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A Comprehensive Study on Waste Segregation Techniques

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***Abstract*-With ever increasing urbanization and growth all over the world, we need a stable and sustainable development plan. One of the vital parts of the urban development plan is proper waste management in which waste collection is a very complicated process which involves efficient management of the entire system, beginning with the collection to the dumping of wastes hygienically. Segregation of collected waste is essential due to the fact that if all waste materials such as polythene bags, old furniture, and e-waste get mixed up in the landfills, it could lead towards contamination of the land through leaking toxic substances. Wet waste fraction is converted either into compost or methane gas. Compost can replace chemical fertilizers demands, and biogas can be used as a source of energy. The metallic, plastic and paper waste can be reused or recycled. An automated waste segregation process is the most basic requirement for kick-starting management process. Thus in this paper, we have compared various automated waste segregation processes implemented using different technologies.**

Index Terms - Urban development, biogas, e-waste, automated waste segregation.

INTRODUCTION

In today's world common problem faced in waste collection and dumping is mainly: overflowing garbage bins and waste segregation as per its type. Nearby 62 million tons of waste is generated each day by 377 million people living in urban India of which 45 million of waste is left untreated and disposed of unhygienically causing severe health problems and environmental degradation [1]. A rage of notable inflation in the municipal solid waste generation has been registered. worldwide due to overpopulation, industrialization and economic growth and overflowing landfills are impossible to reclaim because of the improper disposal of wastes on outskirts of cities causing vital environmental entanglement in terms of water pollution and global warming causing a reduction in average lifetime of the manual segregator [2]. In India, ragpickers and conservancy staff play a crucial role in the recycling of urban solid waste and have higher jejuneness due to infections of the skin, respiratory system, gastrointestinal tract, and other allergic disorders. This can be diminished if segregation takes place at the source of the municipal waste generation which will also give a higher quality of the material is preserved for recycling thereby recapturing more value from the waste. This not only reduces occupational hazard for rag pickers but also reducing the processing time of segregating the waste after collection. The economic value of the waste generated is realized after it is recycled completely and there are different techniques available to recycle and reuse the municipal solid waste. When the waste is segregated into basic categories such as wet, dry and metallic, it has an intense perspective of improvement, and accordingly, recycled and reused. Thus in this paper, we have done a comprehensive survey of different existing techniques for automation of waste segregation [3][4].

I. CATEGORIES OF WASTE

Waste can be classified into different categories. Moreover, some types of wastes can be recycled and others may not.

2.1.Liquid Waste– Liquid waste is usually found both in homes as well as in industries. It includes dirty water, wash water, organic liquids, even rainwater, and waste detergents.

2.2.Solid Waste– Solid waste can include items found in your household along with commercial and industrial locations. Commonly broken down into several types.

2.2.1. Paper Waste– Includes packaging material, newspapers, cardboard, etc. Paper can be recycled and reused thus should be disposed of in recycling bin.

2.2.2. Metals– Mostly generated as industrial or household waste. It can be recycled thus should be preferably disposed of separately.

2.2.3.Plastic waste– Consists of bags, jars, bottles, etc. that can be found in the household. It is non-biodegradable, but most of them can be recycled. Plastic should not be mixed with regular waste, it should be sorted and placed in a separate bin. Recycling of plastic overcomes energy usage up to 90%.

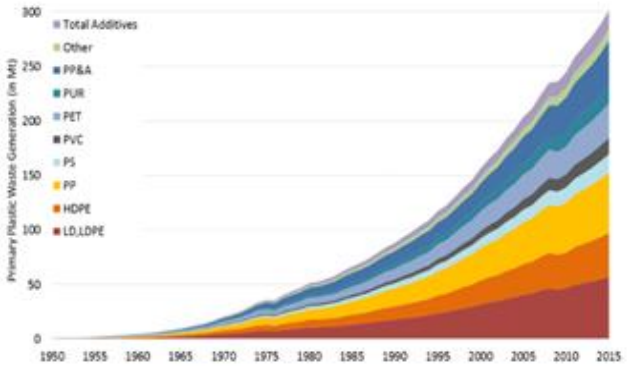

Fig 1- Primary plastic waste generation.
Source-https://cosmosmagazine.com/society/global-plastic-waste-totals-4-9-billion-tonnes

Above figure shows different types of plastic waste generated from 1950 to 2015. It was observed that PP&A, PUR, and PVC contributes the maximum to the plastic

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wastes. The most common polymers in the waste stream were polythene and polypropylene, which account for under half of all the waste plastics produced. This is majorly due to the widespread use of packaging plastic and non-recyclable plastic.

