

Assessment of Microbial and Parasitic Contamination on Currency Notes at Nnamdi Azikiwe University, Awka

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The pervasive use of currency notes in daily transactions makes them a potential vector for microbial contamination. This issue is particularly pertinent in developing countries like Nigeria, where sanitation practices may be less stringent, and public awareness of microbial risks is often limited. This is important in light of recent outbreaks such as COVID-19. Despite this there remains a notable lack of comprehensive studies specifically addressing the extent and types of microbial contamination present on Nigerian currency. This study investigates the microbial and parasitic contamination of Nigerian currency notes, highlighting the potential health risks associated with handling money. A total of 70 currency samples were analysed, revealing presence of various protozoan parasites and bacterial pathogens. Samples for bacterial culture were prepared by swabbing currency notes with sterile saline moistened cotton swabs. Bacteria were cultured on Salmonella Shigella media, incubated, and analysed for colony characteristics. Remaining samples underwent microscopic examination for protozoan parasites after centrifugation and resuspension. Among the protozoa, *Entamoeba coli* was the most prevalent, found in 35.7% of samples, followed by *Enterobius vermicularis* (57.1%) and *Entamoeba histolytica* (7.1%). Notably, no significant correlation was observed between the prevalence of these parasites ($P = 0.38$). Bacterial contamination was also assessed, with *Klebsiella* spp. detected in 50% of samples, while *Escherichia coli* and *Proteus* spp. were each found in 25% of the samples. Again, no significant association was noted among the bacterial contaminants ($P = 0.377$). The study further differentiated between polymer and paper notes, revealing that polymer notes (10 to 50 naira) were free from contamination, while paper notes exhibited varying contamination rates, with 100-naira notes showing 35.7% contamination. Mutilated notes had highest contamination level at $22.97 \pm 4.51\%$, compared to clean and dirty notes. Overall, the findings underscore the necessity for improved hygiene practices regarding currency handling to mitigate potential health risks.

Keywords: Microbial, Currency Note, Bacteria, Protozoa

Introduction

The proliferation of currency notes as a medium of exchange has made them an integral part of daily transactions worldwide. However, the physical nature of these notes, often passed from hand to hand, raises concerns regarding their potential role as vectors for microbial contamination. In Nigeria, where cash transactions dominate the economy, understanding the extent of microbial contamination on currency notes is crucial for public health and hygiene. Previous studies have indicated that currency notes can harbour a variety of pathogens, including bacteria, viruses, and fungi, which can pose significant health risks to the population (Sunil *et al.*, 2020; Meister *et al.*, 2023). Despite the existing body of literature on microbial contamination of currency notes globally, there remains a notable research gap concerning the specific context of Nigeria. While some studies have been conducted in various countries, including India and the United States, focusing on the types of microbes found on currency, there is limited data on the Nigerian context, particularly

regarding the implications for public health and hygiene practices (Sani *et al.*, 2021). Previous studies have documented the presence of various microorganisms on currency notes in different countries, revealing a troubling correlation between the handling of money and the spread of infectious diseases (Limaye, 2020). However, there is a notable lack of comprehensive research focusing specifically on the microbial contamination of Nigerian currency notes. Despite the existing body of literature, significant gaps remain in understanding the extent and types of microbial contamination present on Nigerian currency.

The proliferation of currency notes as a medium of exchange has long been recognized as a potential vector for microbial and parasitic contamination, raising significant public health concerns. In Nigeria, where cash transactions remain predominant, the role of currency notes in facilitating the transmission of pathogens is particularly alarming. Despite the growing body of literature on the microbial contamination of banknotes globally, there remains a conspicuous gap in

