ANTIBIOTIC SUSCEPTIBILITY PROFILE OF BACTERIAL PATHOGENS AND HEALTH HAZARDS ASSOCIATED WITH MUNICIPAL SOLID WASTES IN GBOKO TOWN, NIGERIA

ABSTRACT

Municipal solid wastes constitute one of the most challenging health and environmental hazards facing urbanizations in African countries. This study was therefore carried out on antibiotics susceptibility profile of bacterial pathogens and possible health hazards that could be associated with municipal solid wastes in Gboko town, Nigeria. Fourty samples were collected for bacteriological analyses. The municipal solid wastes collected were mixed homogenously, segregated and each segregate was weighed and recorded. The bacteriological loads and flora of the wastes were determined with their antibiogram undertaken. A structured questionnaire was administered to households in order to assess the challenges and hazards associated with the wastes in Gboko town. The biodegradable bulks occupied the total mean of 63.59 % while the non-biodegradable matter formed the remaining 36.41% respectively. The bacterial isolates from the dumps with their respective percentage frequencies of occurrence and their mean percentage antibiotic susceptibility profiles in brackets were *Salmonella typhi 84.12 (61.90), Escherichia coli* 87.49 (50.00), S*taphylococcus aureus* 82.19 (60.44), *Proteus sp* 46.10 (91.11), *Streptococcus sp* (65.75 (83.33) and *Pseudomonas aeruginosa* 85.23 (60.32). The bacteria isolated are generally known pathogens; hence their presence in the dumps in such high prevalence levels could pose health hazards to the public in the town.

Keywords: Municipal solid waste, Biodegradable wastes, Biomass energy, Antibiotics susceptibility

INTRODUCTION

Wastes are substances, materials or objects discarded as worthless or unwanted, defective of no further value for human economic production processes or activities [1]. They have also been described as any substances in solution, mixture or article for which no direct use is envisaged but which is transported for dumping, reprocessing, elimination by incineration or other mixture [2]. Man's unwanted materials which are non-gaseous, non-liquid and consist of organic matter (easily biodegradable) and inorganic (non-biodegradable which include metals, plastics, bottles and broken glasses) are called solid wastes. Municipal solid wastes are those generated in urban centers and consist of household garbage, agricultural and industrial garbages as well as those from construction and recreational activities of man [3].

Reports from PAI Associates International, 2010 [4] indicated that solid wastes from some Nigerian cities are biodegradable from food processing and other ruminants with figures varying between low and high density areas. According to [5], virtually all the states or

Nigeria are highly polluted, largely from domestic solid waste, with as many as 25% of the people living in the towns.

Bacteria associated with wastes and waste biodegradable substances as determined by [3] in Angwan-rogo slum in Jos metropolis include *Staphylococcus aureus, Escherichia coli* and *Salmonella spp.* Faecal coliforms and *Streptococci* have been reported to be associated with wastes. *Arthrobacter, Bacillus* and *Pseudomonas spp* were reported by [6] to be associated with waste. [7] reported *Enterobacter, Escherischia coli, Sarratia* among others. *Pseudomonas* has been widely reported to be associated with wastes [8].

Solid waste management has emerged as one of the greatest challenges facing municipal authorities worldwide especially in developing countries [9]. At an increased rate, the amount of solid waste generated in the environment has continually increased than resources available to contain it. Health and education has been a challenge to municipal solid waste management (MSWM) to the top of the list the making situation in developing nations is more critical since their resources are usually meagre [10]. Monuments of solid waste adorning the streets of urban centers in countries like Nigeria has been ill conceived and operated epileptic MSWM systems that leave. At an alarming rate over the years without corresponding efficient and modern technology for managing the waste, the quantity and generation rate of solid waste in Nigeria have increased [11]. In developing countries, there is an increased and compounded cycle of poverty, population explosion, decreased standards of living and poor governance and low level of environmental awareness caused by the indiscriminate and improper dumping of MSW. In any available open space, waste generated is illegally disposed, hence the term “Open Dump Site”. Solid waste in Nigeria poses many problems including blockage of drainage and channels causing flooding and presenting breeding grounds for mosquitoes and other vectors and pathogens [12]. In Nigeria, more than 25 million tonnes of solid waste is generated annually with average rate from 0.44 kg/cap/day in rural areas to 0.66 kg/cap/d in urban cities [13].

