-sufficient and develop their lifestyles, thus viewed as a business opportunity. Public awareness is paramount in order to create realization of the importance of source segregation at the source.

This will ensure that biodegradables, inert and recyclable materials in waste are correctly managed from the outset. Through education the public will alter their views and recognize the significant service of rag-pickers. A communal initiative should be introduced to create manpower to carry out cleaning work and renamed Green brigade/crew or similar. Many European countries ensure containers for paper, plastic, glass, food and general waste are kept separate from the outset. This approach eases the sorting process as individual citizens take responsibility in the segregation of waste. It reduces the labor as well as money input by the government. Those countries make laws that companies must produce their packaging material as reusable and it should be marked with green dot.

Figure 2.3: Solid waste management hierarchy

2.4 ADVANTAGES OF SOLID WASTE MANAGEMENT

2.4.1 Reduced Quantity of Waste

Incinerators can decrease the quantity of waste by as much as 95% and reduce the solid quantity of the original waste by as much as 80-85% depending on the components that were in solid waste. Incineration thus reduces dependency on landfills. Hence, even though incinerators do not completely remove the need for a dumping ground, they significantly decrease the quantity of land needed. For countries with limited space like Japan, this is particularly helpful since landfills take up large amounts of land that can be used for other productive uses. Moreover, the ash that comes from the combustion of waste is cheaper to transport compared to unburned trash; it will also reduce liability issues.

2.4.2 Efficient Waste Management

Incineration plays a vital role in making waste management easier and more efficient. Incineration can burn up to 90% of the total waste generated and sometimes even more. Landfills on the other hand only allow organic decomposition without making much difference while non-organic waste keeps accumulating.

2.4.3 Production of Heat and Power

Incineration plants generate energy from waste that can be used to generate electricity or heat. For example, during the 1950s, when energy costs were increasing, a lot of countries incorporated the heat and energy produced from waste incinerators for the generation of power by using steam turbines. The energy produced can then be used to power the needs of people living nearby. Countries with cold weather utilize the heat from the incinerators for warming their homes and places of work in areas near the plant. Examples include Europe and Japan integrating incinerators into modern heating systems, and Sweden generating 8% of its heating needs from waste incinerators. On average, a single facility can burn up to 300 million tons

2.4.4 Reduction of Pollution Compared to Landfills

Research has shown that solid waste incinerators are less likely to pollute the environment than landfills. One particular study done during a 1994 lawsuit in the US showed that a waste incinerator location was more environment-friendly compared to a landfill. The research Fund that the landfill was releasing higher quantities of greenhouse gases, nitrogen oxides, dioxin, hydrocarbons, and non-methane organic compounds in comparison to an incineration plant. In addition, landfills leach poisonous chemicals into the water below, thus contaminating underground water systems. This contaminated mixture can penetrate underground aquifers and add pollutants such as unsafe quantities of salts, heavy metals, volatile organic compounds, also other toxic or corrosive chemicals or substances found in household trash. Unlike landfills, incineration doesn't add any toxic elements tothe groundwater. One of the initial concerns with the incineration of solid waste was the release of hazardous compounds, particularly dioxin. Thus, standards were created requiring incinerator plants to use filters to trap hazardous gases and particulate dioxin. Incineration plants are required to operate within the required pollution limitsrecommended by the Environmental Protection Agency and international protocols.

2.4.5 Reduced Reliance on Transportation

Thanks to its lower demand for land, waste incineration plants can be near cities or towns. This is advantageous since it means waste does not have to be driven long distances for dumping. This significantly reduces the cost of transport and reduces the harmful gases released by vehicles during transportation, thus drastically reducing the overallcarbon footprint. The money saved on transportation can then be spent on other uses such as the well-being of the community and sustaining the growth of a city or district.

2.4.6 Better Control Over Odour and Noise

Waste incineration plants emit less foul odour compared to landfills because instead of letting waste decay in the open air which contributes to air pollution, waste gets burnt inside a facility where the by products of the incineration process can be controlled. In addition, the production of methane in landfills may lead to explosions that cause noise pollution, which is unheard of when it comes to the use of incineration plants.

2.4.7 Provides Better Control Over Odour and Noise

Incineration plants can provide less bad smells because waste gets burnt, unlike landfills, where waste is allowed to decay, thereby emitting unpleasant smells, which cause air pollution. The production of methane in landfills may also lead to explosions that cause noise pollution, which is unheard of when it comes to the use of incineration plants.

2.4.8 Prevents the Production of Methane Gas

The decaying of waste in landfills produces significant amounts of methane, which is a big contributor to global warming. Apart from being bad for the environment, methane is also combustible, making it a safety hazard. Waste incineration plants do not produce methane, therefore making them safer and more environment-friendly.

2.4.9 Operates in Any Weather

Thanks to their mostly enclosed nature, waste incinerators can function in any type of weather. For instance, during the rainy season, waste cannot be dumped in a landfill because the rain will likely wash down poisonous chemicals into the ground and consequently create leachate, thus contaminating the underground water as well as the neighbouring land. Waste can also not be dumped when it is windy since it will get blown into the surroundings. On the other hand, incinerators are not limited to weather changes since they burn waste without leakages. Incineration plants also function 24 hours a day and are more efficient in managing waste compared to landfills.

2.4.10 Effective Material Recycling

When incinerators are burning waste, the metals remain whole because they have a high melting point. After the process of burning waste is done, the workers remove the remaining metal and recycle it. This eliminates the need for separating any metal before waste disposal. The leftover ash can be used in construction and/or in landfills. When raw garbage is taken to a landfill, it is usually not organized, which results in the wasting of resources that could have been recycled. Therefore, using an incinerator makes it easier to remove and reuse materials.

2.5 DISADVANTAGES OF SOLID WASTE MANAGEMENT

2.5.1 High Operating Costs

The installation of a waste incineration plant is an expensive process, mostly due to the expensive infrastructure and equipment needed to build an incineration plant.Apart from its high initial cost, a waste incineration plant requires the employment of trained and devoted personnel to man its operation. The regular maintenance of the plant, which increases as the plant ages, adds another considerable cost to the operation of a waste incineration plant.

2.5.2 Significant levels of pollution

While waste incinerators produce significantly fewer pollutants compared to landfills, they still contribute a considerable level of pollution especially to the area immediately around them.The smoke produced during the burning process may include acid gases including but not limited to the carcinogen dioxin, particulates, heavy metals, and nitrogen oxide. These gases are poisonous to the environment.

2.5.3 Health and Environment Risk

The communities where waste incineration plants are built are at a higher risk for long-term negative health effects such as cancer, birth defects, reproductive dysfunction, neurological problems, and other health effects that are known to occur at very low exposures to many of the metals, and pollutants released by incineration facilities. Respiratory problems, increased cancer rates, reproductive abnormalities, and other health effects are common in areas where incinerator plants are built. The leftover ash contains several poisons and heavy metals which require further treatment. If not disposed of correctly, it can cause serious harm to the public and the environment.

2.5.4 Environmental Racism

It refers to any policy, practice, or directive that differentially affects or disadvantages (whether intended or unintended) individuals, groups, or communities based on race or color. Less well-off areas especially those with poor representation are where these so-called waste-to-energy plants are commonly built. This situation is very common among minority groups and is highly detrimental to the local community.

