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## RESEARCH ARTICLE

# BACTERIOLOGICAL CHARACTERIZATION OF URBAN AND RURAL MARKETS WASTE DUMP SITES IN BENIN CITY, EDO STATE, NIGERIA

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**ABSTRACT**

Bacteriological characterization of waste dump sites, soil and air environment of an urban and a rural market during wet and dry days was conducted to determine the bacterial population and distribution in order to ascertain the market hygiene and environmental safety. A total of 64 soil samples were collected within three months and examined for heterotrophic bacterial counts. The mean bacterial counts ranged from $13.08 \pm 2.29 \times 10^4$ cfu/g to $22.39 \pm 5.38 \times 10^4$ cfu/g and $10.85 \pm 0.66 \times 10^4$ cfu/g to $21.50 \pm 1.67 \times 10^4$ cfu/g in the urban and rural markets respectively during the dry days. The mean bacterial counts ranged from $30.05 \pm 5.49 \times 10^4$ cfu/g to $38.05 \pm 5.27 \times 10^4$ cfu/g and $18.73 \pm 5.45 \times 10^4$ cfu/g to $24.33 \pm 4.14 \times 10^4$ cfu/g in the urban and rural markets respectively during the wet days. The bacteria isolated included *Escherichia coli, Shigella sp, Staphylococcus aureus, Salmonella sp, Bacillus aureus, Enteroccoccus faecalis, Clostridium perfringens, Proteus vulgaris, Klebsiella pneumoniae* and *Pseudomonas aeruginosa. E. coli* was the most prevalent bacterium in the urban market with percentage prevalence of 93.76% while *Enterococcus faecalis* was the most prevalent bacterium in the rural market with percentage prevalence of 37.51%. There was significant difference ($p< 0.05$) between the bacterial population in the rural and urban markets during the wet and dry days. An effective waste management and disposal method in markets is therefore necessary to prevent potential disease outbreak.



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## INTRODUCTION

Local markets in towns and villages in Nigeria are laden with putrefying wastes in open dumps without regards to health hazards and aesthetics (Ademoroti and Akpovi, 1987). There is increase in solid waste production due to population increase making garbage pollution a serious problem (Khupe 1996). The risk of the dump sites is increase in the population of microbial pathogens, which is potentially significant, especially relative to the risks from residual composite soil and unregulated evacuation of wastes in and around homes and common sites (Achudume and Olawale, 2007). In most urban and rural markets in Benin City, waste materials are deposited in open dump sites and allowed to pile up until they are taken away by waste by waste management officials after a week or more. Buying and selling in the market is conducted within heaps of waste and harmful microorganisms can be transmitted to food sold through disease vectors and air currents. Also, the wastes can contaminate soil and air which poses more problems for humans, other species and ecosystems (Obire *et al.,* 2002). The unsightly accumulation of the wastes generally reduce the aesthetic value of the market environment, increases the breeding conditions of some disease vectors and pathogens which may increase the spread of malaria, Lassa fever, cholera, dysentery among the local residents (Ukpong *et al*., 2015). Market waste dump sites create an important public health problem as a result of direct toxicity of the several species of potentially pathogenic bacteria they may contain (Achudume and Olawole, 2007). The pathogenic microorganisms and harmful chemicals like heavy metals in the solid waste are introduced into the environment when the wastes are not properly managed (Ogbonna and Igbenijie, 2006). Therefore the aim of this study was to identify the prevalence of bacteria species associated with urban and rural market dump sites, soil and air environment during dry and wet days and ascertain the market hygiene and safety.

