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Waste Management using ML and IoT

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***Abstract*—The main objective is the management of waste through segregation using supervised machine learning algorithms for the socio-economic factors modeling Internet of Things(IoT). The supervised learning follows a classification model that maps the waste and segregates it into biodegradable and non-biodegradable waste. The pseudonymous waste uses an unsupervised learning model of clustering, the cluster model is built through a neural network. IoT plays a crucial role by distinguishing waste to stack for further management. The neural network model would recognize the underlying segregation of the waste. A data pre-processing and integration framework would be built to generate a dataset with sufficient data quantity. The approach and purpose is to develop tools for sourcing, data-preprocessing and an integrated framework for a dirt-free environment of waste management.**

***Keywords*—Supervised Learning, Unsupervised Learning, IoT, Neural Network**

I. INTRODUCTION

There is an increasing amount of waste being generated rapidly due to population growth that makes it highly challengeable to manage the waste .The inconsiderate amount of waste which is reusable and nonbiodegradable creates havoc for our environment. The waste which is collected from homes and other sources like shops, complexes have not been segregated accurately, which makes it intricate to manage and dump. So, there is an emerging demand for technology that manages waste astutely, utilizing an arising solution - managing through Artificial Intelligence(AI) and Machine Learning (ML)[1].The subsequent years have shown that land used for dumping is getting reduced due to high demand for lands in commercial and domestic use. And the industrial waste that flows into the river makes it filthy. The segregation is an essential requirement because the wet waste when dumped in an open area degrades with oxygen.

The segregation is an essential requirement because the wet waste when dumped in an open area degrades with oxygen and emits methane[2].to reduce dependency on land usage.The technology which can reuse, recycle, reduce the waste thus contributing through a safe environment.

According to the census of the world bank, 2.01 billion tonnes of waste generation was recorded as of now, at least 33% of this waste is not being managed in an environmentally safe manner

The waste seems to be increasing over the span of time over a period of 40 years from 1971-2011. The waste is composed of non biodegradable waste consisting of Glass, Rubber & Leather, Metal, Plastic and others of about 37 % which creates havoc among species and disturbs the environment. The waste also predominantly known as solid waste directly contributes to Greenhouse gas emission further causing global warming. The solid waste also causes viral diseases and irritation in the body not only to the people near to the waste but people who are far away. India Consists of 18% of total population and generates 12% of the Municipal solid waste. To manage the waste the most preferred waste in landfill which reduces the fertility and the soil binding capability. The other way is the incineration which not affects the environment but causes a living crisis to flora and fauna due the emission of gasses. The census confirms that by 2050 we might reach the peak of our waste which might not be manageable if the current trends of avoiding waste as trivial matters continues[3].

The perilous waste generated which is not managed efficiently is cigarette butts, the unsmoked cigarette, containing tobacco. These usually contain more than 7000 chemicals, their ignition causes high amounts of intoxication through Mainstream Smoke (MS), Sidestream Smoke (SS), Second Hand Smoke (SHS), Third Hand Smoke (THS) and Cigarette Butts (CB)[4].

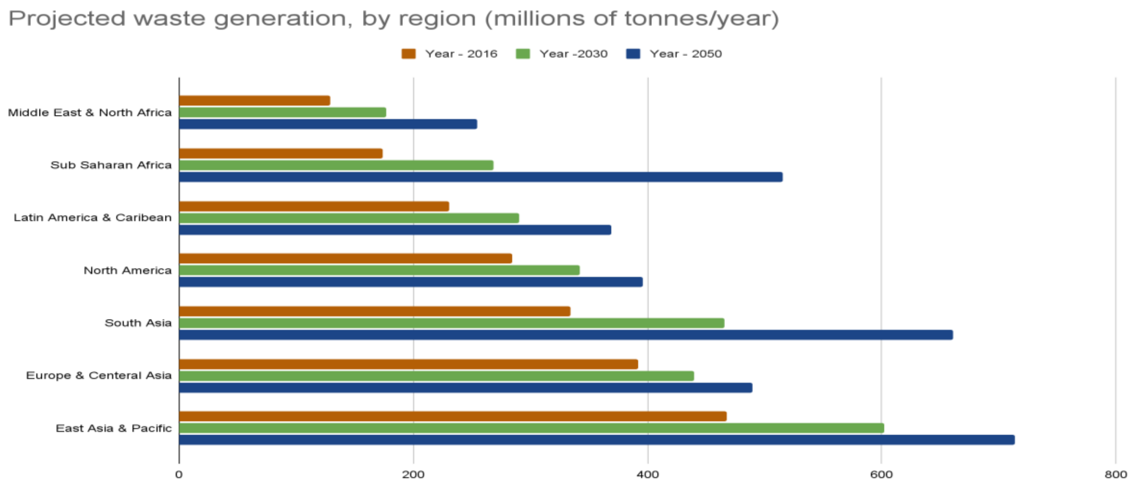

Figure 1 - Projected waste generation, by region (millions of tonnes/year)[5]

