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Isolation and Characterisation of Microorganisms Associated with Waste Collectors and Scavengers in Port Harcourt Metropolis, Rivers State, Nigeria

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ABSTRACT

Municipal solid waste management in developing countries exposes waste collectors and scavengers to pathogenic microorganisms through direct contact with waste materials. This study characterised bacteria and fungi from the palms, feet and used gloves of formal waste collectors and informal waste scavengers in Port Harcourt, Nigeria. A total of 352 samples comprising surface swabs of palms (155 samples), feet (155 samples), and 42 used gloves were collected from different dumpsites and landfill. Samples were analysed using standard microbiological techniques. The isolates were identified based on morphological, microscopic and biochemical techniques. Hamolysis and biofilm were the virulence test adopted for the isolates. Data obtained showed that *Staphylococcus aureus* (20.7%) predominated on palms, *Bacillus* spp. (52.0%) on feet and *Escherichia coli* (34.7%) on gloves. Among fungi, *Candida* spp. was most frequent on gloves (40.0%) and palms (30.1%) while *Aspergillus* spp. dominated on feet (30.5%). Most isolates exhibited β-haemolysis (70.1%) and strong biofilm-forming capacity (82.8%). The study therefore showed that waste collectors and scavengers harbour bacteria and fungi of significant occupational and public health concern, thereby necesiting the need for improved personal protective equipments, hygiene protocols and regular health surveillance to reduce infection risk among these workers.

Keyword: Waste Collectors, Scavengers, *E. coli*, *Bacillus* spp., *Aspergillus* spp., Occupational and Public Health.

Introduction

Municipal solid waste (MSW) management has emerged as one of the most pressing environmental and public health challenges confronting developing countries in the 21st century. Rapid urbanization, population expansion, and increased industrialization have significantly escalated the volume and complexity of waste generated in urban centres. As noted by Bundhoo (2018), MSW has become a persistent problem in developing regions where infrastructural development has not kept pace with population growth.

Similarly, Nguyen et al. (2021) emphasized that the situation is expected to worsen as urban populations continue to expand beyond the capacity of existing waste management systems, particularly in densely populated metropolitan areas.

A critical issue underpinning MSW management challenges in developing countries is the incompatibility between modern waste management technologies and the realities of urban planning in these regions. Bundhoo (2018) observed that many cities still rely heavily on manual waste handling techniques due to infrastructural limitations such as narrow roads, unplanned settlements, and inaccessible areas.

Consequently, the use of wheeled containers and manual collection methods remains prevalent, particularly in densely populated informal settlements where mechanized systems are impractical. This reliance on manual processes not only reduces the efficiency of waste management operations but also exposes workers to hazardous conditions, including physical injuries, toxic substances, and pathogenic microorganisms.

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Although waste collection has been contributing greatly to human health by reducing the risk of several infectious diseases, solid waste collectors are at high risk of diseases, fatal and non-fatal injuries because about 80% of them are employed in unsafe work environments and only 5% to 15% have access to occupational health services (Temesgen et al., 2022). In Nigeria, municipal solid waste workers collect waste door to door and from commercial areas that need to be shoveled by hand, picked up by hand or emptied from sacks in which the workers have direct contact with solid waste, and are exposed to harmful microorganisms and strenuous working conditions (Bogale et al., 2014). The present study was carried out to characterise the microorganisms associated with the hands and feet of waste collectors in some areas in Rivers State (Oviasogie & Agbonlahor, 2013).

Materials and Methods

Study Area

The study was conducted in Port Harcourt, the capital of Rivers State, Nigeria (coordinates 4^0 49'27"N $7^0$2'1"E). Selected sites included operational bases of the Rivers State Waste Management Agency (RIWAMA) and major dumpsites: Nkpolu Oroworokwu, Mgbundukwu (Mile 2), Orominieke (D-line), St. John Oroworokwu, Iwofe, Rumoula, Rumuepirikom (Ada george), Ozuoba, Rumuokuta, Rumueme, MCC- Rumuigbo, NTA - Mgbogba, Rumuodara, Rumuokoro, Rumuwoji (Mile 1), Rumuosi and Aluu/Rukpuku Landfill. These sites represented formal waste collection routes and informal scavenging locations with high human-waste contact. The map of the studied location is presented in Figure 1.