To ensure compliance with state and federal regulations, modern MSW landfills are well-engineered facilities that are located, designed, operated, and monitored. MSW landfills are required to meet design, siting, operating, closure and post closure requirements [10]. There are design standards (consisting of re-compacted soil overlain by a flexible membrane liner), a multilayer cap system and surface water management, a leachate management system (designed to limit the level of leachate on the liner system to one foot) for the composite liner system. The rules allow alternative materials and thicknesses to accommodate advances in technology. Every 10 years the facility undergoes a review of the landfill design to demonstrate it is consistent with current design standards (OAC 2010) [14].

Solid wastes pose unsightly scenes; they create putrefying organic matter producing nauseating odours [15]. The dumps are also hazardous because they constitute breeding ground for disease vectors and pathogens or their toxins which are known or suspected to

cause diseases in animals and humans [16]. Wastes pose great threat to both man, animals and the soil. Like chemical hazards, aerologic agents might be dispersed in the environment through water and wind. Poisonous plants, insect's animals and indigenous pathogens are biological hazards that may be encountered at the waste site. Waste management in Nigeria is usually equated with land disposal or discharge into the bodies of water [17]. This method of waste management is unscientific and causes nuisance to the public and constitute pollution when waste is dumped in the land. Soil microorganism including bacteria and fungi, readily colonize the waste, carrying out the degradation and transformation of degradable (organic) materials in the waste [18]. This research aims to determine the antibiotic susceptibility profile of bacterial pathogens and health hazards associated with municipal solid wastes in Gboko town, Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in Gboko town in the four major zones (that is Gboko North, South, East, and West) of Benue State, Nigeria. Gboko has a landmass of 2,264 square kilometers, a population of 358, 936 people (2006 Census), making it one of the most populous local government area in Benue State. On the political map of Nigeria, it is located between latitude $6^0$30' and $8^0$10' North of the equator and longitude 8' and 10' east of the Greenwich meridian. The climate is tropically sub humid with daily temperature of about 32^0C, while mean annual rainfall is between 1200 and 1600mm. Rainy season starts from April to October, while dry season, is from early November to March. Geographical boundaries show that Gboko local government is bounded by Tarka and Guma to the south, Buruku local government to the west, Konshisha and Ushongo to the south-west. Most inhabitants are farmers.

Collection of Samples

Samples collections were carried out in Gboko town, Nigeria. The municipal solid wastes were collected randomly from forty sampling dump site at Gboko town. The samples were taken in the four location of Gboko town namely Gboko North, Gboko South, Gboko East, and Gboko West. Each dump site ten (10) samples were collected in the four different locations in Gboko town, making a total of forty (40) samples.

At each sampling station, the surface, sub-surface and the depth of about 10cm were scoped into sterile sample cans and appropriately labeled.

Lab coat, sterile gloves and nose masks were worn during collection of wastes to prevent infection by pathogens. After collection of wastes, wastes samples were transported to the laboratory and treated within 24 hours (after collection) for isolation and characterization of microorganisms. After which the wastes were homogeneously mixed and then segregated

into various classifiable bulks and then weighed separately and the weight determine using top loading balance.

Isolation and Enumeration of Bacteria in Waste Sample

Nutrient agar (NA), MacConkey, (MCA), *Salmonella Shigella* agar (SSA) were used as culture media, they were prepared as described by Prakasam *et al* 2017. From the dumps collected, 500g of each sample was thoroughly shaken in 250ml of sterile distilled water and vigorously shaken to produce suspension of bacteria contained in the waste. An aliquot (1.0ml) was transferred aseptically into a test-tube containing 9mls of sterile distilled water and diluted serially in one tenth stepwise to 10^6 dilutions [19]. From the dilution 10^4 of each sample, 1ml of aliquot was transferred aseptically into freshly nutrient agar plate, MacConkey plate and *Salmonella Shigella* agar plate and spread with a sterile bent glass rod [19]. The dilution of 10^4 were used and a duplicate of each plate were made. The inoculated plates were then inverted and then incubated at 37^0C for 24 hours, after which the plates were examined for growth. The developed discrete colonies were counted and the average counts for duplicate cultures were recorded as total viable aerobic heterotrophic bacteria in sample. This procedure was repeated for each dump samples.

Identification and Characterization of Bacteria in the Waste Dump Site

The pure cultures were identified and characterized on the basis of their cultural, morphological, physiological and biochemical characteristics in accordance with methods described by [19].