TABLE 1. Projected waste generation, by region (millions of tonnes/year)[5]

Area	**Year**		
	2016	***2030***	***2050***
Middle East & North Africa	129	177	255
Sub Saharan Africa	174	269	516
Latin America & Caribbean	231	290	369
North America	284	342	396
South Asia	334	466	661
Europe & Central Asia	392	440	490
East Asia & Pacific	468	602	714

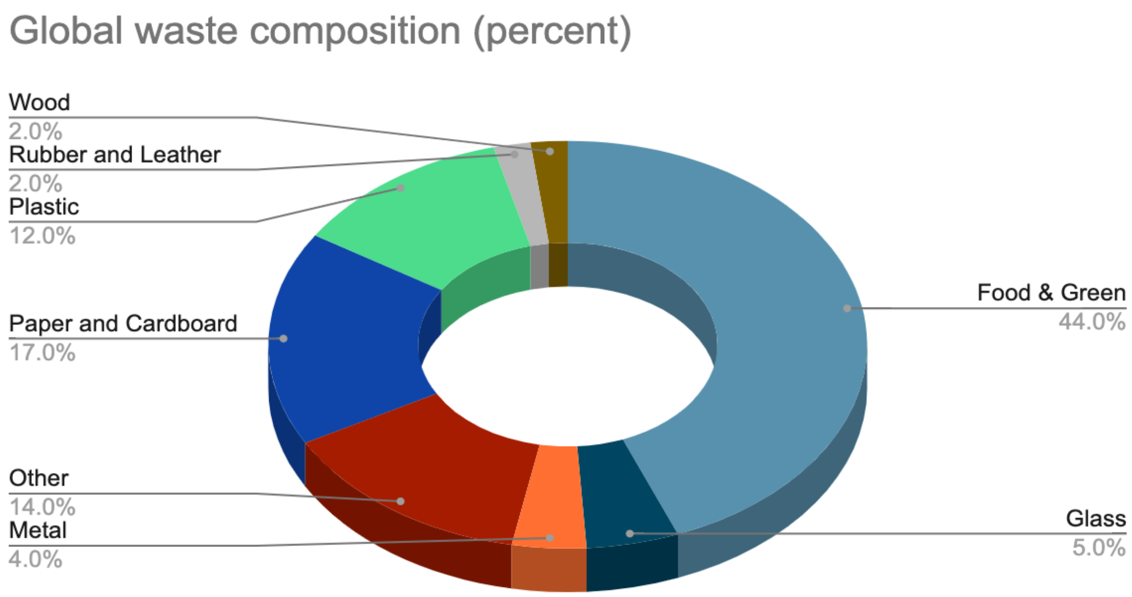

FIGURE 2. Global waste composition (percent)[5]

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Category	Percentage
Food & Green	129
Glass	174
Metal	231
Other	284
Paper and Cardboard	334
Plastic	392
Rubber and Leather	468

