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Isolation and Characterisation of Bacteria Flora from Dumpsites in Keffi Metropolis, Nassarawa

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ABSTRACT
Management of solid waste has become a national issue because of the nuisance created by solid waste generated from commercial activities. Each year, over 5.2 million people (including up to 4 million children) have been reported to die from waste related diseases. Given the lack of data, this study isolates and characterizes bacteria from different dumpsites in Keffi metropolis, and determines their susceptibility pattern to some antibiotics. Soil samples were collected from various dumpsites and adjacent control sites. The bacterial load counts for the various dumpsites and the adjacent control sites were counted using Mise and Misra serial dilution method. Aerobic and facultative anaerobic bacteria were isolated from various dumpsite samples using five different culture media (Mueller Holton Agar, MacConkey agar, Chocolate agar, Blood agar and Salmonella Shigella Agar). Phenotypic test was assayed using double disc method to check for ESBL and metallo-β-lactamase enzyme among the Gram negative bacterial isolates. Pseudomonas aeruginosa was the predominant bacterial in all the dumpsites and the adjacent control sites with a percentage appearance of 65.2% and 44% respectively. Escherichia coli had a prevalence of 21.7% in the various dumpsites and 9.40% from the adjacent control sites; Klebsiella pneumonia had a prevalence of 13.1% from the various dumpsites and 3.80% from the adjacent control sites. However, Staphylococcus aureus recorded 0.0% from the various dumpsites and 3.80% from the adjacent control sites. Ciprofloxacin and Ofloxacin were highly sensitive to P. aeruginosa and K. pneumonia isolated from the various dumpsites in Keffi metropolis. Streptomycin, Cefuroxime and Pefloxacin were highly sensitive to K. pneumonia isolated from the various dumpsites in Keffi metropolis. E. coli isolates showed varying degree of sensitivity to all drugs used in this study. However all the bacterial isolates show various degrees of resistance to the different drugs used in this study. Pseudomonas aeruginosa (9), E. coli (5) and K. pneumonia (1) were observed to be Extended-Spectrum Beta-Lactamase (ESBL) positive. Pseudomonas aeruginosa (50) E. coli (10) and K. pneumonia (6) exhibited extensive drug resistance to less than or equal to 2 classes of antibiotics used (table 4.9). Pseudomonas aeruginosa (40) E. coli (20) and K. pneumonia (3) exhibited Multi drug resistance (MDR) pattern to greater than 2 classes of antibiotics used. This study has indicated that dumpsites in Keffi metropolis harbor many pathogenic bacteria that could be harmful to persons leaving around these dumpsites and by extension to others through vectors, scavengers and daily human activities.

Keywords: *Nigeria, Keffi, dumpsites, Solid Waste, bacteria flora, resistance, Extended-Spectrum Beta-Lactamase*

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I. INTRODUCTION

Dumpsite can be referred to as areas or land sites where material wastes from several sources and processes are deposited. The wastes include both municipal solid wastes and industrial wastes including liquid effluents containing heavy metals (Ilusanya *et al*., 2023). Solid wastes are made up of all forms of waste arising from the byproducts of human and animal activities. Also industrial diversification and the provision of expanded health-care facilities have also contributed to a considerable quantity of industrial hazardous waste and biomedical waste into the waste stream with potentially severe environmental and human health consequences (United Nations ESCAP 2020).

However, the management of solid waste has become a national issue because of the nuisance created by solid waste generated from commercial activities (Elizabeth *et al*., 2014). In most developing countries like Nigeria, waste dumps are nonchalantly placed at various common sites. Improper waste disposal has been previously documented to cause various forms of pollutions including air, soil, and water (Tchobanoglous *et al*.,

2002). In urban areas, indiscriminate dumping of waste contaminates surface and ground water supplies, clogging drains, creating stagnant water for insect breeding and floods during the rainy.

Each year, over 5.2 million people (including up to 4 million children) have been reported to die from waste related diseases (Uche *et al*., 2010). The disease burden associated with waste exposure in middle- and low-income countries has been shown to be increasing, although it remains largely unacknowledged (Landrigan *et al*., 2015). Numerous studies have identified inadequate waste management as a significant cause of soil and groundwater contamination globally (Marsilib *et al*., 2009; Landrigan *et al*., 2015; Fazzo *et al*., 2017). In general, poor waste management leads to serious health hazards and contributes to the spread of infectious diseases. Unattended waste attracts flies, rats, and other disease-carrying creatures, while decomposing wet waste produces foul odors, creating unhygienic conditions that increase health risks (Mattiello *et al*., 2013).