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## MATERIALS AND METHODS

**Sample Collection:** This study was carried out between March and May (representing dry and wet seasons) in Benin City (5°

37'E, 6° 20'N), Edo State Nigeria. Samples were collected from the Oba market (an urban market), which is the most populous market in Benin City and Ekiadolor (6° 29'N, 5° 35'E) market (a rural market) about 7 km from the outskirts of Benin City. A total of sixty four soil samples were collected from four different waste dump sites about 30 to 40 metres apart in the markets. Samples collected included the decomposing wastes from the top dump (sample A), surface soil from depth of 0 – 10 cm (sample B), soil 25 m away from the waste dump sites (sample C) and market air current around the dump sites (sample D). Samples A, B and C were randomly collected using hand trowel and Dutch Auger cleaned with 70% alcohol, the soil was scooped into sterile polyethylene bags. The samples were treated within 2 hours of collection (Obire *et al*., 2002). Samples were stored in a refrigerator at 4°C until they were examined (Oviasogie *et al.,* 2010). Sample D was collected by exposing a set of petri dishes containing Desoxycholate Citrate Agar (DCA), Tryptone Soy Blood Agar and Nutrient Agar to air current around the waste dump sites for 15 – 20 minutes. They were transferred to the laboratory immediately for incubation and further analysis.

**Bacteriological Analysis:** Cultivation and enumeration of the total viable aerobic heterotrophic bacteria count was done in duplicates. One gram (1 g) of each sample A, B, and C was weighed and mixed thoroughly in 10 ml distilled water. Then 1 ml of the suspension was transferred aseptically into another test tube containing 9 ml distilled water and diluted serially into other test tubes till a $10^{-5}$ dilution was made. An aliquot of 0.1 ml of each dilution was aseptically plated out using pour plate method on Tryptone Soy Blood Agar (Lab M Ltd UK), Desoxycholate Citrate Agar (Lab M Ltd UK) and Nutrient Agar (Lab M Ltd UK). All plates were incubated at 37$^{o}$C for 24 h to 48 h to obtain total bacterial counts. The discrete colonies were observed and counted. Pure colonies were transferred aseptically on Nutrient Agar slants and incubated at 28$^{o}$C for 24 h. Representatives of the different purified colonies were subjected to various cultural, morphological and biochemical tests. Identification was based on Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 1994).

**Statistical Analysis:** Data were subjected to statistical analysis using F-test in a Two-Way Analysis of Variance at 5% probability level (Ogbeibu, 2005).

## RESULTS

The mean bacterial population (cfu/g) in the samples for the urban and rural markets during dry and wet periods is presented in Table 1. The urban market samples had mean bacterial population of 30.05 ± 5.49 x $10^4$ cfu/g to 38.05 ± 5.27 x $10^4$ cfu/g during the wet period and 13.08 ± 2.29 x $10^4$ cfu/g

**Table 1. Mean Bacterial Population (cfu/g x $10^4$) of Samples in Urban and Rural Markets**

| Samples | Oba market (Urban market) | | Ekiadolor Market (Rural Market) | |
|---|---|---|---|---|
| | Dry Period | Wet Period | Dry Period | Wet Period |
| A | 20.43 ± 7.93 | 36.05 ±1.54 | 14.58 ± 1.05 | 21.43 ± 7.54 |
| B | 22.39 ± 5.38 | 38.05 ± 5.27 | 21.50 ± 1.62 | 24.33 ± 4.14 |
| C | 16.53 ± 4.43 | 30.05 ± 5.49 | 15.25 ± 3.59 | 19.60 ± 3.22 |
| D | 13.08 ± 2.29 | 30.40 ± 2.02 | 10.85 ± 0.66 | 18.73 ± 5.45 |

Note: Sample A= top soil of waste dump site Sample B= soil at depth of 10cm of waste dump site
Sample C = soil 25 m away from waste dump site Sample D= air current around waste dump site

