Assessment of Potential Health Hazards Associated with Bacterial Diversity in Municipal Solid Wastes of Okitipupa LGA in Ondo State, Nigeria

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Abstract: This study was designed to isolate and characterize the microflora associated with selected solid waste dump sites in Okitipupa Local Government Area (LGA) of Ondo State, Nigeria. Solid waste samples were collected in triplicates from ten (10) dump sites in Okitipupa LGA at two-week interval for three months using a random sampling procedure while culture method is used to isolate the bacteria. The standard method of ASTM-D5231-92 was employed to determine the quantity and composition of wastes. The most prevalent waste was food or green wastes, which ranged from 39.40% to 19.50%, while polythene materials were the least with a range of 5.20% to 0.90%. The mean bacterial counts ranged from 9.2 x 10^6 to 4.6 x 10^6 cfu. Colonial morphology and biochemical identifications of the bacteria from the samples revealed *Serratia* sp. *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Bacillus* sp, *E. coli* and Actinomycetes. Respiratory reactions may be induced in individuals. It is then concluded that, to lower the health risks linked to microflora in solid waste dumpsites, Municipal Solid Waste (MSW) facilities should have regular inspections, clean and disinfect surfaces and equipment, make sure workers wear protective gear, and follow proper waste management and disposal practices.
Key word: Dumpsites, Environment, Microflora, Municipal solid waste, Pathogens

INTRODUCTION

Waste is defined as any substance that is discarded by an individual, home, or entity. Waste is a complex amalgamation of several substances, with only a small number of them being intrinsically detrimental to health (Abdel-Shafy and Mansour, 2018). The broad production, ever-increasing quantities of, and sustainable dispersal of solid wastes are the subject of significant worldwide concern. The vast differences in composition and the complexity that accompany them necessitate a significant amount of effort to collect, process, and dispose of them in an environmentally favourable manner (Masebinu *et al.,* 2017; Liu *et. al.,* 2019; Gelan 2021).

Worldwide, there are numerous factors contributing to the increasing volume of solid refuse generated. As national incomes increase, countries generate more wastes, rising levels of prosperity, rapid urbanization, and population growth have all contributed to an increase in the amount of garbage produced per person. Additionally, waste management is frequently managed by local administrations that possess inadequate financial, operational, and managerial resources in the majority of municipalities (Bruna, 2023). At least 33 percent of the 2.01 billion tonnes of municipal solid garbage produced annually worldwide is not managed in an environmentally favourable manner (World Bank, 2024). The average amount of waste produced per individual per day worldwide is 0.74 kilograms, with a range of 0.11 to 4.54 kilograms (World Bank, 2024). Presently, Nigeria generates 40,959 tonnes of municipal solid waste per day, which totals 14.95 MT annually (Africa Check, 2019). It is anticipated that Nigeria will generate 54.8 MT of solid waste in 2030 and 107 MT in 2050 (Africa Check, 2019). Global waste generation rates may rise to 20 billion tonnes annually by 2050 unless immediate action is taken on numerous waste management fronts. This number is still increasing in most countries of the world (Kaza *et al*., 2018).

Open dumping of municipal solid waste is prevalent in African countries, including Nigeria. Open dumping is the most affordable choice for low-income nations with solid waste collection below 50%, and approximately 95% of the collected waste is disposed of haphazardly at different dumping sites (Ohwoghere-Asuma and Aweto, 2013; Janet and Kelechi, 2016; Gelan, 2021). Multiple studies have shown that in many towns, municipal solid wastes are indiscriminately disposed of in open areas, including major residential areas, roadsides, drainage areas, rivers, riversides, and forests. This practice has resulted in the introduction of dangerous substances, such as heavy metals, into the water and soil ecosystems (introducing various harmful substances, such as heavy metals, into the soil and water compartments (Ogwueleka, 2009; Sankoh and Yah, 2013; Hailemariam and Ajeme, 2014; Kebede *et al*., 2016). This method allows waste to be easily accessed by scavengers and animals, and the production of pollutants is not monitored. Municipal Solid Waste (MSW) is regarded as an important source of microorganisms and a significant "microbial pool", the organic content in MSW supplies the necessary nutrients for the microbiological proliferation of microorganisms, which are primarily responsible for the breakdown of waste to render it safe and stable (Janet and Kelechi, 2016; Wang *et al*., 2017)

Household garbage can transfer contagious pathogenic microorganisms to the environment by direct contact, inhalation, ingestion, or indirect contact via the food chain (Fernández-García *et al.,* 2016; Marquez *et al.*, 2016; Ghazaei 2022)