research specifically addressing the extent and implications of such contamination within the Nigerian context. Recent studies have highlighted the presence of various pathogens on currency notes in different countries, indicating that these notes can harbour bacteria, viruses, and parasites capable of causing diseases (Gedam *et al.*, 2024; Olaleye *et al.*, 2024). For instance, a study conducted in India found that a large proportion of examined currency notes were contaminated with bacteria, including *Staphylococcus aureus* and *Escherichia coli*, which are known to pose serious health risks (Sabesan & Venkatesan, 2024). Similarly, research in Brazil revealed that banknotes could serve as reservoirs for parasites such as *Giardia lamblia* and *Entamoeba histolytica* (De Oliveira *et al.*, 2024). However, despite these findings, there is a notable lack of comprehensive studies focusing on Nigerian currency notes. The unique socio-economic and cultural dynamics of Nigeria, coupled with the high frequency of cash transactions, necessitate an urgent investigation into the microbial and parasitic load on its currency. This study aims to fill this critical research gap by evaluating the microbial and parasitic contamination of Nigerian currency notes, thereby providing essential data that can inform public health policies and hygiene practices. Understanding the extent of contamination is vital for mitigating health risks associated with cash transactions, especially in a country where the informal economy thrives, and cash remains king.

Literature Review

The assessment of microbial contamination on currency notes has garnered significant attention globally due to its implications for public health. Currency notes serve as vectors for the transmission of pathogens, raising concerns about their role in the spread of infectious diseases. Numerous studies have investigated the microbial load on currency notes across various countries. For instance, a study conducted in the United States found that paper currency harbours a diverse range of microorganisms, including bacteria and fungi, with potential pathogenic implications (Cozorici *et al.*, 2022). Similarly, research in India revealed that 80% of the analysed currency notes were contaminated with bacteria, including *Staphylococcus aureus* and *Escherichia coli*, indicating a significant health risk (Pranaya *et al.*, 2025). In Europe, a study in Italy assessed the microbial contamination of banknotes and coins, revealing a high prevalence of bacterial contamination, particularly in high-denomination notes (Meister *et al.*, 2023). These findings underscore the global concern regarding the microbial load on currency and its potential to transmit infectious agents. In Africa, studies have also documented microbial contamination on currency notes, albeit with fewer publications than in other regions. A study in Ghana found that currency

notes were contaminated with various bacteria, including pathogens associated with foodborne illnesses (Nyarko *et al.*, 2022). Similarly, research in Libya indicated that banknotes could harbour significant levels of microbial contamination, with implications for public health (Khalil & Attitalla, 2023). Despite these findings, the body of literature on microbial contamination of currency notes in Africa remains limited, with a notable lack of comprehensive studies in many countries. This gap is particularly evident in West Africa, where only a handful of studies have been conducted. In Nigeria, the assessment of microbial contamination on currency notes has not received adequate attention. A study by Attah *et al.* (2022) highlighted the presence of pathogenic bacteria on Nigerian currency, including *Salmonella* spp. and *Staphylococcus* spp. However, this study was limited in scope, focusing on a small sample size and a restricted geographical area. Another study by Sani *et al.* (2021) examined the microbial load on currency notes in a specific Nigerian city, revealing a significant presence of bacteria and fungi. While these findings are concerning, they emphasize the need for broader studies that encompass various regions of Nigeria and consider the potential seasonal variations in microbial contamination. Despite the existing studies, there remains a significant gap in the literature regarding the comprehensive assessment of microbial contamination on Nigerian currency notes. Most studies are limited in scope, focusing on specific regions or small sample sizes, which may not accurately represent the national situation. Furthermore, there is a lack of longitudinal studies that track changes in microbial contamination over time, particularly in the context of changing public health measures and economic conditions. Additionally, the interplay between socioeconomic factors, hygiene practices, and microbial contamination on currency notes in Nigeria has not been adequately explored. Understanding these dynamics is crucial for developing effective public health interventions aimed at reducing the transmission of pathogens via currency. The assessment of microbial contamination on currency notes is a pressing public health issue that has been explored in various global contexts. While some studies have been conducted in Nigeria, the literature remains sparse and limited in scope. There is a critical need for more comprehensive research to understand the extent of microbial contamination on Nigerian currency notes and its implications for public health. Addressing these gaps will not only enhance our understanding of the issue but also inform policy and intervention strategies to mitigate health risks associated with currency handling.