2.6 METHODS OF WASTE TEATMENT

2.6.1 LANDFILL

In this process, the waste that cannot be reused or recycled are separated out and spread as a thin layer in low-lying areas across a city. A layer of soil is added after each layer of garbage. However, once this process is complete, the area is declared unfit for construction of buildings for the next 20 years. Instead, it can only be used as playground.

All municipal solid waste landfills, industrial landfills, and hazardous landfills are expected to meet minimum national criteria under the "Resoursce Conservation and Recovery Act (RCRA)" to ensure the protection of human health and the environment industrial waste landfill for disposal of non hazardous industrial waste or commercial solid waste is regulated by RCR

i. REGULATION OF LANDFILL

Municipal solid waste landfills (MSWLFs) receive household waste. MSWLFs can also receive non-hazardous sludge, industrial solid waste, and construction and demolition debris. Modern landfills are well-engineered facilities that are located, designed, operated, and monitored to ensure compliance with federal regulations. Solid waste landfills must be designed to protect the environment from contaminants which may be present in the solid waste stream. The landfill siting plan prevents the siting of landfills in environmentally-sensitive areas while on-site environmental monitoring systems monitor for any sign of groundwater contamination and for landfill gas, and provides additional safeguards. In addition, many new landfills collect potentially harmful landfill gas emissions and convert the gas into energy. This chapter provides a comprehensive but brief discussion on all aspects associated with landfill design, construction and operation. Siting, regulations and other important steps that need to happen before design stage are also presented in brief. Information on monitoring and post closure requirements is discussed at the end of the chapter. It should be noted that discussions provided on landfill design are qualitative as they do not include detailed designs. Readers are encouraged to refer to references included for detailed information on landfill designs.

2.6.2 TYPES OF LANDFILL

i. Open dump landfill

Open dumping is a common practice in many developing countries around the world and is defined as a method of disposal of solid wastes indiscriminately without planning or control mechanisms. About 70% of countries around the world use "open dumping" as a method of disposal of municipal solid waste. Since these open dumpsites are not regulated, they are susceptible to open burning, scavengers, disease vectors, and elements. The characteristics of these open dumpsites include lack of planning and control of dumpsites, inadequate or lack of regulation of types of wastes entering the site, waterlogging and leaching resulting in water pollution, open defecation by 2 Journal of Environmental and Public Health the public, lack of confinement of waste body, and uncontrolled burning of waste materials leading to air pollution. These open dumpsites have no proper engineering design and therefore have no groundwater protection or drainage controls.

Environmental risks posed by these open dump landfills need to be investigated to determine remedial actions on whether to close or upgrade the open dump to a controlled landfill. Environmental impact assessments (EIAs) should include flaws in site location (floodplains or groundwater), depth of existing open dumpsite and degree of compaction, variability of wastes within the site, and potential for mining decomposed organic materials

ii. Controlled Landfills

Controlled landfills are one level above open dump landfills, as controlled landfills are subject to basic control mechanisms such as the presence of an authority figure on site, control of vehicular movement and access to landfill, and basic waste handling techniques to ensure control and consolidation of the total body of wastes. At these sites, there is an installation of preliminary drainage control measures and a lack of uncontrolled burning of waste, and scavenging and foraging animals are minimized. Although controlled landfills are more regulated than open dump landfills, they are still not viable since they do not conform with the fundamental principles of waste compaction and covering.

Typical operational procedures include limiting the working face area, installation of litter barrier, and provision of daily cover. Waste volume is subject to control, as well as drainage systems and water quality.

Figure 2.4 Landfill

iii. Engineered Landfills.

Engineered landfills are disposal sites that are constructed through planning and adoption of engineering techniques that ensure control of waste and avoidance of surface water through the installation of welldesigned and well-constructed surface drainage. Other characteristics include excavation and spreading of soil materials to cover the body of wastes, compacting of wastes into smaller layers, removal of leachate from wastes into lagoons or similar structures, venting of landfill gas out of wastes, and most importantly planned isolation of landfills from surrounding geology. Modern landfills are based on the concept of isolating landfills from the environment for proper stabilization of wastes and rendering them innocuous through biological, chemical, and physical treatments. An engineered landfill is represented by the MidMichigan landfill design.

Engineered landfills are often referred to as sanitary landfills due to the high standard of waste disposal. Sanitary landfills require a protected bottom where trash is buried in layers and compressed as a compact solid to ensure the safety of accumulated waste and ease of decomposition. &e design, construction, and development of these landfills require sufficient planning from inception to its after-use stage. Location siting, construction, and operational requirements are much more stringent than other types of landfills. &us, sanitary or engineered landfills are considered to have the least impact on public health and the environment.

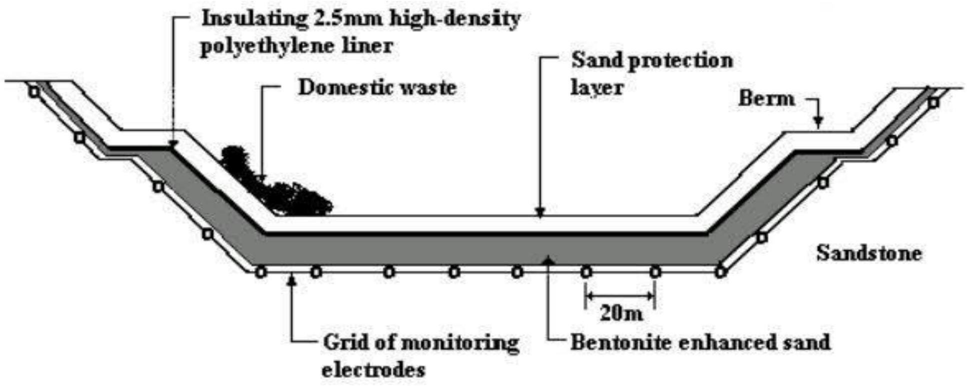


Figure 2.5 Engineered landfill

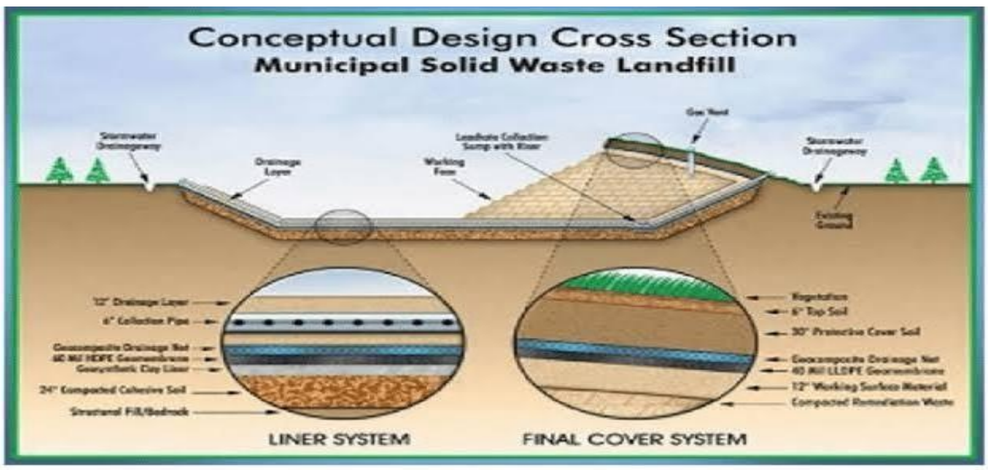


Figure 2.6. Cross section Engineered landfill

iv. Sustainable Landfills

Major driver of engineered or sanitary landfills has been the prevention of waste saturation to minimize the likelihood of leachate leaking into the surrounding ground. &is approach has led to a very slow rate of waste degradation, with a projected stabilization period in the order of hundred years. However, degradation can be accelerated in principle by the controlled circulation of fluids through the waste and thus operating such engineered landfill as a bioreactor. &is approach is more sustainable with regard to airspace, processes, control, and product utilization with minimal negative impacts on the environment and human health.

