iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** III **Month of publication:** March 2024

DOI: https://doi.org/10.22214/ijraset.2024.58947

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue III Mar 2024- Available at www.ijraset.com

Review on the Impact of Waste in Nigerian Manufacturing Firms and Waste Management Practices Using Machine Learning

Isaac Chinedu Chukwuebuka[1], Wei Wang[2]
School of science, Zhejiang University of Science and Technology (Zust), 310023 Hangzhou CHINA

Abstract: The study examined the impact of waste in Nigeria manufacturing firm and waste management practices using machine learning. This paper presents ways of interaction of man with his environment in terms of waste management in Nigeria with the aim of promoting sustainable development. It shows the policies, the agents making these policies less likely to happen and the damage it can cause for the next generation.This article presents how data has been collected and analyzed through survey and series of progressive steps and present some guidelines when practicing waste management. It presents how a region can discover and implement some efficient technique for efficient waste management and comes up with enormous constructive results.In order to automate and optimize garbage generation, collection, transportation, treatment, and disposal, this study examines a variety of machine learning techniques. In order to provide accurate and efficient forecasts for trash creation, segregation, and collection, the system combines several machine learning techniques, such as decision trees (DT), random forests (RF), k-nearest neighbors (KNN), support vector machines (SVM), and clustering algorithms.
Keywords: Machine Learning, Routing Optimization, Municipal Solid Waste Management,, Disposal.

I. INTRODUCTION

Waste management is a critical issue in the manufacturing sector in Nigeria, with improper disposal practices leading to environmental degradation and health hazards. The inefficient handling of waste not only impacts the environment but also affects the productivity and profitability of manufacturing firms. In recent years, there has been a growing interest in leveraging machine learning techniques to improve waste management practices in various industries, including manufacturing. This paper aims to explore the impact of waste in Nigerian and the potential of machine learning in enhancing waste management practices.

A. Challenges

Advanced waste management practices are one of the main characteristics of developed countries, while poor sanitation practices are frequently associated with poverty. Nigeria is a developing country with few, frequently improperly managed resources. A ubiquitous sight in many cities, towns, and shanty communities in populated regions is a waste heap. Waste production has increased as a result of the country's growing population, industrialization push, and internal migration. Efficient and effective waste management in Nigeria has numerous challenges, including the growth of unplanned settlements, traffic jams, ignorance, insecurity, poorly implemented legislation, and the incapacity to enforce environmental laws. In many underdeveloped countries, disposing of waste is one of the most difficult parts of the waste management system. The high cost of waste management, ignorance of the various factors affecting waste management at different stages, inadequate infrastructure and expertise for waste management, the rapidly expanding economic development, and the links required to improve the functionality of waste handling systems are some additional challenges related to waste management that have been identified.

B. Ethical Issues and Legal Frameworks on Waste Management Practices

Nigeria, which has more than 200 million people living there, is one of the largest trash generators in sub Saharan Africa. The country's waste management procedures are becoming more concerning every day, despite laws and regulations. Every year, more than 32 million tons of solid garbage are produced, of which one third is collected. Waste that is disposed of carelessly has obstructed water bodies and blocked drains. Since the country currently lacks the necessary funding to build integrated waste management systems across the states, improper waste collection and disposal are gradually causing an environmental disaster.The majority of developing nations, including Nigeria, lack comprehensive waste management laws, policies, statutes, and regulations, and even those that do exist are often inadequately enforced.

C. Poor Waste Management Practice To The Public Health

Research on the effects of garbage on public health have been conducted all throughout Nigeria. Some of these studies are those by Butu et al. (2013), Egbere et al. (2001), Longe & Williams (2006), Modebe et al. (2009), Momodu et al. (2011), Nwanta et al. (2010), Owaduge (2010), and Oyelola et al. (2009).Due to poor domestic waste handling procedures and a lack of solid waste management facilities in Nigeria, a large number of homes and municipalities dispose of waste carelessly, endangering the health of city dwellers. This is concerning, according to Simon and Modebe et al, since it promotes the growth of pests, houseflies, mosquitoes, rats, and other rodents that help spread infectious diseases.The results of a review of diseases that have been connected to inadequate waste management in Nigeria are shown in Table 1. It contains details about research that show the disease's effects in Nigeria as well as how it spreads. Several studies have highlighted the detrimental impacts of inadequate waste management on adults and children, as well as the disappearance of flora (Kogers et al. 2005; Shagal et al. 2012). According to Olukanni et al. (2014), improper medical waste management is a big issue in Nigeria and other LEDCs.

The majority of Nigerian hospitals, according to Longe & Williams (2006), use state owned solid waste management firms to collect and dispose of their medical waste in designated government dumpsites. This implies that medical waste is disposed of with other types of waste. According to numerous academics (Abah & Ahimain, 2011; Adegbite et al. 2010; Coker et al. 2009; Nguluka et al. 2009; Oke, 2008; WHO, 1999; WHO 2002), medical personnel and the general public are at risk for health problems as a result of improper management and disposal of medical waste. Medical waste exposure increases the chance of contracting diseases like HIV/AIDS, Lassa fever, Meningitis, Tuberculosis, and Ebola. Waste burning outside may result in air pollution and health hazards for people who are in close proximity to the smoke (Babayemi & Dauda 2009; Igoni et al. 2007). According to Onwughara (2010), burning polystyrene foam and outdated e-waste releases a large amount of hazardous gasses into the atmosphere. Especially those with delicate respiratory systems are affected by open burning. According to Njoku et al. (2015), burning garbage releases smoke that significantly affects people's respiratory systems. According to Kram et al. (2014), lead, dioxins, furans, arsenic, mercury, polychlorinated biphenyls (PCBs), carbon monoxide, nitrogen dioxide, sulfur dioxide, and hydrochloric acid are a few of the contaminants found in smoke. Additionally, some of the contaminants may remain in the ash. According to Kram et al. (2014) and Nwaogu (2014), when garbage is burned, harmful chemicals like sulphur dioxide and nitrogen oxide are released into the atmosphere. These pollutants eventually build up and precipitate as acid rain. There have been reports linking burning municipal solid trash to various forms of cancer in humans as well as birth abnormalities (Onwughara, 2010). For instance, burning tires is known to release dioxins and benzene derivatives, which have been connected to cancer and problems with human reproduction (Aderemi & Otitoloju, 2012). Furthermore, according to Cointreau (2006), smoking might exacerbate respiratory problems and result in headaches, nausea, and rashes..

