International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Bacterial contamination of some fruits sold around wastedumps in Owerri metropolis, Nigeria

AFOR IFEOMA ANNA *, OKEKE PETER N and EJIOGU CHRIS C

Department of environmental management, school of environmental sciences, Federal university of technology, Owerri, Nigeria.

International Journal of Science and Research Archive, 2023, 10(01), 812–822

Publication history: Received on 17 August 2023; revised on 09 October 2023; accepted on 12 October 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.10.1.0787

Abstract

Analysis of bacterial contamination of fruits sold near waste dumps in Owerri Metropolis were carried out. The various contamination levels on fruits such as; orange (*Citru X sinensis*), water melon (*Citrullus lanatus*), apple (*Malus pumila*), garden egg (*Solanum melongena*), groundnut (*Arachis hypogeaa*), pawpaw (Carica papaya) and carbbage. The fruit samples, each were collected near wastedumps in Owerri metropolis. Fruit samples used as control were collected where there was no wastedump. Each of the samples was packaged into plastic bag and labelled. Sixty fruit samples were collected. (Fifty-four of which were collected near waste dumps while six of the fruit samples were used as the control). Microscopic, physical examination and biochemical test were carried out; five bacterial species were isolated in the fruit samples: Isolate A; *Bacillus Subtills*, Isolate B; *E. coli*; Isolate C; *Samonella* spp, Isolate D; *Staphlacocus* spp and Isolate E: *Klebsiella* spp. The results indicate that there were bacterial loads in the fruit samples at each sampling point. The total bacterial loads in the fruits samples ware $1.05x\ 10^5$ Cfu· This buttress the fact the wastedump maybe contributing to the level of bacterial in the fruit sold around it. The study recommends that Government should stop people from dumping refuse on open market streets rather trucks should be provided to be carrying refuse from various Locations and take them to the approved dumpsites. People selling fruit should be encouraged to display the fruits on a the table and not a the ground where it can be contaminated.

Keywords: Contamination; Wastedumps; Bacterial; Fruit; Isolate

1. Introduction

Modernization and progress has had its share of disadvantages and one of the major aspect is pollution it is causing to the earth, be it land, air or water. With increase in the number of people in the world and the rising demand for food and other necessities, there has been an increase in the amount of waste being generated daily by each household.

This waste is finally disposed into municipal waste collection centers from where it is collected by the area municipalities to be further thrown into the landfills and dumpsites. However, either due to resource crunch or inadequate infrastructure, all of the wastes do not get collected and transported to the final dumpsite. At this stage, if the management of waste is not done properly, it causes serious environmental impact and serves as breeding ground for pathogens or bacterial.

Waste that is not properly managed, most especially excreta and other liquid and solid waste from household, market center and community are seriously affecting the environment and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats, and other creatures that in turn spread disease and release a bad odour. This led to unhygienic conditions and thereby to a rise in the health problems.

* Corresponding author: AFOR IFEOMA ANNA

The bacterial can spread through air, water, land and into the environment, especially on exposed food items.

Disposing of waste through open dumping with open burning is the way waste is taken care of in most developing countries. This practice has led to creation of dumpsites posing significant risks to neighbouring communities and the environment. Open dumping practices are still being practiced, as the dominant method, in both low-income and upper middle-income countries. The practice tends to be eliminated in the developed world, although there are still reports of illegal dumpsites (European Comparative and International Environmental Law, 2017).

Recent reports indicate that roughly 3.5 - 4 billion people are served by dumpsites where 40% of the total waste generated is disposed of (Swidbert *et al.,* 2022).

Open dumping usually takes place close to the urban centers and in some cases residential areas are formed and expanded around the dumpsites. Of almost all of the world's 50 biggest dumpsites, 5 are located near or even within urban areas and close to natural resources. Forty two out of the 50 dumpsites have settlements in a distance of less than 2 km, 44 dumpsites are close (less than 10 km) to natural resources and 38 dumpsites are close to water sources such as rivers, lakes, oceans, posing a threat to marine and coastal pollution. Obviously, although unquantified, the contribution of dumpsites to marine litter is substantial (Swidbert *et al.,* 2022).

Fruits sold in the open markets play an important socioeconomic role in fulfilling the food and nutritional need of urban consumers at affordable prices in the lowest income groups and are considered to be very convenient and cheap (Aybuike Sezgin, 2016). Fruits sold in the markets in Owerri also provide food security for low-income urban population and the livelihood of a significant proportion of the population in the city. These fruits sold in the markets are described as a wide range of ready-to-eat foods or fruits and are consumed in the market or at home without further washing or are washed casually. These fruits are usually sold by vendors and hawkers in the markets or in other similar public places. While fruits vendors or sellers are appreciated for their convenience, they are also important in contributing to the nutritional status of the population. Contrary to these potential benefits, it is also recognized that these fruits vendors are often poor, uneducated, and lack knowledge in safe food handling, environment, sanitation and hygiene. Fruits are displayed on the ground in most cases and the water used to wash them is not potable water. Consequently, fruits sold on public roads are perceived as a significant major public health risk.

