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ORIGINAL RESEARCH

Microbiological Assessment of Municipal Solid Waste Dumpsites in Yenagoa Metropolis, Bayelsa State, Nigeria

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ABSTRACT
Municipal solid wastes (MSWs) stream undergoes diverse transformation, which could be beneficial or detrimental to public health and the environment as a whole. For instance, microbes can act on decomposing waste by either releasing pathogenic bioaerosols. On the other hand, it can be used to produce power through gasification. The microbial assessment of MSWs was investigated in soil samples from 6 dumpsites in dry and wet seasons respectively. Results for total heterotrophic bacteria was 9.30±0.30 - 20.53±3.06 X 10^6 cfu/g for dry season, and 5.43±0.31 - 13.41±0.26 X 10^6 cfu/g for wet season. Total fungi 16.63±0.47 - 28.56±0.25 and 10.51±0.20 - 20.70±0.20 X 10^4 cfu/g respectively. Other group of microbes were; enterobacteriaceae (14.27±0.58 - 27.90±1.40 and 10.30±0.20 – 21.40±0.30 X 10^4 cfu/g), hydrocarbon utilizing bacteria (5.50±0.40 - 24.46±1.21 and 0.00±0.00 – 19.26±0.15 X 10^2 cfu/g) and hydrocarbon utilizing fungi (3.47±0.61 - 18.53±1.17 and 0.00±0.00 – 8.73±0.24 X 10^4 cfu/g). Microbial densities in dry season was relatively higher compared to wet season as opposed to fungi. Furthermore, predominant microbial diversity with highest relative occurrence in both seasons includes; *Bacillus spp. E. coli Pseudomonas spp* and *Staphylococcus spp* for bacteria, while fungi includes *Aspergillus spp*., *Penicillium spp*., *Rhizopus spp.*, and *Saccharomyces spp.* Also, fungi species were higher in wet season than dry season as opposed to bacteria isolates. Based on these finding, we therefore suggest that household waste dumping should be discouraged and more effort should be made to utilize beneficial microbes as resources, while adherence to aseptic measures should be ensured while handling MSW.

KEY WORDS: *Municipal Solid Waste, Bacteria, Fungi, Yenagoa Metropolis*

INTRODUCTION

Municipal solid wastes (MSW), are non-liquid, needless and ready to be disposed substances including but not limited to; garbage, plastics, bottles, metal, glass, wood, etc. In most developing countries, unsegregated waste is disposed without the envisaged aim of reducing, reusing or recycling them. Due to poor handling of MSW and weak legislation to regulate, reduce, reuse and recycling waste (Angaye and Abowei, 2017), the magnitude of waste stream has acquired an alarming abrupt dimension due to urbanization (Schwarz-Herion, 2008; Amuda *et al*., 2014). In Nigeria, it is estimated that daily density of MSW stream densities ranges from 0.44 - 0.66 kg/capital/day, with an annual generation of 25 million tons (Ogwueleka, 2009). High densities of unsegregated MSW wastes stream was also attributed to urbanization due to rural-urban migration, largely necessitated by yearning of the rural populace to apply contemporary technologies (Adejobi and Olorunnimbe, 2012).

Furthermore, these wastes deface the aesthetically application of public places, due to the fact that, produce foul odour when their organic components are acted upon by putrefying organisms (Odeyemi, 2012), as well as toxic gases released from their unfortunate *in situ* burning

(Angaye and Abowei, 2017). In addition, MSW dumpsites are habitat, breeding ground and reservoir for the transmission of major diseases of public health such as malaria, typhoid fever, diarrhoea, cholera etc. (Sherertz, 1993; Odeyemi, 2012). Vectors from dumpsites such as rat, flies have aided the rapid transmission of these diseases.

As reported by Odeyemi (2012), Dumpsites microorganisms use refuse use the refuse as their source of energy under aerobic and anaerobic condition. For instance, under the anaerobic conditions some microbes convert the organic waste to methane and carbon dioxide. These gases are toxic when released to environment, as they constitute risk to various forms biodiversity. Besides, bioaerosol are released from dumpsites which impairs air quality. It was reported by Stetzenbach *et al*., (2004), that atmospheric mobility is an intrinsic means of microbial dispersal and the transmission of pathogenic bioaerosols that have significant adverse on the ecosystem. Bioaerosol from dumpsites, especially microbes have been reported to be one of the major source of air pollution (Ambrose *et al*., 2015). The transmission of bioaerosol from dumpsites play essential role in public health, economic, and agricultural matters, however there is limited knowledge and low public enlightenment on their identity, densities; however, their distribution and relative abundance needs to be unravelled (Rodríguez de Evgrafov, 2009; Ambrose *et al*., 2015). Also, the pathogenicity, virulence and therapeutic application of dumpsites microbial diversities need to be assessed. As such the Microbial Densities and Diversities of Some Municipal Solid Waste Dumpsites in Yenagoa Metropolis, Bayelsa State, Nigeria is hereby investigated.