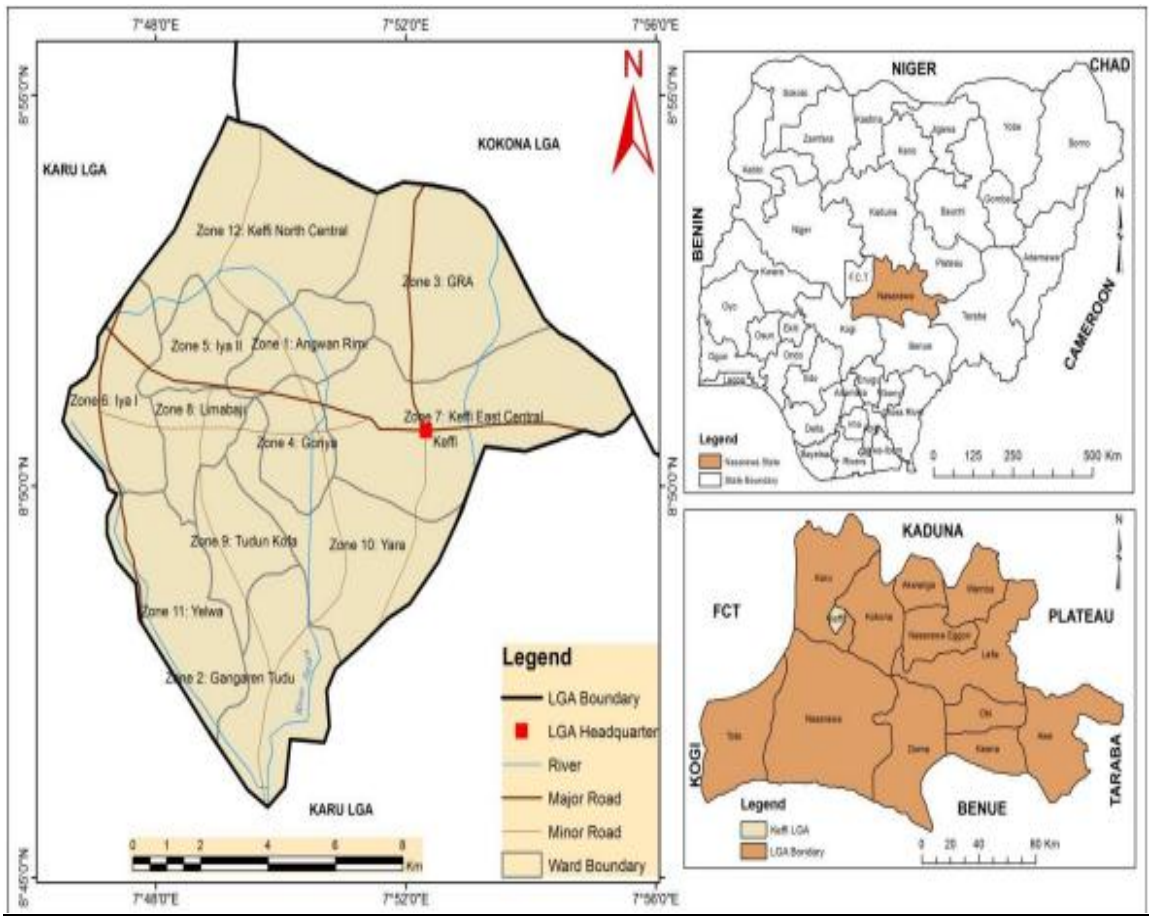
Bacterial pathogens may develop in wastes undergoing decomposition in soils that suffer from environmental pollution as a result of indiscriminate disposal of pollutants. These bacterial pathogens, when increased in population, pose great risk to human health (Onweremadu *et al*., 2009; Awisan *et al*., 2011).

Despite significant investments in the waste management sector, solid waste management remains one of the major environmental sanitation challenges facing the country today and has continually remained at the lowest level, because industrialization and rapid population growth in many cities and towns have led to wastes being generated faster than they are collected, and disposed. Therefore, it is in this context that the present study was carried out to isolate, characterize bacteria from different dumpsites in Keffi metropolis, and determine their susceptibility to some antibiotics.

II. MATERIALS AND METHODS

STUDY AREA AND STUDY LOCATION

The study was conducted in Keffi, a rapidly developing cosmopolitan town in Keffi Local Government Area, in Nasarawa State Nigeria is located within Lat 8˚, 51and 9o 25’ N and Long 7˚52’ 8 0 401 E. It has an area of 138 km² and a population of 92,664 at the 2006 census. It is bound by Karu, in the West, Kokona and Nasarawa LGAS in the South



SAMPLE COLLECTION

Soil samples were collected from nine major dumpsites in Keffi metropolis, including Federal Medical Center, General Hospital, Keffi Old Market, Keffi New Market, Government College, NYSC Camp, Nasarawa State University, School of Health, and Shittu Lao Army Barrack dumpsites. Control samples were collected from nearby control sites adjacent to these dumpsites. Soil samples were taken by randomly selecting a 5x5m area of soil to obtain ten topsoil samples (7.5 cm depth) using an auger with an 8.5 cm diameter. The collected soil samples were placed in sterile containers, appropriately labeled, and transported to the laboratory in a cold chamber for analysis within two hours as described by Cheesbrough (2018)

BACTERIAL ISOLATION AND ENUMERATION

Aerobic and facultative anaerobic bacteria were isolated from dump site samples using five different culture media as per the methods of Haruta *et al*., (2002) and Ruiz *et al*., (2005). After thorough mixing of each sterile universal container contents of the samples, 1g of each sample batch was weighed and suspended in a 10mL of distilled sterile water then was mixed vigorously. A 10-fold serial dilution was performed, stirring between each step. A volume of 0.1 mL from each dilution was spread onto five different solid media using a sterile glass spreader, followed by incubation at 37°C for 24 hours to identify the optimal dilutions for future cultures.