Sustainable landfills often have two different approaches with regard to parameters that control chemical and biological processes such as water content, temperature, microflora, and compaction rates. &ese led to anaerobic bioreactors and aerobic biocells . Anaerobic open landfill Michigan Engineered landfill design, grangernet.com journal of Environmental and Public Health 3bioreactors are similar in design to an engineered landfill with the following basic difference in their operational practice: a built-in leachate collection and recirculation system to enhance waste stabilization, geomembrane liners, a gas collection system, and final cover. Using this system, the methane gas that is predominantly produced can be collected, purified, and sold. Aerobic biocell systems utilize air circulation to maximize the rate of decomposition of waste. &is latter system generates carbon dioxide as a preferred gas. A sustainable landfill utilizing an aerobic biocell design built by the Environmental Control System, Inc. (2001), in South Carolina is shown in Figure 3. Stabilized waste in this system has limited methane gasand odor production, generates less harmful leachate capable of impacting groundwater, and ensures that the landfill recovers valuable airspace paving the way for a recycle (reusable) and sustainable landfill system.

2.7 COMPOSTING AND ITS TYPES

2.7.1 Types of composting systems

In developing countries and in major cities in particular, MSW generation is on the rise as populations grow, and local governments are being confronted with the challenge of how to manage this increased waste. As waste generators are responsible for reducing waste as much as they can, one solution for reducing MSW generation is household-based and community based composting. The more households actively separate organic waste from other waste and compost organic waste themselves, the less MSW municipalities need to collect and manage. If households cannot secure adequate space for composting at home or in communities, local governments may choose to concentrate and manage MSW at composting plants rather than transport organic waste to landfill sites. Since it is difficult to completely remove contaminants such as pieces of plastic and glass from compost, this guideline strongly recommends that organic waste be separated at source as much as possible before collection and transportation.

2.7.2 Household- and community-based composting (decentralised composting)

Households and communities can produce compost on their own from organic waste, if adequate space is available in their houses and communities to set up containers, and if organic waste is separated well at source. Household and community-based composting, also known as a decentralised composting system, is technically easier to manage. Various types of containers are used for composting at the household and community level, such as plastic baskets clay pots, cardboard, and iron or plastic barrels and well-ventilated containers are recommended. Lining the inside of the baskets with cardboard can help keep moisture content stable. The waste in baskets and containers should be mixed regularly to maintain aerobic conditions.

Odour is the most critical environmental issue for household- and community-based composting. Odour occurs in anaerobic conditions caused by excessive moisture during the fermentation process. Moisture content, one of the most important parameters, should be monitored and maintained at around 60% for aerobic fermentation to be successful. The moisture content of food waste is generally around 80%, but food waste with higher moisture content, such as leftover watermelon, should not be included as a raw material. Squeezing or straining out moisture from food waste before disposing of it in baskets and containers can prevent excessive moisture, stop anaerobic decay, discourage odour anddeter insects. Sandwiching dry soil between layers of food waste has a positive effect in absorbing odours and repelling insects, as well as removing moisture.

When community-based composting is introduced, the local government should carefully select and secure spaces where containers can be set up for fermentation based on consensual agreement with the community. An appropriate number of containers should be set up based on the number of households supplying organic waste. Compared with household-based composting, containers used for community-based composting should be equipped with ventilation and drainage functions since a larger amount of organic waste will be placed in these containers which may become anaerobic due to the higher moisture content.

2.7.3 Centralised composting

If local governments have confirmed that they can sufficiently gain the cooperation of local waste generators in separating organic waste, they mayopt for centralised composting. Although the type and number of processes at composting plants depend on the quality of raw materials, composting usually includes the following processes: adjusting moisture content, fermentation, and mechanical separation, in addition to the separate collection of raw materials at source. lustrates the typical flow of the composting process. Plastic bags are removed in the initial process if they are used to collect and transport raw materials. Since raw materials for composting generally have a high moisture content, sawdust and rice husk are often added to absorb and adjust the moisture content. Next, raw materials are biologically decomposed in the fermentation process through aerobic fermentation, the more common type of fermentation.

In addition to vapour, CO2, CH4, and N2O gases are generated as a result of the decomposition of organic waste. After the fermentation process, contaminants such as metals, glass and plastic are removed, and finally compost is produced. Composting plants must also be equipped with a deodorising process if residents are in the vicinity.

The main processes of centralised composting (fermentation, mechanical separation and deodorising) follow below.

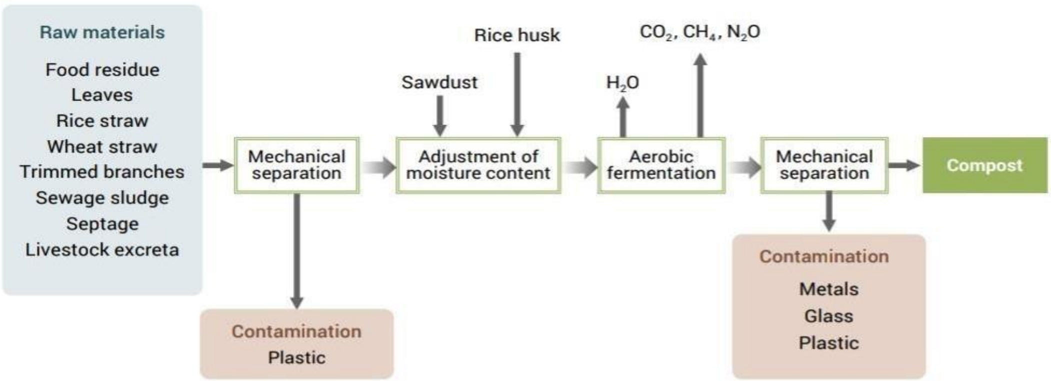


Figure 2.7 Flow chart centralised Composting

2.7.4 Composting aims to:

- Treat organic waste such as food waste, garden waste, livestock excreta, and other types of waste in aerobic or anaerobic states and deactivate causative bacteria, viruses, and weed seeds through the heat of microbial fermentation.
- Produce organic fertilisers that physically improve soil conditions and act as a partial substitute for nutrients such as nitrogen, phosphorus, and potassium contained in chemical fertilisers, upon which modern agriculture fully depends.