Materials and Methods

Sampling design

This study employed a cross-sectional design to assess microbial contamination on Nigerian currency notes. The focus was on identifying bacterial as well as protozoan parasites present on the currency notes. The study was conducted over a period of 2 months. A total of 70 Nigerian currency notes, comprising various denominations (₦10, ₦20, ₦50, ₦100, ₦200, ₦500, and ₦1000) in both polymer and paper forms, were randomly collected from individuals in different locations including motor parks, hostels, food stands, and business centres within the campus. A sample size of 70 currency notes was selected based on its adequacy to achieve a reasonable statistical power for detecting significant differences in microbial contamination levels. According to Cohen (1988), a sample size of 70 is considered sufficient to provide a robust estimate of the microbial load present on currency notes, given that the study does not involve complex group comparisons but rather a general assessment of contamination levels. The purpose of the research was communicated to the participants and their verbal consent was obtained before the collection and exchange of the notes. Each note was handled using sterile gloves to prevent cross contamination. Notes were placed in sterile, sealed bags immediately after collection and stored at room temperature until analysis. The collected notes were categorized based on their physical condition into four groups: mints, clean, dirty, and mutilated dirty, with the mint notes serving as the control group.

Sample preparation

The preparation of samples for bacterial culture was done using methods outlined by Cheesbrough, 2006 and Holt *et al.* 1996. This involved individually swabbing each currency note with sterile cotton swabs moistened with sterile saline (0.85% NaCl). The swabbing was conducted systematically across the entire surface of each note to ensure thorough coverage (Jones *et al.*, 2020). The swabs were then placed into sterile tubes containing 1 mL of sterile saline. Bacterial samples were inoculated onto salmonella shigella culture media and incubated at 37°C for 24 hours. Following incubation, the plates were examined for colony morphology, including characteristics such as size, shape, colour, and

haemolytic properties. Distinct colonies were selected for further identification, which included Gram staining and biochemical tests.

For the identification of protozoan parasites, after isolating bacterial pathogens, the remaining suspension was subjected to microscopic examination (Cheesbrough, 2006). A subsample of the swab suspension from each currency note was centrifuged at 3000 rpm for 10 minutes. The supernatant was discarded, and the pellet was resuspended in 1 mL of sterile phosphate-buffered saline (PBS). A drop of the resuspended sample was placed on a clean glass microscope slide and covered with a coverslip. The sample was then examined under a light microscope at various magnifications (100x, 400x, and 1000x) to identify protozoan cysts and trophozoites.

Statistical analysis

The collected data were analysed using the Chi-square test to assess the significance of the prevalence of microbial parasites between sample groups. The use of chi square is appropriate for this study because it is a simple non-parametric test to determine if there is significant difference in contamination levels between different categorical groups (Raghavendra and Antony, 2011).

Results

The results of the study on assessment of microbial and parasitic contamination on Nigerian currency notes are presented below:

Protozoan parasite species detected on Naira notes following parasitological analysis

Entamoeba coli, Enterobius vermicularis, Escherichia coli. Out of the 70 samples analysed, 35.7% were contaminated with Entamoeba coli, 57.1% with Enterobius vermicularis, and 7.1% with Entamoeba histolytica. The analysis showed no significant correlation between the various parasite species and their prevalence ($P = 0.38$). The Chi-Square test of independence showed no statistically significant association between percentage contamination of the different protozoan parasites, ($X^2(2) = 5.663, p = 0.059$). The protozoan parasites identified and isolated in this study included Entamoeba histolytica,