**Table 2. Percentage Frequency of Occurrence of Bacterial Isolates in Oba Market Waste Dump Site Samples**

| Bacteria Isolates | Sample A | | Sample B | | Sample C | | Sample D | | Total Percentage Occurrence (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | |
| *Escherichia coli* | 6.25 | 12.50 | 6.25 | 31.25 | 0.00 | 15.63 | 0.00 | 21.88 | 93.76 |
| *Shigella sp* | 6.25 | 0.00 | 0.00 | 0.00 | 15.63 | 0.00 | 6.25 | 3.13 | 31.26 |
| *Staphylococcus aureus* | 0.00 | 12.50 | 12.50 | 0.00 | 9.38 | 6.25 | 6.25 | 6.25 | 53.13 |
| *Salmonella sp* | 6.25 | 0.00 | 0.00 | 12.50 | 6.25 | 0.00 | 0.00 | 0.00 | 25.00 |
| *Bacillus sp* | 0.00 | 6.25 | 6.25 | 3.13 | 0.00 | 6.25 | 9.38 | 6.25 | 37.51 |
| *Enterococcus sp* | 0.00 | 15.63 | 9.38 | 21.88 | 9.38 | 0.00 | 0.00 | 0.00 | 56.27 |
| *Clostridium sp* | 0.00 | 3.13 | 6.25 | 0.00 | 0.00 | 3.13 | 0.00 | 0.00 | 12.51 |
| *Proteus sp* | 3.13 | 3.13 | 0.00 | 0.00 | 3.13 | 0.00 | 6.25 | 15.63 | 31.27 |
| *Klebsiella sp* | 0.00 | 3.13 | 3.13 | 0.00 | 0.00 | 6.25 | 0.00 | 0.00 | 12.51 |
| *Pseudomonas sp* | 15.63 | 6.25 | 0.00 | 6.25 | 6.25 | 6.25 | 6.25 | 3.13 | 50.01 |
| Total Isolates | 12 | 23 | 14 | 25 | 11 | 16 | 10 | 17 | 128 |

Note: Sample A= top soil of waste dump site Sample B= soil at depth of 10cm of waste dump site
Sample C = soil 25 m away from waste dump site Sample D= air current around waste dump site

**Table 3. Percentage Frequency of Occurrence of Bacterial Isolates in Ekiadolor Market Waste Dump Site Samples**

| Bacteria Isolates | Sample A | | Sample B | | Sample C | | Sample D | | Total Percentage Occurrence (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | |
| *Escherichia coli* | 0.00 | 9.38 | 0.00 | 12.50 | 6.25 | 0.00 | 3.13 | 3.13 | 34.39 |
| *Shigella sp* | 0.00 | 6.25 | 6.25 | 0.00 | 3.13 | 0.00 | 3.13 | 0.00 | 18.76 |
| *Staphylococcus aureus* | 3.13 | 3.13 | 3.13 | 6.25 | 0.00 | 9.38 | 3.13 | 3.13 | 31.28 |
| *Salmonella sp* | 0.00 | 3.13 | 0.00 | 9.38 | 3.13 | 0.00 | 0.00 | 0.00 | 15.64 |
| *Bacillus sp* | 6.25 | 0.00 | 0.00 | 3.13 | 6.25 | 0.00 | 0.00 | 6.25 | 21.88 |
| *Enterococcus sp* | 9.38 | 0.00 | 18.75 | 0.00 | 0.00 | 6.25 | 3.13 | 0.00 | 37.51 |
| *Clostridium sp* | 0.00 | 0.00 | 6.25 | 0.00 | 0.00 | 3.13 | 0.00 | 0.00 | 9.38 |
| *Proteus sp* | 0.00 | 3.13 | 0.00 | 12.50 | 3.13 | 0.00 | 0.00 | 12.50 | 31.26 |
| *Klebsiella sp* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Pseudomonas sp* | 0.00 | 6.25 | 6.25 | 6.25 | 0.00 | 9.38 | 0.00 | 0.00 | 28.13 |
| Total Isolates | 6 | 10 | 13 | 16 | 7 | 9 | 4 | 8 | 73 |

Note: Sample A= top soil of waste dump site Sample B= soil at depth of 10cm of waste dump site
Sample C = soil 25 m away from waste dump site Sample D= air current around waste dump site