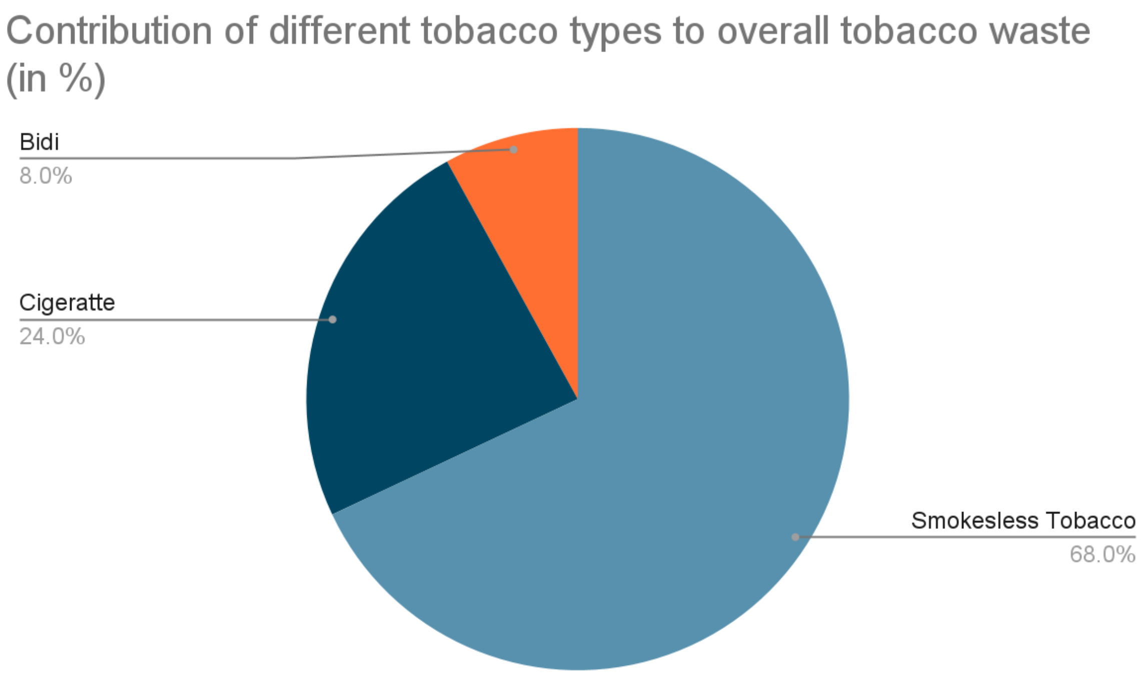

FIGURE 3. Global waste composition (percent)Contribution of different tobacco types to overall tobacco waste (in %)[6]

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Type	Percentage
Smokeless Tobacco	68
Cigarette	24
Bidi	8

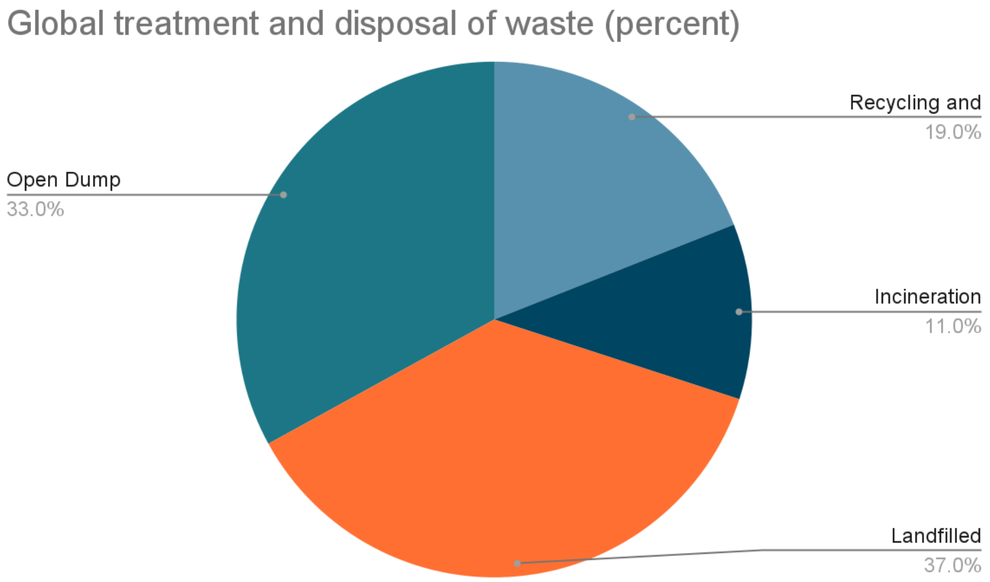

FIGURE 4. Global treatment and disposal of waste (percent)[7]

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Category	Percentage
Recycling and Composting	19
Incineration	11
Landfill	37