1.1. Statement of the Research Problem

Improper dumping of garbage leads to the accumulation of waste at fruit vending sites. This leads to an increase in the pest population and also an increased risk of fruit contamination. Food-borne microbial disease is a major health problem associated with fruits or foods sold in unclean environment (Khan Redzwan, 2016). In addition, the resistance of food-borne microorganisms to multi-drug has made the food security situation more vulnerable in public health (Narayan *et al.,* 2023). "Diarrheal diseases are cases of intoxication most common in fruits in Nigeria and in some cases can lead to death. Diseases are caused either by the toxin from the microbes or by the reaction of the human body to the microbes. The traditional processing methods used in the preparation, improper storage temperature and, and poor personal hygiene of food or fruits handlers are some of the main causes of street fruit contamination (Oduro-Yeboah *et al.,* 2020). In addition, fruits sold in these markets are not effectively protected against flies and dust (Mohamed, 2015). In Owerri, fruits are mainly displayed in most cases on the ground or on small height platforms without covering in various markets streets, roadside and some vendors hawk it around. A study is needed to determine the concentration of bacterial in fruits sold around selected waste dumpsites.

Aim and Objectives of the Study

The aim of this study is to ascertain the level of bacterial contamination on fruits sold in open market near waste dumps in Owerri Metropolis.

This is to be achieved through following objectives

- To determine the level of bacterial contamination of the fruits.
- To ascertain the various bacterial isolates in the fruits, such as orange (*Citru X sinensis*), water melon (*Citrullus lanatus*), apple (*Malus pumila*), garden egg (*Solanum melongena*), groundnut (*Arachis hypogeaa*), pawpaw (*Carica papaya*) and carbbage.
- To determine the bacterial load and varieties in the fruits sold around the sites and the market environment.

1.2. Significance of the Study

Waste is said to be hazardous if it is infectious, meaning containing viable microorganisms or their toxins which are known or suspected to cause diseases in animals or humans. Waste disposal poses threats to both man , animals and the environment. Poisonous plants, insects, indigenous pathogens are biologic hazardous agents that might spread into the environment through wind and water. Through the spread of bacterial from the waste,fruit items can be contaminated. Hence, the need to study the Contamination of bacterial on fruit items sold around selected wastedumps in Owerri Metropolis, in Imo State.

1.3. Scope of the Study

The study was done in selected sale outlets around wastedumps in Owerri Metropolis which include MCC Road, Emmanuel College, Wetheral, Douglass Road, ABA-Owerri Road, Egbu Road Relief Market Maria-Assumpta Area, Nekede Road and Okigwe.

Laboratory analysis was carried out to determine the level of contamination in each sample.

The pathogen(bacterial) isolated were Isolate A; *Bacillus Subtills*, Isolate B; *E. coli*; Isolate C; *Samonella* spp*,* Isolate D; *Staphlacocus* spp and Isolate E: *Klebsiella* spp*.*

Material and methods

1.4. Study Area

1.4.1. Location

Owerri Metropolis consists of three areas including Owerri Municipal, Owerri North and Owerri West, (the three local government areas are called Owerri Metropolis) has an estimated population of approximately 1,401,873 as of 2016 and is approximately 100 square kilometres (40 square miles) in area. Owerri is borders the Otamiri River to the east and the Nworie River to the south, (Alex, Acholonu 2008). The coordinates of Owerri are on latitude 5.476310^{0}N and Longitude7.025853^{0}E.