Table1: Diseases in Nigeria linked with poor waste management practice

Disease	Causative Agent	Impact on public health in Nigeria and context with waste
Cholera	Transmitted through water or food contaminated with the bacterium *Vibrio cholera*, as a result of poor waste management	On December 26, 1970, cholera was first reported in Nigeria in a community close to Lagos (WHO, 2011a). Due to this, there was an outbreak in 1971 that resulted in 22,931 cases, 2,945 deaths, and a Case Fatality Rate (CFR) of 12.8%. Ever since, there have been sporadic outbreaks that are linked to inadequate waste management. Severe outbreaks that began in northern Nigeria in the latter half of 2010 resulted in over 3,000 illnesses and 781 deaths (Adagbada et al. 2012). In May 2013, there was another outbreak that lasted until October 12, 2014, with 40,608 cases and 898 deaths, resulting in a CFR of 1.95% (Interhealth Worldwide, 2014).Between January 2014 and October 12, 2014, there were over 34,000 suspected cases and 664 recorded deaths. Nineteen out of thirty-seven states (51%) have reported suspected cases of cholera, including Bauchi, Borno, Adamawa, Katsina, K ebbi, Kaduna, Kano, Plateau, and Zamfara. To learn more about the illness and develop treatment options, numerous research have been conducted (Ariba, 2015; Dalhat et al. 2014; Interhealth Worldwide, 2014; Marin et al. 2013; and WHO

		2014). Cholera poses a serious risk, especially in densely populated places with unsanitary conditions, where the general public lacks access to potable water, efficient sewage systems, and solid waste management practices.
Diarrheal diseases	Many different kinds of bacteria, viruses, and parasites—mostly rotaviruses—can cause diarrhea. Poor solid waste management is linked to diarrheal illness.	Joshua (2013) reports that diarrheal diseases kill 2.5 million people worldwide each year, with 60–70% of those deaths occurring in children under five (Cesar et al. 2000; Ruxin, 1994). In SSA (Yilgwan & Okolo, 2012), diarrhea is directly linked to approximately 25% of under-five fatalities. In LEDCs, diarrhea is a recognized cause of childhood deaths (Cesar et al. 2000; Gutierrez et al. 1996; Ruxin, 1994). Due to a lack of access to basic sanitation, hygiene, and drinkable water, poor waste management has been associated in the literature with diarrhea (Oloruntoba et al. 2014). Inadequate sanitation, such as inadequate SWM that clogs drains and creates stagnant water that acts as a breeding ground for flies and insects, is another contributing factor. and failing to wash hands with soap and water before preparing meals and after urinating..
Hepatitis	Liver disease acquired from tainted blood and improperly disposed of hypodermic needles	Globally, hepatitis is a significant contributor to the morbidity and mortality of liver disease (Musa et al. 2015). It is brought on by both extremely poor medical waste management and dangerous injection practices. An estimated 8–16 million instances of hepatitis B virus (HBV) infection and 2.4–4.5 million cases of hepatitis C virus (HCV) infection occur globally as a result of injections. World Health Organization
Lassa Fever	Rats are primarily responsible for Lassa fever transmission, and they are linked to unclean habitats and solid waste. Choose (2016) asserted, however, that human-to-human interaction is another possible method of lassa fever transmission.	Hemorrhagic Lassa fever is common in Nigeria and four other African countries. Over 2,900 cases were reported in 2012 as a result of major outbreaks that occurred in several states in Nigeria (WHO, 2012). It occurs annually throughout Nigeria's dry season (WHO, 2015). The WHO reported that the high case fatality rate of about 37.9% was observed in Bauchi, Edo, FCT, Kano, Nasarawa, Niger Oyo, Plateau, Rivers, and Taraba. Choon (2016) reports that there are 300,000 cases and 5,000 deaths per year. Rats are primarily responsible for Lassa fever transmission, and they are linked to unclean habitats and solid waste. Choon (2016), however, noted that human-to-human contact is another possible method of lassa fever transmission.
Malaria	Through their bites, mosquitoes are the cause of malaria transmission. Mosquito breeding locations are unclean areas where garbage obstructs drains.	Malaria is a serious public health issue in Sub-Saharan Africa (SSA), particularly in Nigeria, where it is the leading cause of cases and fatalities worldwide (Aribodor et al. 2016). An estimated 584,000 persons died from malaria in 2013, of which 2 million cases were documented; 70% of the victims were children under five (UNICEF, 2016; WHO 2014). Twenty-five percent of malaria cases worldwide are in Nigeria (WHO, 2012). Ineffective waste management can result in standing water, which serves as a mosquito breeding habitat.

Typhoid Fever	caused by Salmonella Typhi or Paratyphi bacteria. In places with inadequate waste management and poor sanitation, it spreads through tainted food and water supplies.	An estimated 12-33 million cases are reported each year, resulting in 216,000–600,000 fatalities. The illness is prevalent in areas with a general warm, humid climate, inadequate waste management, poor hygienic practices, poverty, and ignorance. Because of inadequate waste management (sanitation and hygiene), the disease is common in LEDCs (Okore et al. 2015). According to WHO (2008), the disease is contracted by consuming food or water tainted by an infected person's feces. Furthermore, the Centers for Disease Control and Prevention (CDCP) noted in 2007 that flies like Musca domestica had the ability to spread it.

D. *Waste Management Practices Using Machine Learning*

Machine learning algorithms have the capability to analyze large volumes of data and identify patterns that can optimize waste management practices in manufacturing firms. By utilizing historical data on waste generation, disposal methods, and associated costs, machine learning models can predict future waste generation levels and recommend efficient waste management strategies. These strategies may include recycling, reuse, and proper disposal methods to minimize environmental impact and reduce operational costs. One approach to waste management using machine learning is the development of predictive models that can forecast waste generation based on various factors such as production volume, type of products manufactured, and seasonal variations. These models can help manufacturing firms plan their waste management processes effectively, ensuring that resources are allocated efficiently and waste is handled in a sustainable manner. Additionally, machine learning can be used to optimize waste collection routes, schedule maintenance of waste disposal facilities, and monitor compliance with environmental regulations.