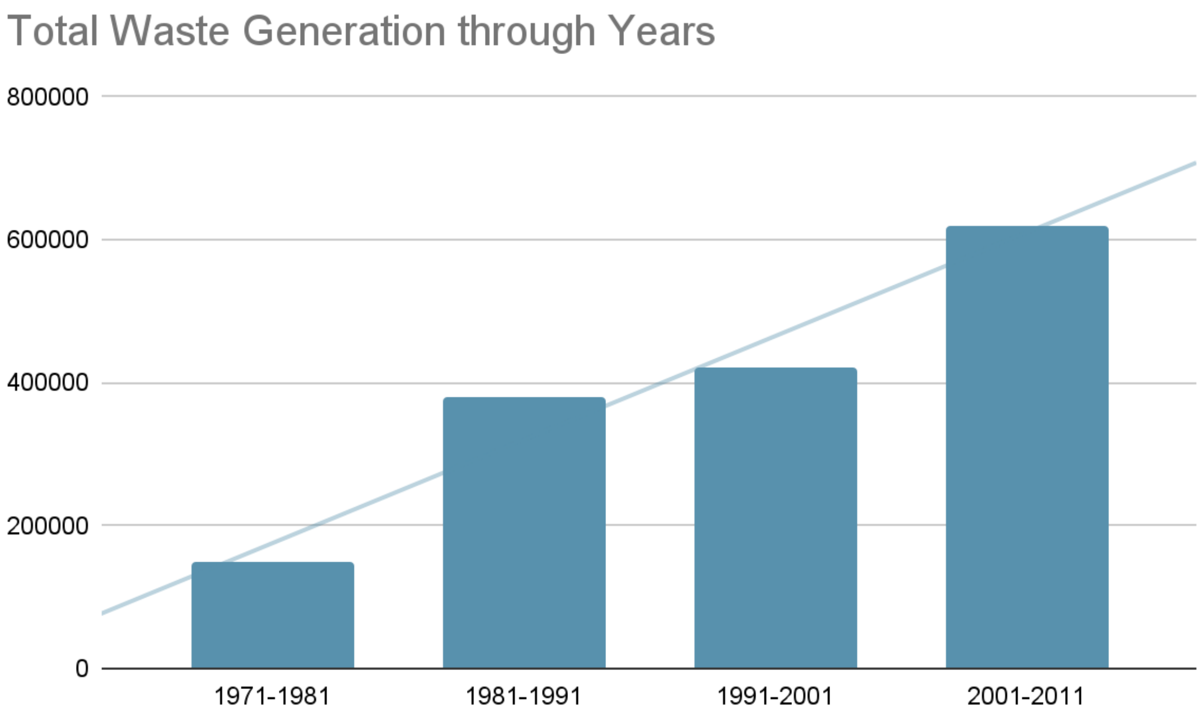

FIGURE 5. Total Waste Generation through Years[8]

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Years	Waste in tonnes
1971-1981	150000
1981-1991	380000
1991-2001	420000
2001-2011	62000

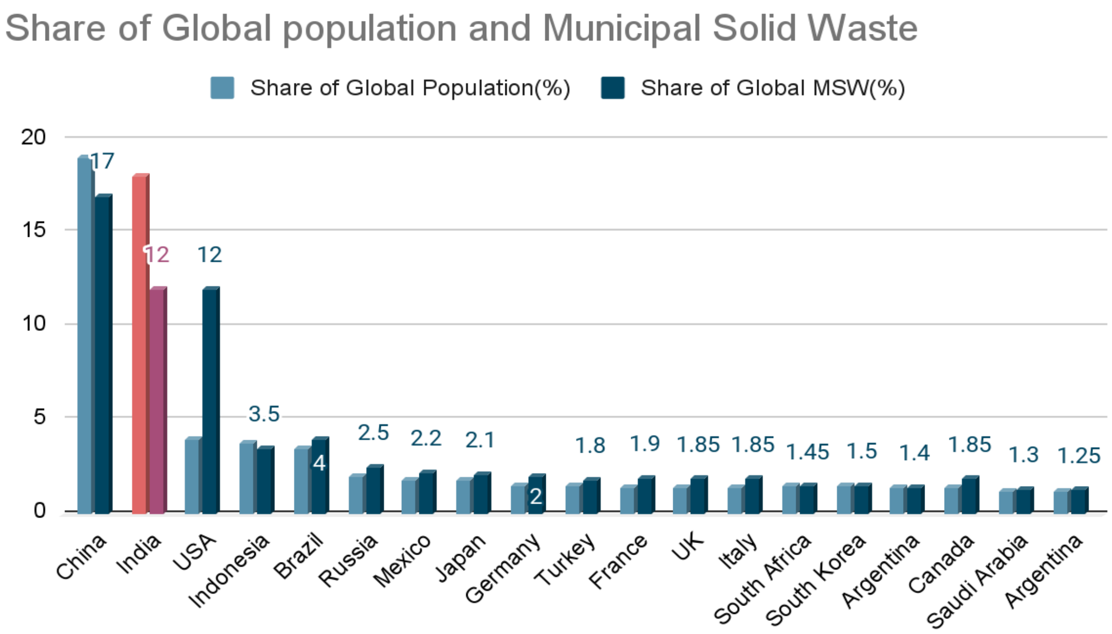

FIGURE 6. Share of Global population and Municipal Solid Waste[9]