Morphological and Biochemical Identification of Isolates

The bacterial isolates were reconfirmed by sub culture, Gram staining, Morphology and other biochemical test as described by Cheesbrough (2018).

Antibiotic Susceptibility Tests

The disc diffusion method established by Stokes *et al*. (1993) was employed for the susceptibility tests. The antibiotics tested included ciprofloxacin (10 µg), cefuroxime (30 µg), peflacine (10 µg), ceftazidime (30 µg), gentamicin (10 µg), ceftriaxone (30 µg), ofloxacin (10 µg), streptomycin (30 µg), augmentin (30 µg), and ceporex (10 µg). The antimicrobial activity of the overnight broth culture was standardized using the 0.5 McFarland turbidity standards and evenly inoculated onto the surface of a nutrient agar plate, which was then tilted in various directions. The plates were incubated at 37°C for 24 hours, after which the diameters of the zones of inhibition were measured with a ruler.

Screening for multi-drug resistance

All confirmed isolates were subjected for multiple drug resistance test. The standardised inocula were inoculated on a Mueller Hinton agar plate, and different classes of antibiotics discs obtained from (Bio-Rad, Turkey) and (Oxoid UK) were used. These includes; ciprofloxacin (10µg), cefuroxime (30µg), peflacine (10µg), ceftazidime (30µg), gentamicin (10µg), ceftriaxone (30 µg), ofloxacin (10µg), streptomycin (30µg), augmentin (30µg), and ceporex (10µg).

ESBL Screening test

This was carried out as described by CLS (2014). The isolates were treated for sensitivity to 3rd generation cephalosporin discs using disc diffusion method, according to the CLSI guidelines. Isolates showing inhibition zone size of ≤ 22 mm with Ceftazidime (30µg) (Bio-Rad, Turkey) and ≤ 25 mm with Ceftriaxone (30µg) (Bio-Rad, Turkey) were identified as potential ESBL producers and employed for confirmation of ESBL production.

Confirmatory Tests for ESBLs (The Double disc synergy test)

The Double disc synergy test (DDST) method was employed for the confirmation of all ESBL screened isolates. This was carried out as described by CLSI (2014). This test requires the use of two discs of third generation cephalosporin, either Cefotaxime or Ceftriaxone or Ceftazidime or Cefpodoxime. A Ceftriaxone and Ceftazidime 30µg disc each (Bio-Rad, Turkey), were placed beside augmentin (30µg) (Bio-Rad, Turkey) at distances of 25 – 30 mm apart, centre-to-centre on a lawn culture of the test isolate on Mueller Hinton Agar (MHA) plate and Incubated overnight at 37°C. ESBL production was inferred when the zone of inhibition around the ceftazidime or Ceftriaxone disc was expanded by the augmentin in a clover leaf fashion (Devi *et al*., 2014).

Ethical approval

A protocol of this research was approved by the National Health Research Ethics Committee, Ministry of Health, Nasarawa State, with NHREC Protocol No:18/06/2017

Statistical Analysis

The results obtained were subjected to two-way ANOVA, Chi-square test, and Charts using SPSS software version 20.0.

III. RESULTS

Bacterial Load of Samples in the Studied Dumpsite in Keffi Metropolis

The bacterial load from the various dumpsites soil and the adjacent control soil per gram is shown on table 1 below. Bacterial load count from Shitu Alao Barracks, NYSC camp, Old Market, College of Health Tech, New Market, Federal Government College, Nasarawa State University, Government College, Federal Medical Centre and General Hospital dumpsites were highly significant at p-value of ($p<0.01$) compared with the adjacent control sites.

Table 1: Bacterial Load in Samples Collected from Dumpsites in Keffi Metropolis

Location	Dump site	Control site	P-values
Shitu Alao Barracks	$3.31\times10^{7} \pm 1.5\times10^{2}$	$2.11\times10^{6} \pm 1.5\times10^{2}$	P<0.01
NYSC Camp	$1.68\times10^{8}\pm2.2\times10^{2}$	$1.15\times10^{6}\pm2.2\times10^{2}$	P<0.01
Old Market	$1.93\times10^{8}\pm1.4\times10^{2}$	$1.23\times10^{6}\pm1.4\times10^{2}$	P<0.01
College of Health Tech Keffi	$2.66\times10^{8}\pm1.7\times10^{2}$	$2.66\times10^{6}\pm1.7\times10^{2}$	P<0.01
New Market Keffi	$3.14\times10^{8}\pm1.5\times10^{2}$	$1.14\times10^{6}\pm1.5\times10^{2}$	P<0.01
Federal Government College Keffi	$3.32\times10^{8}\pm1.9\times10^{3}$	$2.32\times10^{6}\pm1.9\times10^{3}$	P<0.01
Nasarawa State University Keffi	$4.13\times10^{8}\pm0.9\times10^{2}$	$1.33\times10^{6}\pm0.9\times10^{2}$	P<0.01
Government College Keffi	$2.97\times10^{8}\pm0.6\times10^{2}$	$1.27\times10^{6}\pm0.6\times10^{2}$	P<0.01
Federal Medical Centre Keffi	$2.53\times10^{8}\pm0.8\times10^{2}$	$1.33\times10^{6}\pm0.8\times10^{2}$	P<0.01
General Hospital Keffi	$3.23\times10^{8}\pm0.4\times10^{2}$	$1.53\times10^{6}\ 0.4\times10^{2}$	P<0.01