II. LITERATURE REVIEW

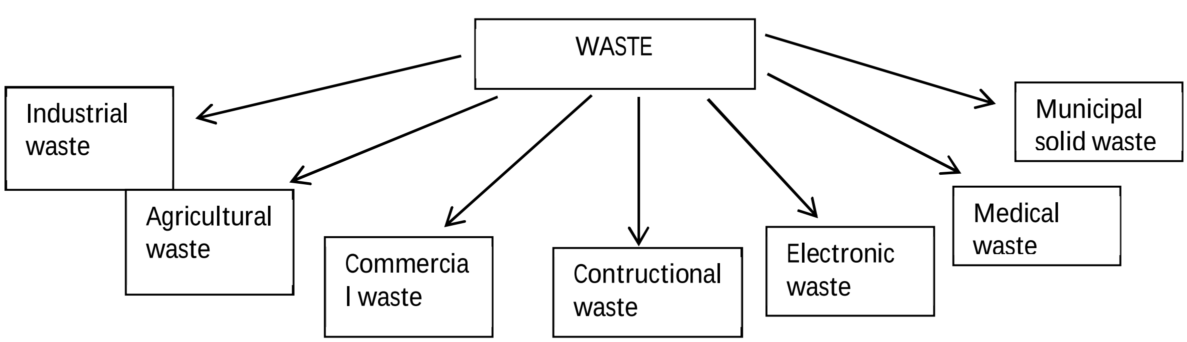
The literature review will be used as a foundation to clarify the importance of waste management in a society, tools to achieve the objectives and establish an overview analyses on waste management approach will also be review. The topics covered in this chapter are: waste definition, types of waste, waste management system, impact of waste and waste disposal, sustainable waste management approach, the old and new approach to conservation of resources. A lot of literature has discussed current practices, challenges and future solutions on waste managemen and these studies allow comparison to adapt the best practice wherever applicable.

A. *Waste*

Waste can be described as something that has no value, useless and that want to be discard by the owner. Waste variably refer to lack of use or useless remain. From a financial point of view, waste is anything that has no financial value either future or the present because there is no demand for such item in the marketplace. But also rural communities utilize food waste for animal feeding and also animal waste as manure which is feasibly rear in an urban center. The status of an item's Price, age, level of damage can influence repair to avoid being discarded. Moreover, it is understood that what could be regarded as a waste can as well be valuable to another person and trading opportunity may arise.

B. *Types Of Waste*

Wastes are discarded or unwanted materials that are generated by households and other sectors like industrial, agriculture, commercial and construction institution which are dangerous to the people and its environs. The following are the type of wastes that are generated by human activities



1) Industrial Waste

Industrial waste is refer to as waste or remaining generated by human activities carried out in the industry. In another words industrial waste is waste that results from or is incidental to operations of industry, manufacturing, mining, or agriculture.

Figure1; Industrial waste

2) Agricultural Waste

Agricultural waste are plant residue from agriculture. Agricultural waste are all part of crops that are not used for human or animal food. Crops residue consist mainly of stems, branches (in pruning), and leaves. It is estimated that, on average, 80% of the plant of such crops consist of agricultural waste.

3) Commercial And Institutional Waste

Commercial and institutional waste is generated from anything from paper and packaging of obsolete equipment in different sectors like, retail stores, hotels, restaurants, health care, banks, insurance companies. Commercial and institutional waste generated a significant portion of municipal waste

4) Construction And Demolition

C&D waste is any unwanted material produced directly or incidentally by the construction industries, this are waste generated when there is an activity such as building and demolition of roads, bridges, and fly over. It comprises of inert and non biodegradable material such as concrete, plaster, metal, wood, plastics etc.

5) Electronic Waste

electrical trash encompasses a wide variety of electrical items that are no longer wanted by their owners. These products include consumer electronics, computers, air conditioners, refrigerators, gas cookers, cell phones, and washing machines. They are frequently thought of as e-waste. In addition to valuable materials like metals and polymers, these wastes include a wide variety of hazardous materials, such as heavy metals and brominated flame retardants (BFR). Two significant global challenges have arisen as a result of the rise of electronic wastes: the sustainability of the electric sector due to the scarcity of mineral resources and potential damage to human health, as well as environmental hazards associated to informal recycling processes.

6) Municipal Waste

In addition to waste from other sources, such as the commercial and industrial sectors, municipal solid waste also consists of waste from households. There has been a notable increase in the amount of MSW generated globally. Almost two billion tonnes of MSW are produced worldwide.Currently, 15% of this waste is recycled and the remaining 85% is collected.

7) Medical Waste

A number of additional waste products from industrial, building, and agricultural activities, as well as health care services, have significant negative effects on the environment.

Specifically, the provision of healthcare services frequently resulted in the production of certain waste materials. The public's health and the environment may be at danger from these products. The main source of medical waste (MW) production is healthcare facilities. It is dangerous to store medical waste in health facilities and transport potentially hazardous garbage to treatment facilities. Whereas the latter implies a public health risk connected to the transportation of these hazardous items, the former concerns an occupational risk tied to the storage and transfer of these materials.

C. Waste Management Practice

In Nigeria, waste management practices in manufacturing firms are often subpar, leading to environmental pollution and health hazards. The lack of proper waste disposal systems and recycling facilities has resulted in large quantities of waste being dumped in landfills or water bodies. This not only harms the environment but also poses risks to human health. Additionally, the inefficient handling of waste can lead to increased production costs and reduced profitability for manufacturing firms.

D. Solid Waste Composition In Nigeria

A comparison of the waste composition from these studies is presented in Figure 2, which includes the capital Abuja as well as cities from each of Nigeria's six regions. It is significant to remember that every publication that was utilized in this comparison was solely concerned with municipal solid waste, which suggests that it contained residual waste as well as, in certain situations, recycling waste in the event that homeowners failed to separate it for collection. Putrescible16 was the main waste stream component in all of the investigations, with percentages ranging from 26% in Maiduguri to 56% in Nsukka. According to some other research, putrescible waste levels may reach 78%–90% (Cointreau, 1982; Ogwueleka, 2009; Otti, 2011). The percentage of paper in Akure ranged from 6.0% to 25%, plastics from 7.7% to 18.1% in Maiduguri, metal from 3.1% in Abuja to 17.2% in Portharcourt, glass from 2.5% in Nsukka to 13.5% in Portharcourt, and textiles from 2.5% in Makurdi to 7.6% in Portharcourt. Other wastes included ash, dust, rubber, soil, bones, e-waste, scrap tires, diapers, and sanitary waste made up the remainder.