2.2.4. Ceramics and glass – Ceramic wastes are separated into two categories in accordance with the source of raw materials. One category is formed through generated fired ceramic wastes by structural ceramic factories that use only red pastes for product manufacture. The second encompasses fired ceramic waste which is produced in stoneware ceramic. It is 100% recyclable since the process of melting used glass requires far less energy compared to the production of glass from virgin materials. Currently, up to 60% of transparent and 90% of green glass bottles in Europe are already made of recycled glass.

2.3.Organic Waste– Organic waste includes food waste, garden waste, manure, and rotten meat are classified as organic waste. Approximately 300-400 kg of compost can be produced from 1 ton of biodegradable waste and can be utilized as organic fertilizer in agriculture or landscaping. Over time, as organic waste is turned into manure by microorganisms, in landfills they cause the production of methane, so wet waste must be discarded separately.

2.4.Ferrous metal– They are 100% recyclable and can be recycled countless times. The use of ferrous metal waste in steel production saves natural resources and more than 75% of the energy needed for steel production from iron ores.

2.5. Hazardous Waste– It includes all types of wastes that are combustible, toxic, eroding and reactive.These items can injure you as well as the environment and must be disposed of rightly.

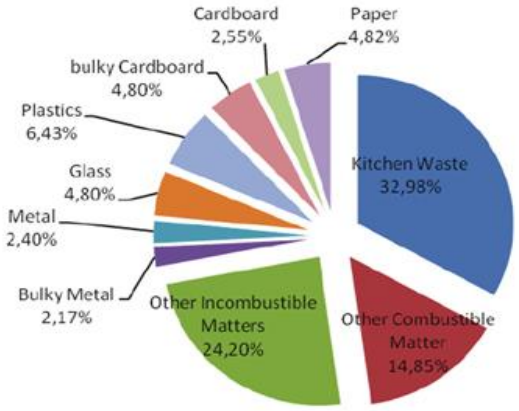

Fig. 2 Distribution of different types of waste
Source- https://www.researchgate.net/figure/Distribution-of-Waste-Types_fig4_285601246

II. RECYCLING OF WASTE

Recycling is the method of improving waste materials into new materials. It is an alternative to "traditional" waste disposal that can not only help lower greenhouse gas emissions but also save resources. Recycling can limit the wastage of potentially useful materials and reduce the consumption of fresh raw materials, thereby reducing energy usage, air pollution, and water pollution.As discussed above some can be recycled and some cannot be so the below table shows the statistics of recycling of different waste.

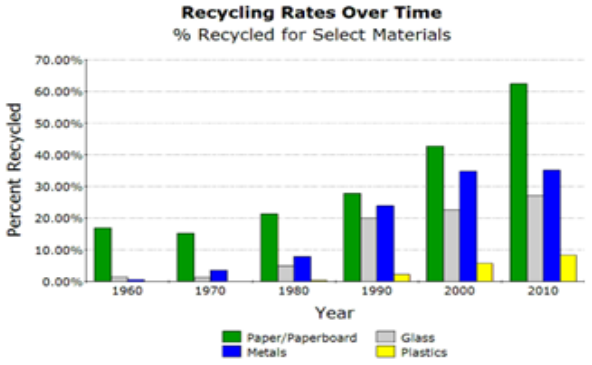

Fig 3- Recycling Statistics of different waste materials

Source -https://recycle.epa.gov.tw/en/NAV06Content.htm

Above bar graph compares American recycling rates for paper, glass, metals, and plastics over a fifty-year time frame, using ten-year intervals. Large green bars on represent paper recycling rates between 1960 and 2010. Over years American recycling habits grew, with beverage container recycling explained the reason for the increase in glass, plastics and metal recycling in 1990. In 1990, yard trimming recycling rates, not presented in the top bar chart, also occupied a greater portion of the average American's recycling efforts which by 2010 had reached 57.5% of all their yard trimmings.

