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(RESEARCH ARTICLE)

MICROBIAL CONTAMINATION OF CURRENCY NOTES; PUBLIC HEALTH IMPLICATIONS

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ABSTRACT

It has become pertinent to study microbial communities in non-traditional settings such as currency notes because of its possible effects on health. This study explores the microbial assay of Nigerian banknotes/currency(the naira) in use in the exchange of goods and services in the economic environment of Bayelsa State, Nigeria. A total of 24 naira notes of different denomination commonly used were aseptically collected from shop owners at the city market Swali and transported to the laboratory for immediate examination. Microbial analysis of the naira notes showed that bacterial load on the naira notes ranged from 1.9 x 10^3 cfu/g to 5.8 x 10^3 cfu/g and the fungal loads ranges from 1.0 x 10^2sfu/g to 3.0 x 10^2sfu/g. The study also found out that 20 naira notes had the highest bacterial loads with 5.8 x 10^3cfu/g while the 500 naira notes had the highest fungal load with 3.0 x 10^2sfu/g. The study therefore recommends more investigation of the environmental factors influencing microbial contamination on currency notes and also advised a cashless kind of exchange of goods and services so that people don't need to touch currency notes.

Keywords: Currency notes, Microbial, Contamination, Public health.

1 INTRODUCTION

The naira currency notes serve as the legal tender for exchange of goods and services in Nigeria and it is used every day by a wide variety of persons. Through this continuous movement of currency notes, a complex network for the spread of microbes is created, and they may be dangerous species that could endanger both the general public and individuals who handle cash directly [1]. The microbial assay of these naira notes becomes so vital so as to gain insights of the possible consequences for public health and safety. Bacteria, fungi, viruses, and other microbes that can flourish in the many microenvironments encountered during currency circulation could also be found on currency notes [2]. Microbial communities flourish and persist on surfaces such as the naira notes due to factors like, temperature, humidity, human interaction, and storage conditions. It is then important that these microbes are identified and characterized so as to

understand some dynamics connected to currency notes and develop well-informed control methods for potential health hazards [3]. In their study, Abraham et al. [2] investigated the bacterial and fungal diversity on Nigerian banknotes. Numerous fungal species, such as *Aspergillus, Penicillium, and Candida species,* were found by the study. A thorough evaluation of the microbial landscape requires an understanding of this variety because, similar to bacteria, fungus can host pathogenic species that have an impact on public health.

Investigations by [4] [5]have identified the numerous component of money contamination, highlighting the need for a comprehensive microbiological examination that takes into account the whole range of possible pathogens on currency notes.There are a number of reasons why microbial colonies grow and survive on banknotes e.g. handling, environmental and climatic factors. Nkanga et al. [1] emphasized the significance of taking regional climate circumstances into account while highlighting the impact of these elements in their study. Microbiological growth on currency surfaces is facilitated by the tropical climate of Bayelsa State, which is marked by high temperatures and humidity levels.

Furthermore, handling procedures and human contact have a big influence on microbiological contamination. In their investigation of bacterial contamination in Kaduna Metropolis markets, Musa et al. [6] found that frequent hand-to-currency contact significantly increased microbial burdens. The study emphasized how important it is to comprehend how people behave and use currencies in order to create focused treatments that successfully reduce microbiological risks.

Recognizing the part surfaces and materials play in microbial persistence is essential to understanding microbial dynamics. Microbial adherence and survival are influenced by the material composition of currency notes, which are constantly changing hands and habitats. Study by Pabari *et. al*. [3] provides important information about how to reduce the danger of contamination on currency notes.

1.1 Public Health Implications of contamination of naira notes

Given how frequently bank notes are used in daily transactions, there are significant public health consequences to their microbiological contamination. Ofoedu*et al*.[7] highlighted the possibility of dangerous germs spreading within the food business, as banknotes could act as carriers for the spread of pathogenic microbes. The possibility for infectious disease transmission within communities is a concern due to the interconnection of economic transactions and the transfer of microbes through cash handling.Pabari *et al*. [3]emphasized the dangers to one's health that come with microbiological contamination of banknotes. Hence this study was carried out to assess the contamination of naira notes in use in Bayelsa State of Nigeria.

2 MATERIAL AND METHODS

2.1 Study setting

The study was carried out in one of the main markets (Swali market) in Yenagoa metropolis, the capital of Bayelsa State (geographic coordinates 4°56’1” N, 6°16’13” E). The Swalimarket is in the heart of the Yenagoa metropolis and has over 500 shops operating various businesses. Bayelsa State's tropical climate, which is marked by high temperatures and humidity, increases the possibility of microbial growth on currency notes. The state's distinct environmental factors, such as its cultural diversity and economic activity, may also have an impact on the kinds and quantity of microorganisms that are present on currency surfaces [8].