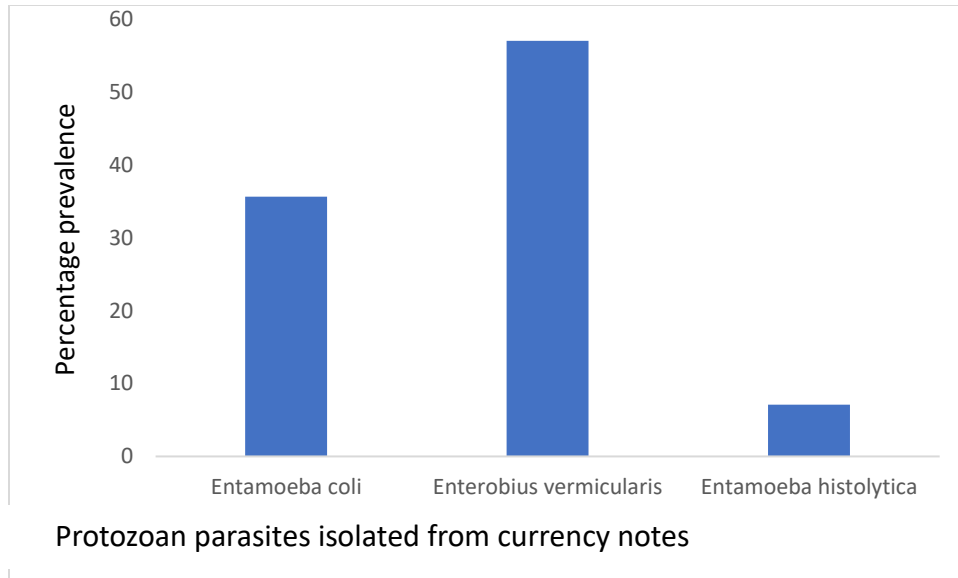


Figure 1: Prevalence of protozoan parasites on naira currency notes

Bacterial parasite species detected on Naira notes following parasitological analysis

The bacterial pathogens identified and isolated in this research include *Klebsiella* spp., *Escherichia coli*, and *Proteus* spp. Out of the 70 samples examined, 50% were contaminated with *Klebsiella* spp., while 25% showed

contamination with *Escherichia coli*, and another 25% with *Proteus* spp. The Chi-Square test of independence showed no statistically significant association between percentage contamination of the different bacterial parasites, ($X^2(2) = 8.60, p = 0.377$).

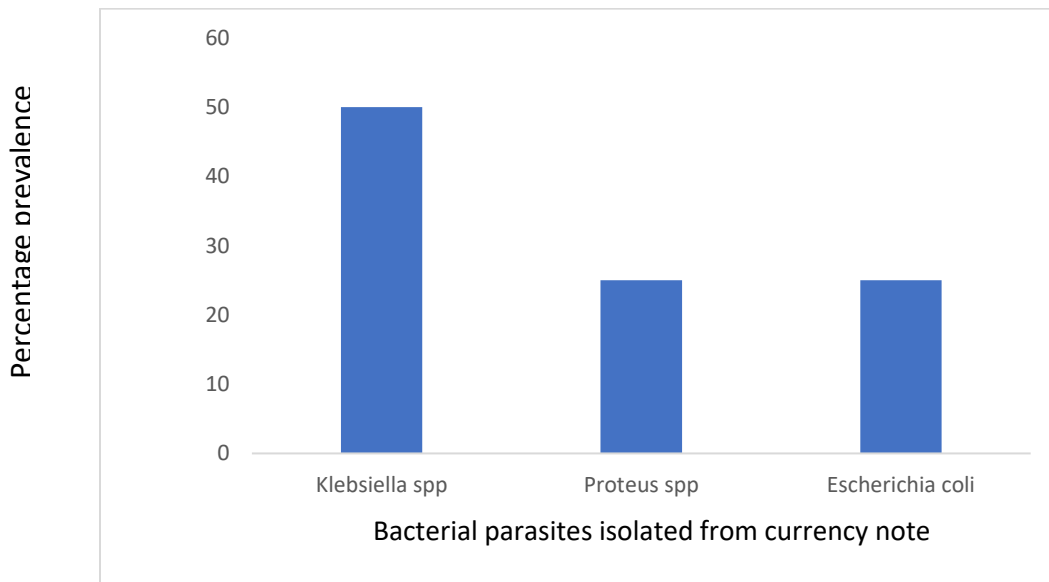


Figure 2: Prevalence of bacterial parasites on naira currency notes

Parasites prevalence on Naira notes in relation to currency denomination and types of notes

The assessment of microbial contamination indicated that polymer notes (10 to 50 naira) showed no signs of contamination (0.00%). In comparison, paper notes exhibited different levels of contamination: 100-naira

notes had a contamination rate of 35.7%, 200-naira notes showed 28.6%, 500-naira notes recorded 14.3%, and 1000-naira notes had a prevalence of 21.4%. The Chi-Square test of independence showed no statistically significant association between percentage

contamination of the different bacterial parasites, ($X^2(2) = 16.250, p = 0.012$)

