Al - Saeed University Journal of Applied Sciences
journal@alsaeeduni.edu.ye
Vol (8), No(2), Dec., 2025
ISSN: 3104 - 8978 (Print) ISSN: 3104-8986 (Online)

Prevalence of Bacterial Contamination on New Paper Currency Notes in Taiz city, Yemen

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Received: 9/10/2025 **Accepted: 3/12/2025**

Journal Website: https://journal.alsaeeduni.edu.ye

انتشار التلوث البكتيري على العملات الورقية الجديدة في مدينة تعز، اليمن

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محاضر في قسم المختبرات الطبية
كلية العلوم الطبية، جامعة الجند للعلوم والتكنولوجيا

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الملخص

خلفية: تُعد العملة الورقية من الأشياء المتداولة يوميًا على نطاق واسع، وتشكل وسيلة محتملة لانتقال الميكروبات. في اليمن، وخاصة في مدينة تعز، هناك معلومات محدودة حول التلوث البكتيري للنقود الجديدة، مما يشكل مصدر قلق محتمل للصحة العامة. **الهدف:** هدفت هذه الدراسة إلى تقييم مدى انتشار وأنواع التلوث البكتيري على النقود اليمنية الجديدة المتداولة في مدينة تعز. **طرق البحث:** أُجريت دراسة مقطعية خلال الفترة من أكتوبر 2024 إلى يناير 2025. تم جمع 48 عينة من النقود اليمنية الجديدة عبر ثلاث فئات نقدية (200، 500، و1000 ريال يمني) من ثمانية مصادر، تشمل المحافظ النقدية، الحافلات، المستشفيات، أسواق اللحوم، موظفي الجامعات، الصرافين، المختبرات، وكافيتريا المدارس. تم تحديد كمية البكتيريا باستخدام طرق التخفيف التسلسلي وزراعة الأجار الغذائي، بينما تم تحديد البكتيريا الممرضة باستخدام وسائل انتقائية، وصبغة جرام، والاختبارات البيوكيميائية. تم تحليل البيانات باستخدام برنامج SPSSالإصدار 21. **النتائج:** وُجد أن جميع النقود المختبرة ملوثة بالبكتيريا. وكان أعلى حمل ميكروبي في فئة 500 ريال، تلتها فئة 200 و1000 ريال. أما بالنسبة للمصادر، فقد أظهرت كافيتريا المدارس أعلى معدل تلوث، بينما كانت عينات المستشفيات الأقل تلوثًا. من البكتيريا الممرضة السائدة التي تم تحديدها: *Staphylococcus aureus* بنسبة 30%، *Streptococcus viridans* بنسبة 18.3%، *Escherichia coli* بنسبة 13.3%، *Enterococcus faecalis* بنسبة 11.7%، و*Staphylococcus epidermidis* بنسبة 10%. كما تم عزل أنواع أقل تكرارًا مثل *Bacillus subtilis*، *Klebsiella spp.*، *Staphylococcus saprophyticus*، و*Neisseria meningitidis*. **الاستنتاج:** النقود اليمنية الجديدة في مدينة تعز ملوثة بشكل واسع بالبكتيريا الغير ممرضة والممرضة على حد سواء، مما يشكل خطرًا محتملًا لانتقال الأمراض. وكان التلوث أعلى في الفئات النقدية الأقل وبعض المصادر المحددة، مما يبرز الحاجة إلى تحسين ممارسات النظافة. **التوصيات:** تعزيز غسل اليدين بانتظام، واستخدام مواد مضادة للميكروبات على النقود، وزيادة الوعي العام حول التعامل الآمن مع العملة الورقية أمر ضروري للحد من انتقال البكتيريا عبر النقود.

الكلمات المفتاحية: التلوث البكتيري، العملة الورقية، البكتيريا الممرضة، خطر الصحة العامة.

Prevalence of Bacterial Contamination on New Paper Currency Notes in Taiz city, Yemen

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Abstract

Background: Paper currency is widely circulated and handled daily, serving as a potential vehicle for microbial transmission. In Yemen, particularly Taiz city, there is limited information regarding the bacterial contamination of newly issued banknotes, which poses a potential public health concern. **Aim:** This study aimed to evaluate the prevalence and types of bacterial contamination on new Yemeni banknotes circulating in Taiz city. **Methods:** A cross-sectional study was conducted from October 2024 to January 2025. Forty-eight samples of new Yemeni banknotes across three denominations (200, 500, and 1000 Yemeni Rials) were collected from eight sources, including cash wallets, buses, hospitals, meat markets, university staff, cashiers, laboratories, and school cafeterias. Bacterial load was quantified using standard serial dilution and nutrient agar culture methods, while pathogenic bacteria were identified through selective media, Gram staining, and biochemical tests. Data were analyzed using SPSS version 21. **Results:** All tested banknotes were contaminated with bacteria. The highest microbial load was observed in the 500 denominations, followed by 200 and 1000 denominations. Among the sources, school cafeterias showed the highest contamination, whereas hospital samples were the least contaminated. The predominant pathogenic bacteria identified included *Staphylococcus aureus* (30%), *Streptococcus viridians* (18.3%), *Escherichia coli* (13.3%), *Enterococcus faecalis* (11.7%), and *Staphylococcus epidermidis* (10%). Less frequently isolated species included *Bacillus subtilis*, *Klebsiella spp.*, *Staphylococcus saprophyticus*, and *Neisseria meningitidis*. **Conclusion:** New Yemeni banknotes in Taiz city are extensively contaminated with both commensal and pathogenic bacteria, posing a potential risk for disease transmission. Higher contamination was associated with lower denominations and certain handling sources, highlighting the need for improved hygiene practices. **Recommendations:** Regular hand hygiene, use of antimicrobial materials for banknotes, and public awareness regarding safe handling of currency are crucial to mitigate bacterial transmission from banknotes.

Keywords: Bacterial contamination, Paper currency, Pathogenic bacteria, Public health risk.