RESULTS AND DISCUSSION

As presented in table 1, results on enumeration of microbial densities in dry season indicated that total heterotrophic bacteria (THB) in Mopol base was higher and ranges from 10.16±1.02 - 12.40±0.63 X 10^6 cfu/g being significantly different ($p<0.05$), compared to values of wet season (5.50±0.40 - 9.48±0.20 X 10^6 cfu/g). The highest values of THB were recorded in January and July respectively. At Etegwe, seasonal comparison of THB ranged from 10.10±0.30 - 13.23±0.61 and 5.50±0.40 - 7.67±0.51 X 10^6 cfu/g in dry and wet seasons respectively ($p<0.05$), with November and May recording the highest values. Opolo market indicated values as; 10.13±0.74 - 12.23±0.41 X 10^6 cfu/g in dry season and 5.43±0.31 - 7.43±0.45 X 10^6 cfu/g in wet season ($p<0.05$), with highest values in March and September respectively.

The THB of dumpsite in Kpansia market in dry season was reported as: 11.20±0.36 - 16.93±2.24 X 10^6 cfu/g with highest value in January compared to 6.37±0.25 - 8.50±0.44 X 10^6 cfu/g of wet season ($p<0.05$), having highest value in May. In the same vein, values of the central dumpsites (i.e. CDS 1 and CDS 2) which was relatively highest were reported as; (CDS 1: 11.33±0.41 - 19.73±0.60; CDS 2: 16.40±0.36 - 20.53±3.06 X 10^6 cfu/g) and (CDS 1: 8.97±0.31 - 9.3±0.30; CDS 2: 11.90±0.57 - 13.41±0.26 X 10^6 cfu/g). November and July were the months recording the highest microbial densities in dry and wet seasons respectively. Comparatively, the control site significantly ($p<0.05$), recorded the lowest THB densities ranging from 2.17±0.20 - 2.87±0.07 X 10^6 cfu/g in dry season and 1.23±0.07 - 1.69±0.26 X 10^6 cfu/g.

Table 2 presents the microbial densities of Total Fungi (TF) in the respective dumpsites. The dumpsite in Mopol base indicated the highest values of dry season (17.36±0.41 - 21.60±3.06 X 10^4 cfu/g) in November and wet season (11.30±0.45 - 19.13±0.82 X 10^4 cfu/g) in July with significant difference ($p<0.05$). In dry season, the Etegwe dumpsite recorded values in the range of 16.20±0.62 - 19.40±0.62 X 10^4 cfu/g and 11.54±0.23 - 11.76±1.01 X 10^4 cfu/g in wet season with significant difference ($p<0.05$). With the exception of the months of January and September; the Opolo and Kpansia markets recorded values with significant difference ($p<0.05$), in both dry (11.63±0.47 - 18.13±1.98 and 14.50±0.26 - 19.43±0.66 X 10^4 cfu/g) and wet (10.90±0.62 - 11.46±1.32 and 10.51±0.20 - 19.60±0.10 X 10^4 cfu/g) seasons. The CDS 1 and CDS 2 had the highest values of TF in the range of 25.60±0.26 - 28.56±0.25 and 21.60±0.36 - 27.56±0.41 X 10^4 cfu/g in dry season compared to 17.73±4.04 - 20.70±0.20 and 16.10±0.72 - 18.43±0.40 X 10^4 cfu/g. Comparatively, the microbial densities of TF in the control was significantly lowest ranging from 7.57±0.42 - 9.76±0.61 X 10^4 cfu/g in dry season and 4.43±0.41 - 5.50±0.45 X 10^4 cfu/g in wet season.

The microbial densities of enteobacteriaceae in Mopol base was significantly ($p<0.05$) higher and ranged from 14.27±0.58 - 19.21±0.27 X 10^4 cfu/g in dry season .