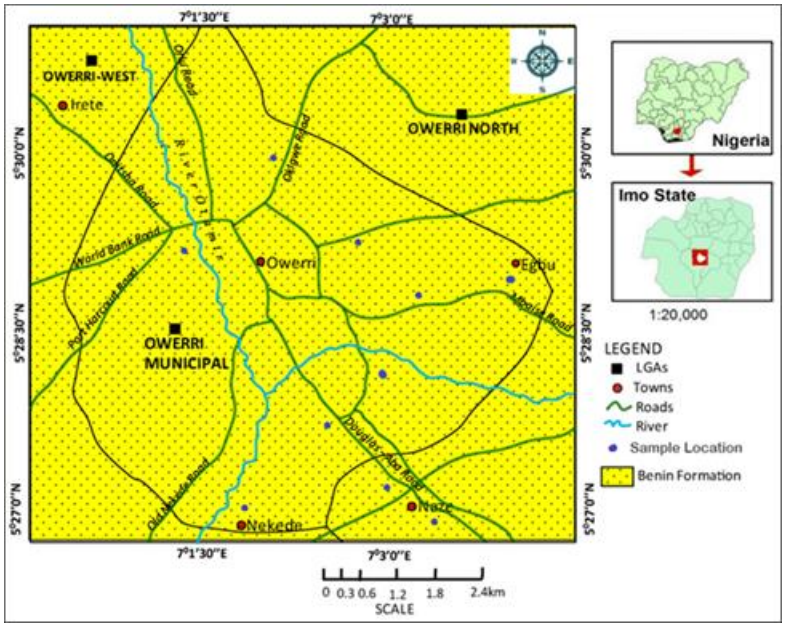

Figure 1 Point of sample collection in Owerri Municipal Council

1.4.2. Climate

Owerri has a humid tropical climate according to the Kopped-Geiger system. Rain falls most of the month of the year with a brief dry season, the city experiences harmattan and is significantly less pronounced than in other cities in Nigeria. The average temperature is 26.4^o C. [Encyclopedia 2023]

1.5. Sample Collection

The samples were collected using systematic random sampling . The two fruit samples of three reprical were collected at each sampling point. Each of the samples was put into a plastic bag and labelled

1.6. Sample Preparation

1.6.1. Bacteriological Analysis for Fruit Samples

Enumeration of Total viable bacteria

- Stock suspension of various sample matrixes were prepared by weighing out 10 g of the sample using a pre weighed sterile container. A 90 mL Sterile distilled water was added to the sample and the mixture shaken vigorously 60 seconds and allowed to settle for 10 minutes
- A 10 fold serial dilution was then carried out using sterile distilled water as the diluents. 1mL of each dilution from 10^3 to 10^8 were aseptically incubated in triplicate.
- Nutrient agar with the above composition was the media used for incubation
- Two undiluted plates were used as control
- The culture were incubated at room temperature for 48 hours
- At the end of incubation period, the plates were counted using colony counter to determine no of colony forming unit per gram of the sample.

Table 1 Location, the food items collected and the type of waste on each dumpsite

Location of Dumpsites	Fruits Sample (a) Morning	Fruit Sample (b) Afternoon	Type of waste
Wetheral	F1aW	F1b W	Domestic and market waste
Emmanuel College	F2aE	F2b E	Domestic and market waste
Mbaise Road	F3a M	F3b M	Domestic and market waste
Relief Market	F4a R	F4bR	Domestic and market waste
Egbu	F5aER	F5bMR	Domestic and market Waste
MCC	F6a MC	F6bMC	Domestic and market Waste
Aba Road	F7a AR	F7bAR	Domestic and market waste
Ekeonuwa Market	F9aEK	F9bEK	Domestic and market waste
Nekede Road	F10aN	F10bN	Domestic and market waste
Okigwu (Control)	F8a C	F8bC	No dumpsite

Key: F1W Food sample collected at Wetheral; F2E food sample collected at Emmanuel College; F3M food sample taken at Mbaise Road; F4R food sample taken at Relief Market; F5ER food sample taken at Egbu Road; F6MC food sample taken at MCC Road; F7AR food sample taken at Aba Road F9bEK food sample taken at Ekeonuwa Mkt; F10N food sample taken at Nekede Road; F8C food sample taken at Okigwu

When collecting the samples, I observed that the waste on the dumpsite as indicated on the table 1 above, was domestic and market waste, waste like nylon, plastic bottles, fruit peels and spoilt food, used diaper, disposable waste, human waste.

1.7. The Statistical Method Used

- Mean
- Standard Deviation
- T- test.

2. Results

Table 2 shows the results of bacteria loads in the fruit samples collected at various point in Owerri metropolis. At each sampling point two different fruit samples were collected in three replicas, which make a total of six fruit samples at

each sampling point. The samples were taken in ten sampling points. The mean and the standard deviation of the loads of bacteria in the two different fruit samples replicas at each sampling point were calculated and recorded.

