# **Original Research Article**

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20171308

# The hygienic and microbial status of Sudanese banknotes, Khartoum state, Sudan

# Mohanad Hassan Mohamed Honua\*

Department of Food Hygiene and Safety, Faculty of Public and Environmental Health, University of Khartoum / Khartoum, Sudan

**Received:** 05 February 2017 **Revised:** 09 February 2017 **Accepted:** 06 March 2017

# \*Correspondence:

Dr. Mohanad Hassan Mohamed Honua,

E-mail: honua123@gmail.com

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

#### **ABSTRACT**

**Background:** Banknotes are one of the items most frequently circulating from hand to hand, and microbial contaminants of banknote may be transmitted directly, through hand-to-hand contact, or indirectly, via food or other inanimate objects. This study was designed to assess the banknotes handlers hygiene and microbial (Bacteria, Yeasts and Moulds) contamination of Sudanese banknotes in Khartoum state, Sudan.

**Methods:** Fifty samples of Sudanese banknotes were collected randomly from handlers through (March - April / 2015). These samples were microbiologically tested for quantify bacteria, identification of bacteria and fungi (Yeasts and Moulds) by using biochemical tests for bacteria and phenotypical characteristics for fungi.

**Results:** The study showed that the mean of total viable count (CFU/cm<sup>2</sup>) of bacteria contaminated of banknotes between (4.5 - 8.3) x  $10^5$  CFU/cm<sup>2</sup>, the study showed 12 different types of bacteria and 5 types of fungi was identified from banknotes with different percentages. From statistically analyzed of 50 questionnaires there were; 76% of handlers had knowledge about contaminated banknotes as being a source of infection; 94% educated handlers at different levels; 64% of the handlers washed hands after using a toilets and before dealing with banknotes again.

**Conclusions:** Sudanese banknotes were contaminated with different bacteria, yeast and moulds. unhygienically handled. The contamination rate was higher in lower denominations than in higher ones.

Keywords: Candida albicans, Banknotes handlers, E.coli, Sudan

#### INTRODUCTION

Banknotes - the most adored, cherished, and highly respected item in human life - are one of the most vastly circulating and traded items between hands of citizens.<sup>1</sup>

As a result of this fast and frequency in circulation of banknotes between handlers, who are of different personal hygiene, medical status, saving of banknotes habits, geographical habitats and business, banknotes are more borne to contamination with different types of pollutants.<sup>2</sup>

Bacteria are not the only microorganisms found on banknote, a number of studies show that fungal (Yeast and Molds) contamination of banknote is also common, some of these are potentially pathogenic to humans and other life forms including plants.<sup>3</sup> Contaminated banknote is incriminated as major disseminator of many diseases especially skin, respiratory and intestinal diseases.<sup>4</sup>

Banknote can be contaminated by droplets during coughing, sneezing, touching with previously contaminated hands or other materials and placement on dirty surface.<sup>2</sup> It is also provides a large surface area as a

breeding ground for pathogens.<sup>5</sup> The survival of microorganisms on banknotes depends on type of microorganisms, their environmental resilience, the environmental conditions and the type of materials that were used for making of banknotes.<sup>6</sup> In some businesses the risk of infection by contaminated banknotes is higher as in bank accountants, transport ticket collectors and beggars.<sup>5</sup>

A number of studies have found multidrug-resistant and virulent strains on banknotes, these have the potential to cause serious infections that are hard to treat, to disseminate in health care and community settings, and to spread antimicrobial resistant determinants to other bacteria.<sup>7</sup>

Scientific information on the contamination of banknote by microbial agents is also lacking in most developing countries in sub-Saharan Africa, including Sudan. This dearth of information may have contributed to the absence of public health policies or legislation on banknotes usage, handling, and circulation in many parts of Africa.<sup>8</sup>

The currency circulating now in Sudan it is the Sudanese Geneah (SDG), which replaced from dinar in January (2007).

#### **METHODS**

Fifty samples of Sudanese banknotes (10 samples from every denomination - 2, 5, 10, 20, and 50 Sudanese Geneah (SDG)), were randomly collected in Khartoum State, from (students, vegetables and fruits sellers, bank accountants, transport ticket collectors and free workers) during (March – April/ 2015).

Each sample was directly kept in alcohol sterilized plastic tube and transferred to the microbiology laboratory of the Faculty of Public and Environmental Health, University of Khartoum. These samples were microbiologically tested for total viable count to quantify bacteria, identification of bacteria using biochemical tests included: (1- Sterilization of materials: Glass wares were sterilized at 121°C for 15 minutes, work surfaces were cleaned and sterilized by swabbing with 95% ethanol, 10 milliliter of normal saline was dispensed into McCartney bottles and then sterilized in autoclave. 2- Preparation the media: MacConkey agar, Manitol salt agar, Blood agar, Plate account agar, Nutrient agar, and Sabouraud dextrose agar were prepared and used according to the manufacture's specification. 3- Culturing process: All denominations of Sudanese banknotes were processed for microbial analyze in a sterile atmosphere. The culturing of media followed the manufacturer's instructions.

The agar was mixed with the appropriate amount of distilled water and autoclaved at 121°C for 15 minutes, then which it was cooled and poured aseptically into plastic Petri dishes, and allowed to cool until it is solid.

Solid agar was inoculated and incubated for 24 hours. after which possible growth were checked for. Pure colonies of isolated microorganisms were identified and characterized using standard microbiological techniques. Nine milliliters of normal saline (0.8 NaCl) was dispensed into test tubes in 4 folds. The test tubes were plugged with cotton wool and sterilized by autoclaved at 121°C for 15 minutes. On cooled, the samples of banknotes were dissolved in flasks every one contained normal saline depending on the distance of the two surfaces of banknotes (2 SDG in 95 milliliters of normal saline, 5 SDG in 105 milliliters of normal saline, 10 SDG in 108 milliliters of normal saline, 20 SDG in 120 milliliters of normal saline, and 50 SDG in 123 milliliters of normal saline), and then mixed by shaking thoroughly and appropriately. Serial dilution method was used for colony forming unit (CFU/cm<sup>2</sup>) on Plate account agar for quantify bacteria by using (Miles and Misra method). Serial dilutions were carried out using sterile syringes to pipette 1ml from the mixed sample into the test tube labeled 10<sup>-1</sup> and then shaken thoroughly. 1ml from 10<sup>-1</sup> was pipette into the next labeled test tube 10<sup>-2</sup> and then mixed, 1ml was pipette again from 10<sup>-2</sup> into 10<sup>-3</sup> labeled test tube and this was done sequentially to 10<sup>-4</sup>. All cultures for bacteria were incubated at 37°C for 24 hours while plates for fungi were incubated at 28°C for (3-7) days in Sabouraud dextrose agar. 4- Identification of bacteria using biochemical tests: included the; indole test, citrate-utilization test, sugar fermentation test, kligler agar test, voges proskauer agar test, urease test, and triple sugar iron agar test).<sup>10</sup>

For identification of fungi (Yeasts and Moulds) using phenotypical characteristics (KOH and lactophenol cotton blue stains). 11

The general hygiene of banknotes handlers was studied using observations and questionnaires to 50 randomly selected banknotes handlers.

# RESULTS

The study showed that the mean of colony forming units (CFU/cm²) of bacteria for: 2 SDG, 5 SDG, 10 SDG, 20 SDG, and 50 SDG was:  $(8.3 \times 10^5 \text{ CFU/cm}^2)$ ;  $(7.2 \times 10^5 \text{ CFU/cm}^2)$ ;  $(6.0 \times 10^5 \text{ CFU/cm}^2)$ ;  $(4.7 \times 10^5 \text{ CFU/cm}^2)$ ; and  $(4.5 \times 10^5 \text{ CFU/cm}^2)$  respectively.

The study showed 12 different types of bacteria in all samples with different percentages: (Staphylococcus aureus 42%; E.coli 24%; Klebsiella pneumonia 18%; Proteus mirabilis 8%; Pseudomonas aeruginosa 20%; Salmonella spp 18%; Shigella spp 20%; Bacillus spp 20%; Streptococcus pyogenes 14%; Acinetobacter spp 20%; Neisseria gonorrhoeae 14%; Staphylococcus epidermidis 32%). Five different types of fungi (Yeasts and Moulds) were identified from all samples with different percentages: (Aspergillus spp 20%; Penicillium spp 14%; Trichoderma viride 8%; Candida albicans 10%; Alternaria tenuis 14%).

Table 1: The occurrence of different bacteria isolates from Sudanese bank notes.

Types of	Value o	of bank no	ote (SDG)		Total	contamination		
bacteria	2	5	10	20	50	Total	percent %	
Staphylococcus	4	6	3	4	4	21	42	
aureus	40%	60%	30%	40%	40%		72	
E.coli	5	-	4	1	2	12	24	
	50%	-	40%	10%	20%			
Klebsiella	1	3	-	4	1	9	18	
pneumonia	10%	30%	-	40%	10%		18	
Proteus	1	-	-	2	1	4	0	
mirabilis	10%	-	-	20%	10%		8	
Pseudomonas	3	3	-	2	2	10	20	
aeruginosa	30%	30%	-	20%	20%		20	
C -111	4	1	3	1	-	9	10	
Salmonella spp	40%	10%	30%	10%	-		18	
Shigella spp	2	2	4	2	-	10	_ 20	
Snigetia spp	20%	20%	40%	20	-		20	
Bacillus spp	3	3	2	-	2	10	<b>—</b> 20	
Висшиз зрр	30%	30%	20%	-	20%		20	
Streptococcus	-	4	2	-	1	7	14	
pyogenes	-	40%	20%	-	10%			
Niesseria	1	2	3	-	1	7	_ 14	
gonorrhoeae	10%	20%	30%	-	10%		17	
Acinetobacter	4	1	-	1	4	10	_ 20	
Acineiobacier	40%	10%	-	10%	40%		20	
Staphylococcus	5	3	2	4	2	16	_ 32	
epidermidis	50%	30%	20%	40%	20%		32	
	33	28	23	21	20			
Total	66%	56%	46%	42%	40%	125		

Table 2: The occurrence of different isolates fungi from Sudanese banknotes.

Tryngg of fyngi	Value of bank notes (SDG)					Total	Contamination	
Types of fungi	2	5	10	20	50	isolated	percent %	
4 '11	3	1	2	3	1	10	20	
Aspergillu spp	30%	10%	20%	30%	10%	10	20	
n · '11'	1	-	1	2	3	7	14	
Penicillium sp	10%	-	10%	20%	30%			
Trichoderma	2	-	-	1	1	4	8	
Viride	20%	-	-	10%	10%		8	
Candida albicans	-	2	3	-	-	- 5	10	
Canada divicans	-	20%	30%	-	-	3	10	
Alternaria tenuis	2	3	1	-	1	- 7	14	
Auernaria tenuis	20%	30%	10%	_	10%	/	14	
Total	8	6	7	6	6	33		
10(a)	24%	18%	21%	18%	18%	33		

Table 3:	Questionnaire	data.
----------	---------------	-------

Handlers answer	Number of educated handlers	Number of handlers washed their hands after using a toilets and before using a banknotes again	Number of handlers washed their hands after dealing with banknotes and before food consumption	Number of handlers kept banknotes in Walt	Handlers aware about contaminated banknotes as a source of infection
Yes	47 (94%)	32 (64%)	36 (72%)	17 (34%)	38 (76%)
No	3 (6%)	18 (36)	14 (28%)	33 (66%)	12 (24%)
Total	50	50	50	50	50

From the statistically analyzed of 50 questionnaires distributed randomly between 50 banknotes handlers there were: 29 male (58%), 21 female (42%); 76% of handlers have aware about banknotes as a source of infection; 94% educated handlers at different levels; 64% of the handlers washed hands after using toilets and before dealing with banknotes again; 70% of the handlers washed hands after dealing with banknotes and before food preparation; 72 % of the handlers wash hands after dealing with banknotes and before food consumption. Places were banknotes kept, (walts 34%; pockets 24%; in boxes 20%; banks 8%; others 14%); 76% of handlers had knowledge about contaminated banknotes as being a source for infection, showed in Table 3.

#### **DISCUSSION**

A total of 50 samples of Sudanese banknotes (10 samples from every Sudanese banknotes denomination) were analyzed for bacterial and fungal (Yeasts and Moulds) contamination, these were 12 different bacterial types and 5 fungal species were presented after samples analyzed.

All samples of Sudanese banknotes were contaminated (100%) and (0.0%) for control samples, this result agrees with reports from other countries which elucidated that currency banknote are usually contaminated by pathogenic microorganisms.  $^{12}$ 

The mean of total viable count of bacteria for samples were between  $(4.5 - 8.3) \times 10^5$  CFU/cm<sup>2</sup>)), and percentages of contamination for banknotes samples were identified to be Staphylococcus aureus 42%; 24%; Klebsiella pneumonia 18%; Proteus mirabilis 8%; Pseudomonas aeroginosa 20%; Salmonella spp 18%; Shigella spp 20%; Bacillus spp 20%; Streptococcus pyogenese 14%; Niesseria gonnorrhoeae 14%; Acientobacter 20%; and Staphylococcus epidermidis 32%; as showed in Table 1, while the percentages of isolated genera of fungi were Aspergillus sp 20%; Penicillium sp14%; Trichoderma viride 8%; Candida albicans 10%; and Alternaria tenuis 14%; as showed in Table 2. These results explain the concept of banknotes act as a potential source of different diseases. For instance, all Salmonellae are pathogenic to several degree, Species of Shigella are responsible for bacillary dysentery, and Klebsiella spp occasionally causes a serious form of pneumonia in humans.

In addition, the results showed that banknotes had more than one microbial contaminant; on the other hand the results showed that high denomination of banknotes such as 50 SDG were less contaminated with bacteria with percentage 40%, compared to low values 20 SDG, 10 SDG, 5 SDG, and 2 SDG, with percentages of 42%, 46%, 56% and 66% respectively.

Banknote which were handled by large numbers of people under a variety of personal and environmental conditions were usually highly expected to be contaminated, and so the low banknotes denomination which were wide spread and exchangeable between people in the community. <sup>13</sup>

The contamination rates of banknotes was found (89.9%, 94%, 96%, and 100%), In present study the contamination rate of Sudanese banknotes was 100%. More handling and frequent exchange lead to more contamination banknotes, and can be a source of infection associated with oral, nasal, skin and fecal contamination. 15

From statistically analyzed questionnaires there were 94% of handlers at different levels education; 64% of the handlers wash hands after using toilets and before dealing with banknotes again; 70% of the handlers wash hands after dealing with banknotes and before food preparation; 72% of the handlers wash hands after dealing with banknotes and before food consumption. Places the banknotes were kept:

Walt 34%; Pockets 24%; in boxes 20%; Banks 8%; others 14%, as showed in Table 3; 76% of handlers have a knowledge about contaminated banknotes as being a source of diseases.

To minimize contamination level in banknotes, we needed health promotion for community about the personal hygiene and proper methods to handling of banknotes to avoid diseases that might be transmitted through the circulation process. <sup>16</sup>

### **CONCLUSION**

In spite of the high number in the educated and knowledgeable handlers, the microbial contamination in banknotes was found to be risky. Sudanese banknotes were highly contaminated, unhygienically handled. The contamination rate was higher in lower denominations than in higher ones.

The study recommends extra health education messages be given to banknotes handlers. Banknotes should be made from materials with antimicrobial activity. Monitoring, evaluation of handling ways and need of legislations concerning banknotes should be updated.

#### ACKNOWLEDGEMENTS

I wish to thank my supervisor Dr. Elrasheed, A. Ali, for his countless hours of reflecting, reading, encouraging, and to all participators throughout the study.

Thanks to the Food Hygiene and Safety laboratory staff, Faculty of Public and Environmental Health (UofK).

Funding: No funding sources Conflict of interest: None declared

Ethical approval: The study was approved by the

Institutional Ethics Committee

# **REFERENCES**

- 1. Cooper E. Intestinal parasites and the modern description of diseases of poverty. Transactions of the Royal Society for Tropical Medicine and Hygiene. 1991;85,168-70.
- 2. Oyero OG, Emikpe BO. Preliminary Investigation on the Microbial Contamination of Nigerian Currency. Int J Trop Med. 2007;2(2):29-32.
- 3. Michaels B. Money and serving ready-to-eat food. Food Service Technol. 2002;2(1):1-3.
- 4. Kuria JK, Wahome RG, Jobalamin M, Kariuki S. M. Profile of bacteria and fungi on money coins. East Afr Med J. 2009;86,151-5.
- 5. Podhajny MR. Paper Currency as a Breeding ground for Pathogens. Southern Med J. 2004;94(4):365-9.
- 6. Thomas, Y, Vogel, G, Wunderli W. Survival of influenza virus on banknotes. Appl Environ Microbiol. 2008;74(10):3002–7.

- Kumar JD, Negi YK, Gaur A, et al. Detection of virulence genes in Staphylococcus aureus isolated from paper currency. Int J Infect Dis. 2009;13:450– 5.
- 8. Food Science Australia. Money handling in food service operations. Food Safety and Hygiene department. 2000.
- 9. Central Bank of Sudan. J Currency issue directorate, first edition. Sudan. 2011: 1-12.
- 10. Cowen ST. Manual of the identification of Medical bacteria. University press. Cambridge. UK: 1981.
- 11. Barnett HL, Hunter BB. Mycologia. Mycological Society of America. USA: 1972.
- 12. Basavarajappa KG, SridharRao PN, Suresh K. Study of bacterial, fungal, and parasitic contamination of currency notes in circulation. Indian J Pathol Microbial. 2005;48:278–9.
- 13. Uneke CJ, Ogbu O. Potential for parasite and bacteria transmission by paper currency in Nigeria. J Environ Health. 2007;69:54-60.
- Hugo WB, Denyer SP, Norman AH, Gorman SP. Russel AD. In Pharmaceutical Microbiology. Oxford: Blackwell Scientific Publications; 1983: 124,146.
- 15. Guerin PJ, Brasher C, Baron E, Mic D, Grimont F, Ryan M, Aavitsland P, Legros D. Shigella dysenteriae serotype 1 in West Africa. Intervention Strategy for an Outbreak in Sierra Leone. Lancet. 2003;362:705-6.
- Igumber EO, Bessong PO, Obi CL, Potgieter TC, Mkasi TC. Microbiological Analysis of Banknotes Circulating in the Venda Region of Limpopo Province. South Africa. South Africa J Science. 2007;103:9-10.

**Cite this article as:** Honua MHM. The hygienic and microbial status of Sudanese banknotes, Khartoum state, Sudan. Int J Community Med Public Health 2017;4:923-7.