Antibiotic susceptibility testing

Susceptibility testing was performed by the disc diffusion assay on Muller Hinton Agar by modified Kirby-Bauer method [19] using the following nine commonly used antibiotics disc, Amoxycillin 25mcg, Co-trimoxazole 25mcg, Nitrofurantoin 200mcg, Gentamicin 10mcg, Ofloxacin 5mcg, ciprofloxacin 5mcg, Augmentin 30mcg, and Tetracycline 30mcg. Standard interpretative chart was used in the interpretation of diameter of growth inhibition zones. Organisms were scored as sensitive or resistant based on the zone diameters of inhibition. Diameters of growth inhibition zones were recorded to the nearest mm for an average of 3 readings in each case.

Statistical Analysis

SPSS software version 21 was used to carry out the statistical analysis. To determine the analysis of variance (ANOVA) using Duncan's multiple range test (JMP v.12 software; SAS Inst., Cary, NC, USA), data were analyzed. P-value less than 0.05 ($P < 0.05$) were estimated to determine the significant differences.

RESULTS

Table 1: Bacterial loads of municipal solid wastes samples collected from different locations of Gboko Town, Nigeria

Sample Codes	**Gboko North ($X10^8$ Cfu/g)**	**Gboko South ($X10^8$ Cfu/g)**	**Gboko East ($X10^8$ Cfu/g)**	**Gboko West ($X10^8$ Cfu/g)**
W_1X4	4.9	7.0	4.9	4.6
W_2X4	4.3	6.7	3.3	6.0
W_3X4	5.4	7.0	4.4	5.6
W_4 X4	4.6	8.0	4.3	4.6
W_5X4	5.3	7.0	5.4	4.6
W_6X4	3.5	6.9	4.3	3.5
W_7X4	6.7	7.8	3.4	5.0
W_8X4	5.6	5.7	2.8	4.0
W_9 X4	3.8	6.0	4.3	3.5
$W_{10}X4$	4.0	5.7	1.5	5.4
Mean	**4.8**	**6.8**	**3.9**	**4.7**

Key

W_nX4 -- Codes for each of the samples from 1 to 10 in each of the four locations of Gboko (North, South, East and West) respectively

Cfu/g -- Colony Forming Unit/Gram

Table 2: Morphological, Microscopic and Biochemical characteristics of Bacterial isolates associated with municipal solid waste in Gboko Town, Nigeria

Isolate colour	GMR	Shape	Arrangement	Motility	Catalase	Coagulase	Indole	Citrate	Oxidase	TSIA	Suspected organism
NA PLATE											
Creamy colony	-ve	Rod	Single/cluster	+ve	+ve	-ve	+ve	-ve	-ve	A/A	*Escheriachia coli*
Yellowish colony	-ve	Cocci	Cluster	-ve	+ve	+ve	-ve	+ve	-ve	K/A	*Staphylococcus aureus*
Swampy colony	-ve	Short rod	Singly	+ve	+ve	-ve	+ve	+ve	-ve	K/A	*Proteus sp*
MCA PLATE											
Pinkish colony	-ve	Rod	Singly/cluster	+ve	+ve	-ve	+ve	-ve	-ve	A/A	*Escheriachia coli*
Milky colony											
Wet colony	-ve	Short rod	Cluster	-ve	+ve	-ve	-ve	+ve	-ve	A/A, gas	*Klesiella sp*
Greenish colony	-ve	Rod	Cluster	+ve	+ve	-ve	-ve	+ve	+ve	K/K	*Pseudomonas aerigonosa*
SSA PLATE											

Pnkish colony	-ve	Rod	Singly	-ve	+ve	-ve	-ve	-ve	-ve	K/A	*Shigella sp*
Blackish colony	-ve	Rod	Singly	+ve	+ve	-ve	-ve	+ve	-ve	K/A, K/Ag	*Salmonella sp*

Legend Key diagnostic Features Use for Identification

1. Catalase + and Coagulase + = *Staphylococcus aureus*
2. Indole + = *Escherichia coli*
3. *Urease + = proteus sp*
4. *Oxidase + = Pseudomonas aeruginosa*
5. *Citrate + = Klebsiella sp*
6. *Tsi (H_2S) = Salmonella sp*
7. *GMR= Gram reaction*
8. *NA= Nutrient agar,*
9. *MCA* = MacConkey agar
10. *SSA = Salmonella Shigella sp*

Table 3: Percentage Frequency of occurrence of Bacterial Isolates Associated with Municipal Solid Wastes in Gboko Town, Nigeria

Bacterial isolates	**Frequency of Occurrence (%)**				
	Gboko North	**Gboko South**	**Gboko East**	**Gboko West**	**Mean**
Salmonella typhi	86.66	86.66	86.66	76.50	**84.12**
Escherichia coli	89.99	93.30	86.66	80.66	**87.49**
Staphylococcus aureus	83.33	86.66	80.00	78.78	**82.19**
Proteus sp	49.99	53.33	46.66	37.98	**46.10**
Streptococcus sp	66.66	73.33	63.00	60.00	**65.75**
Pseudomonas aeruginosa	83.66	87.00	83.66	86.60	**85.23**