Table 2 Results of Bacterial Count on Fruit Samples

SN	Wetheral Road		Douglas Road		MCC Road		Emmanuel College		Aba Road	
	Orange (F1aW)	Watermelon (F1bW)	Apple (F9aDR)	Garden egg (F9bD)	Cabbage (F6aMC)	Groundnuts (F6bMC)	Pawpaw (F2aEM)	Grava (F2bEM)	Pawpaw (F7aAR)	Orange (F7bAR)
1	1.92 x10^3	7.42 x 10^3	3.15 x 10^3	2.87 x 10^4	3.41 x 10^3	3.37 x 10^3	3.25 x 10^3	2.82 x 10^4	2.18 x10^4	0.00
2	1.94 x10^3	7.42 x 10^3	3.12 x 10^3	2.88 x 10^4	3.40 x 10^3	3.35 x 10^3	3.25 x 10^3	3.81 x 10^4	2.17 x10^4	0.00
3	1.92 x10^3	7.43 x 10^3	3.16 x 10^3	2.87 x 10^4	3.40 x 10^3	3.36 x 10^3	3.24 x 10^3	2.82 x 10^4	2.18 x10^4	0.00
$\bar{x}$	1.92 x10^3	7.42 x 10^3	3.15 x 10^3	2.87 x 10^4	3.41 x 10^3	3.37 x 10	3.25 x 10^3	2.82 x 10^4	2.18 x10^4	0.00
SD	1.1 x 10^0	5.6 x 10^0	2.0 x 10^0	5.7 x 10^0	5.8 x10^1	1.0x 10^1	5.8 x10^0	5.8x 10^0	5.7x 10^1	0.00

Table 3 Results of Bacterial Count on Fruit Samples (Continued)

SN	Maria Assumpta		Nekede Road		Control		Relief Market		Egbu Road	
	Apple (F3aMA)	Pawpaw (F3bMA)	Cabbage (F10aN)	Groundnuts (F10bN)	Pawpaw (Fa8C)	Grava (Fb8C)	Grava (F4aR)	Garden egg (F4bR)	Pawpaw (F5aER)	Watermelon (F5bER)
4	4.24 x 10^3	0.00	3.43 x 10^4	3.44 x 10^2	3.15 x10^2	3.16 x 10^2	4.42 x 10^3	4.05 x 10^3	3.46 x 10^3	3.28 x 10^4
5	4.24 x 10^3	0.00	3.45x 10^4	3.44 x 10^2	3.15 x10^2	3.17 x 10^2	4.43 x 10^3	4.06 x 10^3	3.45 x 10^3	3.28 x 10^4
6	4.25 x 10^3	0.00	3.45 x 10^4	3.44 x 10^2	3.14 x10^2	3.19 x 10^2	4.43 x 10^3	4.05 x 10^3	3.46 x 10^3	3.28 x 10^4
$\bar{x}$	4.24x10^3	0.00	3.41 x 10^4	3.44 x 10^2	3.15 x10^2	4.17 x 10^2	4.42x10^3	4.05 x 10^3	3.45x 10^3	3.28x 10^4
SD	5.7x 10^0	0.000	1.15x 10^2	0.000	0.5x10^{-1}	0.57 x10^0	5.8x 10^0	5.8x 10^0	5.8x 10^0	0.000

Table 4 The Proportion of bacterial loads in the fruit samples

Variable CFU\g	Number of Samples	Percentage
No growth 10^0	6	10
Low growth 10^1_ 10^2	9	15
High growth10^3 - 10^4	45	75
Total	60	100

Table 5 Identification of Isolates

SN	Identification Test	Isolate A	Isolate B	Isolate C	Isolate D	Isolate E
1.	Catalase test	+ve	+ve	+ve	+ve	+ve
2.	Citrate test	+ve	-ve	-ve	-ve	+ve
3.	Flagella test	Flagellated	Flagellated	Non flagellated	Non Flagellated	Non Flagellated
4.	Getatine hydrolysis	+ve	+ve	-ve	+ve	+ve
5.	Grain Staining	+ve	-ve	-ve	+ve	-ve
6.	Indole Test	-ve	+ve	-ve	-ve	-ve
7.	Motility	+ve	-ve	+ve	-ve	-ve
8.	Methy red test	+ve	+ve	+ve	+ve	-ve
9.	Nitrate reduction	+ve	+ve	+ve	+ve	+ve
10.	Oxidase test	-ve	-ve	-ve	-ve	-ve
11.	Pigmentation	-ve	-ve	-ve	+ve	-ve
12.	Shape	Rod	Rod	Rod	Cocci	Rod
13.	Spore formation	-ve	-ve	-ve	-ve	-ve
14.	Urease	-ve	-ve	-ve	+ve	+ve
15.	VP (Voges Proskaues) test	+ve	-ve	-ve	+ve	+ve
16.	Glucose Fermentation	+ve	+ve	-ve	+ve	+ve
17.	Lactose Fermentation	-ve	+ve	-ve	+ve	+ve
18.	Maltose Fermentation	+ve	+ve	+ve	+ve	+ve
19.	Xylose Fermentation	+ve	+ve	+ve	-ve	+ve
20.	Starch Hydrolysis	+ve	-ve	+ve	+ve	-ve
21.	Bacteria Species	*Bacillus subtilis*	*E. coli*	*Samonella spp*	*Staphylococcus areus*	*Klebsiella spp*