Table 1: Microbial Densities of Total Heterotrophic Bacteria of Waste Dumpsites

Sampling Points	Dry Season (10^6 cfu/g)			Wet Season (10^6 cfu/g)		
	Nov	Jan	Mar	May	Jul	Sep
Mopol base	10.16±1.02b	12.40±0.63c	9.30±0.30b	5.50±0.40b	9.48±0.20e	7.87±0.15d
Etegwe Bridge	13.23±0.61c	10.10±0.30b	11.57±0.37c	7.67±0.51d	6.43±0.35c	5.50±0.40b
Opolo Market	10.73±0.35bc	10.13±0.74b	12.23±0.41d	6.67±0.20c	5.43±0.31b	7.43±0.45d
Kpansia Market	16.93±2.24d	11.40±0.96bc	11.20±0.36c	7.63±0.25d	8.50±0.44d	6.37±0.25c
CDS 1	19.73±0.60e	11.33±0.41bc	14.27±0.47e	9.33±0.30e	9.31±0.37e	8.97±0.31e
CDS 2	20.53±3.06e	20.20±1.18d	16.40±0.36f	13.41±0.26f	11.90±0.57f	12.57±0.32f
Control	2.87±0.07a	2.17±0.20a	2.64±0.30a	1.69±0.26a	1.43±0.12a	1.23±0.09a

Data expressed as Mean±SD, Differences in alphabets means significant difference. CDS means central dumpsite

Table 2: Microbial Densities of Total Fungi of Waste Dumpsites

Sampling Points	Dry Season (10^4 cfu/g)			Wet Season (10^4 cfu/g)		
	Nov	Jan	Mar	May	Jul	Sep
Mopol base	11.30±0.45c	19.13±0.82c	17.16±0.71c	21.60±1.13e	17.36±0.41d	19.33±0.49c
Etegwe Bridge	11.54±0.23c	11.76±1.01b	11.43±1.55b	19.40±0.62d	16.20±0.62c	17.23±0.41b
Opolo Market	10.90±0.62bc	11.46±1.32b	11.17±0.42b	11.63±0.47b	14.19±0.75b	18.13±1.98bc
Kpansia Market	10.51±0.20b	19.60±0.10c	12.20±0.26b	16.40±0.26c	14.50±0.20b	19.43±0.66c
CDS 1	20.70±0.20e	18.60±0.62c	17.73±4.04c	28.03±0.75e	25.60±0.26f	28.56±0.25d
CDS 2	18.43±0.40d	17.46±0.41c	16.10±0.72c	25.30±0.20f	21.60±0.36e	27.56±0.41d
Control	5.46±0.21a	4.43±0.41a	5.50±0.45a	9.76±0.61a	7.57±0.42a	9.43±0.23a

Table 3: Densities of Enterobacteriaceae of Waste Dumpsites

Sampling Points	Dry Season (10^4 cfu/g)			Wet Season (10^4 cfu/g)		
	Nov	Jan	Mar	May	Jul	Sep
Mopol base	17.77±0.11c	14.27±0.58b	19.21±0.27c	13.30±0.20b	11.30±0.20b	12.27±0.40c
Etegwe Bridge	18.50±0.40cd	18.00±0.96c	15.93±0.35b	11.53±0.35a	14.23±0.28c	10.30±0.20b
Opolo Market	19.93±1.11d	15.76±0.85b	17.23±0.25b	13.10±0.20b	11.60±0.56b	6.70±0.30a
Kpansia Market	15.47±0.76b	18.50±0.52c	19.63±0.85c	11.76±0.61a	10.30±0.40a	12.10±0.34c
CDS 1	27.03±1.00e	22.37±1.51d	27.50±0.40d	19.63±0.58c	13.54±0.77c	21.40±0.30e
CDS 2	27.90±1.40e	23.70±0.85d	27.10±1.90d	21.13±0.37d	20.17±0.25d	20.43±0.25d
Control	13.07±0.77a	11.00±0.79a	12.63±0.65a	11.83±0.80a	10.77±0.61ab	10.23±0.12b