2.8 Benefits of composting:

Composting has two notable benefits: reducing negative environmental impacts from improper waste management and improving soil conditions. However, composting can also have several disadvantages if composting systems do not operate effectively. Similarly, some requirements must be met to introduce composting as a potential practice in terms of technology, the environment, Greenhouse Gas (GHG) emissions, resources and society as a whole.

2.8.1 Reducing negative environmental impacts from improper waste management:

Composting can reduce negative environmental impacts from inappropriate waste management at open dumping or landfill sites. Many developing countries rely fully on open dumping or uncontrolled landfilling in their MSW management practices because it is less expensive to construct and operate sites. However, the direct disposal of untreated organic waste in open dumping or landfill sites has indisputable environmental impacts at both the local and global levels.

Improper disposal of organic waste in open dumping or landfilling results in the generation of GHG emissions and leachate high in BOD, which pollute ground water and rivers if not treated. Such improper landfilling of MSW also results in breakouts of fires, odours and vermin at disposal sites. MSW should be properly treated before it is landfilled to avoid serious environmental impacts. Composting is one of the best options available to reduce the amount of organic waste being directly transported to dumping sites.

2.8.2 Improving soil conditions

Years must pass for soil to form as it is affected by climate, geography, and biology. Soil is a mixture of organic and inorganic components composed of rocks, stones, clay, sand, volcanic ash, and animal and plant residues. Soil contains particles of various sizes, and has a cellular structure of moisture and air. Soil can be divided into three phases: solid, liquid and gas. When in a solid phase, soil physically supports roots and adjusts the supply of nutrients. In a liquid phase, it supplies water and nutrients to roots. Soil in a gaseous phase supplies oxygen to roots. The balance of the three phases greatly affects crop growth, and soil with a solid phase consistency of around 40% is considered suitable for cultivation. Soil would have an extremely hard consistency if it were higher than 50% in a solid phase; at 30%, the consistency would be too soft.

Soil with a higher proportion of clay has greater capacity to retain water but lower capacity to drain water. On the other hand, soil with a larger proportion of sand has greater capacity for drainage but lower capacity to retain water. Soil suitable for farming has the capacity to retain and drain water, retain nutrients and ventilate. To ensure that soil possesses this capacity, it should have an aggregated structure with a moderate mixture of clay and sand, and with “humus” as its key element.

Organic substances are continuously supplied and degraded in soil. Some organic substances do not completely degrade but remain in the soil in a complex composition and structure, known as humus. Humus enhances the soil’s capacity to retain and drain water, preserve nutrients, ventilate, and act as a pH buffer. Humus also contains growth hormones such as auxin and cytokinin, which promote plant growth and result in an increased volume of roots. Compost can partly replace chemical fertilisers in terms of supplying nitrogen, phosphorus, and potassium. More importantly, compost derived from food waste can be a source of humus, which cannot be produced artificially (Hermann et al., 2011) but demonstrates the various advantages mentioned above and contributes to the formation of a sustainable soil management and food recycling system.

2.9 USE OF INTERNET OF THINGS FOR WASTE COLLECTION AND MONITORING

The rise in waste generation and increase of human population correspond to the amount of solid waste produced. Inappropriate solid waste management poses risk to the environment as well as to the healthy living of people. Outmoded way of solid waste management is a cumbersome and complex process, which utilizes more valued human effort, time and cost and is not well matched with advancement in technologies. In this work, a smart bin solution is shown with a three-layered architecture for IoT real time solid waste monitoring.

The lower layer is installed with sensors for measuring waste levels in smart bins; the middle layer is comprised with both Wi-Fi and GSM technologies for data transmission to a central system. A cloud service for receiving and storing data from the sensors is on the upper layer. In order to collect waste, the corresponding cleaning service is notified whenever a smart bin level threshold is reached. Ultrasonic ranger sensor and laser distance sensors were implemented and tested. A web based system to store user's information necessary for monitoring was also developed. The technologies used in the proposed system can solve the problem associated with solid waste monitoring and management and thus provides green environment**.**

2.10 Common challenges in Integrated solid waste management

Local governments often lack the expertise needed to evaluate technologies or solutions in order to identify the most appropriate ones for their situation. Difficult Situations can arise when private companies Contract with cities to provide a technology Limited technical expertise and awareness of best practices or implement a project but abandon the project if the city cannot meet the terms of the contract for example, many waste treatment project Contracts include requirements that the city.

Guarantee a clean or consistent feedstock. Private Companies can and will abandon the work if the city fails to meet these requirements. Cities do not always anticipate these challenges, and Projects can fail as a result. Decision-makers and Staff at the local level are often not aware of best Practices that other cities in similar situations have implemented successfully Technical Knowledge and awareness of best practices can be improved by participating in domestic and international exchanges such as conferences and Webinars organized by the International Solid Waste Association. Centres of excellence – such as those identified in the text box to the right can also be valuable resources for disseminating lessons and experiences.

2.10.1 Limited available land

As urban areas and Populations continue to grow, the amount of Available space for solid waste facilities, local collection locations, and transfer stations decreases. There may not be space, the available Parcels may be too expensive, or local residents May prevent facilities from being developed due to fears of smell depreciating their living conditions or property prices. However, siting these facilities at a distance from cities, where land is more available and less expensive, creates a new set of Challenges because hauling waste long distances Can be time-consuming and expensive. Solid Waste managers can work with local and regional leaders to create a solid waste management plan that emphasizes the importance of route and city planning. Diversion or separation programs will also play a large role in reducing the amount of waste that needs to be collected at one time.

2.10.2 Difficulty in working

Solid waste management workers in developing countries may be underpaid and risk of injury or disease. Studies show that a high percentage of workers who handle waste, and Individuals who live near disposal sites, are at risk of being infected with worms or parasites difficult working conditions also result in a lack of motivation for workers and low employee retention rates.

2.10.3 Lack of planning and evaluation

At both national and municipal levels can negatively affect the success of a solid waste management system. national frameworks or regulations are important to facilitate long-term planning; establish national standards and provide incentives for programs to reduce, recycle, or compost their waste. Planning at the municipal level where implementation occurs is often overlooked and can create challenges later. This is especially prevalent when there are unplanned disruptions such as natural disasters. Creating a national and local plan, which includes a monitoring and verification system, will help create a stable solid waste management.

2.11 OBJECTIVES OF THE PRESENT STUDY

1. To estimate quantum and prevailing treatment practices of municipal solid waste in rural area.

2.To develop strategies for suitable collection, segregation, recycling, treatment method for municipal solid waste in rural areas.

3.To analyse environmental impact of municipal solid waste.

4. To assess the use of municipal solid waste through eco-friendly methods and application of municipal solid waste for different uses in rural areas.

