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A Microbiological study of Bacteria on circulating currency used in Baghdad- Iraq

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Abstract:

A Paper currency note is widely exchanged for different purpose in worldwide and the first time be developed in China. these banknotes may acting as environmental vehicle for the transmission of potential pathogenic microorganisms specially bacteria, which depend of individual who living in poor hygienic conditions and having unhygienic habits(improper hand washing after using the toilet, counting paper notes using saliva, coughing and sneezing on hands then exchanging money, and placement or storage of paper notes on dirty surfaces),which may leads to contaminate the notes with bacteria, then will act as a bridge delivering bacteria to another hands of the next user , then to all the community persons. Hence the aim of this study is isolating the bacteria then identify their types, which may contaminate different circulating and new uncirculated Iraqi currency paper. This study was done in Microbiology lab /Department of Medical Laboratories Techniques at AL-Hikma University College, Baghdad- Iraq, during the period started from December 2024 until February 2025. It was designed to find out the most common bacteria in two hundred thirty-five sterile swab samples taken from different denominations circulating and new uncirculated currency distributed in (250, 500, 1000, 5000, 10000,25000,50000) Iraqi dinar from different locations and different occupational groups in Baghdad city. From each banknote (235) we took one sterile swab with normal saline for bacterial culture on enrichment and selective media then incubated under aerobic condition, at 24-48 hours, next diagnosed and identification by Epi system, our results Tow hundred twenty-eight bacterial isolates represented by (60)G-ve bacterial isolates (Pseudomonas, Proteus, E. coli, Klebsiella) and 168 G+ve bacterial isolates (Staphylococcus aureus and (CoNS) also Streptococcus sp.) ,from circulating and new uncirculated currency in Iraq. The current study concluded that Iraqi currency act as a significant vector for the transmission of Gram positive and negative pathogenic bacteria and may be considered as a source of many infectious diseases. Generally, the personal hygiene of Iraqi individual is very low and that posing a public health threat to community. Based on this study results, to reduce the bacterial on Iraqi currency through: promoting the use of cashless payment methods(Electronic payment card), implementing regular disinfecting measures for currency , and enhancing personal hygiene practices among community individuals starting from the primary school stages and so on through applied and improve programs to how banknotes used , and increased consciousness of the risks and methods of transmission of microorganisms especially pathogenic bacteria.

Key words: Iraqi currency, contaminated, Bacteria,

INTRODUCTION

In mostly country, where the use of cash transactions remains widespread and understanding the microbial

load on circulating banknotes is critical as a risk of disease transmission in the community, particularly the elderly, children, and those with weakened immune systems (Meister et al., 2023), (Almogbel et al., 2025) undoubtedly Currency issued by the financial authorities and distributed within communities, are the most public means used for continuously the life. It's made from special blend of cotton, linen, fiber which mostly in third world countries used, but Modern replaced currency from paper to plastic polymers (Gedam et al., 2018), (Górny et al., 2022). Elshebani and et al., at 2024 study in Libya by, recorded presence of bacterial contamination associated with currency which was obtained from hospital's food outlet when they isolated different types of Gram-negative and positive bacteria, it represented by *Acinetobacter baumanni , Klebsiella pneumonia, Escherichia coli, Pseudomonas* spp , *Pantoea* spp as Gram negative, and *Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus haemolyticus* as positive for Gram stain(Elshebani et al., 2024), which was compatible with other studies in Ghana, Iraq and Bangladesh at 2020 ,2022 and 2025 respectively (Yar , 2020)(Odaa ,2022) , (Mishu et al., 2025), furthermore, currency harbors opportunistic multi-resistant bacteria in different levels for the commonly antibiotics and could act as a reservoir for antibiotic resistance genes among the community(Djouadi et al., 2020).Several factors may play a role of contamination currency papers with bacteria some of them are Internal factors which include :component of currency include :Surface Type and Material/Paper or Polymer, Ink and Printing Materials ,Security Features /Holograms, Watermarks and Thread , Microfibers and Textile Fiber /typically cotton and linen, in addition to the Age, Wear and Torn currency over time ,as well as, Chemical Treatments (Limaye, 2020),other factors are external clarified by studies of Singh and Sharma and Sarkar et al in 2015 and 2016 respectively like: Fluctuating Temperatures, High humidity or moisture from human hands , Dust and Other Contaminants (Cova et al.,2025), furthermore, several routes of transmission the bacteria on currency in community either direct contact (Hand-to-Mouth/Face), indirect Contact (Hand-to-Food), airborne transmission or Hand-to-Surface-to-Hand transmission (Ofoedu et al.,2021), all these factors and routs may participate to contaminated currency and have been established as a possible reservoir for different bacterial species that cause diseases such as food poisoning, typhoid fever, and gastroenteritis (Sharon et al., 2017) (Taiwade et al.,2024)Two studies in 2018 and in 2024, conducted that the developed countries have a high level of attention about the possible role of currency to play as a vehicle for pathogen transmission and resulted to formation of National Agencies responsible for handling and withdrawal of damaged banknotes (Neel et al., 2018), (Basak and Adak,2024), moreover, sterilization these currency from bacteria by; heat treatment , microwave ,ultraviolet (UV) light ,hydrogen peroxide vapor and Ozone gas (O_3). (Hostachy et al.,2014), (Bendjamaa et al., 2020), (Ibrahim,2021), (Sutiari et al., 2024).

Aim of Study

This study focusing on: estimation, prevalence, and identify the bacteria in Iraq banknotes either circulated or new (uncirculated) category: 250 ,500, 1000 ,5000 ,10000 ,25000 and 50000 IQD.

Methodology

This study designed over a period of 4months, from 15th November 2024 till 15th March 2025 to reflect the rate/level of the bacterial contamination of the Iraqi currency paper taken from different locations and different occupational groups in Baghdad city -Iraq.

Samples collection

Sterile swabs moistened in sterile normal saline (Sodium Chloride, 0.9%) were used to take samples from the Two hundred thirty five Iraqi banknotes samples were collected , divided to: 150 circulating currency (Iraqi dinar) in five categories by 30 samples per currency from (250, 500, 1000, 5000,10000 dinars) and 50 circulating currency by 25 samples per currency category from (25000,50000 dinars) and 35 sample new uncirculated currency (Iraqi dinar) kept it in sterile plastic bacs by 5 samples per currency category from (250, 500,1000, 5000 , 10000 , 25000 , 50000 dinars). Samples collection was performed according to (Central Bank of Iraq, 2020)

Media preparation

The culture media were prepared in Microbiology unit/ Teaching Laboratories in AL- Yarmouk Teaching Hospital by using the MediaClave and MediaJet (Integra-Biosciences KK-/Japan). This system can process up

to 1100 INTEGRA Petri dishes in a single hour and provides truly fast and reliable walk-away operation media. It is Equipped with a UV lamp, and the filling chamber where Petri dishes are automatically filled with agar medium which is kept free from c o n t a mi n a t i o n. (h t t p s: / / w w w. I n te g r a b i o s c i e n c e s .com/Japan/en/media-preparation/mediajet). The media used in this study include blood agar, chocolate and MacConkey agars.

Bacteriological analysis

Inoculation of all the swabs on Blood agar and MacConkey agar, were incubated at 35-37°C aerobically for 24 hours while chocolate agar was incubated at 35-37°C for 72 hours under 5-10% CO2 concentration to give chance for microaerophilic fastidious bacteria growth (Jawetz et al. ,2019). Plates were examined daily for bacterial growth, identifying these isolates by using colony morphology, Gram strain of bacteria drawn from bacterial colonies. Species identification was then carried out using API 20 E(REF-20100/20160) and API STAPH(REF-20500) Biomerieux / France.

-Support bacterial tests were: Oxidase biochemical test for G-ve bacteria and Mannitol Salt agar for *Staphylococcus* spp. as a G +ve bacteria.

-Beside to: Micropipette, pasture pipette, disposable gloves, distilled water, incubator, autoclave and sterilizer/disinfectant.

Statistical analysis:

Analysis of data was carried out using the available statistical package of IBM SPSS-29 (IBM Statistical Packages for Social Sciences- version 29, Chicago, IL, USA). Data were presented in simple measures of frequency, percentage. Value of less than 0.05 was considered as significant value. (Daniel and Cross ,2020)

RESULTS

On the basis of the Iraqi banknote's samples were collected during 15th November 2024 till 15th March 2025, a total of Two hundred thirty-five specimens were tested, of which 200 circulating currency, 35 un-circulating (85.1%) and (14.8 %) respectively.

Table (1): Total samples that tested for bacterial isolates

Currency banknotes	Total samples N	Available bacteria N (%)	Not available bacteria N (%)
Circulating	200	189(94.5)	11(5.5)
Un-circulating	35	6(17.1)	29(82.9)
Total	235	195(82.9)	40(17)

p-value = 0.00001 (highly significant at 0.05)

As shown in figure -1-, there was highly significantly relationship between circulating and new banknotes in bacterial isolates (p-value = 0.00001), from 235 sample, the highest bacterial isolates were founded in 195 banknotes (82.9%) and only 40(17%) currency not available bacteria, moreover, highest bacterial isolates recorded in circulating 189(94.5%), while the lowest in new 6(17.1%) IQD.In present study, table- 2- revealed, from the total of 235 currency were tested, high percentage of bacteria was G+ve 168 (56.1%) out of 228 isolates when compared with G-ve percentages 60(26.3%), furthermore, the highest incidence of bacterial contamination in circulating 222 (97.3%), while only 6(2.6%) percentage record non-circulating categories that included in this study.

Table (2): Types of bacteria according to Gram stain in Iraqi currency

Gram stain	Circulating (200)	Un-Circulating (35)	Total
G-ve	60	-	60(26.3%)
G+ve	162	6	168(56.1%)
Total	222(97.3%)	6(2.6%)	228

Table - 3 and 4-, represents the bacterial species that isolated in current study and its distribution from total samples (circulation and non-circulating) Iraqi banknotes. Results showed the highest bacteria were isolated from Iraqi banknotes out of 228 was, Coagulase-negative Staphylococci (CoNS) 86(37.7%) and in 2501QD category 19(36.5%) out of 52, followed by *Staph. aureus* 72 (31.5%) and also its high percent in 250 IQD

category 15(31.5%). *Pseudomonas aeruginosa* as a G-ve bacteria demonstrated the highest rate of bacterial contamination 24 (10.5%), followed by *Escherichia coli* 13(5.7%), and also G-ve exhibit high bacterial percent in 250 IQD category 7 (13.4%) and 6(11.5%) respectively. On the other hand, the second Iraqi banknotes contaminated by bacteria was 500IQD category 44 (19.2%) then 5000 IQD category 35(15.3%).

Table (3): Bacterial species that isolates from total samples (circulation and un-circulating) banknotes

Types of bacteria	No. in Circulating	No. in Un-Circulating	Total %
Staph. aureus	72(32.4%)	-	31.5
CoNS	80(36%)	6	37.7
α-hemolytic Streptococci	8(3.6%)	-	3.5
β-hemolytic Streptococci	2(0.9%)	-	0.8
Escherichia coli	13(5.8%)	-	5.7
Klebsiella pneumonia	11(4.9%)	-	4.8
Proteus sp.	12(5.4%)	-	5.2
Pseudomonas aeruginosa	24(10.8%)	-	10.5
Total	222	6	228

Coagulase-negative Staphylococci (CoNS), Alpha-hemolytic Streptococci (α-hemolytic streptococci), Beta-hemolytic Streptococcus (β-haemolytic streptococci)

Table (4): Distribution of bacterial isolates according to the currency banknotes category

Types of bacteria	250 IQD	500 IQD	1,000 IQD	5,000 IQD	10,000 IQD	25,000 IQD	50,000 IQD	Total
Staph. aureus	15	13	11	12	7	9	5	72
CoNS	19	13	9	15	15	9	6	86
α-hemolytic Streptococci	1	2	2	1	2	-	-	8
β-hemolytic Streptococci	-	1	-	1	-	-	-	2
Escherichia coli	6	5	2	-	-	-	-	13
Klebsiella pneumonia	4	2	4	1	-	-	-	11
Proteus sp.	-	3	2	2	4	1	-	12
Pseudomonas aeruginosa	7	5	3	3	4	2	-	24
Total	52	44	33	35	32	21	11	228

DISCUSSION

Over the last 20 years, studies discussion harbor pathogenic bacteria in currency paper, which suggested a significant role as a potential cause of occasional causes and spread of food borne diseases. (Alemu,2014), (Taiwade et al.,2024).Our results in table-1 and 2- acceptable with the Indian study in 2018 when it published, from a total 448 bacterial isolates were identified in old and new currency, a majority (22.95%) were Coagulase negative Staphylococcus spp. (CONS). While in new currency Micrococcus (64.29%) was found predominant. (Gedam et al., 2018), also current study result agreement with Trickish study in 2020 when scored *Staphylococcus aureus*, coagulase-negative staphylococci (CoNS), *Enterococcus* spp. high percentages were detected (48%, 54.7%, 56%,) respectively (Demirci et al., 2020), on the other hand, our result was incompatible with Al-Nuaimi and et al., when they published, from 48 bacterial isolates, 37 (77%) Gram-negative bacteria and 11 (22.91 %) Gram-positive bacteria (Al-Nuaimi et al.,2022),likewise Ethiopia and Pakistan studies in 2014 and 2018 respectively , explained that Gram-negative bacteria have thicker outer membrane, which offers better protection from environmental factors and allows them to survive longer than Gram-positive bacteria on surfaces like banknotes and this protective outer membrane contributes to their resistance to antibiotics and any other antimicrobial agents, furthermore ,outer membrane could be a possibility play as a source of community or nosocomial acquired infections (Alemu ,2014) ,(Ejaz et al.,

2018),so, the experimental results in AL- Mousel study at 2021 showed that all tested bacteria differed in time of survival on the banknotes and this survives depended to the several factors include: environmental conditions, the type of bacteria if G+ve or G-ve and the mode of its resistance to the community conditions, but they concluded bacteria stable and still cultivable after seven days, and they success to sterilized this currency by UV and represented it as an effective tool. (Abdul Kader and Al-Rawi ,2021)Our study findings in table- 3 and 4 - are supported by a similar Iraqi studies done in Thi–Qar , AL-Mosul and Baghdad , which reported a were identified different bacterial isolates in different categories of Iraqi currency .Thi-Qar study in 2017 exemplify lower result than current study when *Escherichia coli* was predominated 12(18.46%) followed by *Streptococcus* sp. 1(1.53%) , in the same context, AL-Mosul study showed results which was lowest than our results, when out of 48 bacterial species isolated, the *E. coli* represent (11) (36.67%); ; *Klebsiella* (7) (23.34%), Coagulase Negative *Staphylococcus* (7) (23.34%), *Staph. aureus* (4) (13.34%), *Pseudomonas aeroginosa* (4) (13.34%), and *Proteus.* Sp., (4) (13.34%), while our study results was a higher percentage compared with Baghdad study in 2022, showed that *Klebsiella* 18.05%, *Staphylococcus aureus* 16.66%, *Staphylococcus epidermidis* 8.33%, followed by *Streptococcus*, *Proteus mirabilis* and *Pseudomonas aeruginosa* were detected in similar percentage 2.77% . (Abid, 2017), (Al-Nuaimi et al.,2022), (Odaa , 2022), furthermore, our result agreement with India study, when scored 13.33%. out of 50.83% of the currency exhibited bacterial contamination by *Klebsiella* spp. (Taiwade et al.,2024), on the other hand, other studies published corresponding result of our result about bacterial isolates but more variety and more higher percentage when compared with our result, Elshebani with her team in Libya was reported *Lactobacillus* 50%, ,*Acinetobacter* 20.3%, *Klebsiella* 7.4%, *Escherichia coli* 3.7%, then *Staphylococcus aureus* 3.7% , *Staphylococcus epidermis*, *Pseudomonas stutzeri, Rhizobium radiobacter* were 1.8% (Elshebani et al., 2024),also, Yar study from Ghana pointed out bacterial isolates were *Escherichia coli* (28.23%), *Klebsiella* species (11.29%), *Pseudomonas aeruginosa* (5.65%), *Proteus* species (3.23%),*Staphylococcus aureus* (16.94%), coagulase-negative *Staphylococcus* (16.13%), in addition to *Salmonella* sp. and *Shigella* sp. (8.87%)(Yar , 2020), in the same context, Ejaz and et al., from Pakistan issued, G+ve Coagulase-negative Staphylococci (CoNS) (18.3%) and *Streptococcus* spp. (2.3%), in addition to G-ve *Klebsiella* spp. (26.0%), *E. coli* (14.5%), *Pseudomonas* spp. (13.7%), *Citrobacter* spp. (11.5%), *Enterobacter* spp. (5.3%), *Acinetobacter* spp. (5.3%), *Shigella* spp. (1.5%), *Salmonella* spp. (0.8%) and *Pantoea* spp. (0.8%) (Ejaz et al., 2018), in the same context , study in Nigeria when scored *Escherichia coli* (78%), *Klebsiella species* (59%), *Pseudomonas aeruginosa* (16%), *Staphylococcus aureus* (66%) and *Micrococcus* species (31%) , subsequently, Bacteria contamination was higher in polymer notes than in paper notes.(Anidiobu et al., 2022) In this study the most common bacteria isolated from different old Iraqi currency which correspondence with two studies of Alemu,2014 and Neel with his team in Ethiopia and Rwanda respectively, when they found, many pathogenic bacteria were isolated in lower and older denomination paper currency notes than higher category, and he added the coins currency contain more parasites than bacteria and fungi.(Alemu,2014), (Neel et al., 2018), simultaneously , study in Romania explained the risk of bacterial contamination of the banknote bills by their strong survival capacity and adherence according to the materials used for banknotes,(Cozorici et al.,2022), in the same context, other study in Poland at 2021 confirmed that machine of banknotes payment are active sources of microbial emission , which the average concentrations of the pathogenic strains of bacteria and fungi spores in the air and surfaces of tabletop in banknote paper and coin ranking rooms were above the proposed purity levels for indoor surfaces and was very diversified and they suggested treated this microbial contamination which may pose threat health community.(Górny et al., 2021)In study conducted in 2014 on the different banknotes in different countries when they summarized that, India rupee, Bangladesh Teka, Iraqi and Ghanaian currency notes were contaminated with 100% were contaminated with pathogenic or potentially pathogenic bacteria with mixed bacterial growth when compared with other countries which appear less contamination or to some extent like, Palestine ,Colombian , South African , Saudi Arabia and less one in Mexico , 96.25% , 91.1% , 90% , 88% and 69% respectively (Alemu,2014)This contamination in banknotes may explain reason the increase in antibiotic-resistant bacterial isolates which could pose a health threat to users during commercial transactions, therefore, we may need to start using alternative products instead of banknotes (Yar, 2020), (Demirci et al., 2020), in contrast, Meister et al. a

review in 2023 clarified that banknotes and coins do not pose a risk of pathogen infection in a community public. (Meister et al., 2023), notably, India study in 2024 confirmed doubtless, there was a significant decrease in coin contamination during and after the COVID-19 pandemic, and explained that as a result of a rise in online monetary transactions. (Taiwade et al.,2024)Several studies in forgone country like India ,Poland, Germany and Slovak Republic , suggesting that routine handling of contaminated banknotes may lead to the transfer of micropollutants, furthermore, respiratory droplets, hand-to-hand contact, personal hygiene practices also cash money or un electronic money transaction and both unwanted pollution and subsequent secondary emission of microbial contaminants from sorted means of payment and tabletop surfaces, which all my play a role to transmission of different public health of individual and communities relevant bacterial, fungal and viral pathogens and should public education on proper handling with currency categories and transmission/switch to cashless or electronic money transaction should be initiated to avoid such public hazards (Gedam et al., 2018), (Górny et al., 2021), (Meister et al., 2023) and (Cova et al.,2025), simultaneously, Saudi Arabian study in 2025 reported, from 1415 adult Saudi citizens surveyed, 75% lacked awareness about contaminated currency and more than50% not washing their hands after handling contaminated notes and most of them 78% male, and recommended that paper notes be replaced with plastic currency(Almogbel et al., 2025), unsurprisingly, American study concluded, the banknotes could serve as a useful substrate for observation of drug direction either regionally, nationally or internationally as a result of higher frequency used of contaminated currency paper by drug and their impacts toxicologically or pharmacologically. (Hewes et al., 2024)

CONCLUSION

The current study concluded that Iraqi currency act as a significant vector for the transmission of Gram positive and negative pathogenic bacteria and may be considered as a source of many infectious diseases, add the personal hygiene of Iraqi individual is very low and that posing a public health threat to community , this problem was treated by Iraqi government when founded a relative solution by converting the salaries of employees and retirees to electronic withdrawals using cards in addition , can uses these cards in daily dealings

RECOMMENDATIONS:

1.Government proposal

include antibiotics in currency to reduce bacterial contamination

Replace the cotton and linen used in currency with polymer materials because they reduce the presence of bacteria on them.

Implement regular cleaning and disinfection practices for currency in circulation, either by the central bank or through specialized services. This could reduce contamination bacteria on currency

2.promotion the use of digital payment methods, mobile wallets, and contactless payment systems to reduce the reliance on physical currency

3.Educate the public on the potential risks of handling contaminated currency specially when use saliva to account the currency and promote proper hygiene practices, such as washing hands after handling money or using hand sanitizers.

4.Conduct further research focusing on sensitivity test to the different locally antibiotics to explore the extent of bacterial isolates resistance .

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Conflicts of interest

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