Note:
P<0.01 - Highly Significant
P<0.05 - Significant
P>0.05 - Not Significant
Values in Mean ± Standard Error of Mean

Table 2 presents the cultural, morphological, and biochemical characteristics of the different bacterial isolates obtained from various dumpsites in Keffi, Nasarawa State. The results indicate that *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella pneumoniae* were the most frequently isolated bacteria from the dumpsites in Keffi city.

Table 2: Cultural, morphological and biochemical characteristics of *Klebsiella pneumoniae, Escherichia coli* and *Pseudomonas aeruginosa* from dump sites in Keffi Nasarawa State

Cultural characteristics	Morphological characteristics		Biochemical characteristics										INFERENCE
	Gram reaction	Morphology	MOTILITY	OX	CIT	IND	URE	ONPG	VP	LAC	GAS	H_2S	
Pinkish colonies on MCA	–	Bacilli	–	–	+	–	+	+	+	+	+	–	*K. pneumonia*
Pinkish colonies on MCA	–	Bacilli	+	–	–	+	–	–	–	+	+	–	*E. coli*
Pale colonies on MCA	–	Bacilli	+	+	+	–	–	–	–	–	+	–	*P. aeruginosa*

KEY: − Negative; + Positive; OX- Oxidase; CIT- Citrate; IND- Indole; URE- Urease; ONPG- Ortho-Nitrophenyl-ß-galactoside; VP- Voges Proskauer; LAC- Lactose

4.2 Prevalence of Bacterial Isolates from the various Dumpsites and adjacent control sites in Keffi Metropolis

Table 3 illustrates the prevalence of Gram-negative bacteria isolated from the dumpsites in Keffi metropolis. *Pseudomonas aeruginosa* was identified as the most common bacterium across all dumpsites, with a prevalence of 100%, being found in every sample collected from the different dump locations in Keffi. *Escherichia coli* and *Klebsiella pneumoniae* were also detected at each dumpsite, with varied prevalence in the different locations.

Table 3: Prevalence of Gram-negative Bacteria Collected from Various Dumpsites in Keffi Metropolis

LOCATION	NUMBER OF SAMPLES	*E. coli*	*P. aeruginosa*	*K. pneumonia*
Shitu Alao Barracks	15	8 (53.3)	15 (100)	5 (33.3)
NYSC Camp	15	5 (33.3)	15 (100)	3 (20)
Old Market	15	6 (40)	15 (100)	2 (13.3)
College of Health Tech Keffi	15	4 (26.7)	15 (100)	4 (26.7)
New Market Keffi	15	3 (20)	15 (100)	5 (33.3)
Federal Government College Keffi	15	7 (46.7)	15 (100)	3 (20)
Nasarawa State University Keffi	15	4 (26.7)	15 (100)	2 (13.3)
Government College Keffi	15	5 (33.3)	15 (100)	1 (6.7)
Federal Medical Centre Keffi	15	6(40)	15 (100)	2 (13.3)
General Hospital Keffi	15	2 (13.3)	15 (100)	3 (20)
TOTAL	150	50	150	30

Table 4 shows the prevalence of bacterial isolates from the various dumpsites and adjacent control sites in Keffi metropolis. *Pseudomonas aeruginosa* was the predominant bacterial in all the dumpsites and the adjacent control sites with a percentage appearance of 65.2% and 44% respectively. *Escherichia coli* had a prevalence of 21.7% in the various dumpsites and 9.40% from the adjacent control sites; *Klebsiella pneumonia* had a prevalence of 13.1% from the various dumpsites and 3.80% from the adjacent control sites. However, *Staphylococcus aureus* recorded 0.0% from the various dumpsites and 3.80% from the adjacent control sites.

Table 4: Prevalence of bacterial species collected from various dumpsites and adjacent control sites in Keffi metropolis

Isolate	**Dumpsites Soil**		**Soil adjacent**	
	Total number of isolates	Percentage(%) appearance	Total number of isolates	Percentage (%) appearance
Pseudomonas spp	150	65.22%	44	83.02%
Escherichia coli	50	21.7%	5	9.40%
Klebsiella spp	30	13.1%	2	3.80%
Staph. aureus	-	-	2	3.80%

4.3 Comparism of Bacterial Isolates between Dumpsites and Control Sites in Keffi Metropolis

Table 5 below shows the comparism of the various isolates from the different dumpsites and the isolates from the adjacent control sites. *Pseudomonas aeruginosa*, *Escherichia coli,* and *Klebsiella pneumoniae* isolated from the various dumpsites exhibited statistically significant differences ($P < 0.01$) compared to those from the control sites. However, no statistically significant differences were found between other isolates from the dumpsites and the adjacent control sites.

