

Evaluation of the Microbial Contamination of Bangladesh Paper Currency Notes (Taka) in Circulation

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Abstract: Bangladesh paper currency, Taka, the legal tender of Bangladesh were surveyed for microbial contaminations. This study was carried out on hundred paper currency notes belong to all- the notes denominations obtained from different chosen occupational groups in Dhaka City, Bangladesh. Identification and characterization revealed active participation of the following species of organisms in the ascending order of percentage as *Escherichia coli* 58%, *Klebsiella* 50%, *Staphylococcus aureus* 25 %, *Salmonella* 15 %, *Bacillus* 9%. *Pseudomonas*. 7% and *Vibrio cholerae* 5%. One hundred and sixty nine bacterial isolates were recovered belonging to these selected seven species. Currency notes collected from fish sellers, meat sellers, vegetable sellers, food vendors, office workers, students, bus conductors, beggars and shop keepers with 42.85% - 85.71% *Escherichia coli*, 28.57% - 92.85%, *Klebsiella*, 9.09% - 53.84% *Staphylococcus aureus*., 0% - 42.85% *Salmonella* sp., 0% - 28.57% *Vibrio cholerae*, 0% - 25% *Bacillus* sp and, 0% - 28.57% *Pseudomonas* sp. respectively. The study suggested that Bangladesh paper currency is commonly contaminated with pathogenic microorganisms and this contamination may play a significant role in the transmission of potentially harmful microorganisms or different diseases such as cholera, diarrhea, skin infections and also poses antibiotic resistant, so great care should be taken during handling of money and the preparation and handling of food to avoid cross contamination.

Key words: Bangladesh paper currency • Contamination • *Escherichia coli* • Pathogenic microorganisms
• Enteric microorganisms

INTRODUCTION

Paper currency is widely exchanged for goods and services in most countries worldwide. Paper currencies are widely used and each currency is exchanged many times during the time it circulates. If some of these papers money are contaminated with pathogenic bacteria, there is potential to spread these microorganisms. Entering the antibiotic era, it was anticipated that morbidity and mortality from infectious diseases would continue to decrease over time. However, the death rate from infectious diseases increased by 58% from 1980 to 1992, making it the third leading cause of death by 1992 [1]. There is also significant morbidity from infectious disease. Furthermore, with the emergence of drug-resistant pathogens, many infections have become more difficult to treat. Since communicable diseases can spread through contact with fomites, paper currency could play a role.

Bacteria have been shown to be spread from person to person via contact with fomites. Paper currency is commonly and routinely passed among individuals. Thus, bacteria could be spread on the surface of paper currency [2].

Paper Currency, can be contaminated by droplets during coughing, sneezing, touching with previously contaminated hands or other materials and placement on dirty surface. Paper currency is commonly handled by various categories of people during transaction [3]. Contamination of objects by pathogenic microorganisms is of much public health concern as contaminated materials can be sources of transmitting pathogens. Paper money, therefore presents a particular risk to public health, since communicable diseases can spread through contact with fomites [2, 4 - 8]. Although paper money is impregnated with disinfectants to inhibit microorganisms, pathogens are isolated from paper currency notes and coins [9].

Various pathogenic microbes associated with tuberculosis, meningitis, pneumonia, tonsillitis, peptic ulcers, genital tract infections, gastroenteritis, throat infections and lung abscesses had been identified in damaged or soiled notes held together with bits of sticky tapes. A study in Egypt reported that 65% of the paper bills had bacteria like *staphylococcus albus*, *staphylococcus aureus* and *klebsiella pneumoniae* [10].

Studies in different parts of the world have reported high rates of microbial contamination of currency notes in circulation [2, 4, 6, 9 - 16]. The microorganisms implicated included members of the family *Enterobacteriaceae*, *Mycobacterium tuberculosis*, *Vibrio cholerae*, *Bacillus* species, *Staphylococcus* sp., *Micrococcus* sp. and *Corynebacterium* sp. Most likely contaminants of paper money are environmental organisms such as Gram-positive flora (especially *Bacillus* sp.) and those arising from human normal skin flora such as *Staphylococcus aureus* [6].