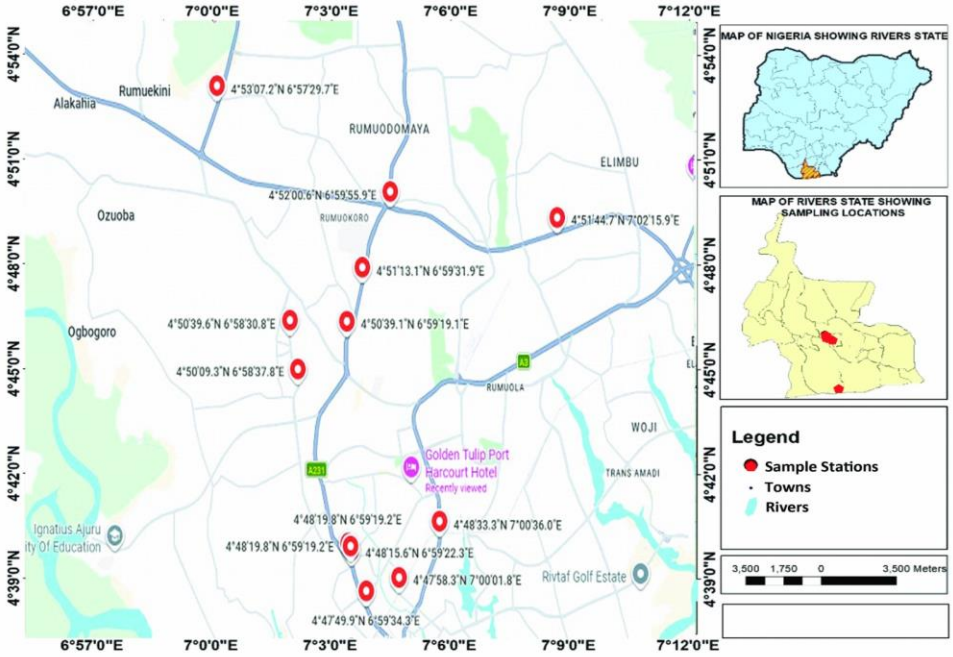


Fig. 1: Map showing the sample locations

Permission and Ethical Clearance

Permission was sorted and granted by the leadership of Rivers State Waste Management Agency and landfill managers to carry out the research.

Research Design

Scavengers' consent was sorted and confidentiality was assured before the face-to-face interview and focus group discussions. Ethical clearance for the conduction of laboratory experiments will be sought from the Rivers State ethical committee.

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A descriptive cross-sectional study design was adopted, and confidence sampling techniques was employed base on willingness and availability of waste collectors and scavengers. The laboratory component involved isolation, identification, characterization, virulence profiling of bacteria and fungi from body surface swabs, and used gloves.

This design is appropriate for occupational health and microbiological risk studies among hard-to-reach informal work populations (Padgett, 2016, Temesgen et al., 2022).

Study Population

The target population comprised formal solid waste collectors employed by RIWAMA and informal waste scavengers operating at selected landfill and dump sites in Port Harcourt who had been engaged in waste-related activities for at least six (6) months and spent a minimum of five hours per day in direct contact with solid waste.

Sample Size Determination

The sample size for the questionnaire survey was calculated using the single-proportion Cochran's formula for cross-sectional studies:

$$n = \frac{Z^2 p(1-p)}{d^2} \quad \text{.....Eqn. 1}$$

Where Z = 1.96 (95% confidence level); P = 0.5 (maximum variability in the absence of precise prior prevalence data for the combined population in Port Harcourt), and d = 0.05 (desired precision).

This yielded a minimum of 384 participants, allowing for 10% non-response. For practical and logical feasibility among mobile informal scavengers, a minimum of 300 completed questionnaires was targeted (Kasemy et al., 2021; Nuripouh et al., 2022).