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Country	Share of Global	
	Population(%)	*MSW(%)*
China	19	17
India	18	12
USA	4	12
Indonesia	3.8	3.5
Brazil	3.5	4
Russia	2	2.5
Mexico	1.8	2.2
Japan	1.75	2.1
Germany	1.5	2
Turkey	1.48	1.8
France	1.38	1.9
UK	1.38	1.85
Italy	1.38	1.85
South Africa	1.45	1.45
South Korea	1.45	1.5
Argentina	1.35	1.4
Canada	1.35	1.85
Saudi Arabia	1.2	1.3
Argentina	1.15	1.25

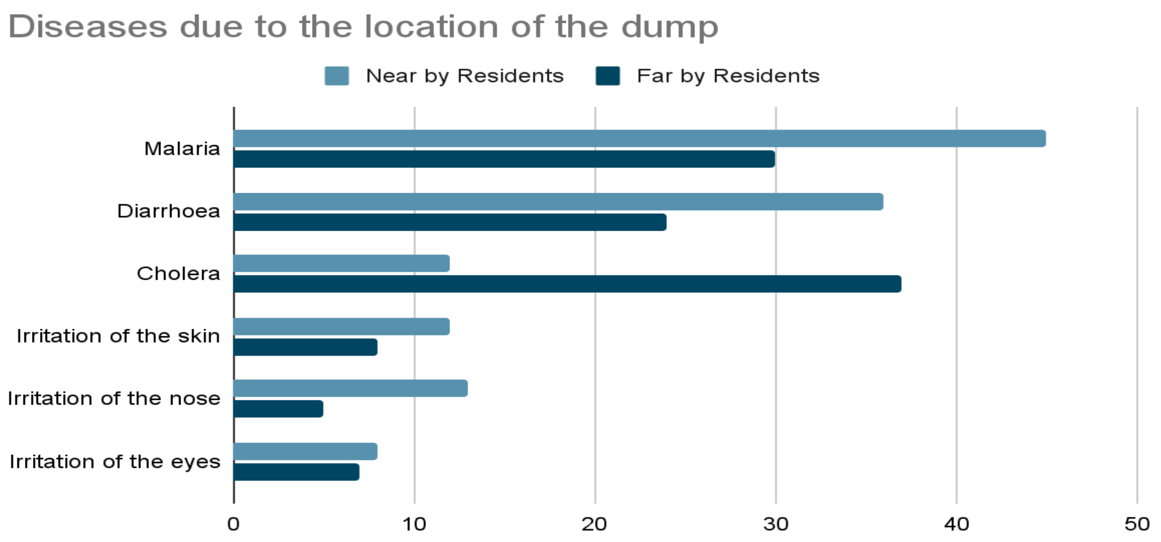

FIGURE 7. Diseases due to the location of the dump[10]

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Disease	**Livelihood**	
	Nearby Residents	***Far by Residents***
Malaria	45	30
Diarrhea	36	24
Cholera	12	37
Irritation of the skin	12	8
Irritation of the nose	13	5
Irritation of the eyes	8	7

Combining new technologies using machine learning is one way to address the problem. Machine Learning Unsupervised model[11] could cluster out the similar and group each other according to their similitude using IoT[12,13]. IoT is one efficient technology and cascading it with Machine learning models would guide manage the waste properly. The other way to increase the efficiency is using Convolutional Neural Networks (CNN)[14], a deep learning[15] model that analyzes and recognizes data using images. This technology will ensure to manage the left out waste that was clustered or associated using the unsupervised machine learning model[16].