Microbial contamination of paper money is not only confined to developing nations. Several studies from the United States reported contamination of coins and paper bills and the identification revealed the presence of pathogenic microbes like *staphylococcus aureus*, *E. coli*, *klebsiella enterobacter* [14,15]. Another survey isolated total of 93 different types of bacteria belonging to the species *staphylococcus*, *Streptococcus*, *Enterobacter*, *Acinetobacter*, *Pseudomonas*, *Bacillus*, *Diphtheroids*, *Klebseilla pneumoniae* and *E. vuluneris* [2]. However, there is a dearth of information on the probable microbes associated with the Bangladeshi currency. The aim of this study was to investigate the likelihood of microbial contamination of Bangladesh paper currency notes. Knowledge of the microbial diversity of currency notes in circulation can provide the basis for raise health consciousness in people during currency handling and effective control of infection transmission.

MATERIALS AND METHODS

Paper Currency Notes: One Hundred samples of all the available denominations in Bangladesh were obtained from artisans and non-artisans in Dhaka. Artisan groups were meat sellers, fish sellers, vegetable sellers, food vendors and Non artisan groups were office workers, students, bus conductors and beggars. While newly minted ones were obtained from a commercial bank were used as control. The currencies were observed to have been in circulation for about four to eight years (2002 - 2009). The paper currency notes are graded using condition, appearance and degree of dirtiness as new, moderate and torn as shown in Table 1.

Sample Collection: A total of hundred paper money were randomly collected from persons in each category of sampling. To collect the paper money, the individual was requested to drop paper money into a sterile plastic packet. The packet was promptly sealed and the individual was given a replacement paper money. The packets were immediately transported to the laboratory for analysis.

Qualitative Bacterial Analysis: Each paper currency was placed in 100 ml of sterile nutrient broth and incubated for 6-8 hours at 37°C. Thereafter the broth cultures were plated on selective and/or differential media, namely Lactose broth, peptone water, Nutrient agar, Eosin Methylene Blue Agar, xylose lysine deoxycholate agar, blood agar, mannitol salt agar, MacConkey agar, TCBS agar, Salmonella Shigella agar, Cetrimide agar, Baird parker agar, Bismuth sulfite agar. The plates were incubated at 35°C - 37°C overnight. Bacterial colonies in each medium were then characterized on the basis of colonial, cellular morphology, staining and biochemical characteristics using standard microbiological technique [17].

Table 1: Physical condition of paper currency of Bangladesh collected from different occupational groups

Denomination	New	Moderate	Old	Torn	Total
BDT 1	2	3	4	6	15
BDT 2	4	5	8	8	25
BDT 5	3	4	3	2	12
BDT 10	5	8	7	4	24
BDT 20	2	2	2	1	7
BDT 50	3	2	1	1	7
BDT 100	2	2	2	1	7
BDT 500	1	1	1	-	3
Total	22	27	28	23	100

BDT = Bangladesh Taka

RESULTS AND DISCUSSION

The present study revealed the extent and the level of contamination of Bangladesh paper money with pathogenic microorganisms. The cultures from the collected Bangladesh paper currency yielded one hundred and ninety one isolates representing selected 7 different types of bacterial species. Identification showed the active participation of these seven species in descending order of percentage as *Escherichia coli* 72%, *Klebsiella* 50%, *Staphylococcus aureus* 25%, *Salmonella* 15%, *Bacillus* 9%, *Pseudomonas* 7% and *Vibrio cholerae* 5%. Table 2 shows the prevalence of pathogenic microorganisms isolated from the Bangladesh paper currency notes from BDT 1 to BDT 500 from different occupational groups mainly artisans and non artisans groups. The results showed in table 2 indicated that all the currency denominations groups had microbial contamination and BDT 500, BDT 100 and BDT 50 had less contamination than other denomination like BDT 1, BDT 2, BDT 5, BDT 10 and BDT 20. These lower denominations paper money are used frequently for different normal daily activities. Higher denominations are not used as frequently as lower denominators. Smaller unit notes appeared to be more highly contaminated than larger unit notes such as BDT 500 notes, probably because the smaller unit notes such as BDT 1, BDT 2, BDT 5 and BDT 10 are most frequently handled in petty, daily monetary transactions. These lower denomination money are often tattered and dirty. Old, tattered and dirty notes were more contaminated than new notes and thus supports the finding that damaged or soiled notes, especially those held together with bits of sticky tape are particularly dangerous [12].