Identification key use from Berger's Manual of Determinative bacteriology

Table 6 Bacterial isolate from the samples sold near market waste dump

Variable	A Fruit Item	C Control
Bacillus subtilis	+	_
E. coli	+	+
Samonella spp	+	+
Staphylococcus spp	+	_
Klebsiella spp	+	_

Key: + = Positive – = Negative

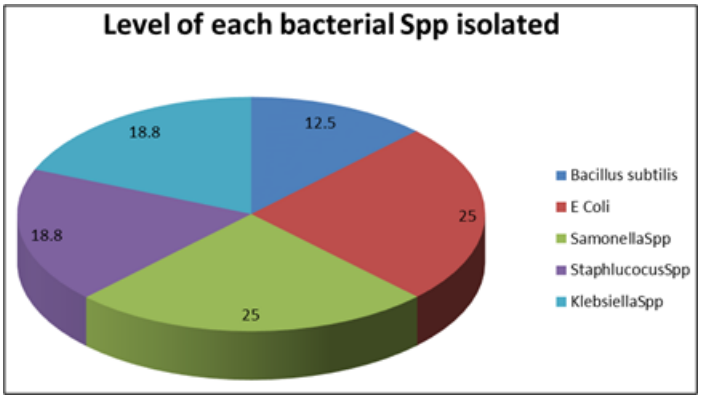

Figure 2 Percentage of each of the bacterial specie isolated in all the samples collected

3. Discussion

The table 2.2 above shows that six of the fruit items sampled had no bacterial growth and nine of which had low bacterial growth. The fruit samples with no and low growth was because they were displayed on a platform and are little bit farther from the wastedumps. Forty-five of the fruit items sampled had high bacteria count; they are displayed on the ground or on a platform with no coverage and most times are very close to a dumpsite, which are 75% of the whole fruit samples analyzed. This agreed with Charles (2020) assertion that, Pathogenic micro-organisms originate from numerous sources in MSW and both enteric bacterial pathogens and viruses have been detected in MSW".

From table 2.1 above shows that the control Fa and Fb have low loads of bacterial due to the fact that there was no waste dump close to the point where the samples are collected, the present low load of bacterial buttress the fact that no place in the market street of Owerri Metropolis is free of waste dump, this is supported by the findings of Oluwadara *et al.* (2018) who reported that in most cities of Nigeria and other developing countries, the greater percentages of waste generated are dumped on the surface of the ground along major roads, street and open spaces. But sample F7aAR and F3aMR has no growth and this was because they were placed on a platform, and partially covered. The remaining fifteen samples are had high loads of bacterial in them, they are displayed on the ground, near the dumpsite or waste dump.

Figure 2.1 above shows the percentage of each bacterial species isolated in the samples collected around the waste dump. *E. coli* and *Samonella* spp. are more abundant in the samples they were 25%, *Staphylococcus* spp. and *Klebsiella* spp. were 18.8% and *Bacillus subtilis.*12.5% which is the least.

4. Conclusion

In Owerri Metropolis there are no proper waste disposal sites, so people use open dumpsite to dispose off their waste. And these open dumpsites are mostly located on the market and residential streets. On the street you will see sellers displaying the food items, the traders mostly those selling fruits display these fruits on the ground not minding the waste dump close to the place, little wonder the fruit samples were found to contain loads of bacterial in them. The total bacterial loads in the fruits samples was 1.05×10^5 Cfu. The test for significance result was 3.745 at p .005 hence, H_0 was accepted.

From fruits Isolates A, B, C, D and E were Isolated, and from the control samples with low microbial loads but isolates B and D were Isolated. Base on the results of microscopic physical examination and biochemical test and in accordance with Bergers manual of Determinative Bacterology.

The Isolates were identified as follows:

Isolate A: *Bacillus subtilis,* Isolate B: *E. coli*, Isolate C: *Samonella* spp., Isolate D: *Staphylococcus* spp. and Isolate E: *Klebsiella* spp.

Though, it was very difficult to find a place without wastedump in Owerri Metropolis and low bacterial growth was found on the fruit samples analyzed as the control, which shows that there was no place in Owerri Metropolis that was free of waste dump.

Recommendations

Based on the findings of the study, the following recommendations are made.

- The government should also provide sanitary dumpsite in the Owerri Metropolis and encourage people to use it.
- People selling fruit should be encouraged to display the fruits on a table and not on ground.
- Government or trade union in each market should build toilets in the market and employ people who will be taking care of the place, thereby maintaining good sanitary condition
- People doing one business or the other in the market should be educated on the danger in defecating or urinating on an open ground or in the waste dump in the market.
- Government should stop people from dumping refuse on open market streets by providing trucks that will be carrying refuse from various store and take them to the proper dumpsite provided by the government while a token will paid by the store owner. This is also a way of generating income for the state and creating employment for the citizens.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Acharya, Tankeghwar (2022). Tests for Bacterial Motility: Procedure Result. Microbe. ONE.