Managing waste efficiently without human intervention is typically the objective to achieve, instead of using incorporating the use of technology at the initial stage for segregation of waste management and manage them separately, the detection of unmanaged waste is carried out after the entire waste has been collected, the entire pile would be clustered and associated using unsupervised model under 3R[17] of the waste management to increase the efficiency the model can be enabled to view the problem as humans let alone make it more cutting edge through the use of deep learning[18]

II. METHODOLOGY

Initially the waste is transferred to a long conveyor belt which would detect all possible waste, Reducing the waste under 3R of waste management, segregation is first step to achieve a healthy environment, that can be attained as -

Stage 1 - The entire heap of squander segregates metal using the metal detector that are incorporated through IoT using cloud, the metal waste can be recycled. Metal detectors such as 3D Imaging Metal Detectors[19] that have high accuracy, provide high coverage and wide range of field as they operate at a higher frequency utilizing smaller coil sizes with radio or electromagnetic systems, can be embodied, to make the model robust and efficacious for finding precious metals like Aluminium, gold and silver. Multi system metal detectors are usually embodied as they combine the functionality of enhanced Long-Range Locator technology for detection of deep metal objects from long distances within a wide area containing more than one search system to confirm the results. The use of real time monitoring using the Convolution Neural network, a deep learning model for anonymous waste to verify the segregation for any anonymous waste, predominantly to ensure elements that sensors fail to detect. CNN is computer vision technology used for object analysis through reading images to differentiate aspects of an image from one another. Pre-processing using ConvNet[20] can make our task achievable as it is analogous to the connectivity pattern of the human Brain.

Stage 2 - For Further investigation, the waste is sorted out in non metallic waste such as wood, plastic, glass, rubber & leather which comprises 2%, 12%, 5% & 2% of waste respectively in tonnes. The waste like glass, wood and plastic have different density and hence wood, plastic and glass can be segregated individually using the unsupervised learning, clustering the collection according to similarity. For detection of non-metallic elements capacitive[21], an electronic device that can detect solid or liquid targets without physical contact. To detect these targets, capacitive sensors emit an electrical field from the sensing end of the sensor. Any target that disrupts the electric field by the capacitive can be detected.

The difference in the density of the non metallic waste is the factor that can be incorporated that helps us to segregate the dump through setting different frequencies to cluster similar dump. Wood is a recyclable waste and a major source of fuel, it can be recycled to make usable products. Sensors like ultrasonic sensors which are set to a certain threshold for wood can detect them easily for further recycling and reusability. Another non-biodegradable waste - Glass that is recyclable, is mixed with other materials which are used in daily products especially for packaging can also be segregated using ultrasonic sensors. NIR Spectrometer[22] are product identification based sensors, performance efficient to detect the plastic waste especially from households like plastic bottles, toys, insulation from wires to increase the efficiency and to eliminate waste to form clusters which can be recycled. These sensors are also used to segregate textile waste consisting of both pure and blended fabric, which are both biodegradable and non-biodegradable. For high density plastic or industrial plastic waste NIR hyperspectral camera[22], is a chemical imaging technique based on reflectance spectroscopy (the light reflected by materials) persisting a high spectral range of 0.395 µm - 2.19 µm. The near infrared spectra comprises vibrational overtones combined with absorption features where spectral signatures identify and map different materials.

Stage 3 - The next step is the segregation of food waste and plastic packaging. This mentioned problem can be solved using X-ray inspection[24], a highly effective technique that detects contaminants whose density differs significantly from the product being detected to the respect of others. This inspection is capable of detecting food waste, for example food inside the carton. Food is packaged using non-biodegradable entities, which are tricky to segregate and detect but technology such as X-ray inspection can detect packaging such as plastic wrappers, Aluminium tins, glass jars and polybags. X-ray can be predominantly used for thin density poly bags or polythene which are difficult to recycle, these waste are better if reused thus needs a high definition inspection. The non biodegradable waste that is still contained in the waste, has to be managed seperately through image analysis. The process is used to extract information from images mainly from digital images by means of digital image processing techniques This waste is composed of numerous chemicals, a threat to the ecosystem as it obliterates the plant bearing soil, furthermore it is fortuitously consumed by aquatic and terrestrial animals. This waste also reacts and makes methane which contributes to global warming. Thus it impairs the quality of life[25]

Stage 4 - Then the waste is screened by the supervised machine learning algorithm paradigm for problems where the available data consists of labeled examples, meaning that each data point contains features and an associated label that classifies waste into biodegradable waste, the classification follows logistic regression of dual class for segregation. The model predicts through the statistical method for a data set. The machine learns through an unsupervised learning algorithm that learns patterns from untagged data. The goal is to train through mimicing allowing the machine to build a precise reprsenation and then generate imaginative content from it by clustering the unidentified waste. The clustering neural network applies self-organizing maps of competitive learning for low dimensional views of high dimensional data. This waste is useful for various uses, and can be input for the bio gas in producing electricity, which can be rendered to the entire city for residential purposes. The waste can also produce natural manure, producing unartificial agriculture, and helps maintain the ecosystem.