Table 4: Densities of Hydrocarbon Utilizing Bacteria of Waste Dumpsites

Sampling Points	Dry Season (10^2 cfu/g)			Wet Season (10^2 cfu/g)		
	Nov	Jan	Mar	May	Jul	Sep
Mopol base	9.03±0.25c	12.03±0.41d	8.33±1.26c	0.00±0.00a	4.40±0.50b	03.06±0.25b
Etegwe Bridge	6.63±0.55b	5.50±0.40b	6.60±0.50b	0.00±0.00a	5.20±0.60bc	3.57±0.29bc
Opolo Market	7.03±1.97b	6.53±0.40c	7.46±0.49bc	3.96±0.70b	5.30±0.34c	4.15±0.22c
Kpansia Market	6.66±0.20b	5.43±0.37b	7.23±0.41bc	4.76±0.35c	5.63±0.70c	5.56±0.49d
CDS 1	20.63±1.36d	17.76±0.51e	19.03±0.81d	11.93±0.25d	9.36±0.50d	7.00±0.70e
CDS 2	24.46±1.21e	27.96±0.97f	22.56±0.66e	19.26±0.15e	14.20±0.26e	12.03±0.15f
Control	0.00±0.00a	3.50±0.40a	4.46±0.40a	0.00±0.00a	0.00±0.00a	0.00±0.00a

Table 5: Population Densities of Hydrocarbon Utilizing Fungi of Waste Dumpsites

Sampling Points	Dry Season (10^2 cfu/g)			Wet Season (10^2 cfu/g)		
	Nov	Jan	Mar	May	Jul	Sep
Mopol base	4.27±0.38b	7.70±0.40c	5.60±0.45c	0.00±0.00a	4.10±0.30b	0.00±0.00a
Etegwe Bridge	4.13±0.21b	3.37±0.25b	4.50±0.26b	0.00±0.00a	3.77±0.65b	0.00±0.00a
Opolo Market	4.53±0.32b	4.07±0.35b	5.67±0.25c	3.70±0.40b	3.20±0.61b	0.00±0.00a
Kpansia Market	5.37±0.61c	3.63±0.35b	5.36±0.41c	3.60±0.30b	0.00±0.00a	0.00±0.00a
CDS 1	11.77±0.41d	8.57±0.77c	9.20±0.62d	8.73±0.24c	4.71±0.63c	4.03±0.32b
CDS 2	12.40±0.51d	18.53±1.17d	10.80±0.36e	8.50±0.36c	6.90±0.87d	7.24±0.61c
Control	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a

compared to 11.30±0.20 - 13.30±0.20 X 10^4 cfu/g in wet season. Similarly, Etegwe dumpsite indicated seasonal variation of enterobacteriaceae densities in the range of 15.93±0.35 - 19.63±0.85 X 10^4 and 10.30±0.20 - 14.23±0.28 X 10^4 cfu/g for dry and wet seasons respectively ($p<0.05$), with highest values in November and July respectively. Meanwhile, values of the Opolo (dry season: 15.56±0.85 - 17.33±0.25 X 10^4 and wet season 6.70±0.30 - 13.10±0.20 X 10^4) and Kpansia (dry season: 15.47±0.76 - 19.63±0.85 X 10^4 and wet season 10.30±0.40 - 12.10±0.34 X 10^4) market dumpsites were significantly different ($p<0.05$) for both seasons. While the control significantly ($p<0.05$) recorded the lowest values (dry season: 11.00±0.79 - 13.07±0.77 X 10^4 cfu/g and wet season: 10.23±0.12 - 11.83±0.80 X 10^4 cfu/g) for enterobacteriaceae. Central dumpsite 1 and 2 had the highest value amongst the dumpsites. While CDS 1 had values in the range of 22.37±1.51 - 27.50±0.40 X 10^4 cfu/g in dry season and compared to wet season (13.54±0.77 - 21.40±0.30 X 10^4 cfu/g). Furthermore, enterobacteriaceae in CDS 2 ranged from 23.70±0.85 - 27.90±1.40 X 10^4 cfu/g in dry season and 20.17±0.25 - 21.13±0.37 X 10^4 ($p<0.05$).

Microbial densities of Hydrocarbon Utilizing Bacteria (HUB) is presented in Table 4. Results showed that HUB in Mopol base ranged from 8.33±1.26 - 12.03±0.41 X 10^2 in dry season, compared to 0.00±0.00 - 4.40±0.50 X 10^2 values of wet season ($p<0.05$). Highest HUB values for both seasons were recorded in January and July respectively. Etegwe had values in the ranges of 5.50±0.40 - 6.63±0.55 X 10^2 and 0.00±0.00 - 5.20±0.60 X 10^2, with highest values for dry and wet seasons being November and July respectively. Highest dry season values for Opolo (6.53±0.40 - 7.46±0.49 X 10^2) and Kpansia markets (5.43±0.37 - 7.23±0.41 X 10^2) were similarly recorded in March compared to their corresponding July wet season values of 3.97±0.70 - 5.30±0.34 X 10^2 and 4.76±0.35 - 5.63±0.70 X 10^2 respectively ($p<0.05$). The CDS 1 having dry season values of 17.76±0.51 - 20.63±1.36 X 10^2 and wet season values of 7.00±0.70 - 11.93±0.25 X 10^2 is significantly different ($p<0.05$) from CDS 2 (dry season:

22.56±0.66 - 27.96±0.97 X 10^2 and wet season 12.03±0.15 - 19.26±0.15 X 10^2). Notwithstanding, the investigation shows that CDS I and 2 recorded the highest HUB values amongst the dumpsites with higher values in dry season compared to wet season.

As presented in Table 5, the microbial densities of HUF of dumpsite around Mopol base ranges from 4.27±0.66 - 7.70±0.40 X 10^2 cfu/g in dry season compared to values of 0.00±0.00 - 4.10±0.30 X 10^2 cfu/g in wet season ($p<0.05$) highest values were reported in January and July respectively. At Etegwe, HUF densities ranged from 3.37±0.25 - 4.50±0.26 X 10^2 and 0.00±0.00 - 3.77±0.65 X 10^2 cfu/g in dry and wet seasons respectively. In dry season HUF values of Opolo market ranged from 4.07±0.35 - 5.67±0.25 X 10^2 cfu/g compared to a significantly ($p<0.05$) lower value ranging from 0.200±0.00 - 3.70±0.40 X 10^2 cfu/g. Dumpsite in Kpansia market indicated values of 3.63±0.35 - 5.37±0.61 X 10^2 cfu/g in dry season and 0.00±0.00 - 3.60±0.30 X 10^2 cfu/g. Furthermore, the CDS recorded the highest values amongst all dumpsites with CDS I ranging from 8.50±0.77 - 9.20±0.62 X 10^2 and 4.03±0.32 - 8.73±0.24 X 10^2 cfu/g in dry and wet seasons respectively ($p<0.05$). In the same vein, HUF values of CDS 2 was in the range of 10.80±0.36 - 18.53±0.17 X 10^2 cfu/g in dry season and 6.90±0.87 - 8.50±0.36 X 10^2 cfu/g in wet season ($p<0.05$).

Results presented in Table 6 show that, in dry season the predominant bacteria diversities in the dumpsites with total (100%) frequency distribution were reported as: *Bacillus species*, *Staphylococcus species*, *Escherichia coli* and *Pseudomonas species*. Other species reported were: *Klebsiella species* (83.33%), *Streptococcus species* (61.11%) and *Shigella species* was 72.22%. While *Micrococcus* and *Enterococcus species* were similarly *species* 55.56%, *Proteus species* was 50.00%, while *Salmonella typhi* was 33.33%. In wet season, the relative abundance or frequencies of *Saccharomyces species* amongst the sampling points was 66.67%, while *Aspergillus* and *Rhizopus species* were similarly 61.11%. *Penicillium species* was reported as 55.56%. Other species includes; *Candida species* (44.44%), *Fusarium species* (44.44%), *Mucor species* (33.33%), *Absida species* (27.28%), *Cladosporium* (22.22%), *Tricoderma species* (16.67%), *Alternaria species* (11.11%).

The frequency of bacteria and fungi diversity in wet season is presented in Table 7. Results show that, some bacteria species had total predominance (i.e 100% frequency distribution) in the dumpsite. They include; *Bacillus species*, *Escherichia coli*, and *Pseudomonas species*. *Staphylococcus species* was had frequency distribution of 88.88%, while *Klebsiella species* was 72.22%, *Streptococcus species* was 33.33%, *Enterococcus* and *Shigella* were similarly *species* 55.55%. while Proteus and Salmonella species were 38.88% and 16.67% respectively. In wet season, fungal frequency occurrence amongst the sampling points was 77.78% for *Saccharomyces species*, 83.88% for *Aspergillus* and 88.88% for *Rhizopus species*. Other species reported were 83.33% for *Penicillium species*, 61.11% for *Candida species*, 55.56% for *Fusarium species*, 38.88% for *Mucor species*, 33.33% for *Absida species*, 27.28% for *Cladosporium*, 22.22% for *Tricoderma species*, and 16.66% for *Alternaria species*. Generally, it was observed that the frequency distribution of bacteria diversity was higher in dry season compared to wet season, as opposed to the frequency of fungal diversity which was higher in wet season compared to dry season. In tandem, another study confirmed that bacteria density in dumpsites is higher in wet seasons compared to dry seasons, as opposed to fungi (Igborgbor and Ogu, 2015).