III. CURRENT SCENARIO

In the present world of digitizing everything in our surroundings have been equipped with modern technology and the internet to ease our work and gain more efficiency. But the systems existing today for waste management are the same as they were before in most of the countries. Currently, for the collection of waste in some countries, we have a door to door collection systems that require a lot of efforts and money. A waste collector has to visit everybody's place, knocking the doors and has to wait until each resident brings the waste to them. Moreover, residents have to be available in order to get their waste collected at that particular time which brings in a major disadvantage of this system [5].

Also in some countries, systems do exist in which waste is collected from the trash bins of each colony, but this system also brings a disadvantage that many a time dustbins are overfilled and waste isn't collected from it, as waste is collected on a particular day and not according to its status. This also makes dustbins, a place facilitating bacterial growth, feeding animals and a breeding place for insects. Also at times, it happens that dustbin collection is done in prior resulting in a wastage of fuel and increasing costs of waste collection. So, at each step, a lot of fuel and money is invested unnecessarily for the process [6].

IV. NEED OF WASTE SEGREGATION

Waste segregation is extremely crucial due to the fact that if all waste materials such as polythene bags, old furniture, and e-waste get mixed up in the landfills, could lead to

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contamination of the land and water through leaking harmful substances in the atmosphere. Moreover, non-segregation also affects climate change which may lead to drought conditions. Thus, it is essential to separate waste before disposing into the landfill. Waste segregation is also not only important but also beneficial for human beings. The recyclable parts of the waste can be recycled into useful resources after the segregation process. It has a large meaning for the current society which is facing the problem of resource shortage.

If we segregate waste at the source itself, it solves more than half of our task and the main problem that we face in managing solid waste would lessen considerably. Only we need to behave responsibly to accomplish the goal of waste separation. To increase the activity of recycling, a basic requirement is to concentrate on waste segregation that helps to recognize the degradable and non-biodegradable parts of the waste. Since the degradable waste is organic, its disposal does not cause any harm. The non-biodegradable waste is the inorganic part that is good for recycling. The biggest danger is when the inorganic waste finds its way back to the earth and raises the pollution measurement besides causing other damages to the environment. The inorganic waste reaches the market that deals in scrap materials where further segregation breaks it into its elements like paper, plastic, metal, etc. These materials ultimately pass through the market chain and reach the manufacturers who use it as raw material.

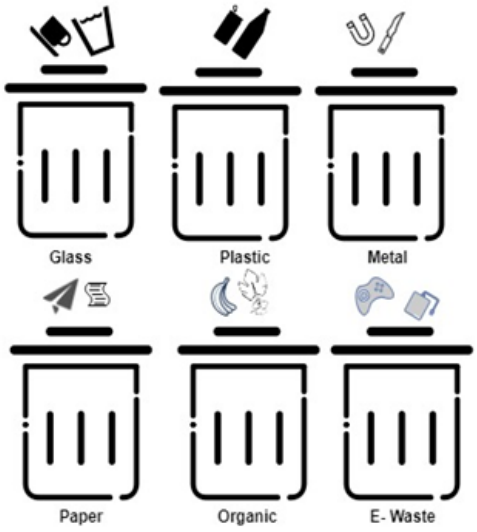

Fig. 4- Waste Segregation

V. LITERATURE SURVEY

This section covers the work done by various researches using different technologies for segregating the waste. Mainly 3three techniques used for waste segregation namely-- Internet of Things(IoT), Image Processing and Deep Learning.