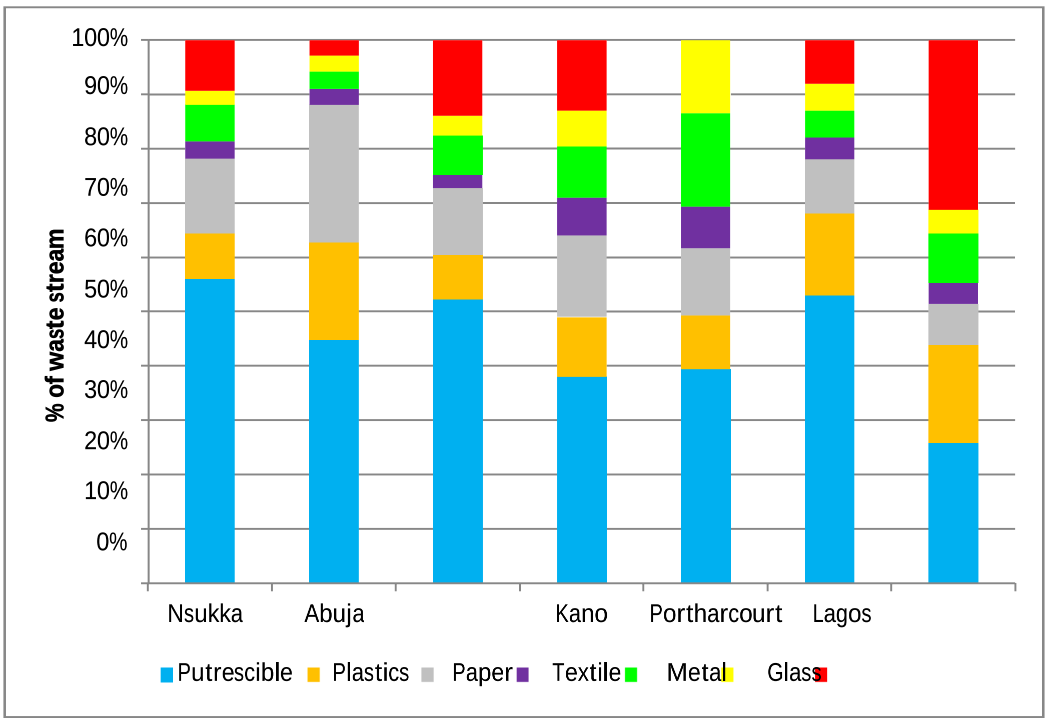


Figure 2 Waste stream composition from different cities in Nigeria by weight Source: Collated from Abuja Environmental Protection Board (2003)

The amount of solid waste generated in Nigeria has been estimated to have increased from 9 million tonnes in 1993 (Uchegbu, 1998) to 13 million tonnes in 1995 (Chikwendu, 1997) to 17.9 million tonnes in 2006 (US EPA, 2010) based on analysis of more recent studies. Ogwueleka (2009) reported an annual generation of 25 million tonnes in 2009. More recently, 32 million tons of solid garbage were produced in 2016, according to Bakare (2016).

Table 9 Waste generation in urban centres in Nigeria 2024

City	Population	Tonnes per month	Waste Density (kg/m^3)	kg/capita/ day
Lagos	8,029,200	255,556	294	0.63
Kano	3,348,700	156,676	290	0.56
Ibadan	307,840	135,391	330	0.51
Kaduna	1,458,900	114,443	320	0.58
Port Harcourt	1,053,900	117,825	300	0.60
Makurdi	249,000	24,242	340	0.48
Onitsha	509,500	84,137	310	0.53
Nsukka	100,700	12,000	370	0.44
Abuja	159,900	14,785	280	0.66

The population, degree of industrialization and urbanization, socioeconomic class of the populace, and types of commercial activity all influence the amount and rate of solid waste produced in the various states of Nigeria (Babayemi & Dauda 2009; Ojo et al. 2015). According to Sujauddin et al. (2008), the size of the family, education level, and monthly income all have an impact on the rate of trash generation. Kadafa et al. (2013) have demonstrated a strong relationship between the amount of waste produced and income level.

E. Uncontrolled Approaches

1) Open Dumping And Disposal Of Waste In Streams, Rivers And Drains

In most African countries, open dumping is the usual substitute for hygienic landfills (Remigios, 2010). In Nigeria, trucks transporting trash from urban or city centers frequently engage in open dumping, where waste is placed in uncontrolled landfills (dumpsites) (Ogwueleka, 2009). These open disposal sites may remain for many years and are frequently allowed by the authorities. Typically, there are no rules or regulations at the dumps that protect the environment. According to Ojo (2014), leachate management measures, fences, compactors, liners, and soil cover are not typically present in open dumpsites. Open dumpsites are typically located on undeveloped open spaces, gully erosion sites, or low-lying locations so they can be reclaimed for future development. They are also inexpensive to manage and run.For example, the majority of open dumpsites in Plateau State are located on gully erosion areas, abandoned mine ponds, or places damaged by tin mining activity.On the other hand, waste may be disposed of in the community itself when families receive insufficient waste collection services from waste management agencies (Nnaji 2015). Household waste is unlawfully disposed of in communities, including open spaces, backyards, and the areas next to highways, as Figures 2 to 3 illustrate (Babayemi & Dauda; 2009; Ojo, 2014; Onwughara et al. 2010)

Figure 2: Waste dumped at Market, lagos, Nigeria Source: Danbirni (2018)

Figure 3: Waste disposed in drainage channels at Mararaba, Abuja, Nigeria

For example, the majority of open dumpsites in Plateau State are located on gully erosion areas, abandoned mine ponds, or places damaged by tin mining activity. On the other hand, waste may be disposed of in the community itself when families receive insufficient waste collection services from waste management agencies (Nnaji 2015). Household waste is unlawfully disposed of in communities, including open spaces, backyards, and the areas next to highways, as Figures 2 to 3 illustrate (Babayemi & Dauda; 2009; Ojo, 2014; Onwughara et al. 2010)

It is unsightly, emits an offensive stench, and serves as a haven for illnesses and vermin. According to Momodu et al. (2011), open dumping also has negative effects on ground water pollution, the spread of infectious diseases, and health risks to unpaid laborers. Urban regions may experience floods as a result of trash disposal eventually clogging culverts, streams, and drains (Kofoworola, 2007).

2) Open Burning

Burning garbage outside is a regular practice. This could occur from people burning their trash at home, from people purposefully or unintentionally setting fire to trash in public trash cans, or from people burning trash on dump sites on a regular basis. Some homes choose to burn their rubbish since it's an inexpensive and simple way to get rid of it in their backyards. According to Araba (2010), homes without garbage collection services in low-income areas are the main users of this strategy. Burning rubbish at dump sites is done in an effort to minimize waste volume (Araba, 2010; Igoni et al. 2007). Olufayo & Omotosho, (2007), Adebayo et al. (2006), Nabegu (2010), and Ngwuluka et al. (2009) have testified that burning waste at open dumpsites pollutes the air. In addition open burning waste can lead to fires getting out of control leading to the loss of lives (Aderemi & Otitoloju (2012). Figure 4 provide examples of open burning causing environmental pollution and a public health risk.