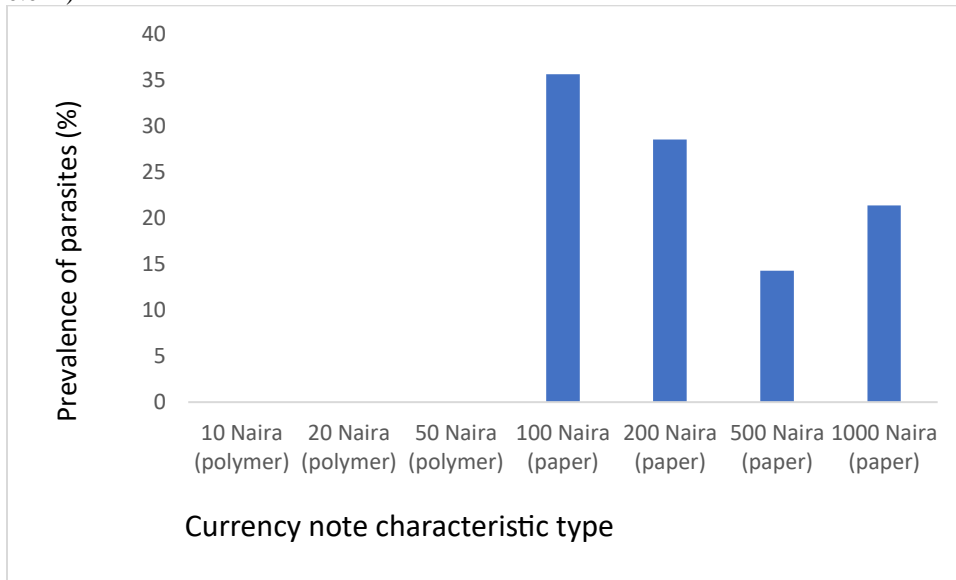


Figure 3: Prevalence of parasites on Naira notes in relation to currency denomination and types of notes

Parasite species composition and prevalence on naira notes in relation to their physical condition

Mint notes showed no presence of parasites. Clean notes exhibited a contamination rate of $4.73 \pm 2.37\%$, while dirty notes had a rate of $5.325 \pm 1.775\%$. Mutilated naira

notes displayed the highest level of contamination at $22.97 \pm 4.51\%$. The Chi-Square test of independence showed no statistically significant association between percentage contamination of the different bacterial parasites, ($X^2(2) = 32.813, p = 0.203$).

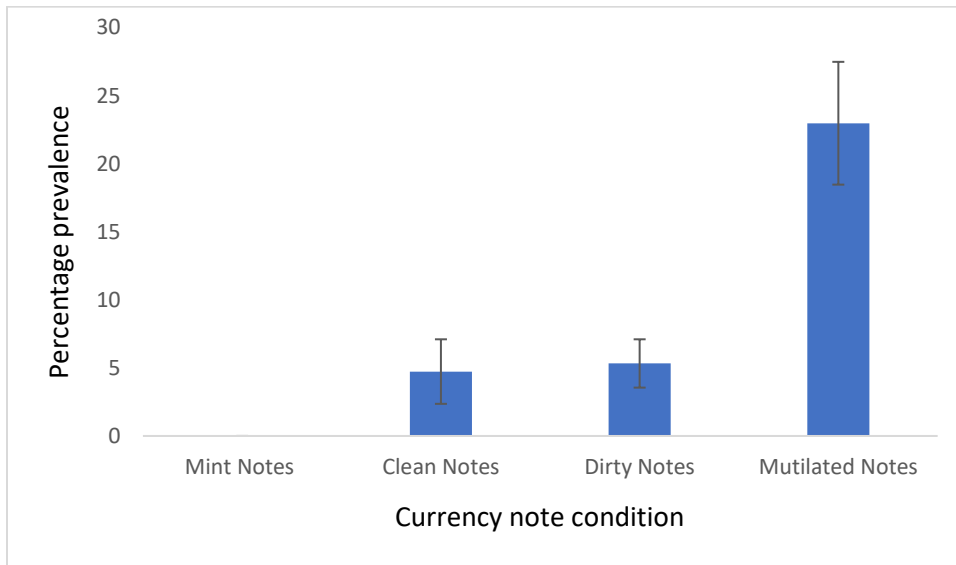


Figure 5: Parasite species prevalence on currency notes in relation to the notes physical condition