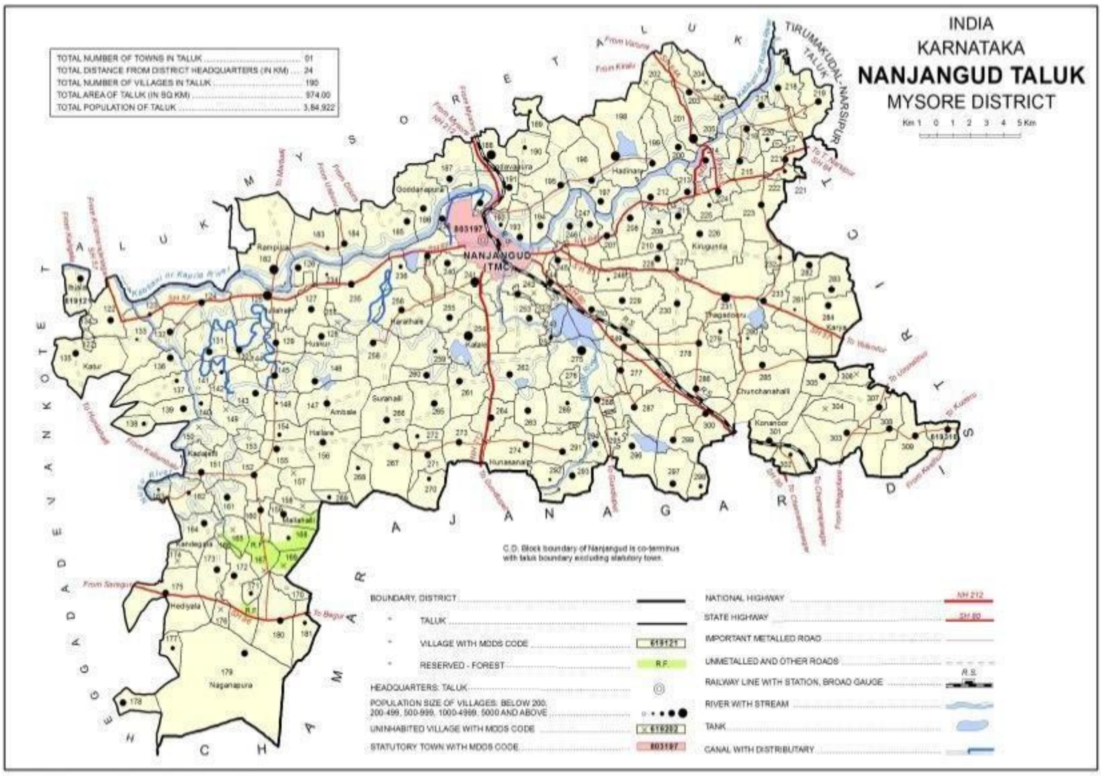
5.Implementaion of modern collecting and monitoring solid waste in rural areas using internet of things.

CHAPTER-3

MATERIALS AND METHODOLOGY

3.1 DESCRIPION OF THANDAVAPURA VILLAGE

Thandavapura is a village in the southern state of Karnataka, India.[1][2] It is located in the Nanjangud taluk of Mysore district in Karnataka. As of 2001 India census, Thandavapura had a population of 5156 with 2722 males and 2434 females. The village has its own railway station where only two slow trains stop.[3] Trains are available from Mysore at 4.50 am, 7.10 am, 8.50 am, 12.20pm, 2.40pm and 1.40pm. The nearest major railway station is Mysore. Buses are easily available to Nanjangud and Chamarajanagar towns. A government primary and high school are present in the village. There is also an engineering college, 'Maharaja Institute of Technology Thandavapura (MITT)', located here.



MAP OF NANJANGUD TALUK

Figure 3.1 Map of Nanjungud Taluk

3.2 PROJECT CYCLE

1. Evaluation of sources of solid waste

2. Monitoring and collection

3. Treatment and recycle

4. Disposal

3.2.1 SOURCES OF MUNICIPAL SOLID WASTE

There are different sources in municipality which are contributing to municipal solid waste there sources include

Table -3.1 Quantity of solid waste generated in Nanjungud Taluk

QUANTITY OF SOLID WASTE GENERATED IN CITY

SL NO	GENERATOR	NUMBER	ESTIMATED QUANTITY (MT)
01	Population	52760	17.98
02	Commercial	1239	2.48
03	Market waste	2	0.30
04	Hotels	49	3.33
05	Meat stall waste	46	0.30
06	others		1.25
TOTAL WASTE GENERATED PER DAY IN MT			**25.43**

3.2.2 MONITORING AND COLLECTION

The solid waste is collected from different sources/establishment by various methods. The solid waste management activity consists of wastes generator throwing the waste into the round RCC bins and masonry bins. The pourakarmika sweeps the road and drains and transfer the waste into small heaps on the road or into the bins. Being a industrial city, there are many location within the city and special contingents of staff are dedicated for these operation. Two types of dust bins are used. These are cylindrical bottomless cement concrete of 0.45-0.8 m3 capacity and rectangular bins with bottom made of masonry of 2-10 m 3 capacity. The collection of waste from these dust bins is planned in accordance with frequency of container becoming full.

The present location of dust bins and the waste collection point have been classified into daily collection (A type), weekly twice collection (B type) and weekly once collection (C type) as part of Nirmal Nagara Programme. In addition, there are 20 dumper placer containers used as primary collection containers in commercial areas and bulk generator. The collection of waste is managed on contract by private contractor authority. The contracts involves sweeping of the wards , transfer of waste to the bins and others collection point ,collection of waste from these point and transporting them to the Waste Processing Facility (WPF) or any other designated disposal point.

Figure 3.2. Collection system

i. COLLECTION SYSTEM

Transportation of solid waste is carried out partially by Town municipal and partially by private contractor. The solid waste is stored temporarily in the dust bins and then transported to the disposal site.

Figure 3.3 Waste transportation

Types of vehicles used for transportation of solid waste are as follows

- Tractor tipper.
- Tractor.
- Trailer.
- Dumper tipper.
- Tractors are more than 15 years old.

Lifting of garbage is done manually. The waste collected from the roads and bins is directly transported to the final dumping site. The refuse vehicles have to travel about 6 Km distance through the city to carry waste up to the dumping site. The tractors and dumpers carrying waste are not covered or partially covered during the journey and waste tends to spill on the roads. Most often workers are not provided with protective hand gloves and shoes so they are directly expose to the waste. Protective measures are necessary to avoid contracting skin allergies and respiratory diseases. The loading and unloading of waste is done through mechanical system reducing direct contact of worker with the wastes.

3.2.3 Disposal of Wastes

Considering quantity and composition of Municipal solid waste generation in the town, a composting plant was set up under the ADB assisted Karnataka Urban Infrastructure Development Project for generation compost from the city refuse.. The plant has the capacity to handle 200 tons of waste per day. The remaining waste is being dumped besides the Excel plant. The city doesn't have disposal sites. There is also a small vermin-composting is operational zones.

3.3 Overview of solid waste management Thandavapura village

The solid waste management in Thandavapura appears to be inadequate and needs up gradation. The solid waste has to be disposed off scientifically through sanitary landfill and recyclable portion of the waste should be salvaged. Segregation of recyclable material would also leads to reduction in quantity of solid waste for final disposal. Higher priority needs to be assigned to the management of municipal solid waste by the local authority and a system approach needs to be adopted for optimizing the entire operation of SWM encompassing segregation at source, timely and proper collection, transportation routes and types of vehicles and development and proper operation of sanitary landfill site, The present system of MSWM in Thandavapura is not satisfactory based on MSW(M & H) Rule 2000.There is need to implement MSW (M & H) Rule 2000 in an integrated manner. More emphasis needs to be laid on segregation and collection of waste at door step. Segregation of recyclable material from mixed waste not only is tedious but also wasteful, therefore the residents should be sensitized towards the importance of segregation of wastes at source. Rather than considering the municipal solid waste simply as residue to be thrown away, it should be recognized as resource materials for the production of energy, compost and fuel depending upon the techno-economical viability, local condition and sustainability of the project on long term basis.