Introduction

Banknotes are widely used on a daily basis worldwide, although the extent of their use varies between countries (El-Dars and Hassan, 2005). In low-income nations such as Yemen, cash remains a primary method of payment, as electronic transactions and credit cards are less common. Banknotes can become contaminated through multiple routes, including cuts, droplets from sneezing or coughing, or contact with unclean surfaces (Hassan et al., 2011).

Microorganisms can spread via food, water, and air, and banknotes have been recognized as potential carriers of pathogenic bacteria and fungi, facilitating person-to-person transmission (Hosen et al., 2006). Moist banknotes provide a favorable environment for microbial growth, benefiting from environmental dust and organic residues deposited from human contact (Haque, 2003).

The material composition and age of banknotes also influence their microbial contamination. Modern banknotes are produced from a unique blend of 25% linen and 75% cotton with fine fiber fragments, creating a durable substrate distinct from ordinary paper (Ahmed et al., 2010). Lower denomination notes generally have a shorter circulation life, often around 24 months (Vriesekoop et al., 2010). Older banknotes, whether made from cotton or polymer, are more likely to harbor bacteria, making them potential vectors for disease (Ghamdi et al., 2011).

Despite the widespread use of cash in developing countries, research on the microbiological contamination of banknotes remains limited, which contributes to the lack of public health regulations regarding currency handling (Ghamdi et al., 2011). Pathogenic bacteria frequently isolated from banknotes include *Staphylococcus aureus*, α-hemolytic streptococci, spore-forming *Bacillus* species, *Escherichia coli*, *Enterobacter* species, *Acetobacter*, *Pseudomonas*, and *Salmonella*, which may cause foodborne or opportunistic infections (Vriesekoop et al., 2010).

Moreover, some viruses, such as influenza, can remain active on banknotes for extended periods, with certain strains persisting up to 17 days, while H3N2 can remain infectious for up to 3 days (Vriesekoop et al., 2010). However, few recent studies have investigated microbial contamination on newly issued banknotes in Yemen, with prior research focusing mainly on older notes (Hanash et al., 2015).

Currently, there is no detailed information on the microbial load or pathogenic bacteria present on new Yemeni banknotes issued between 2015 and 2025. Improper handling practices, such as moistening fingers with saliva while counting money, may introduce serious pathogens. Given the extensive use of cash and limited hygiene practices, such as infrequent handwashing after handling banknotes, the risk of disease transmission is significant. In Yemeni culture, banknotes are widely circulated and not typically stored in wallets except by a small portion of the population.

Study Aim:

The main aim of this study is to evaluate the level of bacterial contamination and to identify pathogenic bacteria present on new Yemeni banknotes collected from Taiz city, Yemen.

Study Objectives

1- To determine the total bacterial count on new Yemeni banknotes.
2- To identify the pathogenic bacterial species contaminating new Yemeni banknotes.

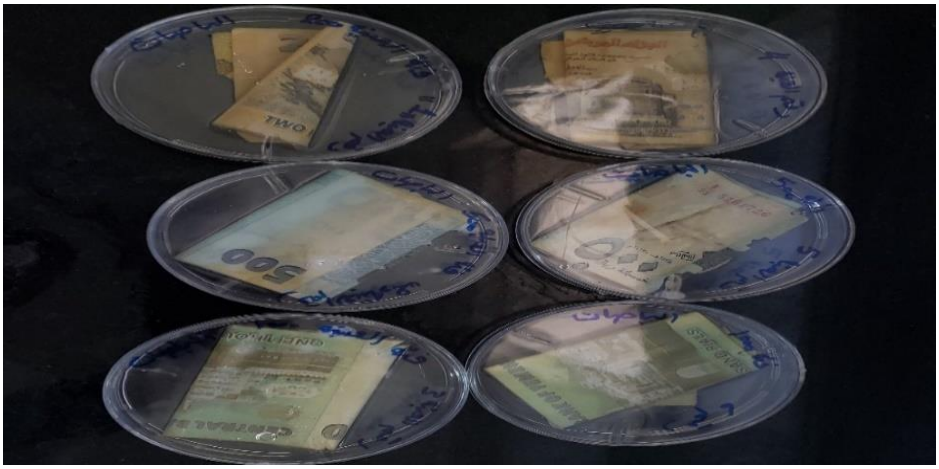
Methodology

Sample collection:

A total of 48 samples of new Yemeni Currency, comprising notes in all three denominations (200,500 and1000) Were investigated. Collected from various locations (cash wallet, buses, hospitals, meat markets, Aljanad university employees, casher, labs, schools' cafeteria) ، in the Taiz City, Yemen. Six samples from each location, by using sterile methods. Samples were randomly obtained between 15/10/2024, and 8/1/2025 in the Taiz city, Yemen. The notes were then placed in sterile bags, sealed, and transported to the microbiology laboratory of the department of medical laboratories, Aljand university.

Preparation of sample:

The banknotes were placed in clean, labelled petri dishes containing the category name, sample number, collection date and sample source. Then, 20 ml of sterile normal saline solution was added, and the sample were left for 30 minutes.



Figure(1): Preparation of Banknotes

Bacteriological analysis:

Bacterial count:

A serial dilution technique was performed by adding 9 ml of normal saline to each of four dilution tubes. Subsequently, 1 ml of the sample was transferred into the first tube and thoroughly mixed. Then, 1 ml from the first tube was transferred to the second tube and mixed, followed by transferring 1 ml from the second tube to the third, and 1 ml from the third tube to the fourth tube. Finally, 1 ml from the fourth tube was discarded to maintain equal volumes across the dilutions.

From each dilution tube, 1 ml of the diluted sample was inoculated into sterile Petri dishes containing nutrient agar using the pour plate method, and all procedures were conducted aseptically in front of a flame to prevent contamination. The inoculated plates were then incubated at 37°C for 24 hours. After incubation, the bacterial colonies were counted using a colony counter, and plates containing 30–300 colony-forming units (CFU) were considered for bacterial enumeration.