Stage 5 - The last scan is for anonymous waste that couldn't be clustered by the model or might have skipped through image analysis. This waste is composed of both non biodegradable and due to similar density the sensors and inspection discarded, hence this stage involves flushing out the waste cleaning and disinfecting. The waste is segregated manually through the naked eye. The unsupervised learning would identify the unlabeled datasets to form clusters. The algorithm identifies unraveled patterns and then forms associations, find the underlying structure of the dataset, group that data according to similarities, and represent that dataset in a compressed format which can be configured with IoT devices as identifiable waste.

III. ADVANTAGES

- **Ensures a healthy environment -** This technology would reduce waste borne diseases that are caused to unmanaged waste due to lack of proper segregation. The chiefmost motive of this technology is to ensure to make environment free from disease caused by waste
- **Saving wildlife from extinction -** Many aquatic species like exotic fishes and plantlife which die as the waste is being discharged and dumped in water bodies. The waste dumped creates as havoc as it blocks the necessary sunlight and oxygen needed for the survival of life. It also affects terrestrial organisms as they consume the waste that makes them gag.
- **Agriculture enhancement -** The segregation technique would increase crop productivity as the manure obtained is highly fertile thus reducing dependency on chemical-based fertilizers, which were hampering the quality of food.
- **Reducing -** The land dependency for dumping would be reduced as the unmanaged waste is segregated and then managed through using 3 R's of environment.
- **Increasing Dependency on existing resources -** Recycling of material reduces the dependency on excavating of resources. For eg : metal and plastic bags can be used after recycling instead of manufacturing a new product
- **Reduces dependency on humans -** Since the process is automatic it reduces manual work and reduces dependency makes it technology compliant with less human interaction.
- **Increased revenue -** The technology is predominantly dependent on the Manufacturing industry for sensors for segregation purposes as the prerequisites which would generate higher amounts of revenue.
- **Reduces air emission -** Since waste is not incinerated it reduces the air emission out in the environment saving the ozone layer.

IV. DISADVANTAGES

- **Expensive technology -** The technology uses high definition sensors and integrates techniques in the model such as machine learning which upscales the cots.
- **Skilled labors -** To use the technology highly skilled labors would be required to monitor and execute the daily task
- **Resource maintenance -** Resources that come in direct contact with waste such as segregation areas over which the waste is kept for processing and sensors are required to be replaced time and again. The life of sensors is not more than a decade and hence need to be changed regularly at the sites.
- **Site maintenance -** The maintenance of the sites are high end since it would comprise all the municipal waste from the city and hence need to be disinfected.
- **Disease-causing site -** The sites become dangerous due to the presence of waste, and can promote many unwanted diseases affecting ecosystems.
- **Biohazard -** If the segregated waste especially the biodegradable waste that is moist and can the chain reaction create methane, not handled properly it can create biohazards for the entire environment.

V. RESULTS AND DISCUSSION

The technology depicts the implementation of the leading technology - ML integrated with IoT to find solutions in making the environment safe and secure. The technology preserves ecosystems and food chains let alone reduces the human labor shielding them from possible diseases. Reducing human interaction for futile and health damaging tasks can be deftly resolved. The fast learning ML technology not only would make things effortless but also is efficient in performing and replacing human labor.

The article opens new doors to handle waste management that is creating havoc and is being avoided. This can be the initiation of promoting a healthy environment by integrating it through cutting edge technology. The figures and tables give enough evidence of our day to day activities contributing towards a perilous enviornment and is an awakening call for adapting a technology based solution that creates experience of no external interference.

VI. CONCLUSION

The outcome ensures a safe environment also, the big amount of waste can be handled without the interference. A hygienic environment is produced and the dumping is reduced. The crop production is increased through the screened waste management. Technology is a great stride towards innovation of technologies . The technology would ensure reusing, recycling that would reduce dependency on excavating resources thus reserving it for further generation.