The findings of our investigation are comparable to studies of other authors. The microbial assessment of Municipal Waste Dumpsite in Uyo metropolis of Akwa Ibom State was investigated by Ambrose et al (2015). Results revealed microbial distribution as; *Bacillus spp* (100%), while *E. coli* and *Psedomonas species* were similarly 80%, *Staphylococcus aureus* frequency was reported to be 60%, and *Micrococcus species* was 40%. For the distribution of fungi species such as *Absidia, Mucor, Penicillium, Aspergillus restrictus and Cladosporium* were reported to have similar frequency occurrence of 60%. While fungal genus like *Alternaria* and *Fusarium* were similarly (40%), *Candida albicans*, *Geotrichum* and *Phoma* were similarly 20%.

Another author in Ikare of Ekiti State, who investigated microbial occurrence in soil sample of waste dumpsites show bacteria distribution of dumpsites as 10.17% for *Staphylococcus species*, 12.70% for *Streptococcus*, 3.08% for *Shigella*, 19.61% for *Escherichia coli*, 13.06% for *Proteus species*, 17.70% for *Bacillus species*, 10.77% for

Table 6: Microbial Diversity of Waste Dumpsites in dry season (Keys: + means present, - means absent, RA means relative abundance expressed in %)

Microbial Isolates	Akenpai			Etegwe			Opolo Market			Kpansia Market			Central Dumpsite 1			Central Dumpsite 2			RA
	Nov	Jan	Mar	Nov	Jan	Mar	Nov	Jan	Mar	Nov	Jan	Mar	Nov	Jan	Mar	Nov	Jan	Mar	(%)
Bacteria Isolates																			
Bacillus spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
E. coli	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
Enterococcus spp.	-	+	-	-	-	-	+	+	+	-	-	-	+	+	+	+	+	+	55.56
Klebsiella spp.	+	-	+	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	83.33
Micrococcus spp	-	-	+	+	-	-	+	-	+	+	-	+	+	-	+	-	+	+	55.56
Proteus spp.	-	-	-	+	+	-	+	-	+	-	-	+	-	+	-	+	+	+	50.00
Pseudomonas spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
Salmonella spp.	-	-	+	+	-	-	-	-	+	-	-	-	-	-	+	+	-	+	33.33
Streptococcus spp.	-	+	-	+	+	-	-	+	-	-	-	+	+	+	+	+	+	+	61.11
Staphylococcus spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
Shigella spp.	+	-	-	+	+	+	-	+	+	+	+	+	+	-	+	-	+	+	72.22
Fungi Isolates																			
Absida spp.	-	-	-	-	-	+	-	-	-	-	-	-	-	+	+	+	-	+	27.28
Aspergillus spp.	-	-	+	+	+	+	-	+	+	-	-	+	+	-	+	-	+	+	61.11
Alternaria spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	11.11
Candida spp.	+	-	+	-	-	+	+	-	-	+	-	-	-	+	+	-	+	-	44.44
Cladosporium spp.	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	+	-	-	22.22
Fusarium spp.	-	+	-	+	-	+	+	-	+	-	-	-	-	-	+	-	+	+	44.44
Mucor spp.	-	-	-	-	-	+	+	-	+	-	-	-	-	+	-	-	+	+	33.33
Penicillium spp.	-	+	+	-	-	+	+	-	+	+	-	-	-	+	+	-	+	+	55.56
Rhizopus spp.	-	+	-	-	+	+	-	+	+	-	+	-	+	+	+	-	+	+	61.11
Saccharomyces spp.	-	-	+	+	-	+	-	+	+	-	+	+	+	+	-	+	+	+	66.67
Tricoderma spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	16.67