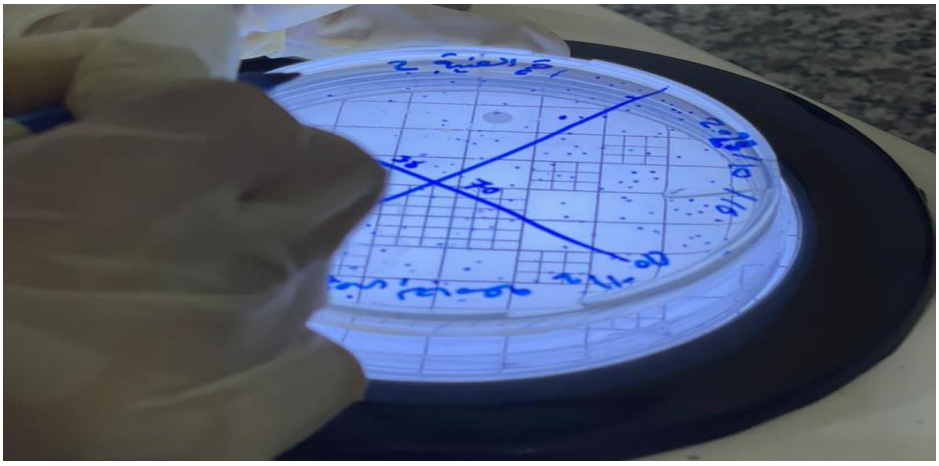


Figure (2): Bacteriological analysis (Bacterial count)

Identification of pathogenic bacteria:

The swabs were directly in collated on MacConkey Agar, Mannitol Salt Agar, S. S. Agar, and Blood Agar. The pairs of inoculated media were incubated aerobically at 35_37c° for 24h and then examined for bacterial growth according to standard protocol described by Chesbrough (2000). The bacteria were isolated by assessing colony Characteristics and Gram reaction and by Various biochemical tests, including indole, citrate urease test, catalase, coagulase and sugar fermentations.

Data Analysis:

The information collected from this study was documented and tabulated. The data in this study were statistically analyzed using software SPSS version 21 and Excel (2010).

Results And Discussion

Microbiological Analysis of Bacteria in Currency

Counting of Bacterial from Currency

Total of 48 currency samples. From 8 sources (cash wallet, buses, hospitals, meat markets, Aljanad university employee's, casher, labs and school's cafeteria) were identified from October 2024 to January 2025, based on morphological features in culture media. The result was reported as number of colony forming unit (CFU) per ml. Each significant bacteria was identified by colony characteristics on the respective media, staining, fermentation on culture media.

The school's cafeteria were the most prevalent sources isolation, it was recovered with 174 (21.1%) of total bacterial currency sample isolation, followed by cash wallet 158.6 (19.4%) and Casher 129.3 (15.7%). The source of Buses that was represented in 110.6(13.4%) next Aljanad university employees that in 105(12.7%). then labs 99 (12%). and meat markets 29.3(3.6%), It was the least source that appeared is Hospitals in 18.6 (2.3%).

Regarding the relationship of microbial load and its distribution between the monetary denominations, we found in our research that the 500 denomination had the highest microbial load (911 CFC/ml), followed by the 200 denomination (842 CFC/ml), and finally the 1000 denomination had the mean microbial load (721 CFC/ml), illustrated in table (1).

Table 1.

Distribution of Bacterial count among currency denominations and source of collection:

Source of Sample	Class	Bacterial count (CFU)		Mean of Microbial load	Dilution
		Mean	SD		
Schools cafetria	200	128	18	174	10^{-1}
	500	160	99		10^{-2}
	1000	234	83		10^{-2}
cash wallet	200	125	11	158.6	10^{-1}
	500	197	127		10^{-1}
	1000	154	67		10^{-1}
Casher	200	161	42	129.3	10^{-1}
	500	133	3		10^{-1}
	1000	94	81		10^{-2}
Buses	200	105	67	110.6	10^{-3}
	500	145	34		10^{-2}
	1000	82	59		10^{-2}
Janad university employee's	200	133	1	105	10^{-2}
	500	126	17		10^{-1}
	1000	56	79		10^{-3}
Laboratory	200	128	21	99	10^{-1}
	500	104	0		10^{-1}
	1000	65	14		10^{-1}
Meat markets	200	42	59	29.3	10^{-1}
	500	46	6		10^{-1}
	1000	0	0		0
Hospitals	200	0	0	12	0
	500	0	0		0
	1000	36	51		10^{-2}

The current results are similar to those obtained by Maritz, *et al,* (2017), and Demirci, *et al,* (2020). The hygienic status of banknotes has been a topic of speculation since the late 1800s. In vitro culture studies have established that microbial contamination of paper currency is widespread, and that money represents an important human-microbe interface. Microbial contamination of paper money can occur by money counting machines, atmosphere, dust, soil, storage process, during usage or production process. Contamination during use is most often caused by handwashing after the toilet or false hand washing, by saliva counting, coughing and sneezing in hands. As a result, paper money is contaminated with microorganisms from the human hand, mouth and even in the gastrointestinal tract microbiota. As a result of the exchange of these contaminated banknotes among people, microorganisms begin to spread, contributing to the spread of both antibiotic resistance and many virulence factors and they pose a risk to public health.

In the present study, the school's cafeteria was the most prevalent source isolation, it was recovered 174 (21.1%) of total bacterial currency sample isolation, followed by source cash wallet that was the second most common Source in 158.6 (19.4%) and Casher Source in 129.3 (15.7%).

Our results are similar to those obtained by Todd, *et al*, (2008), who noted that research during the last 20 years indicates that pathogens on currency notes could represent a potential cause of food borne illness. Many food outlets rely heavily on the exchange of paper currency for their products. If the same person is handling both money and food products (especially ready-to-eat products), the risk of cross-contamination increases. The microorganisms most commonly isolated on money included members of the family *Enterobacteriaceae, Bacillus* spp, *Staphylococcus spp, Micrococcus spp, Corynebacterium spp Mycobacterium tuberculosis* and *Vibrio cholerae* (Lamichhane, *et al*., 2009).