Solid wastes are sometimes burnt so as to decrease the amount of garbage and its ability to spread disease. However, unregulated burning can release harmful substances such as Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) along with other pollutants (Hossain *et al*., 2011). In 2016, approximately 1.6 billion tons of carbon dioxide (CO_2) equivalent greenhouse gas emissions were produced from the treatment and disposal of solid waste. This accounted for 5 percent of global emissions and was determined based on factors such as the volume of garbage generated, its composition, and the methods used for waste management. This is mostly caused by the practice of depositing waste in open dumps and landfills without implementing landfill gas collection systems. Approximately half of all emissions are attributed to food waste. As a matter of fact, and without any changes in the industry, it is projected that solid waste-related emissions will rise to 2.38 billion tons of CO_2-equivalent per year by 2050 (GBAC, 2023)

Municipalities frequently encounter numerous challenges stemming from limited financial resources, improper coordination, and the intricate nature of municipal solid waste that surpasses the capacity of the local government to manage (Sujauddin *et al.*, 2008). The composition of municipal solid trash varies considerably between municipalities and countries. The extent of diversity mostly relies on factors such as lifestyle, economic conditions, waste management policies, and industry composition. The volume and composition of municipal solid waste are crucial factors in determining the proper treatment and management of these wastes. The provision of such information is crucial and valuable for the establishment of a municipal facility that converts solid waste into electricity (World Bank, 2024).

Securing funding for solid waste management systems poses a substantial difficulty, particularly when it comes to covering continuing operational expenses rather than initial capital investments. It is crucial to consider operating costs from the outset. The operating expenses for integrated waste management, which includes collection, transport, treatment, and disposal, typically surpass $100 per tonne in high-income countries. Low-income countries allocate a smaller amount of money to waste operations, often around $35 per tonne or more. (Lisa and Frank, 2018; World Bank, 2024). This study was therefore designed to isolate and characterize the microflora associated with selected solid waste dump sites in Okitipupa Local Government Area (LGA) of Ondo State, Nigeria Additionally, it aimed to evaluate the potential health effects of this microflora on both the environment and humans.

MATERIALS AND METHODS

Study Area: Okitipupa Local Government Area was created in 1974 in Ondo state, Nigeria. Okitipupa Local Government headquarters is located in Okitipupa township with a university, Olusegun Agagu University of Science and Technology (OAUSTECH). The Local Government Area lies between longitude 4º 31'and 4º 55'E of the Greenwich Meridian and between latitudes 6º 48 and 6º 28N of the Equator as shown in Figure 1.

Sample Collection: A random sampling method was used, with field visits for sample collection followed by laboratory-based methods for processing. Okitipupa LGA was chosen as the study area. Solid waste samples were collected from a variety of open solid waste disposal sites. One (1) kilogram of solid wastes was collected with sterile shovel from each open waste dumpsite in sterilized polythene bags throughout the ten locations in triplicates every two (2) weeks for eighteen (18) weeks from various locations in the LGA. The locations are; Okitipupa, Igodan, Okunmo, OAUSTECH, Ayeka, Sabo, Ikoya, Erinje, Idepe, and Igbodigo as shown in Figure 1 above. All samples were properly labelled and transferred to the laboratory for analysis within three (3) hours after collection.

Characterization of solid waste: Quantification/composition of waste was determined by a standard method of ASTM-D5231-92 (ASTM, 2008). American Society for Testing Materials (ASTM) has termed this technique as ASTM-D5231-92 standard technique for the analysis of the MSW composition (Worrell and Vesilind, 2011). This step involves determining the quantity and composition of solid wastes generated over a given period. It helps in understanding waste generation patterns, estimating waste management requirements, and planning appropriate waste management strategies.

Isolation of Bacteria: Bacteria isolation from the solid wastes was done on nutrient agar at 37°C for 24 h. Pure colonies were then obtained and stored. Gram staining and biochemical tests were performed for the confirmation and identification of bacteria species using the methods described by Manandhar and Sharma (2018).

RESULTS AND DISCUSSION

The composition of MSW in this research is as shown in Table 1. The observed composition of MSW varies considerably across municipalities and countries. The extent of difference mostly relies on factors such as lifestyle, economic conditions, waste management rules, and industry composition (Africa Check, 2019).