6.1. IoT based Segregation techniques

In [7], authors SharanyaA et al. aims to sort the waste into three major classes, namely metallic, wet and dry and further separating dry into paper and plastic. The most important feature of this work is that it is not only cost-efficient but also compact with a simpler design thereby making the waste management system more persuasive. In this paper, authors have used Arduino UNO which makes the working of the system to be smooth and convenient making the design less complicated. Each of these wastes is detected by the respective sensors and disposed into the bins assigned to them wherein these wastes can be taken for recycling or reusing directly. Once it is detected it is moved to the next sensor that is the Moisture sensor which indicates if the trash which is present is a wet or dry waste. After being detected as dry waste it moves to the next sensor which is an Inductive Proximity sensor that shows if the trash is metallic or not. Next sensor is the laser LDR Module where if the laser falls on the LDR it is recognized as plastic if it fails to pass then the material is decided as paper. Few of the limitations of this model include, that size of the trash should fit the slot size i.e. 100mm X 85mm and the width of the trash should be minimum of 30mm. The system can separate only one type of waste at a time with an allocated priority for wet, metal and dry waste. The segregation of non-transparent plastic is not possible due to the low intensity of laser light.

In [8], authors Gopal Kirshna Shyam et al. presented a waste collection management solution based on providing intelligence to waste bins, using an IoT model with sensors. It can collect, transmit and read a large volume of data over the Internet. When such data is put in a spatiotemporal processed and context by intelligent algorithms, can be used to dynamically manage waste collection mechanism. Simulations for several cases are carried out to investigate the benefits of such a system over a traditional system. It is responsible for measuring the waste level in the waste bins and send this data to a server for storage and processing. This data helps to compute the optimized collection routes for the workers.

In [9], authors Aksan Surya Wijaya et al. presented the smart waste-bin that can manage the waste in a smart city project. The system consists of sensors to measure the weight of waste and the level of waste inside the bin. The system also adapts with the network environment, to manage all information from waste management. Load cell calibration approach, simplifies calibration process so it can be attached to commonly used waste-bin without modification. The level sensors also can be attached to common waste-bin.

In [10], authors Sudharani Ashok Ghadage et al. proposed a system 'IoT based Garbage Management (monitor and acknowledgment) System' shall provide the smart solution regarding the overflowing of garbage bins.The System uses ultrasonic sensors to sense the level of garbage in the bin, flame sensor to detect the fire and moisture sensor to separate out wet and dry garbage. The system was beneficial in keeping dry and wet garbage separately so that different processes- composting, recycling, incineration shall be applied to different kinds of garbage. By intimating the notification of garbage filled, the use of the garbage collecting vehicle shall be optimized.

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In [11], authors Pooja Shela et al. proposed smart alert system for garbage leeway by giving a signal to the municipal web server for instant cleaning of dustbin with proper verification based on the level of garbage filling. The process is assisted by the ultrasonic sensor which is interfaced with Arduino UNO for checking the level of garbage filled in the bin and sends alerts to the municipal web server once before bin overflows. After cleaning the dustbin, the driver verifies the task of clearing the garbage with the aid of RFID Tag. RFID is used for the verification process.

In [12], authors M.S.Killedar et al. It is the implementation of a smart garbage management system using a microcontroller, IR sensor and Wi-Fi module. Their system guarantees the cleaning of dustbins soon when the garbage level reaches its tip. If the dustbin is not washed in a specific time, then the record is sent to the higher authority who can take proper action on the concerned contractor. This system also helps to watch the fake reports and hence can reduce corruption in the overall management system. This decreases the total number of trips of garbage gathering vehicle and hence reduces the overall expense associated with the garbage collection. It ultimately helps to keep cleanliness in society. Therefore, the smart garbage management system makes the garbage collection more efficient. Such systems are exposed to the plundering of components in the system in different ways which need to be acted on.