Figure 4: Open burning of waste at a dumpsite (2016)

III. METHODOLOGY

To investigate the impact of waste in Nigerian manufacturing firms and the potential of machine learning in waste management practices, a mixed methods approach will be employed. Data will be collected through surveys, interviews, and observations in selected manufacturing firms in Nigeria. The data will be analyzed using descriptive statistics and machine learning algorithms to identify patterns and trends in waste generation and disposal practices.Statistical and supervised machine learning techniques are used in this study's investigation. Predictive modeling was employed in the course of implementing research on machine learning-based waste management techniques.

Additionally, this study uses a machine learning approach to forecast trash creation from residential units in the future. In order to predict waste creation, we first build a model by contrasting the effectiveness of machine learning methods using neural networks (NN) and gradient boosting regression trees (GBRT).

A. Data Collection

Data will be collected from a sample of manufacturing firms in Nigeria, including small, medium, and large enterprises. The data will include information on the types and quantities of waste generated, current waste management practices, and the associated costs their opinions, beliefs, experience, or behaviors. Surveys will be conducted with key personnel in the firms, including production managers, environmental officers, and waste management specialists. In addition, on site observations will be carried out to assess the physical conditions of waste disposal facilities and the overall waste management processes..The key data that we used to train our neural networks came from Google Maps, online tracking, document and record, and imagery data of Nigerian states. With the use of the Google Static Maps API key and the zoom level and geographic location information, high resolution photos may be simply generated. Google Maps' zoom levels, which span from 0 to 19, describe the scale of the map, while the geographical location, which consists of a place's longitude and latitude values, indicates its location in the real world.An online survey was utilized to conduct a collection of structured questions with predefined response options, such as rating scales and open-ended inquiries.

1) Is waste collection time reasonable yes/ no
2) What problems do you think exist in your area for waste management yes/ no
3) How do you evaluate the state of solid waste in your house area yes/ no
4) Are you satisfied with the current waste collection methods yes/ no

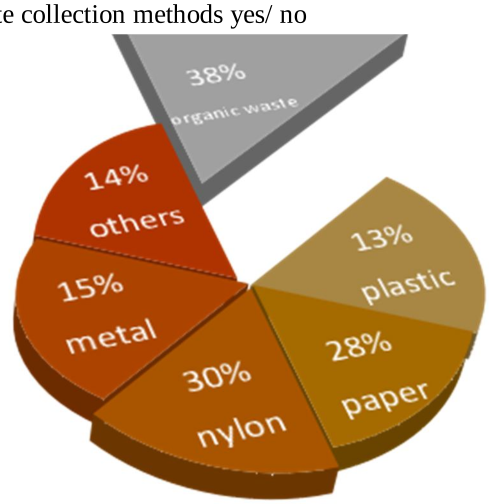


Figure 5 questionnaire survey and composition of waste collected

B. Model Training

This entails feeding the model with preprocessed data and modifying its parameters to reduce the discrepancy between the ground truth labels and the anticipated outputs. Python was the programming language utilized, and 85% of the data obtained was used to train the model using YoloV5. The greatest amount of information about current waste management procedures and their results was obtained from a variety of sources, including waste management firms, municipal governments, and citizens.We used a neural network algorithm to process input layer data (such as population size, types of waste produced, and disposal methods) after data collecting, cleaning, and preparation. After that, the model makes predictions, modifies the data, and computes differences.After the model has been created, data can be used to train it. In order to do this, data must be fed into the model so that it can learn from it. The accuracy of the model increases with the amount of data entered.

C. Application Of Different Machine Learning Methodologies In Solid Waste Generation

1) Artificial neural network (ANN)

ANN have proven to be an efficient tool for predicting the formation of MSW. ANNs can be used in both short- and long-term MSW generating processes due to their learning capacity and capacity to simulate nonlinear systems.

However, overfitting and irrelevant data might have an impact on an ANN's accuracy. These problems are addressed by methods such as wavelet transform and principal component analysis. Improving ANN's efficiency and getting over its constraints are still unresolved issues.

2) Adaptive neuro-fuzzy inference systems

Waste generation prediction has been investigated using adaptive neuro-fuzzy inference systems (ANFIS), a data-driven modeling technique that combines artificial neural networks (ANN) and fuzzy logic.Few research examined the efficacy of ANN and ANFIS models in predicting the formation of MSW. When taking into account variables like recycling, demographic shifts, and economic developments, ANFIS proved to be a trustworthy model. ANFIS's capacity to anticipate waste generation with little input data was shown by Chen and Chang (2000). Fuzzy target regression was utilized by Chen and Chang (2000) as well as Noori et al. (2009) to increase the accuracy of ANFIS predictions.

3) Support Vector Machine

A cutting-edge neural network method called the SVM algorithm uses maximum margin classifiers. Finding the ideal separation hyperplane with the largest margin over the data is the aim of support vector machines (SVM). SVM applies the structural risk minimization principle, in contrast to conventional neural networks that minimize misclassification error. SVM is used in trash generation forecasting to reasonably accurately anticipate weekly MSW generation. The precision and resilience of the model were improved by applying wavelet transform to preprocess the input data.

4) K-nearest neighbors

Because of its ease of use, the k-nearest neighbors (KNN) technique is frequently employed for regression and classification applications. KNN has been used in time series forecasting with nonparametric locally weighted regression settings. Applying KNN to univariate time series is based on the idea that processes that consistently generate data display recurring behavioral patterns. It is possible to gather important data for making short term future predictions by recognizing comparable historical trends. Nevertheless, more efforts have not yet been undertaken.The KNN method simplifies recycling and disposal processes by effectively identifying new waste samples.

5) Random Forest (RF)

RF is a popular machine learning method that has been investigated for solid waste generation prediction. This approach, which falls under the ensemble learning category, builds a potent prediction model by combining several decision trees. The RF model may capture intricate correlations and produce precise projections by being trained on historical data that includes trash generation trends and pertinent aspects, such as demographic and economic variables. In order to automate decision-making, industrial companies can also incorporate machine learning algorithms into their waste management systems. Machine learning models have the ability to generate insights and suggestions for better waste management techniques in real time by continuously analyzing data on waste generation and disposal. This can help manufacturing firms reduce waste generation, minimize environmental impact, and enhance overall operational efficiency.