[2] Adekunola Mobolaji Omemu Uchechukwu Ifeoma, Adewule O. Obdina Mobolaji O. Bankola, & Samuel Agofemi, (2018). Microbiological assessment of maize ogi cofor mented with pigeon pea. Food Science Nutrition. 5: 1253 – 1258.

[3] Adogu, P.O.U., Uwakwe, K.A., Egenti, N.B., Okwuoha, A.P. & Nkwocha, I.B. (2015). Assessment of Waste Management Practices among Residents of Owerri Municipal Imo State Nigeria.

[4] Adrienne Santos-Longhurst (2019). What You Need to Know About Pathogens and the Spread of Disease

[5] Afinotan Ojitobome (2016). Poor sanitation. Academia idu.

[6] Albert A. Bergwerff & Sylvia B. Debast (2021). Moclenization of control of pathogenic micro-organisms in the food-chain requires a durable role for Immunoaffinity – Based Defection Methedology. National Library of Medicine Foods, 10(4): 832.

[7] Al-Khatib, I.A., Abu Hammad A., Sharkas, O.A. & Sato, C. (2015). Public concerns about and perceptions of solid waste dump sites and selection of sanitary landfill sites in the West Bank, Palestinian territory. Environ. Monit.187:186.

[8] Amir, M. Mohagh & Zhangjian Yang (2019). Detection and occurrence of indicator organism and pathogens. Water Environ Res.

[9] Andrady, A., Law, K.L., Wilcox, C., Narayan, R., Jambeck, J.R., Geyer, R., Siegler, T.R. & Perryman, M. (2015). Plastic waste inputs from land into the ocean. Science. 2347:768 –771.

[10] Awuchi Godswill, C., Awuchi Godspower, C., Amagwula Otuosorochi, I. & Igwe Somtochukwu, V. (2023). Industrial and Community waste management: Global Perspective. African Journal of Physical Sciences. 1(1): 1 – 16.

[11] Aybuike Sezgin (2016). Street food consumption in terms of the food safety and health. Journal of Human Science. 13(3): 4072.

[12] Briana, R. W., Alexender, R. B., Masaki, M., Kazunori, H. & Yoshiaki, T. (2017). Trends mol. Med. Author Manuscript.

[13] Center for Disease Control and Prevention (2023). E. coli (Escherichia coli).

[14] Charles, P. Geba (2020). Microbial pathogen in Municipal solid waste: Taylor and Francis e-Book. Pg. 1 – 20. https://www.taylorfrancis.com.

[15] Charles R. Rhyner, Leander J. Schwartz, Robert B. Wenger & Mary G. Kohrell (2017). Waste Management and Resource Recovery. Research Gate, Doi 10-1201/ 9780203734278.

[16] Cheshire, A., Adler, E., Barbière, J., Cohen, Y., Sverker, E., Jarayabhand, S., Jeftic, L., Jung, R.T. & Kinsey, S. (2015). Journal of Environmental Protection, 6446-456. http://dx.doi.org/10.4236/jep.65043

[17] Chetan, D.M., Raghavendra, H.L. and Prithviraj. H.K. (2017). Isolation and Characterization of Bacteria from Solid Waste Department of Biotechnology NMAM Institute of Technology, Nitte, Karkala, 574110, Karnataka, India College of Health and Medical Sciences. 6

[18] Clifford Nkamnaso Obi (2021). Production and provision analysis of ogiri condiment from melon, carthy oil pumpkin and watermelon seeds. Research Gate. www.nsmjournal.org.

[19] Czajczyńska, D., Anguilano, L., Ghazal, H., Krzyżyńska, R., Reynolds, A.J., Spencer, N. & Jouhara, H. (2017). Potential of pyrolysis processes in the waste management sector. Thermal Science and Engineering Progress. 3: 171–197.

[20] Dos Muchangos, L.S., Tokai, A. & Hanashima, A. (2015). Analyzing the structure of barriers to municipal solid waste management policy planning in Maputo city, Mozambique. Environ.16:76–89

[21] Ejiogu Christopher, Ogeocha, I.O., Okwujiako, I. A. & Opara, K.A. (2019). Heavy metals in Soil and Cassava cultivated in farms near dumpsite in Nekede Mechanic village Owerri, Nigeria. Paripexindian Journal of Research.

[22] European, Comparative & International Environmental Law (2017). Towards effective implementation of the EU Environmental Crime Directive: The case of illegal waste management and trafficking offences. Wiley online Library.