3.4 FUNCTIONAL ELEMENTS OF INTEGRATED SOLID WASTE MANAGEMENT

The four components or functional elements of ISWM include source reduction, recycling and composting, waste transportation and landfilling. These waste management activities can be undertaken either in interactively or hierarchically. Following are brief discussion of each of these functional elements of ISWM

i. SOURCE REDUCTION

Also known as waste prevention, aims at reducing unnecessary waste generation. Source reduction strategies may include a variety of approaches, such as:

• Products that are designed for recycling, durable, sustainable goods and, where possible, in concentrated form. Reusable products, including reusable packaging, as reuse and increasingly becomes an important component of the circular economy.

• Refurbishing of goods to prolong product life, another important element of the circular economy model .

• Redesign of goods and utilize less or no packaging.

• Reduction of food spoilage and waste through better attention to food processing and storage

• Avoidance of goods that don't last long and can't be reused or recycled, such as Halloween decorations.

• Waste source reduction helps us to lessen waste handling, transportation, and disposal costs and eventually reduces methane generation.

ii. RECYCLING AND COMPOSTING

They are crucial phases in the entire ISWM process. Recycling includes the accumulation, sorting and recovering of recyclable and reusable materials, as well as the reprocessing of recyclables to produce new products. Composting, a component of organics recycling, involves the accumulation of organic waste and converting it into soil additives.

Both recycling and composting wastes have a number of economic benefits such as they create job opportunities in addition to diverting material from the waste stream to generate cost- effective sources of material for further use . Both recycling and composting also significantly contribute to the reduction of greenhouse gas emissions.

iii. WASTE TRANSPORTATION

It is another waste management activity that must be integrated systematically with other waste management activities to ensure smooth and efficient waste management. typically this includes the collection of waste from curbside and businesses, as well as from transfer stations where waste may be concentrated and reloaded onto other vehicles for delivery to the landfill.

iv. WASTE DISPOSAL

In particular through the use of landfills and combustion, are the activities undertaken to manage waste materials that are not recycled. The most common way of managing these wastes is through landfills, which must be properly designed, well-constructed and systematically managed.

3.5 WASTE TREATMENT METHOD

Composting is the one of the simple and widely used method for the process of waste treatment

3.5.1 Procedure for composting

1. To prepare compost, either a plastic or a concrete tank can be used. The size of the tank depends upon the availability of raw materials.
2. Collect the biomass and place it under the sun for about 8-12 days. Now chop it to the required size using the cutter.
3. Prepare a cow dung slurry and sprinkle it on the heap for quick decomposition.
4. Add a layer (2 – 3 inch) of soil or sand at the bottom of the tank.

5.Now prepare fine bedding by adding partially decomposed cow dung, dried leaves and other biodegradable wastes collected from fields and kitchen. Distribute them evenly on the sand layer.

6.Continue adding both the chopped bio-waste and partially decomposed cow dung layer-wise into the tank up to a depth of 0.5-1.0 ft.

7.After adding all the bio-wastes, release the earthworm species over the mixture and cover the compost mixture with dry straw or gunny bags.

8.Sprinkle water on a regular basis to maintain the moisture content of the compost.

9.Cover the tank with a thatch roof to prevent the entry of ants, lizards, mouse, snakes, etc. and protect the compost from rainwater and direct sunshine.

10.Have a frequent check to avoid the compost from overheating. Maintain proper moisture and temperature.

3.5.1 COMPOSTING OF SOLID WASTE

i. Waste suitable for composting

Organic waste that can decompose biologically is suitable for composting. Below are examples of organic waste that can be used as raw materials for composting:

a) Food waste such as residue from cooking preparation and leftovers after meals

b) Leaves and trimmed trees

c) Cattle and swine faeces

d) Vegetable and fruit wastes coming from fresh or public markets.

Figure 3.4 composting soil

Figure 3.5 composting pit

Seashells, eggshells, shrimp shells, chicken bones, pork bones, beef bones, coconut shells and fruit seeds are not suitable for composting due to the difficulty in degradation although these wastes are often categorised as food waste. These wastes should preferably be removed from the raw materials for composting if facilities do not have the proper processes to remove them. Also, waste with high salt and pungent components should be minimised because this renders bacteria inactive during the composting fermentation process.

Waste that does not biologically decompose, such as plastics, metals, glass, oil, cigarette butts, gum, diapers, and other such items, is not suitable for composting since it may interfere with the composting process. Paper waste is often categorised as unsuitable for composting even though paper is biodegradable. The aerobic fermentation process for composting generally takes from ten days to three months but a much longer period is required for paper to decompose. Farmers tend to avoid using low-quality compost containing pieces of nonbiodegradable waste, such as plastics and glass.

Hazardous and harmful waste, such as medicines, dry batteries, spray cans, pesticides, mercury thermometers, and other items, should not be mixed in raw materials for composting since mixing hazardous waste has an adverse effect on the quality of compost and eventually threatens the health of people who ingest the crops harvested on farmland where compost was used.

The use of cattle and swine faeces and sewage sludge requires careful attention to be paid to the proximate and chemical composition. Milk cows ingest copious amounts of water and faeces contain higher moisture content. On the other hand, the faeces of cows used for meat have a much lower moisture content, while pig faeces generally contain a significant amount of moisture. Bedding for cows and pigs such as rice straw, rice husk and sawdust is an excellent mixture used for reducing the moisture content of faeces. Residual components of herbicides in feed crops may remain in faeces and cause growth problems for crops when compost derived from cattle and swine faeces is used on farmlands.