Collection of Samples

A total of 352 samples (108 samples for palms of waste collectors, 108 samples for feet of waste collectors, 42 samples for used gloves of waste collectors, 47 samples for palms of waste scavengers, 47 samples for feet of waste scavengers) were collected from the selected participants in the study.

Surface swabs of palms and feet of the waste collectors and waste scavengers who spend not less than 5 hours a day collecting waste or at the landfill were collected. The swab sticks were thereafter placed into their casing to avoid contamination and drying, and then the swabs were labelled appropriately.

The transport medium used was sterile normal saline, which was transferred into the swab casings. The samples were taken to the Microbiology Laboratory, Rivers State University in ice pack containers for microbial analysis after collection.

Microbial Analysis

The swabs were inoculated by swabbing (Robinson et al., 2023) on the enrichment media (Nutrient agar, Mannitol salt agar, Eosin methylene blue agar, Thio-citrate bile sucrose agar, MacConkey agar, Salmonella-Shigella agar, Sabouraud dextrose agar and Cetrimide agar) and incubated at 37 ℃ for 24 -48 hours for bacteria, while the fungal plates (SDA) were incubated at 22℃ for 2-5 days (Cheesbrough, 2006).

Identification and Characterization of Bacterial Isolates

The microbial isolates were identified on the basis of colonial morphology, Gram reaction, Biochemical tests (catalase, oxidase, indole test, coagulase test and methyl red test etc).

Further confirmation of the isolates were carried out by comparing their biochemical response to those in Bergey's manual of Determinative Bacteriology and also the use of Advanced system for bacterial identification (ABIS).

Haemolysis Test

Investigations were made into the isolates' haemolytic activity. This was done to determine whether the bacterial isolates could break down red blood cells. By streaking the isolates onto freshly made blood agar medium according to Robinson et al. (2023).

The plates were incubated at 37℃ for 24-48 hours after which the plates were read for the presence of beta (complete zone of inhibition), gamma (no haemolysis) or alpha (partial clearing of zones) haemolysis

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Biofilm Test

Congo red agar was the medium used in the CRA plate test. With the use of this technique, it is possible to directly analyse the colonies and distinguish between slime-forming strains (which show up as black colonies on red agar) and non-slime-forming strains (red-coloured colonies). The strains that pass the test have red colonies with unchanging colour and black spikes on them. As a result, bacterial isolates were grown on CRA plates that were made by mixing 1 L of Brain Hart Infusion agar (BHI) with 0.8 g of Congo red and 36 g of saccharose (both from Sigma, Missouri, EUA) (Oxoid, Basingstoke, Hampshire, England). After that, the plates were incubated for 24 hours at 37 °C. Slime-producing strains were distinguished from non-slime-producing isolates (red smooth colonies) by the presence of rough black colonies (Robinson et al., 2023).

Data Analysis

Descriptive statistics was adopted to obtain the prevalence of microbial growth in the samples. The statistical package for social science (SPSS version 27) was used in the analysis.

Results

The result of the prevalence of bacteria and fungi of waste collectors and scavengers are shown in Tables 1 and 2. Data obtained for the overall prevalence of bacterial species (Table 1); on the palm showed that, *Staphylococcus. aureus* had the highest (20.7%) prevalence, while the least prevalence (0.4%) was recorded for *Listeria* spp and *Aeromonas* spp respectively.

On foot, *Bacillus* spp had the highest (52.0%) prevalence, while the least prevalence (0.0%) was recorded for *Serratia* spp, *Klebsiella* spp, *Providentia* spp, *Listeria* spp, *Proteus* spp, and *Aeromonas* spp respectively.

On the glove, *E. coli* had the highest (34.7%) prevalence, while the least prevalence (0.0%) was recorded for *Citrobacter* spp, *Serratia* spp, *Shigella* spp, *Enterobacter* spp, *Klebsiella* spp, *Providentia* spp, *Listeria* spp, *Proteus* spp, and *Aeromonas* spp respectively.