D. Application In Waste Management

It has been discovered that machine learning based models are employed in numerous academic disciplines, including engineering, agriculture, and medicine. It has been discovered that machine learning techniques are suitable for playing a key role in trash management. Waste generation needs to be sufficiently controlled to protect the environment and public health. There are numerous machine learning models that can be used to manage solid waste. Every machine learning model has a distinct function. Date of prediction and classification. Big data is handled by an additional artificial neural network in order to conduct geographic analysis. ML application sectors include waste bin level detection, waste characteristic forecasting, process parameter prediction, process output prediction, vehicle routing, and SWM planning. While waste characteristics prediction involves trash classification, waste compression ratio, and waste generation trends, waste detection in the bin is related to monitoring the fullness of garbage bins. The clever bins' automated process will simplify the chore of sorting and transporting soil. Trash is simply thrown into the bin; the bin uses sensors to identify the type of garbage disposed of and determines what should be done by analyzing and comparing the collected trash with historical trash data. Trash is sent to the proper disposal system based on the instructions provided by sensor-based programs. (Vaid & Sharma, 2021).

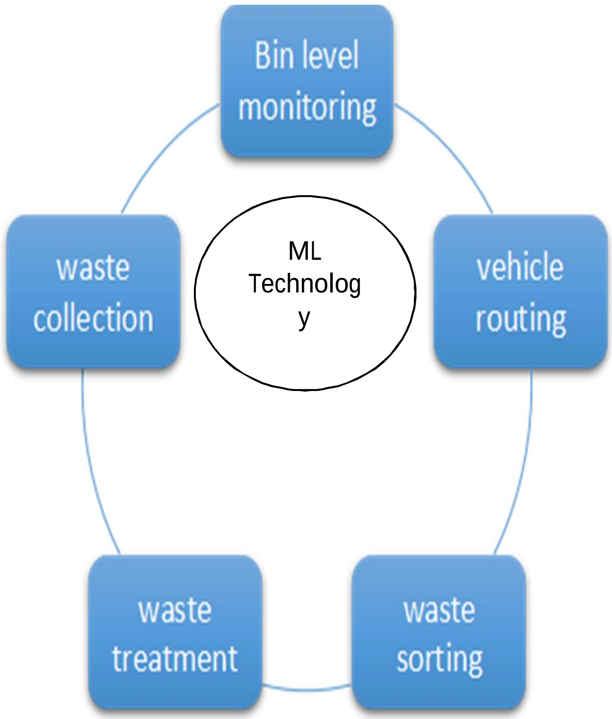


Figure 7 application of machine learning in waste management

E. Modelling Methods

Demographic and socioeconomic parameters were typically employed in conventional trash generation prediction models, such as correlation and regression models. The majority of the prediction models took into account a number of independent factors.

1) Prediction of Waste Generation Using ARIMA Model

Time series forecasting using the autoregressive integrated moving average (ARIMA) model is a traditional statistical technique. The goal of the ARIMA model is to transform time series data into a stationary form by analyzing the relationship between target values and lag observations. But when compared to machine learning models, the ARIMA model performs quite poorly even with parameter tuning.

2) Prediction of Waste Generation Using NARX Model

A particular kind of neural network called the non-linear autoregressive exogenous model (NARX) is intended for the modeling of non-linear time-series data. It can capture intricate patterns and relationships because it integrates recurrent feedback connections from other network layers. In this study, we assessed the effectiveness of our suggested approach using the NARX model as a baseline.

IV. STATISTICAL ANALYSIS

In order to get significant results from the study, quantitative data were examined using statistical analysis (Ali and Bhastar, 2016). The primary benefit of statistical analysis is its ability to swiftly and precisely score and analyze big data sets (Bryman and Cramer, 2001). Researchers use statistical analysis in the majority of their studies. Descriptive and inferential statistics are the two types of statistical methods they employ. In descriptive statistical analysis, different patterns in data found during a study are described using frequencies, percentages, means, and standard deviations. In this study, waste composition analysis and quantitative data from the home questionnaire were analyzed using descriptive statistics. In the composition study maximum, minimum, mean and median quantities of waste components were determined, and graphical techniques such as tables, pie charts, bar charts and box plots were also used to present results from this analysis. This analysis was undertaken in order to generate a descriptive picture of the data gathered on the demographics of residents, waste management behaviour and waste levels and composition.Table 5 The research area's total waste composition was determined by weighing the collected solid garbage. With 466 people living in the homes that were sampled, the total amount of garbage produced by the 74 families was 786.4 kg, or 0.47 kg/capita/day.

Table 5: Overall composition of waste sampled by weight and percentage

Category	Total waste (kg)	% of waste sampled
Food	198.2	39.2
Ashes of unburnt wood	131.2	28.4
Plastic filmsand bags	99.7	18.4
Fines	44.7	7.8
Misc. comb	42.0	5.1
Paper and card	50.8	5.7
Textiles and materials	39.2	5.4
WEEE	34.3	4.7
Glass	43.7	4.6
Metals	31.0	3.2
Others	30.6	4.1
Dense plastic	27.1	3.7
Garden waste	13.9	1.9
Total	786.4	132.2

The largest fraction was food waste which made up 29.2% of the total waste sampled. The food items were unprocessed with high moisture content consisting mostly of unavoidable waste materials. Figure 50 provides examples of unavoidable food waste sampled including bitter leaf stems, spinach stems, ogwu ribs, mango and yam peelings.