Table 5: Comparism of bacterial species collected from various dumpsites and adjacent control sites in Keffi metropolis

Isolates	**Dump site**	**Control site**	**c^2**	**P-values**
Pseudomonas spp	150	44	8.758	P<0.01
Escherichia coli	30	5	2.778	P<0.01
Klebsiella spp	20	2	0.581	P<0.01
Staph. aureus	-	2	1.000	P>0.01

Note:
P<0.01 - Highly Significant
P<0.05 - Significant
P>0.05 - Not Significant
Values in Mean ± Standard Error of Mean

4.4 The Susceptibility Profile of Bacterial Isolates from Various Dumpsites in Keffi Metropolis

Tables 6 and 7 present the susceptibility profiles of the 36 bacterial isolates obtained from the dumpsites in Keffi metropolis. Ciprofloxacin and Ofloxacin showed high sensitivity against *P. aeruginosa* and *K. pneumoniae* isolated from these dumpsites. Additionally, *K. pneumoniae* was highly sensitive to Streptomycin, Cefuroxime, and Pefloxacin. *E. coli* isolates demonstrated varying levels of sensitivity to the antibiotics tested in this study. Nevertheless, all bacterial isolates exhibited varying degrees of resistance to the different drugs used in the study.

Table 6 The Susceptibility Profile of Bacterial Isolates from various dumpsites in Keffi metropolis

Isolates	No. Tested	CXM	CIP	OFX	STR	PEF	CN	AUG	CTX	CEP	CAZ
Escherichia coli	50	30 (60.0)	45 (90.0)	45(90.0)	40(80.0)	45(90.0)	35(70.0)	20(40.0)	35(70.0)	35(70.0)	30(60.0)
P. aeruginosa	150	120(80.0)	150 (100.0)	150(100.0)	135(90.0)	145(96.7)	134(89.3)	120(80.0)	135(90.0)	130(86.7)	120(80.0)
K. pneumonia	30	30 (100.0)	30 (100.0)	30 (100.0)	30 (100.0)	30 (100.0)	25(83.3)	15(50.0)	30(100.0)	20(66.7)	25(83.3)

KEY: Antimicrobial agent

CIP= CIPROFLOXACIN
CXM=CEFUROXIME

PEF= PEFLOXACIN
CAZ= CEFTAZIDIME
CN= GENTAMYCIN
CXT=CEFOTAXIDENS
OFX=OFLOXACIN
STR=STREPTOMYCIN
AUG= AUGMENTIN
CEP=CEPOREX

Table 7: Antimicrobial Resistance of the Bacteria Isolated from the Dump Sites in Keffi Metropolis

ANTIMICROBIALS	DISC CONTENT (µg)	*E. coli* (50)	*P. aeruginosa* (150)	*K. pneumonia* (30)
CEFUROXIME	30	20 (40.0)	30 (20.0)	0 (0.00)
CIPROFLOXACIN	10	5 (10.0)	0 (0.00)	0 (0.00)
OFLOXACIN	10	5 (10.0)	0 (0.00)	0 (0.00)
STREPTOMYCIN	30	10 (20.0)	15 (10.0)	0 (0.00)
PEFLACINE	10	5(10.0)	5 (3.3)	0 (0.00)
GENTAMYCIN	10	15 (30.0)	16 (10.7)	5 (16.7)
AUGMENTIN	30	30 (60.0)	30 (20.0)	15 (50.0)
CEFTRIAXONE	30	15(30.0)	15(10.0)	0 (0.00)
CEPOREX	10	15(30.0)	20 (13.3)	10 (33.3)
CEFTAZIDIME	30	20(40.0)	30 (20.0)	5 (16.7)