The study was in accordance with Umeh *et al.*, [18] who showed that the microorganisms isolated from Nigerian paper currency were *Escherichia coli* (80%), *Aerobacter* (59%), *Salmonella* (40.1%), yeast cells (36.4%), *Streptococcus faecalis* (31.8%), *Staphylococcus aureus* (27.3%), coagulase-negative staphylococci (18.2 %), *Streptococcus faecalis* (31.8%), *Aerobacter* (59%), *Salmonella* (40.1%) and yeast cells (36.4%). They also found that 73.4% of old and tattered notes had a high level of contamination, whereas only 42.9% of new notes had a high level of contamination. Thus, the level of contamination differed significantly between old notes and newer notes.

Table 3 shows the level of contamination of notes with pathogenic microorganisms collected from artisans like fish seller, meat seller, vegetable seller food vendors and shop keepers. The level of contaminants recovered from currencies obtained from the artisan group was in descending order of percentage as from the fish seller, meat seller, vegetable seller, food vendors and store keepers. Taka notes 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, 50.0 and 50.0 %; with *Klebsiella* species at the rate of 92.85, 61.54, 54.54, 33.33 and 50.0%; with *Salmonella* species at the rate of 42.85, 38.46, 18.18, 0.0 and 0.0%; with *Staphylococcus aureus* at the rate of 7.14, 53.84, 9.09, 16.67 and 33.33%; with *Bacillus* species at the rate of 7.14, 7.69, 0, 16.67 and 0.0%; with *Pseudomonas* species at the rate of 28.57, 7.69, 9.09, 8.33 and 0.0%; with *Vibrio cholerae* at the rate of 28.57, 7.69, 0.0, 0.0 and 0.0% respectively. The highest level of contaminants were recovered from currencies obtained from the fish sellers and meat sellers as compared with others.

Table 2: Percentage occurrence of microorganisms per denomination of Bangladesh paper currency from different occupational groups (total sample =100)

Denomination	<i>E. coli</i> %	<i>Klebsiella</i> species%	<i>Staphylococcus aureus</i> %	<i>Salmonella</i> species%	<i>Bacillus</i> species%	<i>Pseudomonas</i> species%	<i>Vibrio cholerae</i> %
BDT 1(n=15)	53.33	66.67	33.33	6.67	6.67	6.67	0
BDT 2(n=25)	64	52	28	12	12	8	4
BDT 5(n=12)	50	33.33	16.67	8.33	0	0	0
BDT 10(n=24)	70.83	70.83	25	20.83	8.33	12.50	8.33
BDT 20(n=7)	4						
(57.14%)	28.57	14.28	28.57	14.28	14.28	14.28	
BDT 50(n=7)	3						
(42.85%)	28.57	14.28	14.28	14.28	28.57	0	
BDT 100(n=7)	42.85	14.28	0	28.57	24.28	0	14.28
BDT 500(n=3)	33.33	33.33	0	0	0	0	0
Total frequency among all denominations	58%	50%	25%	15%	9%	7%	5%

n= number of sample per denomination

Table 3: Percentage occurrence of different isolates from different artisans groups (n=56)