Data obtained for the overall fungi prevalence on the palm showed that *Candida* spp had the highest prevalence as shown in Table 2 (30.1%), while *Cunninghamella* spp had the lowest (1.4%). On the foot, *Aspergillus* spp. had the highest prevalence (30.5%), while *Fusarium* spp. had the lowest (0.0%).

For the glove samples, *Candida* spp. had the highest (40.0%) prevalence, while the lowest prevalence (0.0%) was recorded for *Rhizopus* spp., *Mucor* spp., *Cunninghamella* spp., *Blastomyces* spp., *Gliocladium* spp and *Geotrichum* spp.

Table 1: The Overall Prevalence (%) of Bacteria

S/N	Organisms	Palm (%)	Foot (%)	Glove (%)
1	*Pseudomonas* spp	17.97	10.20	17.39
2	*S. aureus*	20.74	11.22	13.04
3	*Citrobacter* spp	3.69	0.12	0.00
4	*Bacillus* spp	18.43	52.04	8.70
5	*E. coli*	14.75	9,18	34.78
6	*Serratia* spp	3.23	0.00	0.0
7	*Shigella* spp	2.30	2.04	0.0
8	*Micrococcus* spp	1.84	1.02	4.35
9	*Vibrio* spp	4.15	5.10	13.04
10	*Enterobacter* spp	2.76	2.04	0.00
11	*Klebsiella* spp	2.30	0.00	0.00
12	*Providentia* spp	1.38	0.00	0.00
13	*Samonella* spp	4.61	6.12	8,70
14	*Listeria* spp	0.46	0.00	0.00
15	*Proteus* spp	0.92	0.00	0.00
16	*Aeromonas* spp	0.46	0.00	0.00
	Total	**100**	**100**	**100**

Table 2: Overall Prevalence of Fungal Species

S/N	Organisms	Palm (%)	Foot (%)	Glove (%)
1	*Rhizopus* spp	2.7	1.7	0.00
2	*Mucor* spp	8.2	3.4	0.00
3	*Aspergillus* spp	23.3	30.5	33.3
4	*Rhodotorula* spp	4.1	3.4	6.7
5	*Candida* spp	30.1	25.4	40.0
6	*Penicillium* spp	13.7	20.3	13.3
7	*Cunninghamella* spp	1.4	3.4	0.00
8	*Blastomyces* spp	2.7	5.1	0.00
9	*Fusarium* spp	11.0	0.0	6.7
10	*Gliocladium* spp	2.7	3.4	0.0
11	*Giotrichum* spp	-	3.4	0.0
	Total	**100**	**100**	**100**

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The result of haemolytic pattern of the isolates and the results of the potential of the isolates to form biofilm are as presented in Table 3. The haemolytic pattern of the isolates showed that *Aeromonas* spp and *Listeria* showed no breakdown of red blood cells, *Proteus* showed complete breakdown of red blood cells (100%), followed by *Citrobacter* (88.9%), *Micrococcus* (83.3%), *Staphylococcus* spp (81.4%), *Pseudomonas* spp (81.1%), *E. coli* (75.5%), *Shigella* spp (72.9%), *Serratia* spp (71.4%), *Providencia* (66.7%), *Enterobacter* spp (62.5%), *Salmonella* spp (61.7%), *Bacillus* spp (61.3%), *Klebsiella* (60%), and *Vibrio cholera* (47.1%). On the other hand, the results of the potential of the isolates to form biofilm showed that *Aeromonas* spp, *Micrococcus*, *Proteus*, *Providencia*, *Salmonella* spp, and *Serratia* spp have 100% potential to form biofilm, followed by *Staphylococcus* spp (91.5%), *Pseudomonas* spp (88.7%), *Enterobacter* spp (87.5%), *Shigella* spp (87.5%), *Citrobacter* (77.8%), *Bacillus* spp (76.3%), *Vibrio cholera* (70.5%), while *Listeria* showed no potential of forming biofilm.