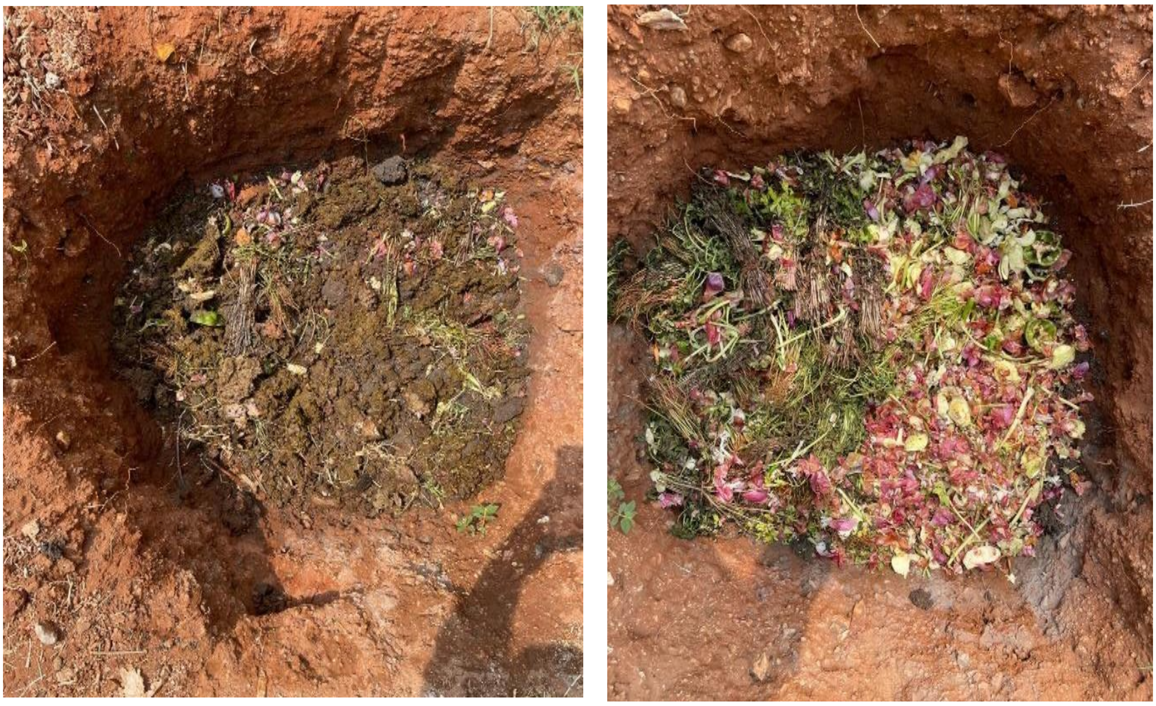


Figure 3.6 Pit with composting materials

ii. Objectives of composting

The role of compost, organic fertiliser derived from waste, has been overshadowed by the excessive use of pesticides and chemical fertilisers in agricultural practices. The lack of compost used in farm fields and the dependence on chemical fertilisers have had a number of negative impacts, such as deteriorating soil conditions, deficient or excess nutrients, insect outbreaks, and solidified soil, to name a few. However, organic waste generated in daily life can help recover soil fertility if it is used to produce compost.

The Food and Agriculture Organization of the United Nations (2011) has reported that roughly one-third of the food produced around the world is lost or wasted, a figure that is almost equivalent to a staggering 1.3 billion tonnes per year. Food waste makes up a significant part of MSW and contains a substantial amount of moisture. Untreated MSW in developing countries is mainly disposed in uncontrolled landfills or dumping sites and has been proven to be a source of methane (CH4) gas due to the decomposition of food waste in an anaerobic state. Moreover, the direct disposal of organic waste in landfill sites results in the generation of putrid odours in surrounding areas and leachate rich in concentrations of Biochemical Oxygen Demand (BOD).

Organic waste, and food waste in particular, is a biogenic material and decomposes naturally. When organic waste is treated properly instead of dumped in landfill sites, fewer greenhouse gases are generated, and various environmental problems that result from improper disposal, such as odours, vermin, compromised water quality, fires and smoke, and pollution from vehicles transporting waste to landfill sites, can be alleviated. Composting, a biodegradation process that transforms organic matter into water, carbon dioxide, energy, and composted matter has been adopted throughout the world over the years as a technology that can stabilise organic residues. Compost the product of organic waste composting, can act as a partial substitute for chemical fertilisers.

Compost is an effective soil conditioner. The longer farmers utilise chemical fertilisers, the worse the soil quality of farmland becomes. Compost can be used to recover soil conditions that are crucial to ensuring sustainable agricultural practices.

3.6 Use of Internet of Things IOT for proper collection and monitoring of solid waste

We are living in an age where tasks and systems are fusing together with the power of IOT to have a more efficient system of working and to execute jobs quickly! With all the power at our finger tips this is what we have come up with. The Internet of Things (IOT) shall be able to incorporate transparently and seamlessly a large number of different systems, while providing data for millions of people to use and capitalize. Building a general architecture for the IOT is hence a very complex task, mainly because of the extremely large variety of devices, link layer technologies, and services that may be involved in such a system. One of the main concerns with our environment has been solid waste management which impacts the health and environment of our society. The detection, monitoring and management of wastes is one of the primary problems of the present era.

The traditional way of manually monitoring the wastes in waste bins is a cumbersome process and utilizes more human effort, time and cost which can easily be avoided with our present technologies. This is our solution, a method in which waste management is automated. This is our IOT Garbage Monitoring system, an innovative way that will help to keep the cities clean and healthy.

3.6.1 Issues regarding solid waste collection

Nowadays, there are tons of flats and apartments which have been built in the rapid urbanization area. This is due to high housing demands which have been drastically risen as a result of migration from villages to cities to find work. In order to accommodate the growing population in the urban area, the government has also constructed more apartment complexes. There are several issues faced by the residents of the flats. One of them is disposal of solid waste.

Unlike private houses, the residents of all the apartments use a common dustbin, which tends to fill up very quickly. This overflowing of garbage is a sanitary issue which might cause diseases like cholera and dengue. Moreover it is a waste of fuel to travel around a complex or an area to find that some of the garbage are filled and some are not. Also, on rare days, problems might arise that there is so much garbage that the truck doesn’t have enough capacity.

The idea struck us when we observed that the garbage truck use to go around the town to collect solid waste twice a day. Although this system was thorough it was very inefficient. For example let's say street A is a busy street and we see that the garbage fills up really fast whereas maybe street B even after two days the bin isn't even half full. This example is something that actually happens thus it lead us to the "Eureka" moment What our system does is it gives a real time indicator of the garbage level in a trashcan at any given time. Using that data we can then optimize waste collection routes and ultimately reduce fuel consumption.

It allows trash collectors to plan their daily/weekly pick up schedule. An Ultrasonic Sensor is used for detecting whether the trash can is filled with garbage or not. Here Ultrasonic Sensor is installed at the top of Trash Can and will measure the distance of garbage from the top of Trash can and we can set a threshold value according to the size of trash can.

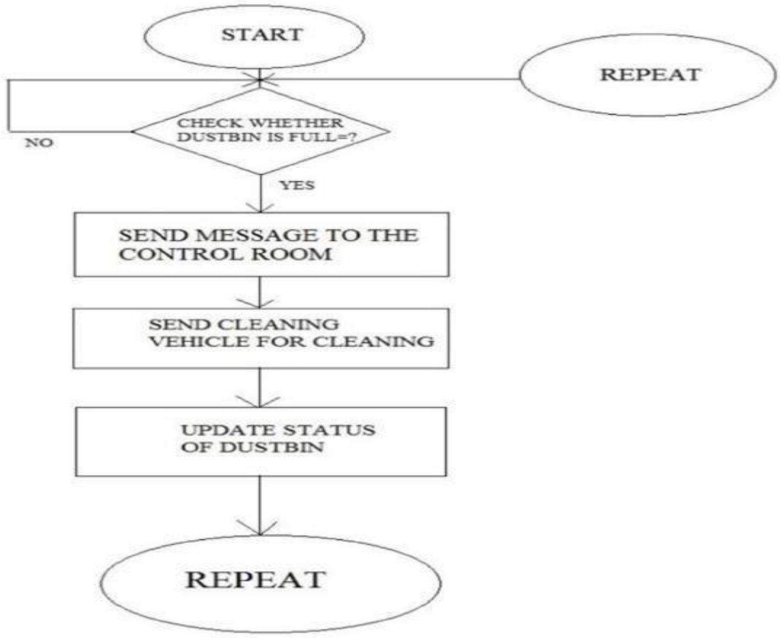


Figure 3.7 Flow chart of IOT working

If the distance will be less than this threshold value, means that the Trash can is full of garbage and we will print the message "Basket is Full" on the message and if the distance will be more than this threshold value, then we will print the distance remaining for the garbage vat to be full.