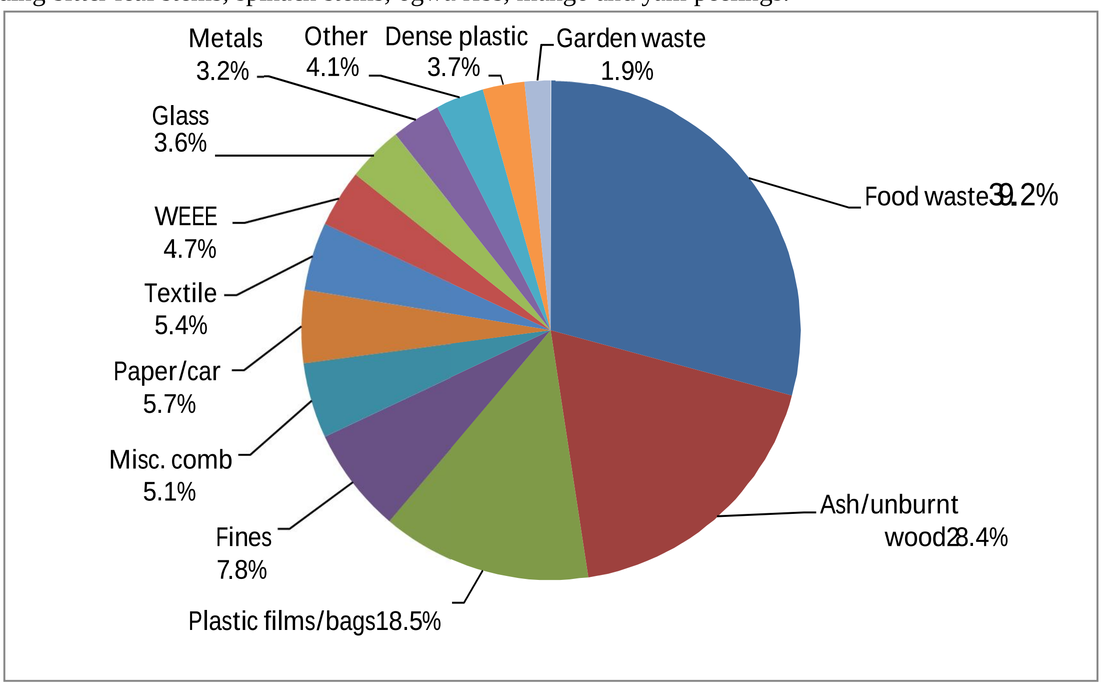


Figure 3: Overall waste composition of the study area by weight

V. SUMMARY

The primary conclusions of the waste composition study indicate that the waste generated in the study area was composed of 65.2% biodegradables, 13.2% recyclables, and 21.6% residuals. The waste materials that should be prioritized for prevention are the biodegradables, which include food waste, ash/unburnt wood, fines, paper, textile, and garden waste; the recyclables are dense plastic, glass, and metals; and the remaining waste materials are recyclables. Consequently, 78.4% of the waste stream from study area households could be managed through waste prevention or recycling.

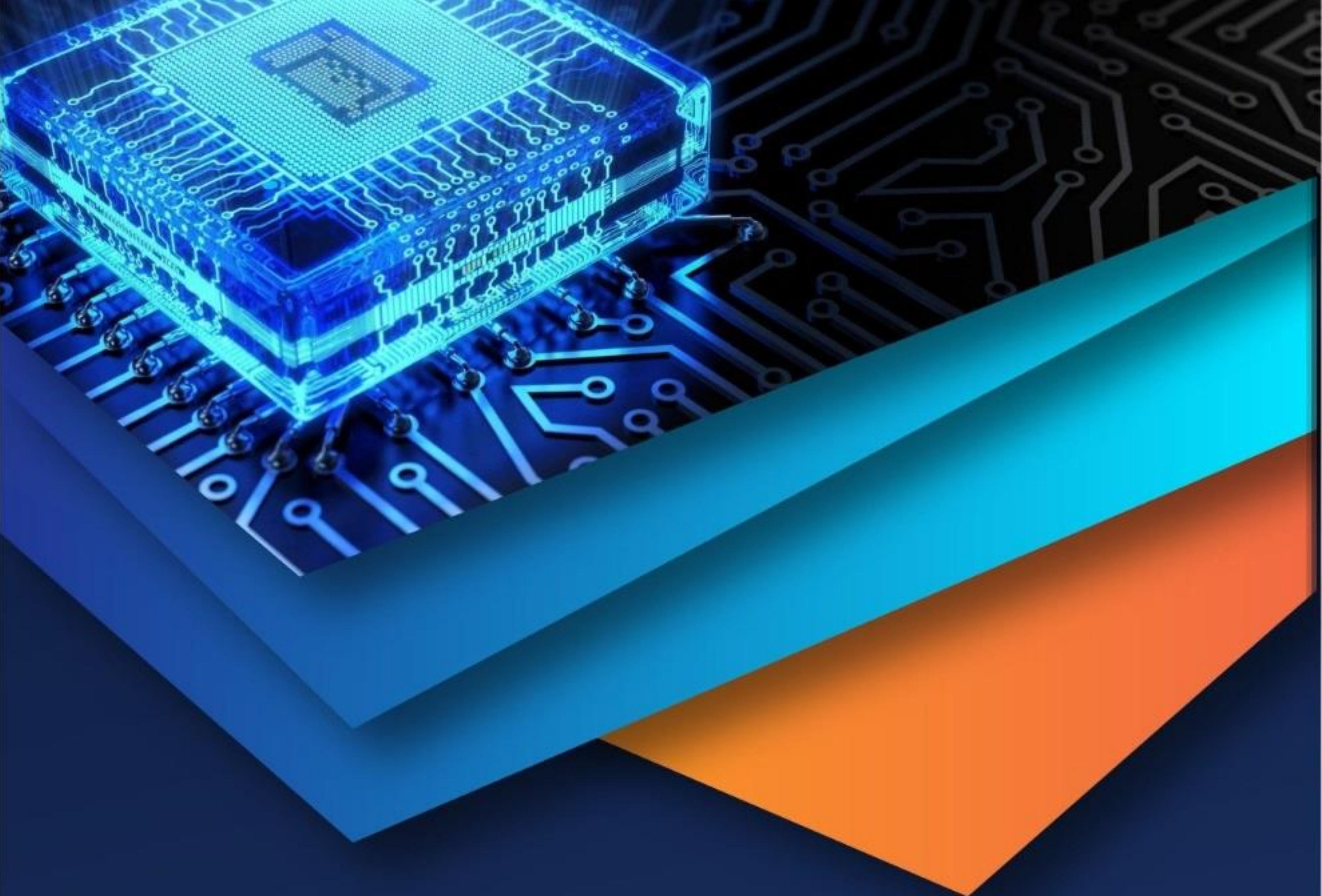
VI. CONCLUSION

It is evident that industrialization and poor waste management techniques have caused a proportionate rise in the amount of waste produced in various Nigerian cities.We reviewed research that presents a predictive model for managing and optimizing the production and disposal of garbage. The worrisome rate at which home and municipal garbage are growing underscores the critical necessity of this research topic. After implementing well-known machine learning techniques, our analysis of the survey provided insightful conclusions regarding the subject of study, including the significance of waste data collecting and the positive impact on the forecast of solid waste creation. In conclusion, trash has a major influence on Nigerian manufacturing companies, making the use of creative waste management techniques necessary. Manufacturing companies can lower costs, optimize waste management procedures, and lessen environmental risk by utilizing machine learning techniques. Nigeria's industrial sector could become more efficient and sustainable if machine learning is included into waste management procedures. Investing in technology and innovation is crucial for manufacturing organizations in order to effectively tackle the difficulties presented by waste and improve their overall environmental performance. The efficacy and efficiency of waste management can be increased with machine learning.