to 22.39 ± 5.38 x $10^4$ cfu/g during the dry period. Sample B had the highest mean bacterial population of 38.05 ± 5.27 x $10^4$ cfu/g and 22.39 ± 5.38 x $10^4$ cfu/g during the wet and dry periods respectively and samples C and D had the lowest values of 30.05 ± 5.29 x $10^4$ cfu/g and 13.08 ± 2.29 x $10^4$ cfu/g during the wet and dry periods respectively for the urban market. For the rural market, Sample B had the highest mean bacterial counts of 24.33 ± 4.14 x $10^4$ cfu/g and 21.50 ± 1.67 x $10^4$ cfu/g and Sample D had the lowest count of 18.73 ± 5.45 x $10^4$ cfu/g and 10.85 ± 0.66 x $10^4$ cfu/g during the wet and dry periods respectively. The percentage prevalence of the bacteria species isolated (*Escherichia coli, Shigella sp, Staphylococcus aureus, Salmonella sp, Bacillus aureus, Enterococcus faecalis, Clostridium perfringens, Proteus vulgaris, Klebsiella pneumonia* and *Pseudomonas aeruginosa*) from the urban and rural markets is presented in Tables 2 and 3 respectively. *E. coli* (93.76%) and *Enterococcus faecalis* (37.51%) had the highest total percentage prevalence and *Klebsiella pneumonia* had the lowest total percentage prevalence of 12.51% and 0.00% in the samples from the urban and rural markets respectively.

## DISCUSSION

The mean bacterial population was higher during the wet period than the dry period for all the samples from the urban and rural markets. The urban market samples had higher values for the bacterial population than the rural market samples. The significantly higher number of bacterial population ($p<0.05$) during the wet period than the dry period corroborated with the study of Obire *et al.* (2002) who reported highest number of total viable aerobic heterotrophic bacteria during raining season than dry season. Bacterial populations respond differently to seasonal influence (Obire *et al*., 2002). Factors such as moisture content, nutrient availability, temperature, type and number of microorganisms' present, natural antimicrobial agents present, pH and types of gases determine microbial growth (Prescot *et al.,* 1999). Therefore, the higher microbial count of Samples A (top soil of waste dump) and B (soil at depth of 10 cm of waste dump) was probably as a result of nutrient availability, moisture content and type of gases present in the decomposing wastes, which favoured their growth. The surface run off during rainfall that carried the wastes along could have led to the heavy load of bacteria 25m from the waste dumps in the rural and urban markets (Obire *et al*., 2002).

The air flora of the markets showed that the waste dumps were the likely sources of the bacteria found in the air. The risk of acquiring diseases through dump sites where arrays of exposed food items are displayed is very high, with common filth houseflies being active mechanical transmitters of potentially pathogenic bacteria agents (Adeyeba and Okpala 2000). The urban market had significantly higher ($p<0.05$) bacterial population due to pollution and the higher population of the residential building in the area with many residents using the market dump site as dumping ground for their wastes (Adeyeba and Akinbo, 2003). The exposure to high concentrations of microbes in the air frequently lead to allergies, asthma, hay fever (Newson *et al.,* 2000), pneumonia and many other infections (Allsopp *et al*., 2004). The bacteria species isolated in this study were similar to those isolated in the studies of Oviasogie *et al.,* (2010) Williams and Hakam (2016) and Obire *et al*., (2002). The high prevalence of *E. coli, S. aureus, Entericoccus faecalis, Bacillus aureus, Proteus vulgaris* and *Pseudomonas aeruginosa* in both the urban and rural market samples is an indication that they naturally populate the soil (Williams and Hakem, 2016) and that they are capable of producing enzymes that can degrade wastes (Obire *et al*., 2002). The presence of enterotoxigenic bacteria such as *Salmonella sp, E. coli and S. aureus* suggests that typhoid fever, dysentery and diarrhea could be common infectious diseases with contaminated food and water in these markets (Adeyeba and Akinbo, 2003). Types of infections caused by *Pseudomonas sp* which can proceed to septicaemia (Achudume and Olawale, 2007) have been linked to dumpsites. The combination of improper dumping of market refuse and poor handling of foods sold in the market environment could increase the risk of epidemic outbreak of cholera, typhoid fever, dysentery and other food borne diseases. The basic sanitary need of our markets is the elimination of the gross causes of infectious diseases through hygiene (Reilly, 1995).

**Conclusion**

The presence of bacteria pathogens from the waste dump sites and the environs in the urban and rural markets studied is of public health significance in order to prevent potential disease outbreak. Effective waste management and disposal methods should be in place in the markets. Although there is weekly environmental sanitation in the markets, daily clean up and removal of the market wastes is necessary.

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