Table 1: Quantification of MSW in location sites across Okitipupa LGA

Parameters (%)	Okitipupa	Igodan	Okumo	OAUSTECH	Ayeka	Sabo	Ikoya	Erinje	Idepe	Igbodigo
Paper	12.50	21.40	18.30	20.50	17.50	33.20	16.80	16.30	38.30	37.40
Plastic	10.20	9.70	8.10	7.50	6.40	7.20	8.30	6.70	9.60	11.30
Metal	15.40	4.10	4.70	15.10	5.30	5.70	15.20	27.40	6.30	4.70
Food Wastes	25.20	39.40	36.50	31.50	29.30	38.40	27.50	28.20	24.70	19.50
Glass	12.40	4.50	7.40	5.70	18.40	3.30	18.50	7.70	9.40	10.20
Polythene Bags	2.70	1.40	3.50	5.20	1.70	1.60	2.00	1.80	3.40	0.90
Wood	7.40	3.70	7.80	4.10	3.00	2.30	1.90	2.00	1.80	2.80
Textile	6.70	7.50	7.50	1.70	11.90	2.10	1.50	1.90	4.70	10.20
Others	7.50	8.30	6.20	8.70	6.50	6.20	8.30	8.00	1.80	3.00
Total	100	100	100	100	100	100	100	100	100	100

Key MSW=, LGA=, OAUSTECH=

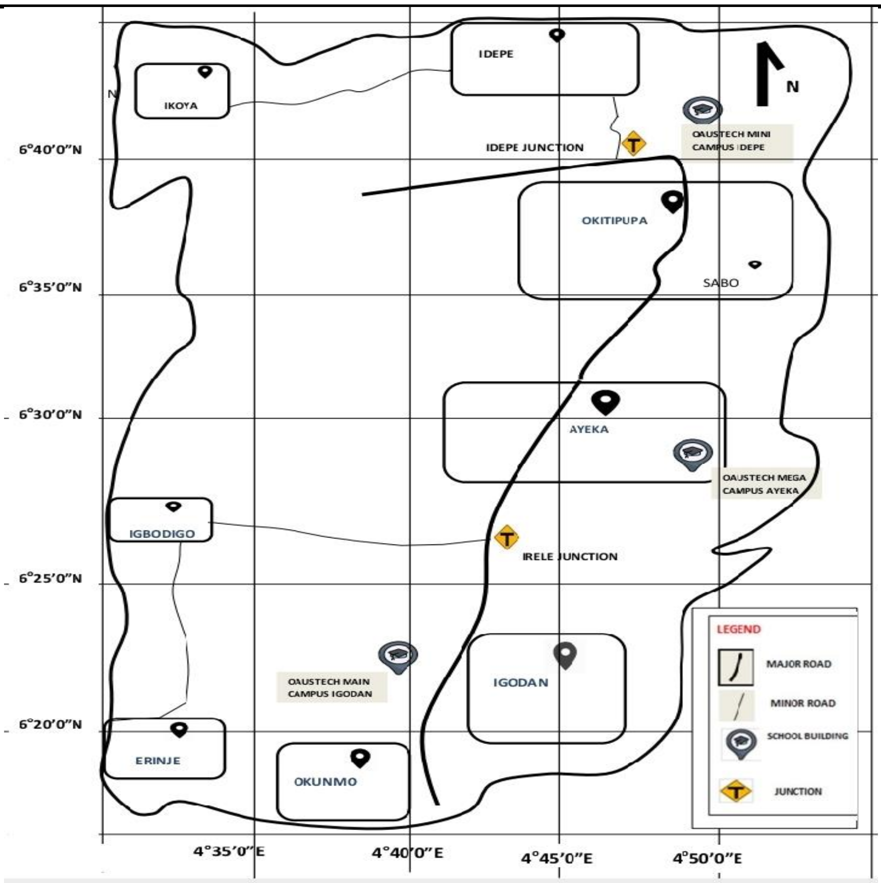

Figure 1: Map of Okitipupa LGA showing sample collection sites

Waste disposal in Okitipupa is still largely random and uncontrolled, and large quantities of waste go uncollected. It was found that, although MSW collection services owned by private organizations is available for the residents in the areas surveyed, majority of the residents are not taking the advantage of the services due to unwillingness to pay for these services. Oral discussion with inhabitants on the management of garbage collected by MSW collection agencies indicated that in most of these places, there is a lack of adequate treatment or dumping procedures for the collected wastes. On the contrary, the most prevalent method was the incineration of rubbish in open dumpsites.
This is why most residents have also opted for open and indiscriminate dumping of wastes at every available space. This same trend has also been reported by other researchers in subsharan Africa and across the globe (Agbefe *et al*., 2019; Ayeleru *et al.*, 2020; Domingo and Manejar, 2021; Muheirwe *et al*., 2023). Waste characterization revealed that food and green wastes account for the highest waste generated across the various locations ranging from 39.40% in Igodan to 19.50% at Igbodigo. This research finding aligns with that of World bank that stated that food and green waste accounted for 44% of the global waste composition in her research and that food and green waste is the largest waste produced across the countries of the world (World Bank, 2024). It has been reported that the content of waste varies depending on economic levels, which is indicative of different consumption patterns(World Bank, 2024) . In high-income countries, the proportion of food and green waste is relatively low, making up just 32 percent of the total garbage. On the other hand, these countries produce a larger amount of dry waste that has the potential to be recycled, such as plastic, paper, cardboard, metal, and glass, which accounts for 51 percent of the waste. Fifty three percent of food waste and