3.6.2 MATERIALS REQUIREMENTS

We will need the following hardware to accomplish our project.

1. HC-SR04 ultrasonic sensor.
2. Arduino Uno.
3. GSM module
4. Connecting wires.

i. ARDUINO UNO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

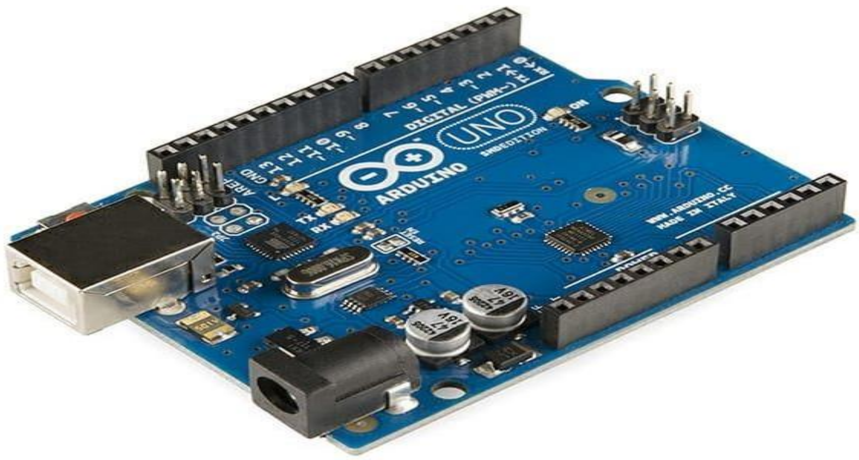


Figure 3.8 Arduino UNO

The Arduino is a microcontroller board based on the ATmega8. It has 14 digital -input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a ACto-DC adapter or battery to get started .The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter .Revision 2 of the Uno board has a resistor pulling the 8U2HWB line to ground, making it easier to put into DFU mode. Revision of the board has the following new features added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board.

ii. HC-SR04 ULTRASONIC SENSOR.

HC-SR04 is an ultrasonic sensor which is used for measuring the distance between the top of the lid to the top of the garbage.

The HC-SR04 Ultrasonic (US) sensor is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The sensor works with the simple high school formula that

$$\text{Distance} = \text{Speed} \times \text{Time}$$

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module. Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a microcontroller or microprocessor.

Figure 3.9 Ultrasonic sensor

iii. GSM MODULE.

A GSM modem or GSM module is a device that uses GSM mobile telephone technology to provide a wireless data link to a network. GSM modems are used in mobile telephones and other equipment that communicates with mobile telephone networks. They use SIMs to identify their device to the network.

GSM/GPRS module is used to establish communication between a computer and a GSMGPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer.

GSM/GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

- SIM800L Module is a miniature cellular GSM/GPRS breakout board that allows GPRS transmission, sending and receiving messages and making and receiving calls. This module supports quad-band GSM/GPRS network, which is available for GPRS and SMS data remote transmission.
- At the heart of the module is a SIM800L GSM cellular chip from Simcom.
- The operating voltage of the chip ranges from 3.4V to 4.4V, making it an ideal candidate for direct LiPo battery supply. This makes it an excellent choice for embedding in projects with limited space.

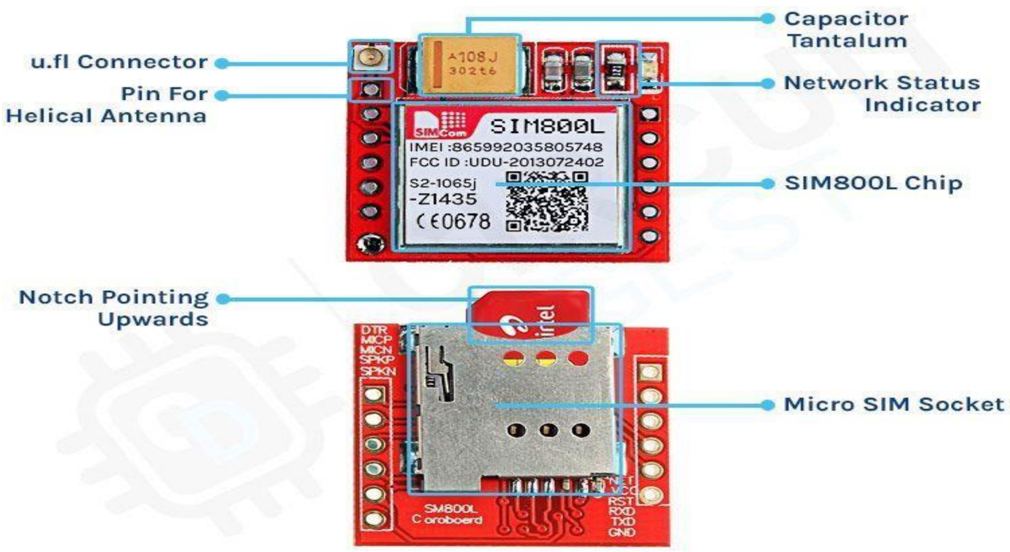


Figure 3.10 GSM module

At the heart of the breakout board, there is the SIM800L GSM/GPRS Module made by Sim Com. As mentioned in the above pin out section, the operating voltage of this device is 3.4V to 4.4V which means you can power this module directly from a lithium polymer battery. Other than that all the usable pins are broken out to a 0.1” pin pitch that makes this module very breadboard friendly. It also has auto baud rate detection for ease of use. The module needs an external antenna to connect to the network, which is why there are two antenna options available for this board. In the package, you will get a helical antenna that you can directly solder to the NET pin of the module.

But if you want to keep the antenna far away from the module board there is an option for connecting the external antenna with the on board UFL connector. Any sim card with 2G connectivity will work with this module. If you take a closer look at the SIM800L module there is not much on the PCB. On the front side of the PCB, we have the UFL connector and the SIM800L module itself. We also have some capacitors for decoupling and we have a 1K current limiting resistor for the LED. Finally, we have a big 100uF, 16V tantalum capacitor on board. On the backside of the board we have the sim holder that is a push-to-lock type connector. This means you just need to insert a SIM card and push it for the card to work.

POSSIBLE OUTCOMES

- Provide efficient and economical refuse collection, recycling, and disposal services.
- Expected to reduce the requirements of more human effort.
- Helps to maintain clean and healthy environment which inturn reduce the spread of diseases and also improve the asthetic appearance of the city.
- To reduce time and cost for the monitoring and collection of solid waste.

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