2.2 Study design

This was an experimental study. Systematic random sampling was used to select shops for the study. Naira samples were collected from every 7th shop in the market.

2.3 Selection criteria

All the Naira currency denominations currently in use in Nigeria from the selected shop owners were included with the exception of ten naira and five naira because they are less in circulation. The samples were collected from only numbered and marked shops.

2.4 Sample collection

Four (4) samples of each of (₦20, ₦50, ₦100, ₦200, ₦500 and ₦1,000) Naira denominations in circulation totaling 24 samples were collected from marked shop owners engaged in different businesses in Swali market in the metropolis of Bayelsa State, Nigeria. The Naira note samples were collected aseptically by letting the owners drop them into a sterile

ziplock bag and it was sealed immediately. They were immediately taken to Wizlink Environmental Laboratory Yenagoa for microbial assay.

2.5 Sample preparation

Each set of naira notes were soaked in 10ml of pre-sterilized normal saline in flat bottom flask and shaken vigorously to soak and allowed to stand for about 20 minutes. This stock solution was then serially diluted to the sixth tube dilution.

2.6 Preliminary identification of coliform presence

One (1) ml of each stock sample was inoculated into pre-prepared lactose broth incorporated with Durham tube and incubated at 37°c for 24 to 48hrs. These were inspected for colour change and gas production.

2.7 Enumeration of microbial contaminants

Briefly, the collected Naira notes were placed aseptically into different sterile test tubes containing 10ml of sterile normal saline and shaken for few minutes. After 3 minutes, the notes were removed from the test tubes and a 3 serial 10-fold dilution (10^{-1} to 10^{-3}) were made. An aliquot of 1ml from the 10^{-2} dilution was aseptically inoculated on Nutrient agar plates by the pour plate method. All plates were incubated at 37°C for 24 hrs, and examined for bacterial growth, and the number of colonies on each plate was counted using a digital colony counter. Identification of bacterial isolates was done using a combination of morphological characteristics such as shape, colour, elevation, consistency etc. and biochemical characteristics including triple sugar iron (TSI) agar, catalase, and citrate tests.

For enumeration of fungi, 1 ml of 10^{-2}dilution was inoculated onto Potato Dextrose agar (PDA) supplemented with 0.01% chloramphenicol by the pour plate technique. The plates were incubated for five days at room temperature (25^{0}C). Identification was done based on cultural (mould or yeast form, pigment production) and microscopic morphological characteristics.Plates were inspected, colonies counted and reported in colony forming unit (cfu /g) and spore forming unit (sfu/g)

2.8 Isolation and characterisation of bacteria and fungi

Distinct colonies from bacterial culture plates were morphologically characterised and then streak plated on freshly prepared nutrient agar and lactose broth. These culture plates were incubated at 37^{0}c for 24hrs then inspected for growth on agar plate and colour change and gas formation in lactose broth. Positives isolates were further characterised with gram staining, catalase test, oxidase test, coagulase, TSI test, and citrate test. Gathered characteristics were then marched with existing literatures and isolates tentatively identified**.** While for fungi colonial morphology, broth culture growth and microscopy were basically used for tentative identification.

3 RESULTS

3.1 Mean Variable Bacteria Count

as indicated in Table 1 below, the mean microbial count on the naira notes showed that the ₦1000 notes had a mean value of 4.1 x 10^{3}cfu/g for bacterial count and 1.4 x 10^{3}sfu/g for the mean value for fungal count with p-value of 0.0263 which is statistically significant. The statistical analysis of mean viable count of bacteria and fungi at 95% confident limit for all other naira notes were found to be significant.

Table 1: Mean viable bacteria and fungi count from the naira notes in circulation in YenagoaBayelsa State

Sample ID in Naira ₦	Bacteria count cfu/g	Fungi count sfu/g	Statistical analysis of mean viable count of bacteria and fungi at 95% confident limit	
			p- value	Statistical inference
1000	4.1 x 10^{3}	1.4 x 10^{3}	0.0263	Statistically significant
500	1.9 x 10^{3}	3.0 x 10^{2}	0.0009	Statistically significant
200	2.6 x 10^{3}	1.0 x 10^{2}	0.0002	Statistically significant
100	2.9 x 10^{3}	1.7 x 10^{2}	0.0013	Statistically significant
50	2.5 x 10^{3}	1.0 x 10^{2}	0.0142	Statistically significant
20	5.8 x 10^{3}	1.3 x 10^{2}	0.0001	Statistically significant

The preliminary evaluation of the naira notes as indicated on ***table 2*** inferred that coliforms were absent or in low density in that ₦1000, ₦500 and ₦20 currency notes while coliforms or other lactose fermenters and gas producers were inferred to be present in ₦200, ₦100 and ₦20 currency notes.