[23] Fahad, A. & Al-Dhabaan, (2019). Morphological, biochemical and molecular identification of petroleum hydrocarbons biodegradation bacteria isolated from oil polluted soil in Dhadaan, Saudi Arabia. Saudi Journal of Biological Sciences. 26(6): 1247 – 1252.

[24] Fernando, L., Gordillo, A. & Jeremy, J.B. (2019). Phage Therapy in the Postantibiotic Era.

[25] Gadafi, I. B. & Denis B. Y. Jeni, Afua D. & Priscilla, A. K. (2020).Microbial contamination, and increasing to the consumption of fresh fruits and vegetables in Today's World. International Journal of Microbiology 2020 (2020) - 3029295

[26] Guathami, Penakalapati, Jenna Swarthout, Miranda, J., Deloby Lydia McAliley, Breanna Wodnik.

[27] Gueladio Cisse (2019). Food-borne and water-borne diseases under climate change in low-and middle income Countries: Further efforts needed for reducing environmental health exposure risk. Acta trop. 194: 181 – 188.

[28] Horinko, Marianne & Cathryn, Courtin. (2016). "Waste Management: A Half Century of Progress." EPA Alumni Association.

[29] Ifeoluwa, O. B. (2019). Harmful effects and management of indiscriminate solid waste disposal on human and its environment in Nigeria: A review. Global Journal Research Rev. 6(1): 1.

[30] Ihedioha J.N., Ukoha P.O. & Ekere N.R (2017). Ecological and human health risk assessment of heavy metal contamination in soil of a municipal solid waste dump in Uyo, Nigeria. Environ. Geochem. Health. 9:497–515.

[31] Iñiguez, M.E., Conesa, J.A. & Fullana, A (2016). Marine debris occurrence and treatment: A review. Renew. Sustain. Energy Rev. 64:394–402.

[32] Jack Macy (2023). Zero Waste Case study: San Francesco, United States Environmental Protection Agency. (415): 355 – 375.

[33] Khan Redzwan Habib (2016). Understanding challenges faced by street food vendors to maintain street food hygiene in Dhaka City. Journal of Food and Nutrition Sciences. 9(4): 78 – 85.

[34] Kumar, Sunil; Dhar, Hiya; Nair, Vijay V.; Bhattacharyya, J. K.; Vaidya, A. N. & Akolkar, A. B. (2016). Characterization of municipal solid waste in high-altitude sub-tropical regions. Environmental Technology. 37 (20): 2627–2637.

[35] Marcela Spisakova, Peter Mekros & Tomas Mandicak, (2021). Construction waste Audit in the framework in construction project. Research Gate.

[36] Marcin, Piglowski (2019). Pathogenic and Nonpathogenic microorganisms in Rapid Alert System for Food and Feed. International Journal of Environmental Research and Public Health. 16(3): 477.

[37] Micheal, J. P., Fran, P. N. & Adriano, G. R. (2019). Immune Response in Human Pathology: Infections caused by Bacteria, Viruses, Fungi and Parasites. Springe Nature. 165 – 178.

[38] Microbiologynote.com (2022). Methyl red and Voges Proskauer Test-Principles: https://microbiologynote.com.

[39] Modak, P., Wilson, D.C. & Velis, C, (2015). Global Waste Management Outlook. UNEP; Athens, Greece. Waste Management: Global status; pp. 51–79.

[40] Modemed, E.K. (2015). Sust repository – Sudan University of Science and Technology: Sudan University of Science and Technology. 12(3): 152 – 168.

[41] Narayan, P., Victor, B., Anihowi, D., Joseph, H. & Maltshwarelo, M. (2023). International Journal of Food Microbiology, 249.

[42] Nash, Anthony A.; Dalziel, Robert G. & Fitzgerald, J. Ross (2015). Mechanisms of Cell and Tissue Damage. Mims' Pathogenesis of Infectious Disease (6th ed.). London: Academic Press. pp. 171–231.

[43] Navarro, F. & Vincenzo, T. (2019). Waste Management in Developing Countries: A review of Global issues. International Journal of Environmental Research Public Health, 16(6): 1060.

[44] Obiora B. Ezendu et al. (2021). Coproduction in solid waste management: Analysis of emerging cases and implications for circular economy in Nigeria. National Center for Biotechnology Information.

[45] Oduro-Yeboah, C., Achal, N.B., Akonar, P.T., Amponsah, S.K. & Mboom, F.P. (2020). Food safety knowledge and practices among fresh coconut vendors. Scientific African. 8, 321-332.

[46] Ojo Rotimi (2018). Waste Management. Introduction of a waste conservation course at University in Nigeria.