Table 3: Haemolytic Pattern and Biofilm Formation of the Isolates (Percentage %)

S/N	Bacterial Isolates	Haemolytic Pattern of the Isolates (n %)			Biofilm Formation of the Isolates (n %)	
		α (%)	β (%)	γ (%)	Positive (%)	Negative (%)
1	*Aeromonas* spp	0.0	0.0	100	100	0.0
2	*Bacillus* spp	20.4	61.3	18.3	76.3	23.7
3	*Citrobacter* spp	11.1	88.9	0.0	77.8	22.2
4	*E. coli*	204	75.5	4.1	69.3	30.6
5	*Enterobacter* spp	25.0	62.5	12.5	87.5	12.5
6	*Klebsiella* spp	40.0	60.0	0.0	100	0.0
7	*Listeria* spp	0.0	0.0	100	0.0	100
8	*Micrococcus* spp	0.0	83.3	16.7	100	0.0
9	*Pseudomonas* spp	7.5	81.1	11.3	88.7	11.3
10	*Proteus* spp	0.0	100	0.0	100	0.0
11	*Providencia* spp	33.3	66.7	0.0	100	0.0
12	*Salmonella* spp	27.8	61.7	11.1	100	0.0
13	*Serratia* spp	28.6	71.4	0.0	100	0.0
14	*Shigella* spp	57.1	72.9	0.0	85.7	14.3
15	*Staphylococcus* spp	11.9	81.4	6.8	91.5	8.5
16	*Vibrio cholera*	29.4	47.1	23.5	70.5	29.4
	Total	**18.3**	**70.1**	**11.5**	**82.8**	**17.2**

Discussion

Bacterial isolation from palms, feet and gloves demonstrated a diverse genus of both Gram-positive and Gram-negative organisms. Results for the gloves showed *E. coli* as the leading isolate, followed by *Pseudomonas* spp. and equal prevalence of *S. aureus* and *Vibrio* spp. Least prevalent taxa included *Listeria* spp., *Aeromonas* spp., *Serratia* spp., *Klebsiella* spp. and others on specific sites. These findings are consistent with the study of Nwankwo et al. (2025) on waste handlers in Abia State, Nigeria, which reported the presence of *S. aureus, Bacillus* spp., *Pseudomonas aeruginosa*, *E. coli* and related Enterobacteriaceae on skin and respiratory sites (Auta & Paul, 2020).

The high prevalence of *Bacillus* on the feet of waste collectors and scavengers in this study is unsurprising given the organism's environmental ubiquity and spore-forming resilience, while the enrichment of enteric organisms (*E. coli, Salmonella*, and *Vibrio*) on hands and gloves points to faecal contamination of waste streams and inadequate barrier protection.

The presence of *Pseudomonas* across sites further highlights the presence of opportunistic pathogens capable of thriving in moist, nutrient-rich waste environments. The diversity of bacterial species, including *Pseudomonas, E. coli*, and *Salmonella*, reflects the complex microbial ecosystem in waste environments (Mbata et al., 2024).

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These findings corroborate recent investigations highlighting the occupational hazards posed by microbial contamination among waste handlers, with concerns about the spread of antibiotic-resistant strains (Lee et al., 2022; Nguyen et al., 2023).

In this study, the prevalence of fungi was equally concerning. These genera (*Aspergillus, Candida, Penicillium, Mucor*, and *Rhizopus*) are well-documented colonizers of waste environments and human skin under occupational exposure (Nwankwo et al., 2025). Notably, *Aspergillus* and *Candida* species in particular are opportunistic pathogens capable of causing invasive disease in immunocompromised hosts or superficial infections in individuals with compromised skin barriers, a condition common among bare-handed or poorly protected waste workers (Nwankwo et al., 2025). This is consistent with the findings of Hassan *et al*. (2021), who reported similar fungal colonization patterns in waste workers (Otokunefor et al., 2024).