Source include buses that were represented in 110.6 (13.4%) next Aljanad university employees that in 105 (12.7%). then labs *that* was represented in 99 (12%). and Meat markets that appeared in 29.3 (3.6%). It was the least Source that appeared is Hospitals in 18.6 (2.3%).

Our results are similar to those obtained by Ahmed, *et al.*, (2010). They showed that the findings of another study carried out in Bangladesh carried found that taka collected from fish sellers, meat sellers, vegetable sellers, food

vendors and shop keepers were contaminated with *E. coli* at the rate of 69.23, 69.23, 63.63, 50 and 50%; with *Salmonella spp*. at the rate of 42.85, 38.46, 18.18, 0.0 and 0.0% and *Staphylococcus aureus* at the rate of 7.14, 53.84, 9.09, 16.67 and 33.33%, respectively.

Regarding the relationship of microbial load and its distribution between the monetary denominations, we found in our research that the 500 denomination had the highest microbial load (911), followed by the 200 denomination (842) and finally the 1000 denomination had the mean microbial load (721).Our results are similar to those obtained by Assayaghi, *et al.*,(2021), who reported that about 140 swabs from Yemeni currencies (paper and coins) collected from different areas in Sana'a city; culture results of bacteria isolated from these currencies were (53.4%) of both Gram positive and Gram negative, bacteria that isolated from the same currency's paper or coins while only (3.0%) was with no bacterial growth. Another study carried out in Ethiopia by Girma, *et al.*, (2014) showed that lower denomination of Ethiopian paper currencies (1, 5 and 10 notes) had A higher degree of contamination with various microorganisms than upper denominations (50 and 100 notes).

Class 500 was the class with the highest microbial load, especially in the cash wallet source, then it was followed by class 200 and was present in the casher source, and finally class 100 had the lowest microbial load and was present in the labs. Our results are similar to study in Bangladesh carried out by Barua, *et al.*, (2019) the highest total viable count of 8.96 log cfu/pc recorded from class 10 collected from egg sellers and lowest value of 6.85 log cfu/pc from class 1000 collected from grocer. According to different occupational groups, the highest total viable count value of mean log 8.40±0.56 cfu/pc was found in egg seller and lowest value of mean log 7.44±0.32 cfu/pc in grocer. Based on different denomination of paper currency notes, the average total viable count value ranged from 7.48±0.50 to 8.48±0.60 log cfu/pc; whereas highest one was recorded from Class 100 and lowest one from BDT 1000 notes, respectively.

Identification of pathogenic bacteria

Distribution of pathogenic bacteria among currency samples

Our study showed that *Staphylococcus auraus* was the most prevalent isolation, it was recovered 18(30%) of total bacterial currency sample

isolation, followed by *Streptococcus viridans* that was the second most common representing in 11(18.3%), and *Escherichia coli* that appeared in 8(13.3%). *Enterococcus faecalis* that was represented in 7(11.7%). And *Staphylococcus epidermidis* that appeared in 6(10%). *Bacillus subtilis* that was represented in 4(6.7%).and *Klebsiella* that appeared in 3(5%). *Staphylococcus saprophyticus* that was represented in 2(3.3%). It was the least bacteria that appeared is *Neisseria meningitidis* in 1(1.7%), illustrated in Fig. (1).

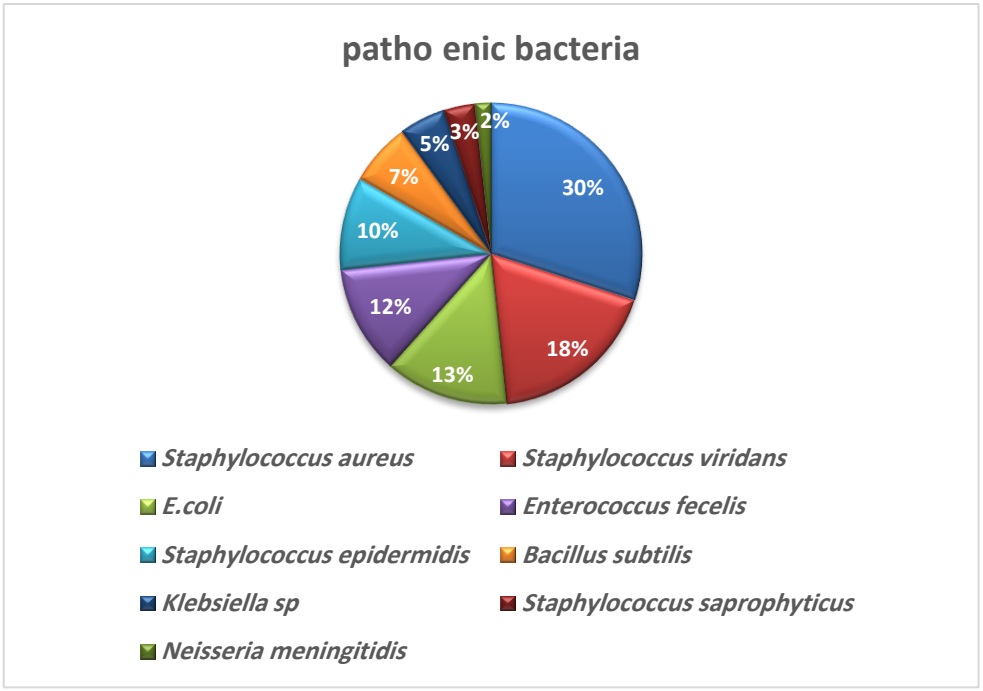


Fig. (1): Distribution of pathogenic bacteria among currency samples

Similar results obtained by study carried out in Sudan by Ali, et al., (2020) reported that *Staphylococcus aureus* 28(17%), followed by *Klebsiella pneumoniae* 14 (8%), *Enterobacter species* 9 (5%), *Enterococcus faecalis* 6 (4%), *Pseudomonas aeruginosa* 3 (2%), *Escherichia coli* 2 (1%)). While the other consider as Normal flora was form 107 (64%) (There were *Bacillus species* 33 (20%), followed by *Staphylococcus epidermidis* 24 (14%), *Micrococcus Species* 1 (1%) and fungi was present 49 (29%) of all isolates. *Staphylococci spp* were most presdominant isolated bateria in our study and many previous studies reported that, in study carried out in Sanaa city by

(Assayaghi, *et al.*, 2021) the percentage of different types of bacteria isolated from the currencies were as follow; *Staphylococci spp* (22.2%), *Alcaligenes spp* (11.2%), *Pseudomonas aeruginosa* and, Gram positive bacilli (10.0%), *Escherishia coli* (9.3%), *Seratia marcescans* (6.8 %), *Streptococci spp* (5.3%), *Enterobacter aerogene* (3.0%), *Klebsilla pneumoniae* (3.0%), *Enterobacter cloacae* (2.3%), *Yersinia enterocolitica* (2.3%), *Citrobacter spp* (2.3%), Gram posative diplococci (1.5%), *Shigella spp* (1.5%), and same percentage (0.8%) of Gram negative cocci, *Vibrio cholerae, Actinomysis spp, Proteus vulgaris, Proteus mirabilis*. While a study was conducted in Yemen at Taiz city by (Hanash *et al.*, 2015) mentioned that *E. coli* (50.28 %) followed by *Staphylococci aureus* (14.04 %) were isolated from currencies. Another study in Nigeria carried ut by (Alemu, 2014) revealed that *Staphylococci aureus* was (22.5%) and *Pseudomonas aeruginosa* was (6.25%).

Distribution of pathogenic bacteria among currency denomination:

Our study showed that *Staphylococcus auraus* most bacteria found especially among class 1000(50%) then 200(27.8%), Finally class 500(22.2%). illustrated in Fig. (2). Similar results were obtained by Bhalakia, (2005); and Oyero & Emikpe, (2007). The presence of pathogenic *Staphylococcus aureus* on money was expected because *S. aureus* carriers and diseased persons are common in the population. Simple nose rubbing, coughing or sneezing could cause contamination of the notes. Paper currency has recently been identified as a mode of transmission of community-acquired *S. aureus*. In this study the *Staphylococcus aureus* was the most bacteria found especially class 1000(50%) then 200(27.8%), followed by 500 (22.2%). Different results reported by Hanash *et al.*, (2015), where *Staphylococcus aureus* was most predominant in class 100 (20.68%) followed by class 250 (18.62%) whereas class 1000 the percent of contamination by *Staphylococcus auraus* was (0%).

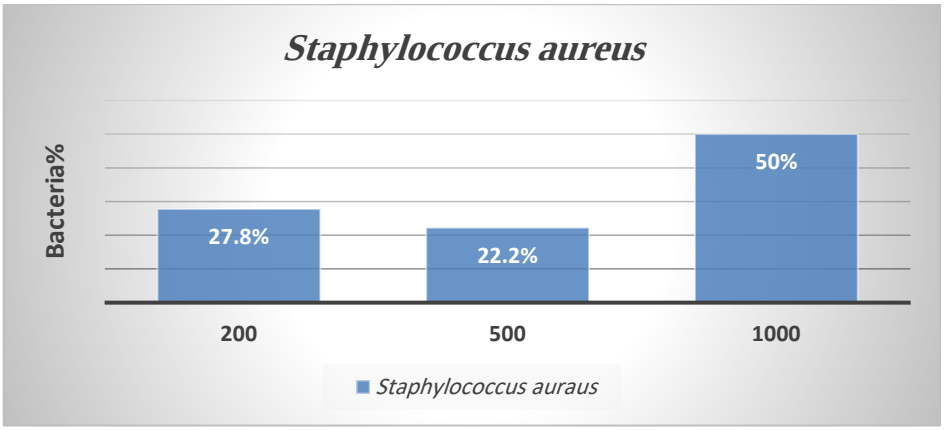


Figure (2): Identification of *Staphylococcus aureus*

Similar results, *S. aureus* is an important pathogen due to a combination of toxin-mediated virulence, invasiveness, and antibiotic resistance. This organism has emerged as a major pathogen for both nosocomial and community-acquired infections. *S. aureus* is a desiccation tolerant organism with the ability to survive in potentially dry and stressful environments, such as the human nose, and on skin and inanimate surfaces such as clothing and surfaces. *S. aureus* can remain viable on hands and environmental surfaces for extended durations after initial contact (Chaibenjawong and Foster, 2011).

The study shows that *Streptococcus viridians* was most prevalent in the class 200 (31.3%), followed by class 1000(25%), and finally class 500(18.8%), illustrated in Fig. (3).

Different were results obtained by Al-Ghamdi, *et al*, (2011*)*. They reported that *Streptococcus viridans* was most prevalent in the class 200 (31.3%), followed by class 1000(25%), and then class 500(18.8%).

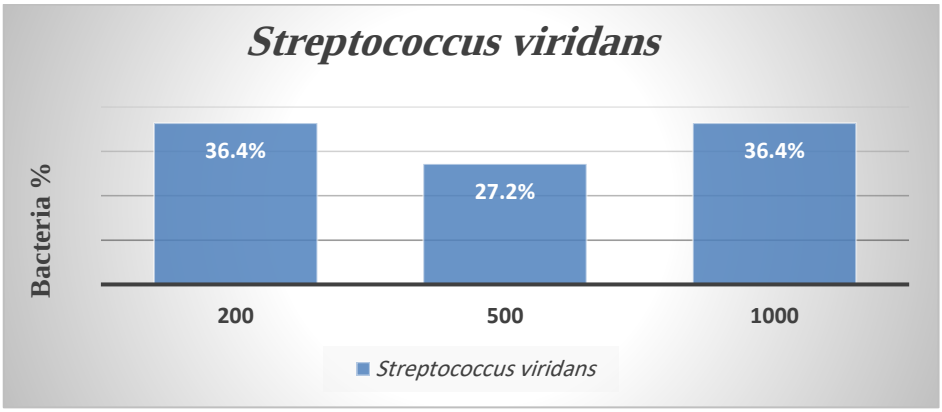


Figure (3): Identification of *Streptococcus viridians*

Our study shows that *E.coli* was most prevalent in the class 200(62.5%), followed by class 1000(25%), and finally class 500(12.5%), illustrated in Fig. (4). Similar results obtained by Sunil *et al.*, (2020), who noted that *E.coli* were widely distributed in various denominations of currency notes collected from both the hospital and open market groups than other organisms. Their detection in currency is indicative of fecal contamination and poor personal hygiene practices of currency handlers. Sunil, *et al*, (2020). Percentage of *E. coli* and *S. aureus* was more in lower denomination (Rs. 10) than the higher denominations (Rs. 50 and Rs. 100). Prolonged stay of paper currency notes in circulation increases the chances of the notes to be more contaminated. These contaminants include pathogenic organisms that cause disease in healthy individuals as well as bacterial that cause diseases for hospitalized and immuno-compromised patients (Michaels, 2002).

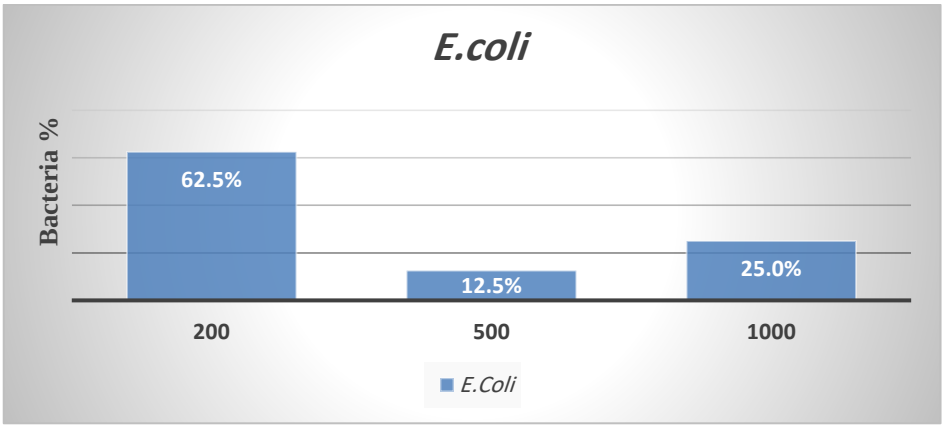


Figure (4): Identification of *E.coli*.

Our study shows that *Enterococcus faecalis* was most prevalent in the class 500(42.8%), followed by class 1000(28.6%), and finally class 200(28.6%), illustrated in Fig. (5). Similar results were obtained by AL-Ghamdi, *et al*, (2011), who showed that 4th version notes had mixed bacterial growth: Gram-positive *bacilli* (79%), *Staphylococcus aureus* (38%), Coagulase-negative *Staphylococci* (75%), *Viridians* group *Streptococci* (VGS) (8%), *Pseudomonas spp* (19%), *Klebsiella spp* (21%), *Escherichia coli* (9%) and non-hemolytic *Streptococci* (4%). Seventy six percent of the newer 5th version notes had mixed bacterial growth Gram-positive *bacilli* (68%), coagulase-negative *Staphylococci* (64%), *S. aureus* (13%), *Klebsiella spp*,(9%),*E.coli* (%2).

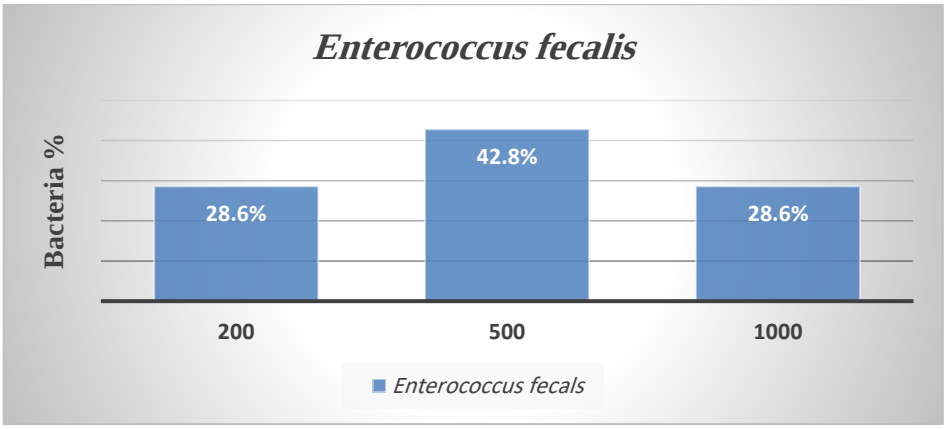


Figure (5): Identification of *Enterococcus faecalis*

The study shows that *Staphylococcus epidermidis* was most prevalent in the class 500(50%), followed by class 200(33%), and finally class 1000(16.7%), illustrated in Fig. (6). Similar results were obtained by Mohammed, *et al*, (2013), who showed that isolated aerobic spore forming *bacilli* (91%), *Staphylococcus epidermidis* (63.3%), *Klebsiella pneumoniae* (31.7%), *Enterococcus* (24.1%), *Enterobacter* (19.2%), *E. coli* (17.5%), *Lactobacilli* (10.8%), *Corynebacterium* (7.5%), *Staphylococcus aureus* (4.2%), alpha hemolytic *streptococcus* (4.1%), *Streptococcus pneumoniae* (1.7%), *Proteus* (l.7%), *Pseudomonas aeruginosa* (0.8%), *Shigella flexneri* (0.8%) from samples 120 currency notes.

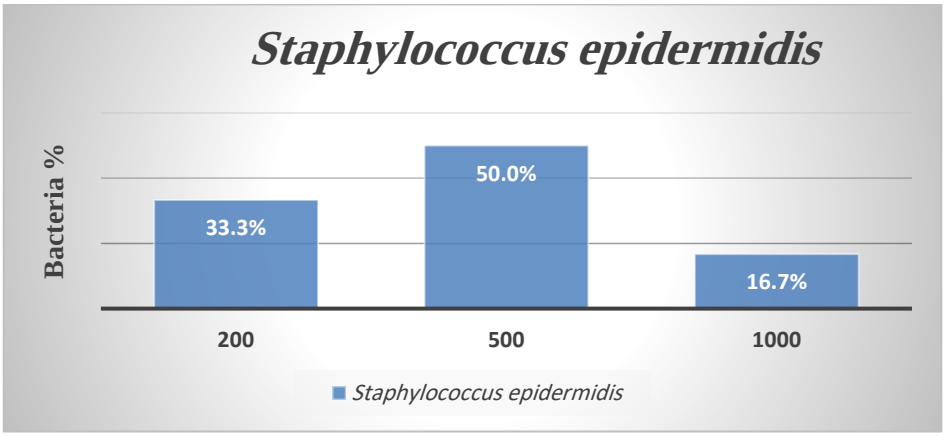


Figure (6): Identification of *Staphylococcus epidermidis*

The current results showed that *Bacillus subtilis* was most prevalent in the class 200(50%), with equal percentage in class 500(25%) and 1000(25%)

class the same percentage. illustrated in Fig. (7). Similar results were obtained by Odaa, (2022) In Iraq, the results of study who found *Bacillus sp.* 30.55 % was found to be as the most frequently isolated bacterial species from Iraqi banknotes currency in circulation in Baghdad city.

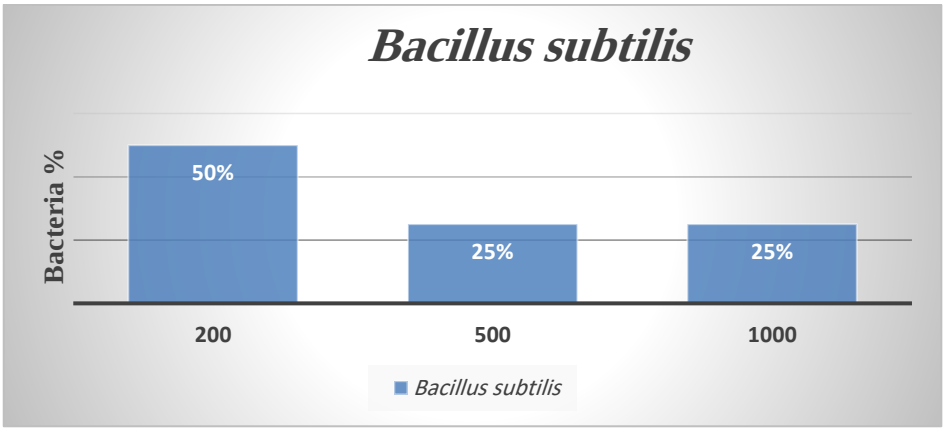


Figure (7): Identification of *Bacillus subtilis*

The current study showed that *Klebsiella* was most prevalent in class 1000(66.7%), followed by class 500(33.3%), but not found in class 200(0%), illustrated in Fig. (8). In similar study carried out in Pakistan by Ejaz *et al.*, (2018), who noted to about (26.0%) of the bacterial isolates discovered from Pakistani paper currency notes were *Klebsiella spp.*

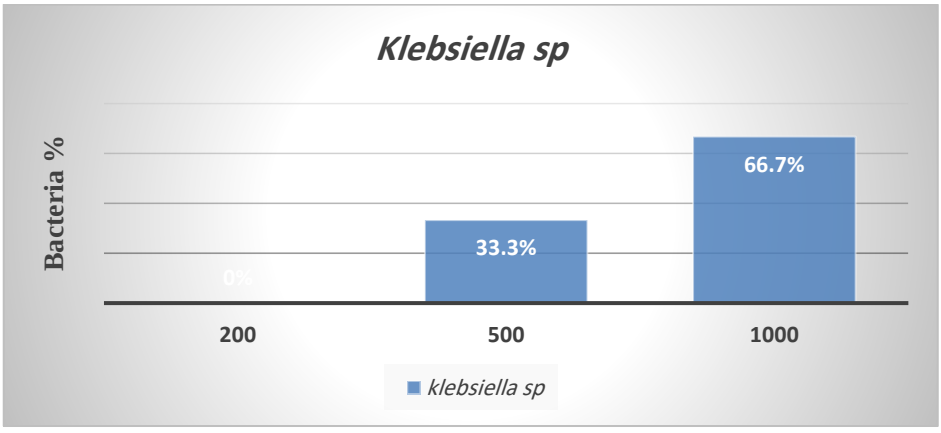


Figure (8): Identification of *Klebsiella sp*

The current study showed that *Staphylococcus saprophyticus* found in the equal ratios in class 200(50%), and class 500 (50%) but not in class 1000(0%), illustrated in Fig. (9). Similar results were obtained by Sawsan, (2013).

Showed that a total of one hundred and twenty-eight Iraqi dinar notes were analyzed for bacterial contamination. Seventeen different bacteria species were obtained from currency notes from studied places representing 100% contamination. Isolated bacteria from the paper notes with its percentage of contamination were *Staphylococcus aureus* (83.3%), *Streptococcus pyogenes* (83.3%), *Pseudomonas species* (83.3%), *Klebsiella species* (75%), *Staphylococcus epidermidis* (66.6%), *Escherichia coli* (66.6%), *Staphylococcus saprophyticus* (58.3%), *Streptococcus pneumonia* (58.3%), *Streptococcus faecalis* (58.3%), *Enterobacter species* (58.3%), *Proteus species*(50%), *Citrobacter species* (41%),*Corynebacterium species* (25%), *Yersinia species* (25%), *Salmonella species* (25%), *Acinetobacter species* (16.6%). His results were quite in accordance with the results obtained from this study.

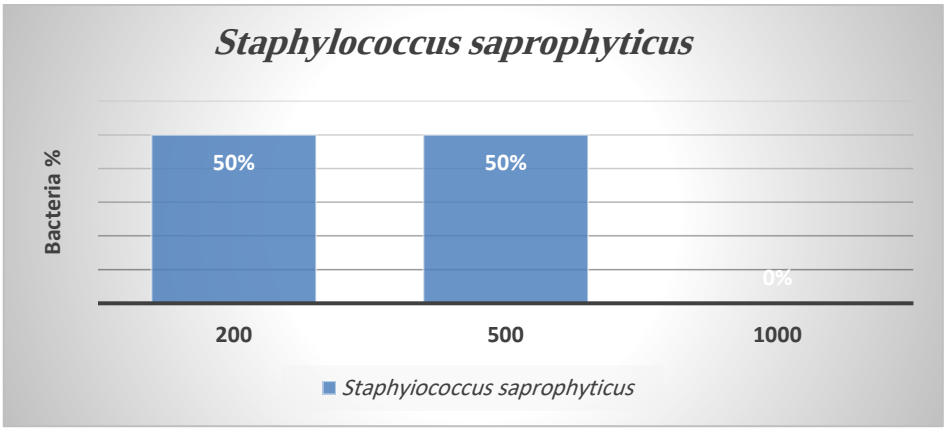


Figure (9): Identification of *Staphylococcus saprophyticus*

The current study showed that *Neisseria meningitides* was found only in class 200(100%). and not found in other classes. illustrated in Fig. (10). Currency notes and coins on which pathogenic microorganisms might survive represent an often overlooked reservoir for enteric diseases, food poisoning, wound and skin infections, respiratory and gastrointestinal problem to life threatening diseases like septicemia, meningitides etc (Elumalai, *et al*,2012). There has been no study to prove the presence of *Neisseria meningitides* due to its difficult growth requirement.

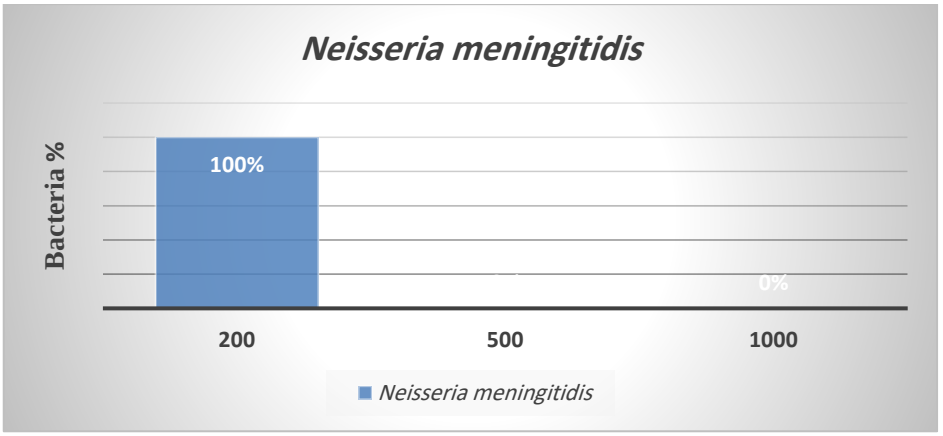


Figure (10): Identification of *Neisseria meningitidis*

The presence of pathogenic microorganisms on currency notes is of great concern because the notes might play a role in the transmission and spread of diseases. In the hands of bus conductors and fish and meat sellers, currency notes become literally pestilent. Currency notes carry various bacteria (Barro, *et al.,* 2006).

Conclusions

Among the 48 Yemen currency samples, collected from 8 Sources (Cash wallet, busses, hospitals, meat markets, staff, casher, Labs, and School's cafeteria) from October 2024 to January 2025. School's cafeteria was the most prevalent source of bacteria (Total bacteria count), while the hospital samples were the least source.

Regarding the relationship between the microbial count and distribution between denominations, class 500 had the highest microbial count. For distribution of pathogenic bacteria among whole samples, *staphylococcus aureus* was the most prevalent 30% of total bacterial samples. Whereas *streptococcus viridans* was appeared in 18.3%, *E.coli* appeared in 13.3 %, *E. fecalis* that was represented in 11.7%, *staphylococcus epidermidis* appeared in 10%, *Bacillus Subtilis t*hat was represented 6.7%, *Klebsiella* that appeared in 5%, *staphylococcus saprophyticus* that was appeared in 3.3%, and finally *Neisseria meningitidis* represented 1.7%. For distribution of pathogenic bacteria among currency denominations, *staphylococcus aureus* was the most bacteria prevalent among class1000 and 500 Samples, *E.coli* and *S.aureus* bacteria were equal in class 200.

Recommendations

This research shows contaminated banknotes are a public health risk when associated with the simultaneous handling of food, and currency may spread nosocomial infections. The potential for banknotes and coins to carry bacteria, and spread infectious agents could be controlled or reduced by:

1- Wash hands: They may have a lower risk of contracting the virus if all cash or banknote users have clean, washed and sanitized hands.
2- Use Antimicrobial polymer materials: They can be used in the manufacture of banknotes and banknote paper to limit risks of contamination.
3- Use food-handling tools: They can help prevent cross-contamination occurring between money and food through contact with the hands.
4- Keep hand hygiene: We reinforced the need for good hand hygiene after handling money, especially when handling food and money.
5- Isolate money: Many pathogenic or antibiotic-resistant bacteria have to be isolated from money collected from medical staff and food handlers.
6- Avoid the use of saliva: They shouldn't use of saliva during counting of currency notes, placing money in mouth, biting off corners of currency notes.
7- Educate fast food sellers: Fast food sellers should be educated to avoid possible cross contamination between currency notes and the food.
8- Use higher denomination currency: Contamination was correlated with the denomination of the notes. Lower denomination notes were more contaminated.
9- Use counting machines: Studies have shown that, the currency counting machines yielded six different bacterial species and four genera of fungi were isolated.

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