[47] Oludayo, T. (2021). Healthcare availability and utilization in Nigeria's Urban slums. Business. https:// businessday.ng

[48] Oluwadara Oluwaseun Alegbeleye, Ian Singleton & Anderson S. San Ana (2018). Source and contamination routes of microbial pathogen to fresh produce during field cultivation. Food Microbiol. Pg. x, 177 – 208. https://www.nchi.nim.nih.gov.

[49] Organics -Green Bin (2016). Christchurch City Council.

[50] Parameswari, K., Padmini, T.K. & Mudgal, B.V. (2015). Assessment of soil contamination around municipal solid waste dumpsite. Indian Journal of Science and Technology;

[51] Pedro Brancoli, Kim Bolton & Mattias Eriksson (2020). Environmental impacts of Waste Management and volorisation pathways for surplus bread in Sweden. Science Direct.

[52] Peiyve, Li, Kamnanidhi, D., Subramni, T. & Srin-Vasamoorthy, K. (2021). Sources and Consequences of Groundwater contamination. Arch Environ. Contan Toncol. 20(1): 1 – 10.

[53] Ramachandra, T.V., Bharath, H.A., Kulkarni, G. & Han, S.S. (2018). Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India. Renew. Sustain. Energy Rev. 82:1122–1136.

[54] Reyes-López J.A., Ramírez-Hernández J., Lázaro-Mancilla O., Carreón-Diazconti C. & Garrido M.M.L. (2018). Assessment of groundwater contamination by landfill leachate: A case in México. Waste Manag. 28:S33–S39.

[55] Ricardo, F. D. (2019). Advances in chemical and Biological Methods to Identify Microorganisms from past to present. National Library of Medicine.

[56] Rick, M. M. & Henry, J. M. (2023). Regulation of the Host Immune System by helminthes parasites. Journal of Allergy and Clinical Immunology. 138(3): 666 – 675.

[57] Robert Doug Wagner (2017). Effects of Microbiota on GI Health: Gnotobiotic Research. Springe link. 41 – 56.

[58] Sagar Aryal (2022). Simmons citrate Agar – Composition principal, uses, preparation and result interpretation. Microbiology inforcom. https://microbiologyinfor.com.

[59] Samuel, J. C., Abudu, B. D., Reginald, Q., Samuel, O. & Noel, B. (2015). Comparative Assessment of Heavy Metals in Drinking water sources in two small scale mining countries in Northern Ghana. International Journal of Environmental Research Public Health, 12(9): 10620-10634.

[60] Scholarly Community Encyclopedia (2023). Pathogenic Bacteria. https://handwiki.org/wiki/medicine: Pathogenic bacteria.

[61] Sushmeta Dura (2022). Biochemical tests for identification of Gram negative bacteria in Science Notes. https://thesciencenote.com

[62] Swidbert, H., Mary, A. & Ampah, A. (2020). Spatial identification of potential dump deposal site for effective waste management in Sunyani Municipality, Ghana. Journal of Geoscience and Environment Protection. 8: 346 – 358.

[63] Tobias, F., Jonas, N. & Philipp, B. (2023). Pleiotropic Effects of Antibiotics on T-cell Metabolism and T-cell – Mediated Immune Front Microbiol.

[64] Torretta, V., Ferronato, N., Katsoyiannis, I.A., Tolkou, A.K. & Airoldi, M. (2017). Novel and conventional technologies for landfill leachates treatment: A review. Sustainain.

[65] Umunakwe Henry & Kalu Ezera (2019). Impacts of solid waste management activities on man and his environment in Owerri Municipal, Orji and Amakohia satellite towns, Imo State, Nigeria. JLRM, www.jlrm.intes.

[66] United Nations Department of Economic and Social Affairs Statistic Division (2023). Goal 12: Ensure sustainable consumption and production patterns. United Nation Statistics Division.

[67] United States Environmental Protection Agency (2023). Managing and Reducing Waste: A Guide for commercial Building. Official Waste of the United States government.

[68] unstats.un.org. (2017). United Nations Statistics Division - Environment Statistics.

[69] USEPA, (2023). Energy recovery from the combustion of Municipal Solid Waste (MSW). An official website of the United State government.

[70] Wikipedia, (2023). https://en.m.wikipedia.org.

[71] Xiaodi, C., Yuoelu, T. C. & Rongguo, L. (2021). The female vaginal Microbiome in Health and Bacterial Vaginosis front cell infect microbial, 11: 631-972.

[72] Zhenzieng Lu, Weina Guo, & Chang Liu, (2018). Isolation identification and characterization of novel Bacillus. Journal of Vet. Med. Sci. 80(3): 427 – 453.

[73] Zumar, Muhammed & Ali Bundhi, (2018). Solid waste management in least developed countries, current status and challenges faced. Journal of Material cycles and waste management, 20(3): 261 – 282.