Table 4: The Antibiogram of Bacterial isolates from the Municipal Solid Wastes in Gboko Town, Nigeria

Organisms	*Pseudomonas aeruginosa n =7*		*Escherichia coli n=8*		*Salmonella typhi n =7*		*Staphylococcus aureus n=8*		*Proteus sp n=5*		*Streptococcus sp n=8*	
Antibiotics	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
Septrin (30ug)	3	4	3	5	0	7	0	8	4	1	7	1
Chloramphenicor(30ug)	7	0	0	8	3	4	3	5	4	1	5	3
Gentamycin (10ug)	7	0	8	0	7	0	8	0	5	0	4	4
Streptomycin (10 ug)	0	7	0	8	0	7	3	4	5	0	7	1
Ceftriazone (30ug)	0	7	0	8	1	6	7	1	4	1	6	2
Ciprofloxacin (10ug)	7	0	8	0	7	0	8	0	5	0	8	0
Augmentin (30ug)	7	0	8	0	7	0	8	0	5	0	8	0
Amoxicillin (25ug)	0	7	8	0	7	0	8	0	5	0	7	1
Erythromycin (5ug)	7	0	1	7	7	0	5	3	4	1	8	0
Mean (Mean %)	**4.22 (60.32)**	**2.78 (39.68)**	**4 (50.00)**	**4 (50.0)**	**4.33 (61.90)**	**2.67 (38.10)**	**5.56 (69.44)**	**2.5 (30.56)**	**4.55 (91.11)**	**0.44 (0.08)**	**6.67 (83.33)**	**1.33 (16.67)**

Key:

n - Number of isolates
S - Sensitive to antibiotic
R - Resistant to antibiotic

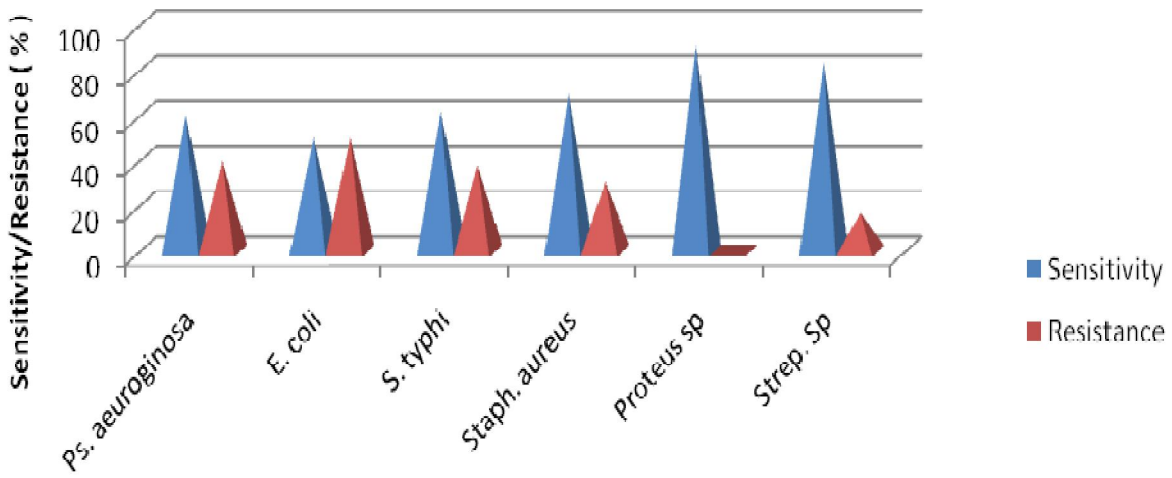

Figure 1: Percentage Sensitivity/ Resistance of Bacteria isolated from Municipal Solid wastes in Gboko Town, Nigeria

Table 5: Relative Abundance (Percentage bulk) of Segregates of Municipal Solid Wastes MSW) Collected from Gboko Town, Nigeria.