VII. MOTIVATION

Mother earth is constantly giving us so much in so many ways and in return we keep on littering our nature and we have been procrastinating the need of a technology which could manage the waste properly so that our environment becomes litter free. It would prevent the diseases borne through the waste thus creating a hygienic environment. Also, the land used for dumping now would be used for fulfilling the demands of emerging needs for cultivation, grazing and industrial purposes. The industrial waste that flows as well into the rivers are endangering aquatic species, moreover there is less than 3% of pure water available so the water bodies wouldn't be filthy anymore. We also have a responsibility to pass the legacy to our upcoming generation to provide a safe environment so that they pass the same legacy to their generation.

VIII. ACKNOWLEDGEMENT

Technology has always been such an ease to humankind and this is quite evident from the article. I am grateful for this opportunity that has let me present my findings and to bridge the gap between the technology in daily tasks.

IX. REFERENCES

[1] Machine Learning and IoT-Based Waste Management Model https://www.hindawi.com/journals/cin/2021/5942574/

[2] wet waste generation methane https://www.indiaspend.com/earthcheck/why-methane-emissions-from-landfills-are-concerning-848571 .

[3] WHAT A WASTE 2.0 What a Waste 2.0. (Accessed 2022-10-24).

[4] Content of toxic components of cigarette, cigarette smoke cigarette butts: A comprehensive systematic review https://www.sciencedirect.com/science/article/abs/pii/S0048969721077457 .

[5] Trends in Solid Waste Management https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html .

[6] Tobacco product waste of 6900 tonnes puts burden on the environment and polluting it: study https://changingtomorrow.in/nation/environment/tobacco-product-waste-of-6900-tonnes-puts-burden-on-the-environment-and-polluting-it-study/.

[7] Sustainability and Circular Economy of Food Wastes: Waste Reduction Strategies, Higher Recycling Methods, and Improved Valorization https://www.researchgate.net/figure/Global-treatment-and-disposal-of-waste_fig1_348694228

[8] Risk Assessment of Hapania Dumping Yard Using Integrated Risk Based Approach

https://www.researchgate.net/publication/264555413_Risk_Assessment_of_Hapania_Dumping_Yard_Using_Integrated_Risk_Based_Approach .

[9] US tops list of countries fuelling the waste crisis https://www.maplecroft.com/insights/analysis/us-tops-list-of-countries-fuelling-the-mounting-waste-crisis/ (Accessed 2022-10-24)

[10] Environmental and Health Impact of Solid Waste Disposal in Developing Cities: A Case Study of Granville Brook Dumpsite, Freetown, Sierra Leone https://www.scirp.org/html/1-6701858/aca33408-ccda-4418-8031-4bdb47df8d12.jpg

[11] Machine Learning and IoT-Based Waste Management Model https://www.researchgate.net/publication/354178840_Machine_Learning_and_IoT-Based_Waste_Management_Model

[12] Waste Management System Using IoT-Based Machine Learning in University https://www.hindawi.com/journals/wcmc/2020/6138637/

[13] Household Waste Management System Using IoT and Machine Learning

[14] https://www.sciencedirect.com/science/article/pii/S1877050920306876

[15] Intelligent waste management system using deep learning with IoT https://www.sciencedirect.com/science/article/pii/S1319157820304547

[16] A Comprehensive Guide to Convolutional Neural Networks — the ELI5 way https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

[17] Unsupervised Machine Learning https://www.ibm.com/topics/unsupervised-learning

[18] The 3R Initiative https://www.env.go.jp/recycle/3r/en/outline.html

[19] An automatic classification method for environment: Friendly waste segregation using deep learning https://ieeexplore.ieee.org/document/7801215

[20] Metal Detector Sensor https://orientdetectors.com/metal-detector-sensor/#Types_of_Metal_Detectors

[21] A ConvNet for the 2020s https://arxiv.org/abs/2201.03545 (Accessed 2022-10-24)

[22] Capacitive Proximity Sensor https://www.omch.co/capacitive-proximity-sensor/

[23] Advanced FT-NIR Analysis for Food Industry https://galaxy-scientific.com/industries/food/?gclid=CjwKCAiA5Y6eBhAbEiwA_2ZWITxeZpOzpi8BF2SXN6N53PR-LuJ1PlbtUGiM6kINC0zvQTiYk8szERoC6qgQAvD_BwE

[24] Hyperspectral cameras for industrial sorting processes https://www.lla-instruments.de/en/products/hyperspectral-cameras.html

[25] PLASTIC DETECTION https://www.mekitec.com/plastic-detection-in-foo/