The overall microbial profile indicates that waste collectors and scavengers serve as reservoirs and potential vectors of both bacterial and fungal pathogens. Continuous dermal contact with mixed municipal and organic waste, combined with imperfect hygiene, sustains high carriage rates. The differential distribution across anatomical sites (enteric organisms more common on hands/gloves; spore-formers and environmental fungi more common on feet) reflects site-specific exposure pathways and underscores the need for targeted personal protective equipment (PPE) and hygiene interventions.

Most of the isolates in the present study exhibited some level of virulence, especially in haemolysing blood and production of biofilm. It has been documented that the ability of an organism to cause infection is highly dependent on virulence (Robinson et al. 2023). Haemolytic activity was widespread in this study. Complete haemolysis was observed in *Proteus* isolates, followed by high rates in *Citrobacter* (88.9%), *Micrococcus* (83.3%), *Staphylococcus spp*. (81.4%), *Pseudomonas* spp. (81.1%), *E. coli* (75.5%) and several other genera. Only *Aeromonas* and *Listeria* showed no haemolytic activity (Okwuanaso et al., 2023). Also, biofilm formation potential was equally elevated: *Aeromonas, Micrococcus, Proteus, Providencia, Salmonella* and *Serratia* isolates formed biofilm, with high rates also recorded for *Staphylococcus* (91.5%), *Pseudomonas* (88.7%), *Enterobacter* and *Shigella* (both 87.5%). Only *Listeria* lacked biofilm-forming capacity. Haemolysins and biofilm production are classical virulence determinants that facilitate tissue invasion, immune evasion and persistence on biotic and abiotic surfaces.

The high prevalence of both traits among isolates recovered from waste workers is consistent with phenotypic characterization of environmental and clinical isolates of the same genera and raises concern that these organisms may establish chronic colonization or cause opportunistic infections in workers with minor skin trauma. Biofilm-forming capacity further enhances resistance to antibiotics and disinfectants, compounding the therapeutic challenges posed by the observed MDR phenotypes (Singh *et al*., 2021).

Conclusion

The overall microbial profile indicates that waste collectors and scavengers serve as reservoirs and potential vectors of both bacterial and fungal pathogens. The study on the bacterial species associated with waste collectors and waste scavengers has indicated that *Staphylococcus aureus* is the predominant bacteria posing bacterial-mediated occupational hazard followed by *Bacillus* spp, *Pseudomonas* spp and *Escherichia coli.*

These findings shows the importance of strengthening the occupational health and safety measures through the compulsory use of appropriate personal protective equipments, improve personal hygiene and regular health surveillance are essential for monitoring and mitigating the risk associated with exposure to pathogenic microorganisms

References

Auta, I. K., & Paul, A. J. (2020). Analysis of some bacterial load on waste scavengers in selected locations within Jere Local Government Area of Borno State, Nigeria. *Science World Journal, 15*(1), 80–83.

Bogale, D., kumie, A. & Tefera, W. (2014). Assessment of occupational injuries among Addis Ababa city municipal solid waste collectors: a cross-sectional study. *BMC Public Health*, 14, 169.

Citation: Essien *et al.* (2026). Isolation and Characterisation of Microorganisms Associated with Waste Collectors and Scavengers in Port Harcourt Metropolis, Rivers State, Nigeria. *International Journal of Microbiology and Applied Sciences*, ***5(3)***, 399 – 405.

Bundhoo, Z. M. A. (2018). Solid waste management in least developed countries: Current status and challenges faced. *Journal of Material Cycles and Waste Management, 20*(3), 1867–1877.

Hassan, A. M., El-Sayed, M. A., & Abd El-Ghany, W. A. (2021). Fungal contamination and health risks among waste handlers: A study from Egypt. *Mycopathologia*, *186*(2), 203-213.

Kasemy, Z.A., Rohlman, D.S. & Abdel Latif, A.A. (2021). Health disorders among Egyptian municipal solid waste workers and assessment of their knowledge, attitude, and practice towards the hazardous exposure. *Environ Sci Pollut Res*.; *28*(24), 30993–1002.