Categories of Wastes	Gboko South	Gboko North	Gboko East	Gboko West	Mean
A. Biodegradable					
a. Food residues	27.55	20.88	21.47	23.19	23.27
b. Plant waste matter	20.56	26.48	24.41	22.45	23.47
c. Paper	8.85	3.66	6.08	6.45	6.26
d. Wood	11.45	9.36	12.36	10.80	10.49
Total (biodegradable)	**68.41**	**60.38**	**64.32**	**61.24**	**63.59**
B. Non biodegradable					
a. Glass	7.10	7.64	6.32	6.45	6.87
b. metals/tin cans	6.30	6.67	7.01	7.21	6.97
c. polythene bags	5.10	6.49	5.38	5.92	5.72
d. Plastics	3.89	6.38	4.53	3.64	4.61
e. Rubber	2.79	3.87	3.55.	3.67	2.58
f. Ceramics	4.41	3.75	4.45	6.78	4.85
g. textiles and others	2.00	4.86	4.44	5.08	4.10
Total (non-biodegradable)	**31.59**	**39.61**	**35.68**	**38.76**	**36.41**

Table 6: Biodata of Respondents on Municipal Solid Wastes and Management in Gboko Town, Nigeria

Parameters	**Gboko North**	**Gboko South**	**Gboko East**	**Gboko West**	**Total (%)**
Age classification (years)					
18 – 30	0	3	2	1	**6 (15.00)**
31 – 40	4	5	6	3	**18 (45.00)**
41 – 50	5	0	2	4	**11(27.50)**
51 – 60	1	2	0	2	**5(12.50)**
61 – ≥70	0	0	0	0	**0(0.00)**
Total					
Marital Status					
Married	10	6	6	9	**31(77.50)**
Divorced/widowed	0	1	2	0	**3(7.50)**
Single	0	3	2	1	**6(15.00)**
Total					
Educational Status					
Primary Education	0	1	0	0	**1(2.50)**
Secondary Education	3	6	6	4	**19(47.50)**
Tertiary Education	7	4	4	4	**19(47.50)**
None	0	0	0	1	**1(2.50)**
Total					
Occupation					
Civil Servant	4	1	4	4	**13(32.50)**
Farmer	1	2	0	1	**4(10.00)**

Business	4	5	6	5	**20(50.00)**
Unemployed	1	2	0	0	**3(7.50)**
Total					
Size of household (Mean)	6.2	5.2	5	6.3	**5.7 (Mean)**

Table 7: Management of Wastes by Respondents in Gboko Town, Nigeria

Parameters	Gboko North	Gboko South	Gboko East	Gboko West	Total (%)
How often wastes are disposed of					
Not at All	0	0	0	0	0 **(0.00)**
Daily	2	2	3	7	14 **(35.00)**
Weekly	6	7	7	3	23 **(57.50)**
Monthly	2	1	0	0	3**(7.50)**
Type of difficulties in disposing wastes					
No difficulties	9	7	10	7	33**(82.50)**
Lack of time	0	1	0	2	3**(7.50)**
Lack of facilities	1	2	0	1	4**(10.00)**
Do you segregate wastes before disposal?					
Yes	1	1	0	0	2**(5.00)**
No	9	9	10	10	38**(95.00)**

Table 8: Responses on the degree of problems Municipal Solid Wastes could pose to the health of people in Gboko Town, Nigeria

Parameter	Gboko North				Gboko South				Gboko East				Gboko West				Total
	No problem at all	Seldom	High	Very high	No problem at all	Seldom	High	Very high	No problem at all	Seldom	High	Very high	No problem at all	Seldom	High	Very high	
Flies	2	6	1	1	1	2	3	4	0	3	2	5	0	3	2	5	**40**
Odour	3	4	3	0	2	3	5	0	0	1	6	3	1	3	5	1	**40**
Loss of scenic beauty	2	8	0	0	2	1	7	0	0	5	5	0	1	6	2	1	**40**
Rodents	7	2	1	0	8	1	1	0	8	2	0	0	3	5	2	0	**40**
Erosion	0	10	0	0	7	0	3	0	2	7	1	0	3	5	2	0	**40**
Injury to people	0	1	9	0	4	0	4	2	0	1	8	1	0	1	9	0	**40**
Water contamination	0	0	4	6	1	1	7	1	0	0	3	7	0	0	5	5	**40**
Psychological problem	0	2	8	0	2	4	3	1	0	1	7	2	0	0	8	2	**40**
Transfer of disease	0	0	6	4	1	4	4	1	0	0	8	2	0	1	6	3	**40**
Sub-mean (%)	**1.5(15)**	**3.6(36)**	**3.5(35)**	**1.2(12)**	**3.1(31)**	**1.7(17)**	**4.1(41)**	**1(10)**	**1.1(11)**	**2.2(22)**	**4.4(44)**	**2.2(22)**	**0.8(8)**	**3.1(31)**	**4.3(43)**	**1.8(18)**	