Table 2: Preliminary evaluation of coliform presence in the naira notes in circulation in Yenagoa Bayelsa State.

Sample ID Naira	Lactosefermentation/gas production + / -	Inference
1000-naira lactose broth	-	Coliforms absent or low density
500-naira lactose broth	-	Coliforms absent or low density
200-naira lactose broth	+	Coliforms or other lactose fermenters and gas producers present
100-naira lactose broth	+	Coliforms or other lactose fermenters and gas producers present
50-naira lactose broth	-	Coliforms absent or low density
20-naira lactose broth	+	Coliforms or other lactose fermenters and gas producers present

Legend (-) = negative; (+) = positive for lactose fermentation and gas production respectively

Probable identification of bacterial isolates was done using forming patterns, colour and shapes.The study identified the following genera present on naira notes, *Bacillus spp, Staphylococcus spp, Streptococcus spp, Citrobacterspp, Clostridium spp.*

Table 3: Characteristics of bacteria isolated from the naira notes in circulation in YenagoaBayelsa State.

Isolates	Nut. agar	Gram type	Lac broth	cat	coa	cit	TSI
Bacillus spp	Creamy flat slimy colony	+ baccili	-	+	NA	+	K/A
*Staphylococcus*spp	Creamy circular raised slimy	+ cocci in cluster	-	+	+	+	K/A
Streptococcus spp	Creamy circular raised	+ cocci in chain	-	-	-	-	K/A
*Citrobacter*spp	Creamy circular raised mucoid	rod	+, no gas	+	NA	+	K/A
Clostridium spp	Creamy flat colony	+ baccili	+, gas	-	NA	-	K/A

Legend: Nut.agar = morphology on nutrient agar; + = positive, - = negative, K/A = glucose fermentation (alkaline slant, acidic butt) Cat = catalase test, cao = coagulase test, cit = citrate test, TSI = Triple sugar iron test

Frequency of the occurrence of the isolates from naira notes showed that *Staphyllocucusspp*and*Streptococcus spp*occurred the most with 83.33% while *Clostridium spp* and *Citrobacterspp* occurred the least with 16.67%.

Table 4: Frequency of occurrence of the isolates from the naira notes in circulation in YenagoaBayelsa State

Isolates	Number and % of isolate in each naira note						
	1000 N	500 N	200 N	100 N	50 N	20 N	Frequency of occurrence %
Bacillus spp	1(4): 25 %	0 (4): 0 %	0 (4): 0 %	3(4): 75%	1 (4): 25%	0 (4): 0 %	50
Staphylococcus spp	1 (4): 25 %	3 (4): 75 %	2(4): 50%	0(4): 0 %	1 (4): 25%	3 (4): 75%	83.33
Streptococcus spp	2 (4): 50 %	1 (4): 25 %	1(4): 25 %	0 (4): 0%	2 (4): 50%	1 (4): 25%	83.33
*Citrobacter*spp	0 (4): 0 %	0 (4): 0 %	1(4): 25%	0 (4): 0 %	0 (4): 0 %	0 (4): 0 %	16.67

Clostridium spp	0 (4): 0 %	0 (4): 0 %	0 (4): 0 %	1 (4): 25%	0 (4): 0 %	0 (4): 0 %	16.67
No. of genera	3	2	3	2	3	2	

Fungal isolates that were found to be on the naira notes are *Aspergillusspp, Cladosporiumspp, Rhizopus spp.*

Table 5: Characterization of fungal isolates from naira notes in circulation in YenagoaBayelsa State.

Fungal ID	Colonial morphology	Surface	Reverse	Microscopy	Broth
Aspergillusspp	Circular green grainy surface with white edges	Green	Creamy and varicose	Large globose conidia head with rough walled conidiosphores	Dark greenish pellicle growth
*Cladosporium*spp	Circular grey colony	Gray - green	Black	Conidia in long branching chains	Blue black hard pellicle growth
*Rhizopus*spp	Cotton growth turning orange and covering plate	Orange	grey	Non septate hyphae with void sporangiospore	White cottony pellicle growth
Rhizopusspp	Whitish colony growth	White	Grey	Non septate hyphae with void sporangiospore	Brownish white pellicle growth

The frequency of the occurrence of the fungal isolates showed that *Rhizopusspp*occurred the most with 100% while *Aspergillusspp* occurred the least with 16.67%.