fifty seven percent of green waste are produced by middle- and low-income countries. As economic development levels decline, the proportion of organic waste increases as also revealed by the result of this finding where larger proportion of the wastes across all the sampled locations are green or food wastes (UNEP, 2024).

Biochemical characterization of bacterial isolates from MSW

A total of six (6) bacterial isolates were recorded in this research work. Bacterial isolates identified via cultural and biochemical characteristics included Actinomycetes (33.3%) which occurred most frequently among the isolates, followed by others – *Serratia* sp. (25%), *Pseudomonas aeruginosa* (16.7%), *Proteus mirabilis* (8.3%), *Bacillus* (8.3%) and *E. coli* (8.3%).

The mean bacterial counts isolated from solid waste dump sites across the LGA are as shown on Table 2, while the results of biochemical tests for the characterization of the bacteria are as shown on Table 3.

Table 2: Total heterotrophic counts (THC) of bacterial isolates from solid waste samples

Locations	Mean bacterial counts (Cfu/ml)
Okitipupa	5.2×10^6
Igodan,	9.2×10^6
Okunmo	6.8×10^6
OAUSTECH	6.6×10^6
Ayeka	5.6×10^6
Sabo	8.6×10^6
Ikoya	5.4×10^6
Erinje	5.8×10^6
Idepe	4.6×10^6
Igbodigo	5.6×10^6

Key: OAUSTECH = Olusegun Agagu University of Science and Technology.

Table 3: Biochemical Characteristics of the Bacterial isolates from the MSW

Isolate code	Gram stain	Shape	Spore	Capsule	Catalase	Oxidase	Glucose	Lactose	Mannitol	Xylose	Coagulase	Probable organism
SD 1	+	R	+	-	-	-	-	-	+	-	-	*Actinomycetes*
SD 2	-	R	-	-	+	-	+	-	-	+	-	*Serratia sp.*
SD 3	-	R	-	-	+	-	+	+	+	-	-	*Pseudomonas aeruginosa*
SD 4	-	R	-	-	+	-	+	-	-	+	-	*Proteus mirabilis*
SD 5	+	R	-	-	+	-	+	-	+	-	-	*Bacillus subtilis*
SD 6	-	R	-	-	+	-	+	+	+	+	-	*E. coli*

Key: - (negative), + (positive), R (Rod)

Extensive literature coverage exists regarding the health ramifications associated with specific bacteria isolated from municipal solid wastes, including *Serratia* sp., *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Bacillus* sp., *E. coli*, and actinomycetes. According to reports, while the majority of *Pseudomonas* species are saprophytic, low-virulent organisms, *P. aeruginosa* and others are recognized globally as significant human pathogens capable of causing severe nosocomial, healthcare-associated, and (less often) community-acquired infections that significantly contribute to morbidity and mortality (Hilmar and Harald, 2010; Fair and Tor, 2014). Penicillin-resistant strains of *P. aeruginosa* are notorious for providing protection against disinfectants and antibiotics via the biofilms produced (Odumosu *et al*., 2013). Reportedly, the bacterial species are capable of acquiring resistance genes that confer resistance to a variety of antibiotics that are frequently employed in the treatment of infections (Kityamuwesi *et al*., 2015. Mishandling of pharmaceuticals and antibiotics in MSW facilities poses a potential hazard by facilitating the growth and dissemination of antibiotic-resistant strains of *Pseudomonas aeruginosa* (Nikokar *et al.*, 2013; Khosravi *et al.*, 2017; Zheng *et al.*, 2019). Other potential health complications encompass respiratory ailments, dermatological irritations, ocular infections, gastrointestinal disruptions, and systemic infections, as previously documented by Sadikot *et al*. (2005) and Barbier *et al.* (2013). In close proximity communities, the existence of *Pseudomonas aeruginosa* within MSW facilities may also present a hazard. Community members may potentially be exposed to the bacteria and develop infections or other health complications if the bacteria contaminate the surrounding environment, including air and water sources (Al-Khatib *et. al.,* 2015)