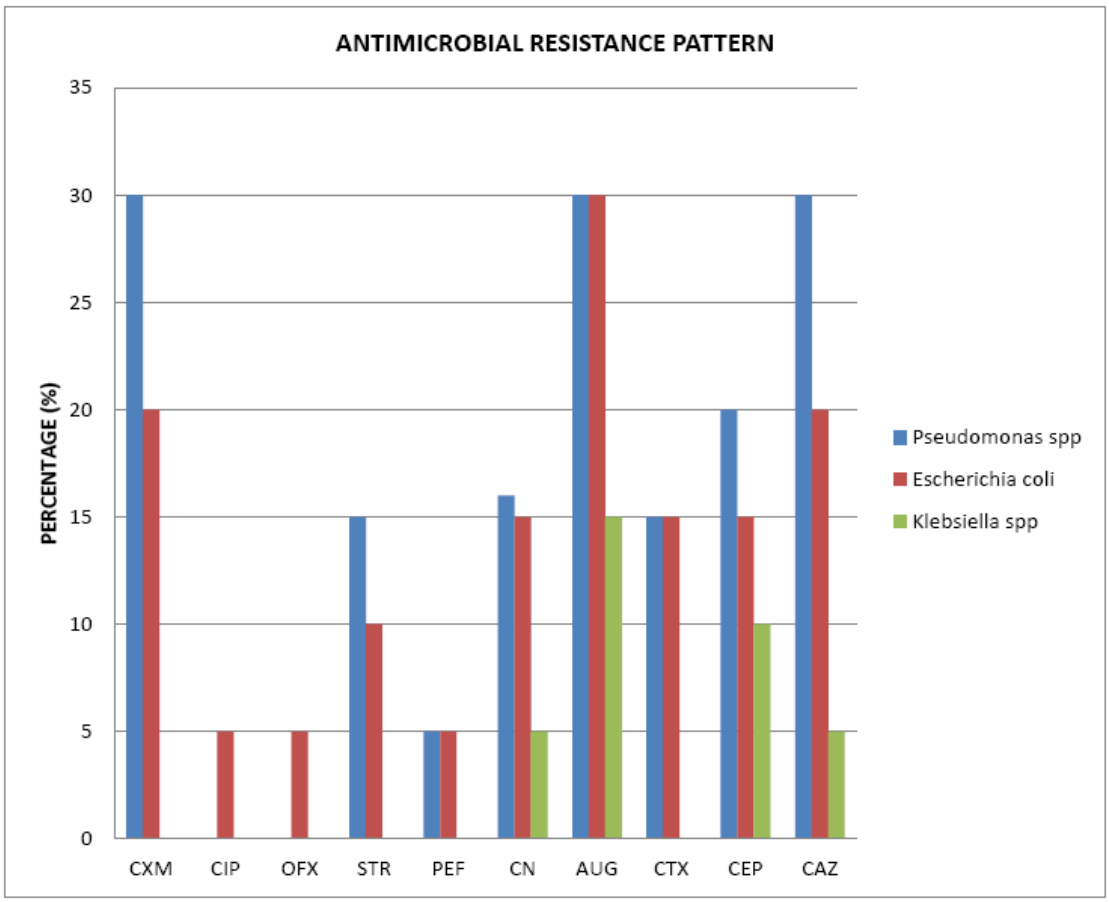


Figure 1: Antimicrobial Resistance Profiles of Bacteria Isolated from Dumpsites in Keffi Metropolis

4.5 Extended-Spectrum Beta-Lactamase (ESBLS) enzyme among the gram negative bacterial isolates from various dumpsites Keffi Metropolis

The phenotypic tests conducted using the double disc method to identify ESBLs among the Gram-negative bacterial isolates (as shown in Tables 8 and 9) revealed that out of the three isolates (*Pseudomonas aeruginosa*, *E. coli*, and *K. pneumoniae*) from the dumpsites in Keffi metropolis, *Pseudomonas aeruginosa* was positive for Extended-Spectrum Beta-Lactamase (ESBL) in 9 cases, E. coli in 5 cases, *and K. pneumoniae* in 1 case. Conversely, *Pseudomonas aeruginosa* (21), E. coli (15), and *K. pneumoniae* (4) were found to be negative for the ESBL test.

Table 8: Occurrence of Extended-Spectrum Beta-Lactamase Isolates from Soil of Dump Sites in Keffi Metropolis

ISOLATES	NUMBER OF CEPHALOSPORIN RESISTANT ISOLATES	NUMBER OF ESBL POSITIVE	NUMBER OF ESBL NEGATIVE
E. coli	20	5 (25%)	15 (75%)
P. aeruginosa	30	9 (30%)	21 (70%)
K. pneumonia	5	1 (20%)	4 (80%)
TOTAL	55	15	40

4.6 Classification of antimicrobial resistance among Isolates in Soil from Dump Sites in Keffi Metropolis

The classification of antimicrobial resistance among the isolates in soil from the dumpsites in Keffi metropolis indicated that *Pseudomonas aeruginosa* (50), E. coli (10), and K. pneumoniae (6) displayed extensive drug resistance to two or fewer classes of antibiotics used (as seen in Table 9). Additionally, *Pseudomonas aeruginosa* (40), E. coli (20), and K. pneumoniae (3) exhibited a multidrug resistance (MDR) pattern to more than two classes of the antibiotics tested.

Table 9: Classification of Antimicrobial Resistance in Soil Isolates from Dumpsites in Keffi Metropolis.

Classes of Antimicrobial Resistance	*E. coli*	*P. aeruginosa*	*Klebsiella Spp.*
XDR	10	50	6
MDR	20	40	3
PDR	0	0	0

Key:
Extensive drug resistance (XDR)=Resistance to less than or equal to 2 classes of antibiotics used.
Multi drug resistance (MDR)= Resistance to greater than 2 classes of antibiotics used.
Pan drug resistance (PDR)= Resistance to all the classes of antibiotics tested

IV. DISCUSSION

Solid wastes are the most conspicuous and repugnant aspect of the environmental problem that are encountered in Nigeria (Igbinomwanhia, 2012). Waste is often indiscriminately discarded at designated sites in developing countries, and the management of such waste has not been adequately assessed regarding its potential risks to waste handlers, the environment, and public health. Dumpsites sites are known to harbor antibiotic-resistant bacteria and genes, which may exacerbate the issue of antibiotic resistance (Wang *et al*., 2018; Ilusanya *et al*., 2023). In Nigeria, several solid waste management practices are implemented, including composting, use of dumpsites, incineration, and recycling (Oviasogie and Agbonlahor, 2013). However, the dumpsites receive waste from all sources within the metropolis.

The results from this study depicts a significant ($p<0.01$) bacterial load count from Shitu Alao Barracks, NYSC camp, Old Market, College of Health Tech, New Market, Federal Government College, Nasarawa State University, Government College, Federal Medical Centre and General Hospital dumpsites compared with the adjacent control sites. The bacterial count ranges from 3.31×107 to 4.13 × 108 cfu/g in soil samples. This finding is in alignment with the report of Ilusanya *et al*. (2023) in the Mile 12 dumpsite popularly called "Gangere", located behind the popular Mile 12 International market within the confines of the Kosofe local government area in Lagos State, Southwest Nigeria. Similar studies have been conducted in various parts of the world, and the results have varied depending on the sample source and location. Alao *et al*. (2012), reported total bacterial counts ranging from 2.2x106 to 3.8x107 cfu/g in soil samples, which is consistent with the high count obtained in the current study. Johnson and Kuehn, (2002) also reported that total bacterial counts in leachate samples from dumpsites ranged from 2.5x106 to 1.1x107 cfu/ml, which is also in alignment with the discoveries of this study. A study by Chetan *et al*. (2017) also reported similar findings from various solid waste samples collected in different seasons; Rainy, winter, and Summer in India.

In this study, three genera of bacteria were isolated from the various dumpsites, with descending order of prevalence: *Pseudomonas spp*. (65.22%), *Escherichia coli* (21.70%), and *Klebsiella spp*. (13.10%). Notably, *Pseudomonas aeruginosa* was the most prevalent bacterium found in all the dumpsites as well as in the adjacent control sites, with occurrences of 65.2% and 44%, respectively. *Escherichia coli* had a prevalence of 21.7% in the various dumpsites and 9.40% from the adjacent control sites; *Klebsiella pneumonia* had a prevalence of 13.1% from the various dumpsites and 3.80% from the adjacent control sites. However *Staphylococcus aureus* recorded 0.0% from the various dumpsites and 3.80% from the adjacent control sites. This finding is in consonant with the report of Omusi *et al*. (2017), who reported the identification of various bacteria isolates *Bacillus spp.* (30.01%), *Klebsiella spp*. (24.27%), *Staphylococcus aureus* (12.62%), Coagulate Negative *S .aureus* (CONS)(10.68%), *Pseudomonas spp*. (6.79), *E. coli* (4.85%), *Alcaligenes sp*p. (4.85%) and *Proteus spp*. (2.91%) from various dumpsites in Benin City metropolis, southern Nigeria. Ilusanya *et al*. (2023) equally reported the identification of seven genera of bacterial isolates which includes; *Providencia spp., Bacillus spp., Salmonella spp.*, *Escherichia coli*, *Shigella spp., Pseudomonas spp.* and *Streptococcus spp.* from the Mile 12 dumpsite in Kosofe local government area in Lagos State, Southwest Nigeria. A study conducted by Williams and Hakam, (2016) in Port-Harcourt metropolis, Nigeria, stated the identification of *Bacillus spp., Escherichia coli, Klebsiella spp., Proteus spp., Pseudomonas spp., Staphylococcus aureus,* and *Streptococcus spp.* respectively. Previous research by Oviasogie and Agbonlahor, (2013) in Benin City, Nigeria, follows a similar trend. Similar bacteria species has been isolated from dumpsites in the south-west regions of Nigeria by other researchers, such as Achudume *et al*. (2007), Adekanle *et al*. (2014), Odeyemi, (2012), and Sulaimon *et al*. (2016). The report of Mwaikono *et al*. (2015), also showed a high abundance of these bacterial presence within municipal dumpsites in Tanzania.

In this study, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella pneumoniae* isolated from various dumpsites exhibited statistically significant differences ($P<0.01$) compared to those from control sites. However, no significant differences were found among other isolates from the dumpsites and the adjacent control sites. Frequent interactions between humans and animals at dumpsites may contribute to the presence of *E. coli*, which can transmit fecal enteric pathogens into the soil. *Pseudomonas spp*. found in the waste dumpsites and nearby control areas are associated with infections and severe diseases. These organisms are clinically significant and opportunistic pathogens, responsible for 5-15% of nosocomial infections. Common infections caused by *Pseudomonas spp*. include urinary tract infections, septicemia in immunocompromised individuals, and acute purulent meningitis. They not only cause serious and often life-threatening illnesses but also exhibit inherent resistance to many antibiotics, with the potential to develop new resistances after exposure to antimicrobial agents.

Klebsiella spp. isolated from the dumpsites and adjacent control areas are frequently implicated in hospital-acquired urinary tract infections, wound and burn infections, and as secondary invaders in respiratory infections. They are the most commonly encountered gram-negative pathogens in lower respiratory tract nosocomial infections, following *E. coli* in cases of primary bacteremia caused by gram-negative bacteria. The findings from this study suggest that the dumpsite is a habitat for diverse bacterial species that may pose a public health risk. Identifying and characterizing microorganisms in soil samples is vital for understanding their ecological roles and potential biotechnological applications. A similar study by Ahmed *et al*. (2019) isolated eleven bacterial species from soil samples at a municipal waste dumpsite in Nigeria, identifying them as *Bacillus spp., Enterobacter spp., Escherichia coli, Klebsiella spp*., and *Pseudomonas spp.* based on their morphological and biochemical traits. Mueen *et al*. (2020) also reported *Bacillus spp., Pseudomonas spp., Serratia spp.*, and *Staphylococcus spp*. in soil samples from a dumpsite in Pakistan. These results align with previous studies that found *E. coli, Pseudomonas spp.,* and *Klebsiella spp.* present in soil samples from dumpsites. The presence of gram-negative bacteria in dumpsite environments has also been documented in various research efforts. Sabir *et al*. (2019) noted that most bacteria isolated from dumpsite leachate were gram-negative rods, including E. coli and *Pseudomonas aeruginosa*. Similarly, Ye *et al*. (2020) reported that the dominant bacterial phylum in dumpsite leachate was Proteobacteria, encompassing gram-negative bacteria such as *E. coli* and *Pseudomonas aeruginosa*. Aerobic bacteria commonly found in dumpsite environments, like those that produce catalase and utilize glucose, exhibit variable results in indole production, citrate utilization, and oxidase activity, suggesting the presence of different species within the same bacterial genera, which is typical in complex environments like landfills. Various microorganisms, including pathogenic bacteria, can contaminate water sources near dumpsites, posing a threat to human health. Previous studies have investigated the microbial quality of borehole water close to dumpsites, revealing the presence of pathogenic bacteria, including *E. coli, Salmonella spp*., and other gram-negative rods (Ayandele *et al*., 2020).

In this study, *P. aeruginosa* and *K. pneumoniae* isolated from different dumpsites in the Keffi metropolis showed high sensitivity to Ciprofloxacin and Ofloxacin. K. pneumoniae isolates were also highly sensitive to Streptomycin, Cefuroxime, and Pefloxacin. *E. coli* isolates displayed varying degrees of sensitivity to all the drugs tested. *P. aeruginosa, E. coli*, and *K. pneumoniae* demonstrated resistance to Augmentin,

Gentamicin, Ceporex, and Ceftazidime, while *P. aeruginosa* and *E. coli* showed resistance to Cefuroxime, Streptomycin, Peflacin, and Ceftriaxone. The notable antibiotic resistance exhibited by these isolates raises public health concerns, as their resistance to commonly prescribed antibiotics for bacterial infections highlights dumpsites as potential sources of antibiotic-resistant strains and the emergence of novel diseases. Previous research has documented antibiotic resistance among bacteria isolated from dumpsite soils, with Adekanle *et al*. (2014) reporting the isolation of antibiotic-resistant bacteria from dumpsites in south western Nigeria, and Odeyemi (2012) indicating high levels of antibiotic resistance among bacteria from dumpsite soils in Ogun State, Nigeria. Sulaimon *et al*. (2016) also found antibiotic-resistant bacteria isolated from dumpsites in Lagos, Nigeria.

Additionally, a study by Mwaikono *et al*. (2015) in Tanzania found significant antibiotic resistance among bacterial isolates obtained from municipal dumpsites. The research indicated that Ciprofloxacin and Ofloxacin were effective against enteric bacterial isolates from these sites. However, this study contrasts with the views of Oviasogie and Agbonlahor (2013), who claimed that fluoroquinolones were effective against isolates from dumpsites. Conversely, the current investigation revealed considerable resistance among organisms to augmentin, gentamicin, ceporex, and ceftazidime. This resistance is likely due to gene mutations that may enable these bacterial species to acquire antibiotic resistance genes. These results highlight the risk of spreading persistent and difficult-to-treat bacterial infections in the local community. Moreover, the inappropriate reuse of food packaging, such as bottles scavenged from dumpsites, provides another means for these isolates to infect humans.

V. CONCLUSION

This study concludes that municipal dumpsites serve as a significant source of a variety of harmful bacteria, negatively impacting the health of individuals living nearby, compounded by a lack of awareness regarding proper waste management. The research identified bacterial isolates from the dumpsites in the following descending order: *Pseudomonas spp*. (65.22%), *Escherichia coli* (21.70%), and *Klebsiella spp*. (13.10%). It was noted that *Pseudomonas aeruginosa* was the most prevalent bacterium across all dumpsites and nearby control sites, with prevalence rates of 65.2% and 44%, respectively. While most antibiotics tested showed high sensitivity against the bacterial isolates, some organisms displayed resistance to commonly prescribed antibiotics. Notably, Ciprofloxacin and Ofloxacin proved effective against the majority of bacterial isolates from the dumpsites.

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