In [13], authors Kavya Balakrishnan et al.proposed a system which is used to segregate three major categories of waste-Plastic, organic and metallic, controlled by an Arduino UNO board. All other parts like ultrasonic sensors, inductive proximity sensor, DC motors, blower, and electromagnet are interfaced to the Arduino Sensor. The waste segregator as the name suggests segregates the waste into three major classes: plastic, organic, metallic. The system proposed would be able to regulate the solid waste collection process and management of the overall collection process. The inlet section is provided with an open and close mechanism to regulate the flow of waste on to the conveyor.

In [14], authors Abdul Kadir et al.have proposed a system that rewards the users by calculating points on the basis of weight and the type of wastes inserted in them using a waste type detection system. This system eliminates the problem of waste sorting as user's points are deducted if the type of waste inserted does not match with the type of dustbin, but detecting the type of the waste is not yet figured and remains conceptual. Also, nothing is done to eliminate the problem of the collection of waste.

In [15], authors RRajkamal et al. proposed an automation-assisted solution for implementing segregation of waste at the source. Thereby the resources can be recycled for effective energy generation. The technology to automate segregation of dry waste into paper, plastics, metal, and glass is available at a commercial level. The indiscriminate mixing of waste at source leads to the failure of these segregation systems. Even though the waste is being separated, the quality of the segregated materials is affected when it is contaminated. The GREEN BIN has constraints wherein dry waste and wet waste should not be mixed.

6.2 Deep Learning and Image Processing Based Waste Segregation Techniques

In [16], the authors M.Vidhyalakshmi et al. proposed a deep learning solution for India's waste management and waste segregation problem. The system uses Artificial Intelligence and Deep Learning Algorithm to detect the garbage waste, the current segregation system in India is manual and labor based which is inefficient and slow, this type of manual segregation also brings various health hazards to the labors involved in the segregation process. The proposed system uses 8051 microcontroller to sort the waste in mainly three categories which are metal, dry and wet waste. The working of the system takes place as follows; firstly the camera captures the picture of the objects to be segregated and the picture is analyzed using trained data the object is
then identified using boundary algorithm. The project uses Caffe an open source deep learning tool for due to its high speed, operability with all OS and reliable results. However the main disadvantages of this system are that the segregations process is time-consuming, also the size of the waste must also be limited according to the size of funnel being used there is also a restriction on segregation of E-waste, medical waste and Sanitary pads due rules and laws imposed by the Government.

In [17], authors Ali Can Karaca et al. proposed automated waste sorting using shortwave infrared hyperspectral imaging system. Hyperspectral images provide significant information about the chemical constituents of materials and they contain a high content of spectral information. Therefore, it has found its use in application area like recycling. Spectrums of materials, which result from inherent chemical properties, provide more robust solutions than others like weight, shape, color. In this system waste materials are scanned via shortwave infrared(SWIR) Hyperspectral Imaging System. and are successfully sorted into six plastic waste types namely Polyethylene Terephthalate(PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyethylene (LDPE), Polypropylene (PP) and Polystyrene (PS), and paper, cardboard, metal, and glass samples using suitable algorithms. So, in conclusion, this paper says hyperspectral imaging can provide more efficient sorting of waste.

6.3 Comparative Analysis

After detailed study of various techniques used for automating the segregation process ,we can say that IoT based technique is used more than deep learning technique or image processing technique and the advantages IoT based system has been that it collects accurate data on real-time and Load cell calibration approach simplifies the calibration process. IoT based system's disadvantage is its expensive hardware. Deep learning and Image Processing techniques can be used for their high accuracy and reliable results. For

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high-speed deep learning, the technique can be used whereas for low-cost image processing technique can be used. The disadvantage of deep learning technique is that it requires a lot of data to be trained on the other hand image processing disadvantage is that it cannot segregate ceramic waste into dry waste and segregates only one type of waste at a time.

VI. CONCLUSION

In this paper, we have studied various ideas proposed for proper waste segregation. Since a stabilized system is needed for preventing harm caused to the environment due to improper disposal. The study shows that mainly IoT based techniques are mostly used for waste segregation but the cost of implementing IoT based system is very high. To make a cost-effective solution, Artificial Intelligence and Machine Learning based system can be developed for automating the process of waste segregation with maximum efficiency and low cost.

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