Lee, S. H., Park, J. H., & Kim, H. J. (2022). Prevalence of antibiotic-resistant bacteria in waste management workers: A systematic review. *Waste Management*, *143*, 231-240.

Mbata, C. A., Aleru, C. P., Isomah, C. J., & Welenya, W. O. (2024). Microbial load burden of solid waste biodegradable microbes of dumps in relation to economic and health implication of waste scavengers in Port Harcourt, Nigeria. *Annals of Medical Laboratory Science, 3*(1), 35–44.

Nguyen, T. T., Tran, V. M., & Pham, H. T. (2023). Bacterial contamination and antibiotic resistance in waste collectors in Southeast Asia. *Environmental Science and Pollution Research*, *30*(10), 27789-27798.

Nguyen, T. T., Zhu, D., & Le, N. P. (2021). Factors influencing waste collection efficiency in developing countries. *Environmental Science and Pollution Research, 28*(12), 14500–14512.

Nuripuoh, J.G., Duwiejuah, A.B. & Bakobie, N. (2022). Awareness and health risk protection behaviours of scavengers in the Gbalahi landfill site, Ghana, in the era of sustainable development. *Discover Sustainability*, 3, 1.

Nwankwo, I.W., Nwachukwu, N.C., Onwuchekwa, E.C., Okamgba, O.C. & Ugbogu, O.C. (2025). Microbial flora of the respiratory tract and skin of artisanal municipal solid waste handlers in Aba, Abia State, Nigeria. *Access Microbiology*, *7* (1), 000876.

Okwuanaso, C. B., Enweani-Nwokelo, I. B., & Obeagu, E. I. (2023). Isolation and identification of microorganisms in individuals associated with refuse disposal sites and collection centres in Awka metropolis, Nigeria. *Academic Journal of Health Sciences, 38*(2), 131–137.

Otokunefor, K., Nwankwo, P. C., Nyema, K. C., & Agbagwa, O. E. (2024). Molecular assessment of resistance and virulence potential of *Vibrio* species isolated from dumpsites in Port Harcourt, Nigeria. *Journal of Advances in Environmental Health Research, 12*(2), 102–107.

Oviasogie, F. E., & Agbonlahor, D. E. (2013). The burden, antibiogram and pathogenicity of bacteria found in municipal waste dumpsites and on waste site workers in Benin City. *Journal of Medicine and Biomedical Research, 12*(2), 115–130.

Padgett, D.K. (2016). Qualitative methods in social work research. *Sage Publications*; 36.

Robinson, V. K., Akani, N. P., Amadi, L. O., & Wemedo, S.A. (2023). Phenotypic determination of virulence attributes of S. aureus and P aeruginosa isolated from clinical specimens in Port Harcourt, Rivers State. *Journal of Advances in Microbiology Research, 4*(2), 38-44.

Robinson, V. K., Wemedo, S. A., Akani, N. P., & Amadi, L. O. (2023). Prevalence and Antibiotic Susceptibility of Methicillin-Resistant Staphylococcus aureus isolated from Clinical Specimens from a Teaching Hospital in Port Harcourt. *International Journal of Microbiology and Applied Sciences, 2(2),* 31–36.

Singh, S., Datta, S., Narayanan, K. B., & Rajnish, K. N. (2021). Bacterial exo-polysaccharides in biofilms: role in antimicrobial resistance and treatments. *Journal of Genetic Engineering and Biotechnology, 19*, 140.

Temesgen, L.M., Mengistu, D.A., Mulat, S., Mulatu, G., Tolera, S.T., Berhanu, A., Baraki, N. & Gobena, T. (2022). Occupational Injuries and Associated Factors Among Municipal Solid Waste Collectors in Harar Town, Eastern Ethiopia: A Cross Sectional Study. *Environmental Health Insights; 16*, 1–8.

Citation: Essien *et al.* (2026). Isolation and Characterisation of Microorganisms Associated with Waste Collectors and Scavengers in Port Harcourt Metropolis, Rivers State, Nigeria. *International Journal of Microbiology and Applied Sciences*, ***5(3)***, 399 – 405.