Table 7: Microbial Diversity of Waste Dumpsites in wet season

Microbial Isolates	Akenpai			Etegwe			Opolo Market			Kpansia Market			Central Dumpsite 1			Central Dumpsite 2			RA
	May	Jul	Sep	May	Jul	Sep	May	Jul	Sep	May	Jul	Sep	May	Jul	Sep	May	Jul	Sep	(%)
Bacteria Isolates																			
Bacillus spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
E. coli	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
Enterococcus spp.	-	+	-	-	-	-	+	+	+	-	-	-	+	+	+	+	+	+	55.56
Klebsiella spp.	+	-	+	-	+	+	+	+	+	-	+	-	+	+	-	+	+	+	72.22
Micrococcus spp	-	-	-	+	-	-	+	-	+	-	-	-	+	-	+	-	+	-	33.33
Proteus spp.	-	-	-	+	+	-	+	-	+	-	-	-	-	+	-	+	+	-	38.88
Pseudomonas spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	100
Salmonella spp.	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	16.67
Streptococcus spp.	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	33.33
Staphylococcus spp.	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	+	+	88.88
Shigella spp.	+	-	-	+	+	+	-	-	-	+	+	+	+	-	+	-	+	-	55.55
Fungi Isolates																			
Absida spp.	-	-	-	-	-	+	+	-	+	-	-	-	-	+	-	+	-	+	33.33
Aspergillus spp.	-	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	83.33
Alternaria spp.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	16.66
Candida spp.	+	-	+	-	-	+	+	-	+	+	-	-	+	+	+	+	+	-	61.11
Cladosporium spp.	-	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	+	+	27.78
Fusarium spp.	-	+	-	+	-	+	+	-	+	+	-	+	-	-	+	-	+	+	55.56
Mucor spp.	-	-	-	-	+	+	-	-	+	-	-	-	+	+	-	+	-	+	38.88
Penicillium spp.	-	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	83.33
Rhizopus spp.	-	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	88.88
Saccharomyces spp.	+	-	+	+	-	+	-	+	+	+	-	+	+	+	+	+	+	+	77.78
Tricoderma spp.	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	+	-	22.22

for *Pseudomonas species* and 12.31% for *Salmonella* frequency (Ogunmodede *et al*., 2014). In Ikotun area of the same state, Assessment of bioaerosols from dumpsite close to destitute home had with mean value of 124.4 cfu/p, had bacterial distribution of 37% for *Escherichia coli*, 19% for *Klebsiella* spp, 13% for *Pseudomonas* spp, 15% for *Serratia* spp, 8% for *Staphylococcus* spp, 7% for *Enterococcus* spp and 1% of *Salmonella species* (Odeyemi, 2012).

Microbial assessment of bioaerosols in dumpsites of Delta state showed the bacterial genera as; *Staphylococcus, Streptococcus, Micrococcus, Bacillus, Pseudomonas*, *Escherichia coli*, and *Klebsiella* species, with THB count ranging from 1.41×10^8 - 29.2×10^{14} cfu/ml. While the fungal distribution was; *Penicillium*, *Aspergillus, Alternaria*, *Mucor, Curvularia, Rhizopus* and *Cladosporium* sp., with density ranging from 1.12×10^8 - 1.39×10^{14} cfu/ml (Igborgbor and Ogu, 2015). It has been documented in literature that some microbes in dumpsite have the ability to convert the organic material to methane gas in a process known as methanogenesis (Odeyemi, 2012). Uncontrolled release of methane gas can be toxic (Kerry *et al*., 2011), but when optimized it can be used to produce power

CONCLUSION

This research investigated the microbial diversities and densities of MSWs dumpsites in Yenagoa metropolis. The study indicated that there are pathogenic microbes of public health on one hand, while on the other hand some microbes that found beneficial application were also indicated. Consequently, microbes play vital roles in the transformation of MSW. Results of this investigation shows that dumpsites of Yenagoa Metropolis have diverse bacterial and fungal isolates which are pathogenic on one hand and beneficial on the other hand as degraders and resources for power generation. These roles could be beneficial or detrimental to the environment. We therefore recommend that the beneficial roles played by microbes should be harnessed as resources, while the detrimental roles played should be ameliorated. In addition, dumping of MSWs close to public places and homes should be prohibited in order to avoid risk of airborne diseases and other vectors that transmit diseases of public health.

MATERIALS AND METHODS

Study area and Sampling Location

The study area is Yenagoa metropolis, which is the capital city of Bayelsa state, Nigeria. It is one of the state created by the Nigerian Government in 1996, its population has since abruptly expended. Its method of waste disposal is landfill system. The State forms part of the Niger Delta and is located southernmost on the Nigerian map. The study area has a tropical humid hot climate with two prevailing seasons. The wet season which is relatively cool and rainy, it ranges from April and October, while the dry season which ranges from November to March, is usually hot and dusty. The Niger Delta has precipitation of over 2000mm per annum, and elevation of 45m above mean sea level.