Inferential statistics tables of Chi square results for microbial parasites assessment

Table 1: Chi-Square result for protozoa parasite species isolated on Naira notes

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.663 ^a	2	.059
Likelihood Ratio	6.610	2	.037
Linear-by-Linear Association	1.828	1	.176
N of Valid Cases	210		

Table 2: Chi-Square result for bacteria species isolated from culture with salmonella shigella agar

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.600 ^a	8	.377
Likelihood Ratio	11.632	8	.168
Linear-by-Linear Association	4.418	1	.036
N of Valid Cases	16		

Table 3: Chi-Square result for prevalence of parasites on Naira notes in relation to currency denomination and types of notes

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.250 ^a	6	.012
Likelihood Ratio	20.508	6	.002
Linear-by-Linear Association	6.359	1	.012
N of Valid Cases	70		

Table 4: Chi-Square result on prevalence of parasites on Naira notes based on Naira note physical condition

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	32.813 ^a	27	.203
Likelihood Ratio	36.003	27	.115
Linear-by-Linear Association	8.374	1	.004
N of Valid Cases	70		

Discussion

The results of this study highlight a concerning level of microbial and parasitic contamination on Nigerian currency notes, particularly paper notes, which can serve as vectors for disease transmission. The identification of protozoan parasites such as *Entamoeba histolytica*, *Entamoeba coli*, and *Enterobius vermicularis*, alongside bacterial pathogens like *Klebsiella* spp., *Escherichia coli*, and *Proteus* spp., underscores the potential health risks associated with handling contaminated currency. The prevalence rates found in this study, with *Entamoeba coli* at 35.7% and *Enterobius vermicularis* at 57.1%, are particularly noteworthy. The higher prevalence of *Enterobius vermicularis*, a common intestinal parasite, suggests that currency notes may act as a reservoir for transmission, especially in populations with limited access to sanitation. Previous studies have reported similar findings, indicating that currency notes can harbour a variety of pathogens, including helminths and protozoa (Limaye, 2020; Sunil *et al.*, 2020). The

lack of a significant association between parasite species and prevalence ($P = 0.06$) suggests that while multiple parasites are present, their distribution may not be uniform across the samples examined.

The stark contrast in contamination levels between polymer and paper notes is significant. The polymer notes (10 to 50 naira) showed no contamination, while various denominations of paper notes exhibited varying levels of contamination, with the 100-naira notes showing the highest prevalence at 35.7%. This finding aligns with previous research that has indicated that polymer banknotes are less conducive to microbial survival due to their non-porous nature (Cozorici *et al.*, 2022). The significant association between currency denomination and prevalence ($P = 0.01$) suggests that higher denomination notes may be handled more frequently or kept for longer durations, increasing the likelihood of contamination.

The study also examined the physical condition of the notes, revealing that mutilated and very dirty notes had

the highest contamination rates (28.6%). However, the lack of a significant association between the physical condition of the notes and prevalence ($P = 0.2$) indicates that while dirtiness may correlate with higher contamination, it is not the sole factor influencing the presence of pathogens. This finding is consistent with the work of Katonge (2025), which found that while dirty notes had higher microbial loads, the relationship was not statistically significant.

The presence of these pathogens on currency notes poses a potential public health risk, particularly in a country like Nigeria, where hygiene practices may vary widely. The transmission of pathogens via currency can contribute to the spread of gastrointestinal diseases and other infections, particularly in vulnerable populations. Public health campaigns emphasizing hand hygiene and the need for regular cleaning of currency notes could be beneficial in mitigating these risks.

Conclusion

In conclusion, this study provides important insights into the microbial and parasitic contamination of Nigerian currency notes. The findings emphasize the need for further research into effective strategies for decontaminating currency and promoting public health awareness regarding the potential risks associated with handling contaminated money. Continued surveillance of currency contamination and its implications for public health will be crucial in addressing these concerns. While, the limited number of samples used in the study may impact the statistical power of the results and the ability to generalize the result to a broader population. Future research should consider increasing the sampling size. It should also focus on understanding transmission pathways as well as role of currency in the spread of disease especially during outbreaks.

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