Escherichia coli isolated from municipal solid wastes in this research is in line with the reports of multiple researchers who have also isolated *Escherichia coli* from municipal solid waste (Costa *et al*., 2006; Sáenz *et al.* 2004; Paulshus *et al.* 2019). Some species of the bacterium *E. coli*, which is frequently encountered in the intestines of both humans and animals, are capable of causing illness if ingested. Foodborne illnesses, including diarrhea, abdominal cramps, and vomiting, have been associated with *E. coli* (Huang *et al.,* 2006; Majowicz *et al*., 2014). Additionally, occupational hazards resulting from water and airborne infections have been reported by health workers involved in solid waste management. (Kretchy *et al.* 2015; Kretchy *et al*. 2020; Tack *et al.* 2020). Vector infestations may result from improper solid waste management, including the attraction of flies, rodents, and cockroaches. These vectors may carry *E. coli* bacteria on their bodies, which they subsequently disseminate to other regions. This reduces the likelihood of *E. coli* transmission to humans and animals via direct contact or through the contamination of food and water sources.

In their investigation, Oshoma *et al*. (2017) isolated *Serratia* sp., *Bacillus*, *Pseudomonas*, and *E. coli* from landfill sites; which is consistent with the findings in this study. However, certain *Serratia* species are innocuous and comprise a normal component of the human microbiota, others are capable of inducing infections and presenting health hazards. Infections caused by *Serratia* can give rise to various clinical manifestations, including but not limited to pain, fever, chills, redness, edema, and sepsis, mortality, and respiratory distress (Casolari *et al.*, 2005; Yoon *et al.*, 2005; StewartGreco *et al*., 2012). *Bacillus subtilis* is responsible for bacteremia, endocarditis, pneumonia, and septicemia, among other infections. However, immunosuppression of the host and high-dose inoculation are required prior to *B. subtilis* infection, as the pathogen typically exploits opportunities to invade hosts (Muzumdar *et al.*, 2011; Kityamuwesi *et al*., 2015; Tsonis *et al.*, 2018). The isolation of actinomycetes from solid residues in India and China, respectively, by Namrata *et al*. (2012) and Yi *et al*. (2017), is consistent with the results obtained in this study. Actinomycetes are indispensable for the decomposition of organic matter in municipal solid wastes. Although, actinomycetes generally aid in the decomposition of waste materials and the promotion of nutrient recycling, their presence in solid waste may have adverse health effects, including the production of secondary mycotoxins that are potentially toxic to humans (Lapalikar *et al.*, 2012; Cserháti *et al.,* 2013). Prior studies have documented that these toxins have the potential to induce carcinogenic effects and cause liver damage, kidney dysfunction, and neurotoxicity (Tuan *et al.*, 2003; Adeyemo *et al*., 2018; Greeff-Laubscher *et al*., 2018).

Shin-Hee *et al.* (2005) isolated *Proteus mirabilis* from retail meat waste sites in Oklahoma, while Zhongjia *et al.* (2021) also isolated *Proteus mirabilis* from Belgian broiler carcasses of retail and human stool. These findings aligns with the results of this research. *Proteus* sp. are commonly found in the intestines of humans and other animals, and are also widely distributed in the environment. Nevertheless, the species *P. mirabilis* is frequently found to be a pathogen in urinary tract infections in humans, particularly in cases of catheter-associated bacteriuria in patients with long-term catheterization. Additionally, it is more frequently detected in the stools of patients with diarrheal disease compared to healthy patients (Sabbuba *et al.*, 2003). In addition, *P. mirabilis* has been implicated in nosocomial infections in immunocompromised persons, such as bloodstream infection, cystitis, pyelonephritis, prostatitis, neonatal meningoencephalitis, empyema, and diarrheal illness (Sabbuba *et al*., 2003; Jacobsen *et al*., 2008).

CONCLUSION

The bacteria associated with solid waste dump site in Okitipupa metropolis had been presented in this study. As a result of no functional sanitary landfill in Okitipupa metropolis, indiscriminate dumping of untreated solid waste can pose significant risks to both human health and the environment. Although, solid waste has a beneficial effect on the soil microflora and enzymatic activities, it is crucial to clean, sort and perhaps treat the wastes before disposing them off in order to minimize the health risks connected with waste dumping. This study has provided valuable insights into the bacterial communities associated with solid wastes in the dumpsites.

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