REFERENCES

[1] Abah, S. O. and Ahimain E. I. 2011: Healthcare waste management in Nigeria: A case study. Journal of Public Health and Epidemiology. 3 (3), pp.99-110.
[2] Adama, O, 2007: Governing from above: Solid waste management in Nigeria’s new capital city of Abuja. Doctoral Thesis Stockholm University Sweden.
[3] Adama O, 2012: Privatizing services as if the people matter: SWM in Abuja, Nigeria. The Nordic Africa Institute. Policy notes 2012/1 Uppsala, Sweden.
[4] Adebayo, W.O, Bamisaye, J.A, Akintan, O.B, Ogunleye, S. O, 2006: Waste generation, disposal and management techniques in an urbanizing environment: A case study of Ado-Ekiti, Nigeria. Journal of Applied Science. 1(1) pp. 63-66.
[5] Achi, H.A, Adeofun, C.O, Gbadebo, A.M, Ufoegbune, G. C, & Oyedepo, J.A, 2012: An assessment of solid waste management practices in Abeokuta, Southwest Nigeria. International journal of Biological and Chemical Research. 29 (2), pp.177- 188.
[6] Achike A.I, & Onoja A.O, 2014: Greenhouse Gas Emission Determinants in Nigeria:Implications for Trade, Climate Change Mitigation and Adaptation Policies. British Journal of Environment & Climate Change. 4(1), pp.83-94.
[7] Adagbada, A.O, Adesida, S.A, Nwaokorie, F.O, Nlemogha, M.T, & Coker, A.O, 2012: Cholera Epidomology in Nigeria: An Overview. The Pan African Medical Journal. pp. 1-12.
[8] Abigo, A, 2016: Facilities Management: enhancing solid waste management practices for urban marketplaces in Nigeria. A thesis submitted in partial fulfilment of the requirements of the University of Brighton for the degree of Doctor of Philosophy, Faculty of Physical Sciences, School of Environment and Technology, UK.
[9] Abila, B, & Kantola, J, 2013: Municipal solid waste management problems in Nigeria: Evolving knowledge management solution. International Journal of Environment, Earth Science and Engineering. 7 (6), pp.1-6.
[10] Abur, B.T, Oguche E.E, & Duvuna G.A, 2014: Characterization of Municipal Solid Waste in the Federal Capital Abuja, Nigeria. Global Journal of Science Frontier Research. 14(2), pp. 1-6.
[11] Abutu, A. 2018: Plastic ban where did Nigeria miss it. https://newsdiaryonline.com/plastic-ban-nigeria-miss/. Accessed 10th January 2018
[12] C.G.Cheah, W.Y.Chia, S.F.Lai, K.W.Chew, S.R.Chia, & P.L.Show, Innovation designs of industry 4.0 based solid waste management: Machinery and digital circular economy. Environmental Research, 213, 113619 (2022)
[13] .A.Lakhouit, M.Shaban,A. Alatawi, S.Y.Abbas, E.Asiri, T.Al Juhni, & M.Elsawy. Machine-learning approaches in geo-environmental engineering: Exploring smart solid waste management. Journal of Environmental Management, 330, 117174 (2023
[14] .L.Andeobu, S.Wibowo,& S.Grandhi. Artificial intelligence applications for sustainable solid waste management practices in Australia: A systematic review. Science of The Total Environment, 155389 (2022)
[15] .S.Pattnaik, & M.V.Reddy. Assessment of municipal solid waste management in Puducherry (Pondicherry), India. Resources, Conservation and Recycling, 54(8), 512-520 (2010)
[16] E.Fagnani, &J.R. Guimarães. Waste management plan for higher education institutions in developing countries: The Continuous Improvement Cycle model. Journal of Cleaner Production, 147, 108-118 (2017)
[17] G. Prasad, H. Mamane, M. V. Ramesh, "Geogenic and anthropogenic contamination of groundwater in a fragile eco-friendly region of southern Kerala, India," Agronomy Research, vol. 20, no. 1, pp. 1-14, 2022, doi: 10.15159/AR.22.010.
[18] M.A.Al Mamun,M.AHannan, A.Hussain, &H. Basri(2014). Integrated sensing systems and algorithms for solid waste bin state management automation. IEEE Sensors journal, 15(1), 561-567 (2014)
[19] G. Prasad, A. S. Reshma, M. V. Ramesh, "Assessment of drinking water quality on public health at Alappuzha district, southern Kerala, India," Materials Today: Proceedings, vol. 46, pp. 4435-4440, doi: 10.1016/j.matpr.2021.05.106(2021)
[20] V. K. Damodaran, G. Prasad, V. T. Joseph, B. Ambat, "Review of Strategy, Framework and Technological Options for Municipal Solid Waste Management," in Kerala Environment Congress 2010, pp. 1-3(2010)
[21] M.Kannangara,R. Dua,L. Ahmadi, &F. Bensebaa .Modeling and prediction of regional municipal solid waste generation and diversion in Canada using machine learning approaches. Waste management, 74, 3-15 (2018
[22] N.Taggio, A. Aiello, G.Ceriola, M.Kremezi, V.Kristollari,P. Kolokoussis & E.Barbone. A Combination of machine learning algorithms for marine plastic litter detection exploiting hyperspectral PRISMA data. Remote Sensing, 14(15), 3606 (2022)
[23] A.Onyanta. Cities, municipal solid waste management, and climate change: Perspectives from the South. Geography Compass, 10(12), 499-513 (2016).
[24] K. Arun, "Geospatial approach for wind farm site selection-A Kerala scenario," 2017 International Conference on Technological Advancements in Power and Energy (TAP Energy), Kollam, pp. 1-5, doi: 10.1109/TAPENERGY.2017.8398491(2017).

[25] L.Ihsanullah, G.Alam, A,Jamal, & F.Shaik . Recent advances in applications of artificial intelligence in solid waste management: A review. Chemosphere, 136631 (2022)
[26] H.N.Guo,S.B. Wu,Y.J.Tian,J. Zhang, & H.T.Liu. Application of machine learning methods for the prediction of organic solid waste treatment and recycling processes: A review. Bioresource technology, 319, 124114 (2021)



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY