



A PROSPECTIVE STUDY OF MICROBIAL CONTAMINATION OF INDIAN CURRENCY

PROF. Dr. BANDARU NARASINGA RAO^{*1} AND B.SRINIVAS²

¹Professor and Head, Department of Microbiology, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Madhurawada, Visakhapatnam – 530048, Andhra Pradesh, India and Research Guide, Saveetha University, Chennai.

²Ph.D Scholar , Saveetha University, Thandalam, Chennai-602105, Tamilnadu,India.

ABSTRACT

Fomites are inanimate objects capable of absorbing, harboring and transmitting infectious microorganisms. Dust and dirt that commonly accumulate on such objects contain infectious agents. Since paper currency is widely exchanged for goods and services world wide, money could play a role in spreading bacteria through contact. This study was performed to survey the microbial contamination of money in the form of paper or coins in and around Srikakulam and Visakhapatnam of Andhra Pradesh, India, and the possible potential spread of micro-organisms from person to person. In this study 530 notes (Rs.1000, Rs.500, Rs.100, Rs.50, Rs.10 and Rs.5 rupees) and 300 coins (Rs.5, Rs.2 and Rs.1 rupee) were collected from different groups of general community in Srikakulam and Visakhapatnam and processed for the presence of pathogenic or potentially pathogenic micro-organisms and identified by swabbing and streaking on appropriate media using standard techniques. Contaminated bacterial isolates were as follows: *Escherichia coli*(8.8%-62.4%), *Bacillus* spp.(4.2% -46.8%), *Klebsiella* spp.(3.6% -32.4%), *Staphylococcus aureus*(2.2%-28.4%) , *Coagulase Negative Staphylococci (CoNS)*(1.2%-22.6%) , *Proteus* Sps.(0%-21.2%) , and *Pseudomonas* spp.(0%-12.2%). *Aspergillus* sps.(1.1% to 6%) and *Candida* sps.(1.1% to 3.4%) were isolated in the present study. Microbial contaminations on coins are less when compared to banknotes. Our results and information from other Studies do suggest that paper currency is commonly contaminated with bacteria and fungi and this may play a role in the transmission of potentially harmful disease producing organisms. According to our study, paper currency may be converted to polymer currency to reduce the possible contamination.

KEYWORDS: Coins, Paper currency, Bacterial contamination, polymer currency.



PROF. Dr. BANDARU NARASINGA RAO.,MD.,PhD.,
Professor and Head, Department of Microbiology, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Visakhapatnam – 530048, Andhra Pradesh, India and Research Guide, Saveetha University, Tamilnadu

*Corresponding author

INTRODUCTION

The environment plays a critical role in transmission of diseases to humans, with many environmental materials serving as vehicles.¹ Microbial contaminants may be transmitted either directly, through hand-to-hand contact, or indirectly, via food or other inanimate objects. These routes of transmission are of great importance in the health of populations in developing countries like India, where the frequency of infection is a general indication of local hygiene and environmental sanitation levels.² Fomites are inanimate objects capable of absorbing, harboring and transmitting infectious microorganisms. Dust and dirt that commonly accumulate on such objects contains infectious agents.³ Paper currency can be contaminated by droplets during coughing, sneezing, touching with previously contaminated hands or other materials and placement on dirty surface and clothes. In India there is a habit of counting the currency by saliva instead of the regular procedure of counting with water in sponge. Some times the people will use the paper currency for removal of ear wax and also to get relief of itching in the ear. The Paper currency and coins are commonly handled by various categories and occupational groups during transaction.⁴ Contamination of objects by pathogenic microorganisms is of much public health concern as contaminated materials can be sources of transmitting pathogens. Paper money as well as coins, therefore presents a particular risk to public health, since communicable diseases can spread through contact with fomites such as contaminated currency.^{5,6,7} Although paper currency is disinfected before sent into circulation to inhibit microorganisms, pathogens are still isolated from paper currency notes and the coins because of their changing trends against disinfection.⁷ Modern banknotes are made from a special blend of cotton, linen, other textile fibre and animal gelatin for the surface coating of banknotes with small segments of fibre. The cotton/ linen/fibre combination of banknotes produce a strong bond and do not pull apart, unlike the fibres of ordinary paper. Studies has shown that paper currency serves as an ideal breeding ground for microorganisms for several reasons. First, the paper currency offer a large surface area for organisms and organic debris to collect⁸ Secondly, folds and/or deliberate depressions or projections specifically engineered into the currency's design as anti-counterfeiting methods serve as settling sites for both organisms and debris, which allow the microorganisms to live longer⁹ Lastly, banknotes weave their way through the population for many years before they come to final withdrawal from circulation. Studies indicates that the age and denomination of a currency note have a direct correlation with the contamination observed (e.g., older notes had the most contamination while newer notes had the least)¹⁰ Paper currency is widely exchanged for goods and services in most countries worldwide. If some of these are contaminated, there is the potential to spread these organisms from person to person and across

borders since money is not screened for microbes. There had been fewer studies on the microbial contamination of currency worldwide and specially in India. Various pathogens had been identified in damaged or tattered notes held together with bits of sticky tapes. Despite the fact that no level of contamination can be regarded as safe, there is need to study the bacterial contamination of currency in our area. This study then focused on the probable bacterial and fungal contaminants of Indian currency either in the form of notes or coins.

MATERIALS AND METHODS

Sample collection

Samples were obtained wearing sterile gloves on both hands from the different chosen occupational groups either artisans or non-artisans. Each currency was kept in a separate sterile polythene bag and transferred to the laboratory for analysis. Currencies of all the available denominations either notes or coins were processed for microbial isolation using the MacConkey agar, Blood agar and Sabouroud's dextrose agar (SDA). The conventional methods of swabbing and streaking were used.¹¹ Pure colonies of isolated organisms were identified and characterized by using standard microbiological techniques.¹² Presumptive identification of the fungal isolates was done on the basis of macroscopic and microscopic examination of the cultures on SDA.¹³

Currency

Five hundred thirty paper currency (Rs.1000, Rs.500, Rs.100, Rs.50, Rs.20, Rs.10 and Rs.5,) and 300 (Rs.5, Rs.2 and Rs.1) coin samples of all the available commonly used denominations in India were obtained from different occupational groups of people either artisans or non-artisans in Srikakulam and Visakhapatnam. While newly minted notes (7) and coins (3) of each one denomination obtained from a commercial bank were used as control. The currencies were observed to have been in circulation for about one to three years (2011-14). The samples were graded using appearance and degree of dirtiness as new, moderate, old and tattered (Table 1). The microbial isolates grew on both the MacConkey agar and Blood agar. Fungal growth was also observed on Sabouraud's dextrose agar.

RESULTS

The cultures yielded 502 isolates representing 89.22% and 10.78% bacterial and fungal respectively. The 89.22% of bacterial isolates and 10.78% of fungal isolates were identified and characterized using the standard microbiology techniques^{12,13} Different denominations and grades of currency notes (Rs.1000, Rs500, Rs100, Rs50, Rs20, Rs10 and Rs5,) and coins (Rs.5, Rs.2 and Rs.1) were shown in Table-1.

Table 1
Denominations of Currency Notes and Coins

NOTES						
S.No.	Denomination	New	Moderate	Old	Tattered	Total
1	₹1000	4	2	2	2	10
2	₹500	8	4	4	4	20
3	₹100	10	18	46	26	100
4	₹50	12	23	28	37	100
5	₹20	15	10	25	50	100
6	₹10	2	8	42	48	100
7	₹5	6	9	25	60	100
Total		57	74	172	227	530
COINS						
1	₹5	20	20	20	40	100
2	₹2	20	20	20	40	100
3	₹1	20	20	20	40	100
Total		60	60	60	120	300

Table-2 showed the percentages of each organism recovered from each denomination and different grades of currency and their microbial contamination. With Rs.10 (Esch.coli 62.4%, Bacillus Sps. 46.8%, Klebsiella Sps. 32.4%, Staph.aureus 28.4%) and Rs.100 (Esch.coli 54.7%, Bacillus Sps. 36.4%,

Klebsiella Sps. 22.6%, Staph.aureus 14.6%) notes and Rs.1 (Esch.coli 38.4%, Bacillus Sps. 24.8%, Klebsiella Sps. 16.4%, Staph.aureus 12.4%) coins having the highest percentage of contaminated isolates. Aspergillus spp.(3.1%) and Candida spp.(1.2%) were isolated in the present study (Table-2).

Table 2
Percentage of occurrence of organisms per denomination

S. No	Denomination	<i>Escherichia coli</i>	<i>Bacillus</i> spp.	<i>Klebsiella</i> spp.	<i>Staphylococcus aureus</i>	<i>Coagulase Negative Staphylococci (CoNS)</i>	<i>Proteus</i> Sps.	<i>Pseudomonas</i> spp.	<i>Aspergillus</i> Sps.	<i>Candida</i> Sps.
NOTES										
1	₹1000	8.8	4.2	3.6	2.2	1.2	-	-	-	-
2	₹500	16.6	12.5	8.8	4.7	2.2	-	-	-	-
3	₹100	54.7	36.4	22.6	14.6	8.6	4.2	2.2	1.2	1.2
4	₹50	36.8	23.5	16.4	11.2	7.4	5.4	2.2	-	-
5	₹20	42.00	36.8	24.4	23.6	14.6	8.6	4.4	-	-
6	₹10	62.4	46.8	32.4	28.4	22.6	21.2	12.2	6.0	3.4
7	₹5	52.6	32.6	16.4	12.4	8.2	4.4	2.4	-	-
COINS										
1	₹5	23.00	18.4	11.4	10.6	8.4	-	-	3.1	-
2	₹2	25.6	22.5	12.4	8.4	6.4	-	-	2.1	1.2
3	₹1	38.4	24.8	16.4	12.4	6.8	-	-	2.1	1.2

The level of contaminants recovered from currency notes and coins obtained from the Artisans (Agricultural labor, Car and two wheeler mechanics, Doctors, Grocery vendors, Fish vendor, Meat seller, Nurses, Vegetable vendors) non-artisan group

(Beggars, Bus conductors, Office staff and Students) was shown in (Table 3). Notes and Coins obtained directly from the commercial banks before circulation has only one note showed contamination with Bacillus Sps.

Table 3
Percentage of Microbial isolates from different occupational groups

NON-ARTISANS (n=90)										
S.No.	Occupational groups	<i>Escherichia coli</i>	<i>Bacillus</i> spp.	<i>Klebsiella</i> spp.	<i>Staphylococcus aureus</i>	<i>Coagulase Negative Staphylococci (CoNS)</i>	<i>Proteus</i> Sps.	<i>Pseudomonas</i> spp.	<i>Aspergillus</i> Sps.	<i>Candida</i> Sps.
1	Beggars (10)	72.2	62.4	38.2	48.8	32.4	8.2	2.2	1.2	1.2
2	Bus conductors (20)	56.6	42.6	17.4	37.2	26.4	2.4	2.4	1.2	1.2
3	Office staff (30)	44.4	28.4	8.4	16.2	16.6	1.2	1.2	0	0
4	Students (30)	36.8	9.8	9.2	19.4	11.8	2.4	1.2	1.2	0
ARTISANS (n=100)										
1	Agricultural labour (10)	66.6	56.6	16.6	24.4	21.6	9.2	6.6	3.3	2
2	Car and two wheeler mechanics (10)	76.4	62.8	43.4	32.6	24.4	12.4	4.4	3.3	1.1
3	Doctors (20)	24.4	12.4	6.4	12.8	4.8	0	0	0	0
4	Grocery vendors (10)	48.4	18.6	13.6	19.6	13.6	0	0	0	0
5	Fish vendor (10)	65.6	58.6	42.6	35.6	12.6	14.4	6.6	2.2	2.2
6	Meat seller (10)	68.8	53.8	46.4	37.8	16.8	13.6	8.8	2.2	2.2
7	Nurses (20)	32.4	16.6	9.2	16.2	6.6	0	0	0	0
8	Vegetable vendors (10)	71.4	57.6	32.6	24.4	17.8	8.4	3.3	2.2	0

DISCUSSIONS

The presence of pathogenic and virulent bacteria on Indian currency is a point for great concern because of paper currency notes and coins probably play a role in the transmission and spread of diseases because every day all types of people use money frequently for their daily activities for purchase of goods required in their routine life. Lower denominations like Rs.5, Rs.10, Rs.20, Rs.50 and Rs.100 notes and Rs.1, Rs.2, Rs.5 coins denominations were found to have the highest level of microbial contaminants as their turnover was more. This accounts for the facts that these small denominations of Indian currency were frequently used and exchanged more times among all types of people. The level of contaminants was more in certain artisan groups like Agricultural labour, Car and two wheeler mechanics, Fish vendor, Meat seller, Vegetable vendors and certain Non-artisan groups like Beggars, Bus conductors as the knowledge of hygiene was very minimal in these groups as they touch the material of their vending directly and exchange the currency to the people who purchased the required items from them without washing their hands at any moment, hence transmitting the infective organisms. For example, a motor mechanic may repair the tyres or its mechanical component of a vehicle which contains faecal matter of either a human or an animal and exchange money for his repair without washing his hands. The study revealed similar pattern of bacterial contamination as those obtained from the previous studies in India and abroad¹⁴⁻¹⁹ and fungal contamination.^{21,22} The bacterial isolates recovered were: *Escherichia coli*(8.8%-62.4%), *Bacillus* spp.(4.2% -46.8%), *Klebsiella* spp.(3.6% -32.4%), *Staphylococcus aureus*(2.2%-28.4%), Coagulase Negative Staphylococci (CoNS)(1.2%-22.6%), *Proteus* Sps.(0%-21.2%), and *Pseudomonas* spp.(0%-12.2%). Fungal contaminants include *Aspergillus* spp.(1.1% to 6%) and *Candida* spp.(1.1% to 3.4%). These findings were in accordance with the findings of other authors from their study.^{14,23-25} In Iran Shekarforous et al.,²⁶ found, 13.3%, 32.5% and 10.8% of the 120 Iranian currency notes were contaminated with *Esch. coli*, *S. aureus* and *B. cereus*, respectively. These authors also found that currency notes collected from butchery, bakery, confectionary, fast food, ice cream and poultry meat shop were contaminated with *Esch. coli* at the rate of 60.0%, 0.0%, 5%, 5.0%, 0.0% and 10.0%; with *S. aureus* at the rate of 55.0%, 30.0%, 10.0%, 25.0%, 40.0% and 35%; with *B. cereus* at the rate of 0.0%, 10.0%, 20.0%, 5.0%, 20.0% and 10.0%, respectively. Goktas and Oktay,²⁶ isolated aerobic sporeforming bacilli (91%), *Staphylococcus epidermidis* (63.3%), *Staphylococcus aureus* (4.2%), *Klebsiella pneumoniae* (31.7%), *Esch. coli* (17.5%), *Proteus* (1.7%), *Pseudomonas aeruginosa* (0.8%), from paper money samples of one hundred twenty currency notes. The presence of *Staphylococcus* species on paper money as well as on coins could have been due to contact with skin during holding or counting. Pathogenic *Staphylococci* especially Methicillin Resistant *Staphylococcus aureus* (MRSA) harbored either by asymptomatic carriers or a person with a disease, can be spread by the hands or expelled from the respiratory tract. Fifty six percent of

Staphylococcus aureus from our study belongs MRSA where as other workers reported the prevalence of MRSA ranging from 9.1% to 76.92%.²⁷⁻²⁹ The *Staphylococci* are natural inhabitants of the humans or animal body are ubiquitous, being found every where in the world and Infections occur when *Staphylococci* enter the body through cuts and abrasions in the skin.³⁰ *Bacillus* Sps., a big group of spore forming species that are ubiquitous could also be transferred on money due to its placement on dirty surfaces or handling with dirty hands. *Bacillus* produces an exotoxin capable of producing food poisoning in man.³¹ Enteric pathogens, such as *Escherichia coli* were isolated from paper-currency samples obtained from meat sellers, fish sellers, vegetable vendors, agricultural labor and motor mechanics who were in touch with *Esch. coli* in one way or other by these groups. The present study suggests that currency notes may carry enteric pathogens also which reveals the poor sanitary conditions of the environment as well as poor personal hygiene practices observed by most of the artisan and non artisan groups observed. These microorganisms can cause urinary tract and diarrheal infections besides other infectious diseases. Pathogens from bank notes and coins may infect the body through abrasions on the hands, or when the hand touches the mouth, nose and through unhygienic practices.

CONCLUSION

In conclusion the present study revealed that Indian paper currency and coins are commonly contaminated with pathogenic bacteria. This may play a significant role in the transmission of various diseases. As per the results of this present study, suggestion may be made to people to improve their personal health consciousness by washing hands as a part of our Swachh Bharat after handling of money notes or coins, taking no food what ever it may be after touching money notes, avoiding using saliva during counting of paper money notes and using for cleaning of wax in the ear. The general awareness about the possibility of acquiring infection and practicing good personal hygiene should be created in the public and reduce risk of infection is recommended especially for those who simultaneously handle food and money. The better way of thinking by governments is by changing paper currency notes to polymer currency as done by Australia, Brunei, Canada, New Zealand, Papua New Guinea, Romania and Vietnam. The advantages of polymer notes include Lower environmental impact and completely waterproof, Clean because they are resistant to dirt and moisture which can be repeatedly washable.

ACKNOWLEDGEMENTS

We acknowledge with immense pleasure for the help received from the researchers whose articles are cited and included in references of this manuscript. The authors are also thankful to authors / editors publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed and used as references.

CONFLICT OF INTEREST

Conflict of interest declared none.

REFERENCES

1. Struthers, JK, and Westran, RP. Clinical Bacteriology. Washington, DC: ASM Press; 2003.
2. Cooper E. Intestinal parasitoses and the modern description of diseases of poverty. Trans R Soc Trop Med Hyg. 1991; 85:168- 170.
3. Forbes, BA, Sahm, DF, and Weissfeld, AS. Laboratory methods in basic mycology. Bailey and Scott's Diagnostic Microbiology, 10th edition. St. Louis, Missouri: Mosby, Inc., 871-959; 1994.
4. Oyero OG. and Emikpe BO . Preliminary Investigation on the Microbial Contamination of Nigerian Currency. Int J Trop Med. 2007; 2(2): 29-32.
5. Michaels, B. Handling money and serving ready-to-eat food. Food Servo Technol. 2002; 2: 1-3.
6. Xu J, Moore JE and Millar BC. Ribosomal DNA (rDNA) identification of the culturable bacterial flora on monetary coinage from 17 currencies. J Env Health. 2005;67(7): 51-55.
7. Khin, NO, Phyu, PW, Aung MH, and Aye T. Contamination of currency notes with enteric bacterial pathogens. J. Diarrhoeal. Dis Res. 1989; 7: 92-94.
8. Lamichhane J, Adhikary S, Guatam P, and Maharjan R. Risk of Handling Paper Currency in Circulation Chances of Potential Bacterial Transmittance. Nepal J Sci Techno.I 2009; 10: 161-166.
9. Ayandele AA, and Adeniyi SA. Prevalence and antimicrobial resistance pattern of micro organism isolated from Naria notes in Nigeria. J Res Biol. 2011;8: 587-593,
10. Pradeep, NV, Marulasiddaiah, BS, and Chetana, M. Microbial Contamination of Indian Currency notes in circulation. J Res Biol. 2012; 2 (4) :377-382.
11. Abrams BL and Waterman NG. Dirty money. Journal of American Med Asso. 1972; 219: 1202-1203.
12. Cheesbrough, M. Medical Laboratory Manual for Tropical Countries Part-2. The The Cambridge University Press, United Kingdom; 1972.
13. Chander Jagadeish.. Text book of Medical Mycology, 2 nd edition, India; Metha publishers; 2002.
14. Basavarajappa KG , Rao PN, and Suresh K. Study of bacterial, fungal and parasitic contamination of currency notes in circulation. Indian J. Pathol Microbiol. 2005; 48: 278-279.
15. Ghamdi-Al AK, Abdelmalek SMA, Bamaga MS, Azharl EI, Wakid MH and Alsaied, Z. Bacterial contamination of Saudi "one" riyal paper notes. South East Asian J Trop Med Public Health 2011; 42(3): 711-716.
16. Oyer OG and Emikpe, BO. Preliminary Investigation on the Microbial Contamination of Nigerian Currency. Int J Trop Med. 2007; 2(2): 29-32.
17. Singh DV, Thakur K. and Goel A. Microbiological Surveillance of Currency. Indian J Med Microbio. 2002; 20(1): 53.
18. Md. Shakir Uddin Ahmed, Sahana Parveen, Tania Nasreen and Badrunessa Feroza. Evaluation of the Microbial Contamination of Bangladesh Paper Currency Notes (Taka) in Circulation. Adv Biol Res. 2010 ; 4 (5): 266-271.
19. Mohammed RafiqKhan , Rajeswari K Venkatesh, Nikhitha Ravi, Reshma Ravikumar and Santhosh Kumar. Assessment of microbial contamination of Indian paper currency notes in circulation. International Journal of Recent Scientific Research 2013; 4(10):1516-1518.
20. Okungbowa FI, and Dede APO. Fungal flora of Nigerian currency notes in circulation in Benin city, Nigeria. Indian J Microbiol. 2010; 50:139-141.
21. Abirami B, Kumar T and Saravanamuthu R. Studies on the fungal flora of Indian currency. Asian J. Res Pharm Sci. 2012; 2:33-36.
22. Alwakeel SS and Naseer AL. Bacterial and fungal contamination of Saudi Arabian paper currency and cell phones. Asian Journal of Biological Sciences 2011; 4:556-562.
23. Alwakeel SS, Nasser LA. Bacterial and fungal contamination of Saudi Arabian paper currency and cell phones. Asian . Biol Sci. 2011 ;4 (7): 556-562.
24. Nasser LA, Alwakeel S. Bacterial and Fungal Contamination of Saudi Arabian Paper Currency and Cell Phones. *Environmental Engineering and Management Journal* 2012; 11 (3) :72.
25. Shekarforoush SH, Khajeh AE and Zarei M. Evaluation of the Bacterial Contamination of the Iranian Currency Notes Iran J Health and Environ. 2009 ; 1(2): 82-87.
26. Goktas P and Oktay G. Bacteriological examination of paper money. Mikrobiyol. Bull. 1992; 26: 344-348.
27. George A. Pesewu, Roger Dogbe, Richard H. Asmah, Michael A. Olu-Taiwo and David N. Adjei. Prevalence and susceptibility profiles of Methicillin Resistant Staphylococcus aureus (MRSA) in the University of Ghana Hospital, Legon, Accra, Ghana. Int J Pharm Bio Sci 2014 July ; 5 (3) : (B) 185 – 193.
28. Umasankari J, Vanitha MC and Sekari C. Prevalence of MRSA and MSSA infection in Diabetic foot Ulcer. Int J Pharm Bio Sci 2015 Jan; 6(1): (B) 468 – 474.
29. Jayarani K, Sunil Shyam Sundar J. Detection of MRSA from nasal carrier among diabetic foot ulcer patients in a tertiary care hospital puducherry. PUDUCHERRY Int J Pharm Bio Sci 2015 July; 6(3): (B) 618 – 623.
30. Pelczar MJ and Reid RD. Microbiology, 2 Ed. New York: mcgraw-hill; 1965. P.446.
31. Silman R, Rahm S, and Shales DM. Bacteriological Serious infections caused by Bacillus sp. Medicine 1987; 66: 218-223.