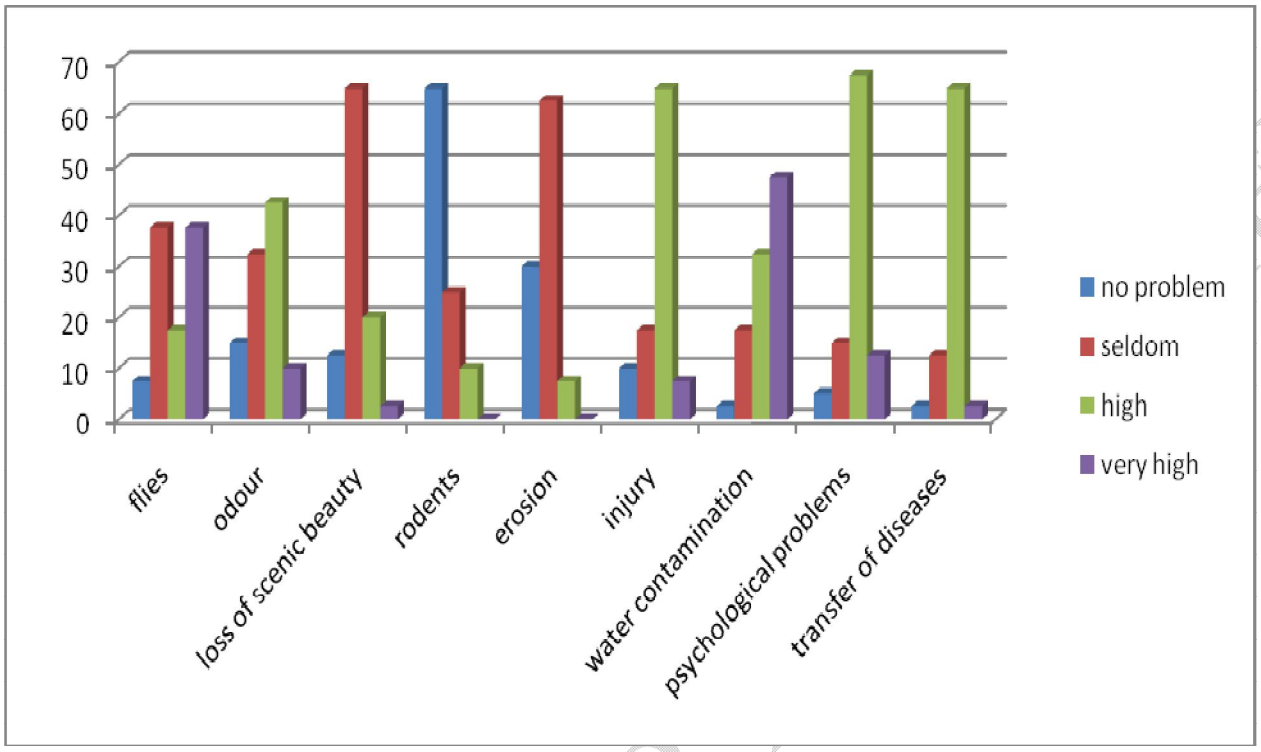

Figure 2: Means of responses of residents of Gboko Town with respect to degrees of problems posed by municipal solid wastes.

Table 9: Summary of Responses on the degree of problems Municipal Solid Wastes could pose to the health of people in Gboko Town, Nigeria (n=40)

SUMMARY	No problem at all	Seldom	High	Very high
Flies	3 (7.50)	15(37.50)	7(17.50)	15(37.50)
Odour	6(15.00)	13(32.50)	17(42.50)	4(10.00)
Loss of scenic beauty	5(12.50)	26(65.00)	7(17.50)	1(2.50)
Rodents	26(65.00)	10(25.00)	4(10.00)	0(0.00)
Erosion	12(30.00)	25(62.50)	3(7.50)	0(0.00)
Injury to people	4(10.00)	7(17.50)	26(65.00)	3(7.50)
Water contamination	1(2.50)	7(17.50)	13(32.50)	19(47.50)
Psychological problem	2(5.00)	6(15.50)	27(67.50)	5(12.50)
Transfer of disease	1(2.50)	5(12.50)	24(60.00)	10(25.00)
Total	**60(15.00)**	**114(29.00)**	**128(32.00)**	**57(14.30)**

Table 10: Categories of wastes that Respondents consider can pose health Hazards in Gboko town, Nigeria

Location	waste water	Solid food waste	Glass & Broken bottles	Plastics	Wood & Paper	Dung & other animals waste
Gboko North	1(10.00)	6(60.00)	1(10.00)	0(0.00)	0(0.00)	2(20.00)
Gboko South	2 (20.00)	2(20.00)	2(20.00)	0(0.00)	0(0.00)	4(40.00)
Gboko East	2(20.00)	4(40.00)	2(20.00)	0(0.00)	0(0.00)	2(20.00)
Gboko West	2(20.00)	6(60.00)	0(0.00)	0(0.00)	0(0.00)	2(20.00)
Total	**7(70.00)**	**18(180.00)**	**5(50.00)**	**0(00.00)**	**0(00.00)**	**10(100.00)**
Mean (%)	**17.50**	**45.00**	**12.50**	**0.00**	**0.00**	**25.00**

The municipal solid wastes collected from the four locations in Gboko town ten (10) in each location Gboko North, Gboko South, Gboko East, and Gboko West.

Table 1 shows the Bacterial loads of municipal solid waste, Gboko South was the highest with the mean of 6.8, followed by Gboko North with the mean of 4.8, Gboko West with 4.7 and the least Gboko East with the mean of 3.9.

Table 2 shows the morphological, microscopic and biochemical characteristics of bacterial isolates associated with municipal solid waste in Gboko town, Nigeria.

Table 3 shows the frequency of occurrence of bacterial isolates associated with municipal solid waste the mean indicate that *Escherichia coli* was the highest occurrence with the mean of 87.49, *pseudomonas aeruginosa* with the mean of 85.23, *staphylococcus aureus* 82.19, *salmonella typhi* with the mean of 82.12, *streptococcus sp* with the mean of 65.75 and least *proteus sp* with the mean of 46.10.

Table 4 shows anti-biograms of bacterial isolated from municipal solid waste in Gboko town, this table indicate the number of isolates sensitive to antibiotic and resistant to antibiotic.

Table 5 shows the different categories of waste which include biodegradable such as food residues, plant waste matter, paper, and wood. The non-biodegradable include glass, metals/tin cans polythene bags, plastics, rubber, ceramics, textile and others. The totals of Biodegradable in Gboko south were 68.41 and the non-biodegradable were 31.59, in Gboko North the total biodegradable were 60.38 and non-biodegradable 39.61, in Gboko East the total non-biodegradable were 64.32 while the total non-biodegradable were 35.68, in Gboko West the total biodegradable were 61.24 and the non-biodegradable 38.76.

Table 6 shows the bio-data of respondents of municipal solid waste and management. The total household mean in Gboko North was 6.2, in Gboko South were 5.2, in Gboko East were 5 and in Gboko West were 6.3.

Table 7 shows the management of wastes by respondents in Gboko town.

Table 8 shows the responses on the degree of problems municipal solid waste could pose to the health of people in Gboko town. In Gboko North the sub-mean (%) of no problem at all were 15(15.00), for seldom was 3.6(36.00), for high was 3.5(35.00), and for very high were 1.2(12.00). In Gboko south the sub-mean (%) for no problem at all were 3.1 (31.00), for seldom 4.1(41.00), for high 1.7(17.00), and for very high 1(10.00). In Gboko East the sub-mean (%) for no problem at all were 1.1(11.00), for seldom 2.2(22.00), for high 4.4(44.00), and for very high 2.2 (22.00). In Gboko West the sub-mean (%) for no problem at all were 0.8(8.00), for seldom 3.1(31.00), for high 4.3 (43.00), and very high 1.8(18.00).

Table 9 shows the summary of responses on the degree of problems municipal solid waste could pose to the health of people in Gboko.

The summary total for no problem at all were 60(15.00), seldom 114(29.00), high 128(32.00), very high 57(14.30).

Table 10 shows the categories of wastes that respondents consider can pose health hazards in Gboko town, Nigeria.

DISCUSSION

Bacterial Loads of Municipal Solid wastes (MSWs) in Gboko

Generally, the bacterial loads of the wastes obtained in this study were higher than those gotten in a study by [20] on municipal solid waste treatment system increasing ambient airborne bacteria and antibiotic resistance genes. The bacterial loads of the MSWs in an area could be as a result of a number of factors, among which is population density of the inhabitants, composition of waste segregates, lifestyle of the people and poor disposal mechanisms adopted by the people among others as reported by [21] on the United States of America municipal solid waste landfills and associated microbial pathogens.

Frequency of Occurrence of Bacteria Associated with Municipal solid Wastes in Gboko

Escherichia coli had the highest occurrence followed by *Psuedomonas aeruginosa*, *Salmonella typhi*, *Staphylococcus aureus*, *Strptococcus* sp and the least *Proteus* sp which could be that the waste was highly contaminated with feacal material due to the presence of diapers and animal dung in the municipal as suggested by the work of [22] on Municipal solid waste management practices and fecal coliform water contamination in the cities of the developing countries and [23] on the isolation and identification of cellulose degrading bacteria from municipal waste and their screening for potential antimicrobial activity.

Antibiotic susceptibility profiles of bacteria associated with municipal solid wastes in Gboko.

This study has shown that the most mean sensitivity profile of *Proteus* sp *(being 91.11%)* was highest followed by *Stroptococcus* sp (83.33%) while the least susceptible organism was *E. coli*, corresponding with the work of [24]. In order words, *E. coli* is the most resistant organism to the cocktail of antibiotics. This findings raises a concern because *E. coli* is both most predominant and also the most resistant to commonly used antibiotics [24][25].

Segregates of Municipal solid wastes in Gboko Town

The mean biodegradable bulk of the wastes was higher than non-biodegradable which could be an indication that a high level of gas would be releasing in the air causing nauseating odour in the environment. The biodegradable wastes are a good breeding ground for diseases and pathogens [26].

Management of Wastes by Respondent in Gboko Town, Nigeria

This study shows that most Gboko residents leave their wastes to stay between one week to one month the implication of leaving wastes to stay for this length of time is that rodents and insects like mosquitoes would be harboured and cause further health hazards like transference of infections like Lassa fever and malaria respectively [27].

The fact that most respondents reported that they had no difficulties in dropping the waste supply that they actually dispose there wastes discriminately into open environment. This insanitary practice could breed vectors of diseases as well [28].

Responses on the degree of problems Municipal Solid Wastes could pose to the health of people in Gboko Town, Nigeria

The response of water contamination was very high, followed by flies which could be as a result of improper waste dumps, some were located very close to houses and some in the houses which could easily attract flies and also be washed by rain water into wells which could be hazardous to human health [29].

Responses of Residents of Gboko town with respect to degree of problems posed by municipal solid wastes.

Generally respondents considered erosion problem physical injury water contamination psychological problem and transfer of diseases as being the major problem of MSW in Gboko town which supports the work of [30].

Categories of wastes that Respondents consider can pose health Hazards in Gboko town, Nigeria

Solid food and waste water was considered to be more hazardous to the respondents in Gboko town due to the odour, presence of flies and mosquitoes which could lead to disease in human and animals. The respondents reported that solid wastes were the highest to pose health hazard. They could have considered this more because these biodegradable wastes usually and deteriorate and release nauseating odour in the environment and also serve as a breeding ground for vector such as rodents and microorganisms, support the findings of [31].

CONTRIBUTIONS TO LEARNING AND CONCLUSIONS

Study on the Antibiotic susceptibility profile of Bacterial pathogens and health hazards associated with the municipal solid wastes in Gboko town, Nigeria showed that the bacterial loads of municipal solid wastes were higher in Gboko Town were alarming high and this could pose hazards to residents in the town.

All the bacterial isolates reported in this study as shown in table 3 with their frequency of occurrence have been reported to be associated with waste and waste biodegradation, [32]. All bacterial genera reported in this study have been reported by [19] as potential pathogens, that is

they are capable of causing diseases such as typhoid fever, diarrohoea and gastroenteritis implicated as food borne and water borne diseases.

RECOMMENDATIONS

Due to the fact that solid waste affects man both directly and indirectly, the general public should be restrained from dumping waste material in the public. In the present study, it was observed that wastes were dumped in the open space on the streets at close proximity to the houses and public places and some were dumped very close to the house.

Wastes that are dump in the manner mentioned above could harbor disease-carrying agents and pose serious health hazards to the general public and for professional engaged in waste collection and processing. Nigerians should therefore direct her effort towards the treatment and recycling of wastes before disposal as to minimize the health hazards associated with dumping of wastes to improve on the economic value and to promote the Biofuel technology in the country. To ensure that it does not affect the environment around the area or cause health hazards to the people living there, Proper methods of waste disposal have to be undertaken.

The health hazards associated with the indiscriminate dumping of wastes around residential areas, market and other ecological sensitive area such as rivers and streams cannot be underestimated. The dweller should be advised to provide wastes cans with cover lids for waste disposal and relevant authority responsible for the cleanliness of the area to empty the waste cans frequently. Also frequent/monthly environmental sanitation declared by the government should not be underestimated.

From the research carried out, the municipal solid wastes contain higher quantities of biodegradable waste; therefore Nigerians should selectively and strategically adopt the biogas technology.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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