Sampling

The sampling points are randomly selected dumpsites within the metropolis and the central dumpsite located on the outskirt of the metropolis. A total of 7 soil samples (control inclusive), were collected in triplicates from 6 stations (Akenpai, Etegwe, Opolo, Kpansia, central dumpsite 1 and 2), in both dry and wet season from November 2016 – October 2017. The samples were collected with soil auger in a composite manner at depth of 0 - 20cm. The soil samples were packaged in sterile foil plates and transported to the laboratory for microbial analysis.

Culture Media, Preparations and Incubation

The microbial inoculation and density enumeration of the soil samples was carried out using serial dilution and pour plate technique as described by several authors (APHA, 1998; Benson, 2002; Pepper and Gerba, 2004). About 1gram aliquots of the soil samples was dispense into the 9.0 ml of sterile distilled water in plugged test tube and agitated for even distribution, making a dilution factor of 10^{-1}. Furthermore, serial diluents ranging from 10^{-2} - 10^{-7} was achieved from the first diluent. About 1ml of each diluent from the respective test tubes were aseptically pipetted unto the individual labeled sterilized Petri dish, before the respective medium were poured to the plates. The inoculation was carried out in a laminar flow, the inoculated plates were inverted prior to their transfer to the incubator. The media used for the investigation were Nutrient Agar for Total Heterotrophic Bacteria (THB) at 35^{O}C for 24 -48 hours, Sabouraud dextrose agar for Total Fungi (TF) 28±2 ^{O}C for 72 - 96 hours, MacConkey Agar for enterobacteriaceae at 37^{O}C for 24 - 48 hours (Ita and Ben, 2004), and Bushnell Hass Media for Hydrocarbon Utilizing Bacteria (HUB) and Fungi (HUF), with crude oil as sole source of carbon energy at 35^{O}C for 7 days. All media were weighed according to manufacturer specification and

transferred to conical flask and autoclaved at 121°C for 15 minutes and allowed to cool at room temperature 37±2^{O}C. The NA media for THB and HUB was fortified with 100 µg/ml of Ketoconazole for the selective enumeration and isolation of bacteria. While for TF and HUF 50 µg/ml tetracycline for inhibition of fungal proliferation. Emerging colonies on the respective medium were enumerated as colony forming units per gram (cfu/g).

Identification of Isolates from pure cultures

The pure cultures were again inoculated into the aforementioned respective medium for the purpose of obtaining purer isolates which were stored in agar slant. The identification of bacteria isolates done by biochemical test including; gram reaction, motility, indole, catalase, coagulase, oxidase, urease and citrate as well as the use of specialized media. Also, morphologically identification was based on shape, colour, texture, margin, and elevation. The emerging characteristics were compared with already established taxa known such as; Bergey's Manual of Determinative Bacteriology, and the scheme of Cheesbrough (2006) and Edet *et al*., (2017). The formation of red colonies in Xylose Lysine Deoxycholate agar (XLD) incubated at 37^{o}C for 24 hours indicates the presence of *Shigella* and *Salmonella species*. While *Shigella species* ferment sucrose Salmonellae does not (Cheesbrough, 2006). In Levine's eosin Methylene Blue (EMB) Agar incubated at 37º C for 24 - 48 hours; *Enterobacter species* forms large greenish metallic sheen as opposed to small greenish metallic sheen of *E. coli*. *Pseudomonas aeruginosa* colonies are fluorescent and greenish brown. *Enterococcus species* have red, minute and round morphology (Ogunmodede *et al*., 2014). On blood agar, *Proteus species* indicates swarming properties. Formation of yellow pigment in Mannitor Salt Ager indicates the presence of *Staphylococcus aureus*. *Bacillus* species are flat and irregular gram positive organisms, with lobate margins, while micrococcus species are gram positive cocci with circular, pinhead convex colonies with bright yellow, non-diffusable pigment (Ohimain *et al*., 2013). In a similar vein, fungal species were identified macroscopically, and microscopically using lactophenol cotton blue stain; already established identification schemes of several authors (APHA, 1998; Benson, 2002; Pepper and Gerba, 2004; Izah and Ohimain, 2013; Edet *et al*., 2017).

Statistical Analysis

All data were expressed as mean ± Standard Deviation using version 20 of SPSS statistical package. Microsoft excel was used to plot graph from derived mean values.

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