Table 6: Frequency of occurrence of the fungal isolates from the naira notes in circulation in YenagoaBayelsa State

Isolates	isolate detected in each naira note(+)(-)						
	1000 N	500 N	200 N	100 N	50 N	20 N	Frequency of occurrence %
*Aspergillus*spp	+	-	-	-	-	-	16.67
*Cladosporium*spp	-	+	-	+	-	-	33.33
*Rhizopus*spp	+	+	+	+	+	+	100
*Rhizopus*spp	+	+	+	+	+	+	100
No. of genera detected in each naira note	3	3	2	3	2	2	

Legend (-) = absent; (+) = present

4 DISCUSSION

The discovery of *Bacillusspp*., a genus well-known for its pervasiveness in the environment, is consistent with research results from earlier investigations on banknotes [6]. Species of Bacillus, which are frequently present in dust and soil, may have contaminated the environment when money notes are handled regularly. *Bacillus spp* are present on these surfaces that are often touched, which highlights the need to look more closely at the environmental elements that encourage microbial colonization [7].

This study exposed the presence of two opportunistic pathogens: *Streptococcus spp* and *Staphylococcus spp*. Because of these bacteria's ability to colonize a variety of surfaces, there may be health dangers involved, particularly for those with compromised immune systems. According to studies by Ofoedu *et al.*[7] the discovery of these bacteria on currency notes consistently occurs across different areas, which emphasizes the significance of comprehending the behavioral aspects of handling cash and the requirement for improved hygiene standards.

Citrobacterspp. has been found in a variety of environmental samples and is frequently linked to fecal contamination [9]. Finding *Citrobacter spp* on banknotes emphasizes the need of practicing good hand hygiene because there is a chance that germs will migrate from hands to money during everyday transactions.

The identification of the genus *Clostridium spp*, which is well known to have the ability to generate spores helps explain why they can survive in a variety of settings [10]. The presence of *Clostridium spp* on currency notes raises concerns about the need for additional research on the particular species and possible health effects. Determining the dangers posed by these microbes requires an understanding of the processes of spore development and survival on banknotes.

Among the Fungi identified on the bank notes*, Aspergillus spp*, which are typically found indoors and are known to release airborne spores were among. Adhikari *et al.,*[11] opined that presence of *Aspergillus spp*on currency notes emphasizes how environmental factors especially air quality have an impact on the microbiological makeup of currency surfaces. This result emphasizes the necessity of taking fungi and bacteria into account when developing methods to reduce health hazards related to handling cash.

Another fungus found in our investigation, *Cladosporiumspp*., is frequently found in outdoor settings [12]. The identification of *Cladosporium spp* on currency notes raises the possibility of a connection to environmental exposure that occurred during storage or transit. The discovery of outdoor-associated fungi on banknotes raises the concern of how transportation and storage circumstances affect the microbial diversity of these frequently handled notes.

On banknotes, there was also evidence of *Rhizopusspp*., a genus of mold that is well-known for its role in the decomposition of organic materials [13]. The discovery of *Rhizopus spp* points to a possible link with environmental sources. However, more investigation is required to pinpoint the precise channels through which banknotes are contaminated.

5 CONCLUSION

In conclusion, the microbiological assay of Nigerian banknotes in Bayelsa State has revealed a wide variety of bacteria and fungi, each of which has unique consequences for public health. Contamination of currency notes is one of the easiest ways of spread of diseases when associated with handling of foods and fluids and could lead to outbreak of infectious diseases. This is so because people engage in unhygienic practices like counting the currency notes with saliva, squeezing the notes, putting it inside the brazier, counting money without washing hand afterwards, etc.

5.1 Recommendation

With the variety of microbes identified on naira notes, this study recommends a cashless policy which is a healthier and easier way of exchanges goods and services. This research highlights how crucial it is to run public awareness programs to inform people about the proper way to handle cash in daily transactions. There should also be policies guiding the handling of the naira notes with regards to mutilation, squeezing, and other practices that could expose the notes to harmful micro-organism. This study recommends that people should practice good hygiene when handling the naira notes to avoid contamination of food or drink. There is need for health education and promotion on the use naira notes especially for those in the rural areas.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

Authors declare that there is no conflict of interest with respect to the authorship or publication of this study.

Statement of ethical approval

This study was approved by the ethical committee of the Department of Biological Sciences, University of Africa Toru-Orua Bayelsa State, Nigeria.

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