Occupational Group	<i>E. coli</i> %	<i>Klebsiella</i> species%	<i>Salmonella</i> species%	<i>Vibrio cholera</i> %	<i>Pseudomonas</i> species%	<i>S. aureus</i> %	<i>Bacillus</i> species%
Meat Sellers n=13	69.23	61.54	38.46	7.69	7.69	53.84	7.69
Fish Sellers n=14	85.71	92.85	42.85	28.57	28.57	7.14	7.14
Vegetable Sellers n=11	63.63	54.54	18.18	0	9.09	9.09	0
Food Sellers n=12	50	33.33	0	0	8.33	16.67	16.67
Shop Keepers n=6	50	50	0	0	0	33.33	0

n= number of sample

Table 4: Percentage occurrence of different isolates from different non artisans groups (n=44)

Occupational Group	<i>E. coli</i> %	<i>Klebsiella</i> species%	<i>Salmonella</i> species%	<i>Vibrio cholera</i> %	<i>Pseudomonas</i> species%	<i>S. aureus</i> %	<i>Bacillus</i> species%
Office workers n=14	42.86	28.57	0	0	0	14.28	0
Students n=12	41.67	33.33	0	0	0	25	8.33
Bus Conductors n=10	60	30	10	0	0	30	20
Beggars n=08	62.5	62.5	12.5	0	0	50	25

n= number of sample

The level of contaminants was determined from currencies obtained from the non artisan group namely office workers, students, bus conductors and beggars. Table 4 indicates that all groups contained some extent of one or more pathogenic microorganisms like *Escherichia coli*, *Klebsiella*, *Salmonella*, *Vibrio cholerae* and other pathogens like *Staphylococcus aureus*, *Bacillus*, *Pseudomonas*. Bangladesh paper money notes collected from office workers, students, bus conductors and street beggars were contaminated with *E. coli* at the rate of 42.86, 41.67, 60.0 and 62.50%; with *Staphylococcus aureus* at the rate of 14.28, 25.0, 30.0%, respectively. *Bacillus* species were isolated in small number. *Vibrio cholera* and *Pseudomonas* were not detected from non artisan groups but *Salmonella* found from bus conductors and beggars.

The presence of pathogenic bacteria on the Bangladesh currency samples is a case for great concern because paper money notes probably play a role in the transmission and spread of diseases because each day people use money frequently for their daily activities. Lower denominations like BDT 1, BDT 2, BDT 10 denominations were found to have the highest level of microbial contaminants, on the other hand BDT 500, BDT 100 and BDT 50 had lower level of contamination as compared to small denominations. This accounts for the facts that these small denominations of Bangladeshi taka are widely used and exchanged many times among all economic class. Paper currencies recovered from the fish sellers, meat sellers, vegetable sellers had the highest percentage of isolates. The study showed that these artisan groups do not give much attention to hygienic practices, their way of exchanging taka are just touching the goods like fish, meat, vegetables and then exchanging the taka notes by the same people. This scenario is a major concern especially in respect of the health status of

the population. The samples collected from nonpartisan groups had less contamination as compared to artisans. This may be due to less likely to touch contamination source as compared to artisans. The notes from office workers and students however, had less microbial load than beggars and bus conductors probably indicating that they are more likely to be conscious of safe personal hygiene.

The study revealed similar pattern of microbial contamination in terms of coliforms as those obtained from the previous studies in Bangladesh which was held at Khulna city, Bangladesh [19]. This study revealed that about 80 and 16% of old two-taka notes were contaminated with total coliforms and fecal coliforms respectively. Contamination level was nearly similar for BDT 10 notes. This study showed the contamination of BDT 2 and BDT 10 only.

The study was also in accordance with similar pattern of microbial contamination as those obtained from the previous studies [2,12]. The bacterial isolates recovered were *Bacillus* sp. *Citrobacter* sp. *Enterobacter* sp. *Klebsiella* sp. *Proteus* sp. *Pseudomonas* sp. *Serratia* sp. and *Staphylococcus* sp. In Iran Shekarforous *et al.*, [20] found, 13.3, 32.5 and 10.8% of the 120 Iranian currency notes were contaminated with *E. 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 *E. 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. The results in the present study was differ from their study only in case of *Salmonella* because *Salmonella* was not isolated from samples in their study.

Goktas and Oktay, [11] found similar result as present investigation. They isolated aerobic spore-forming bacilli (91%), *Staphylococcus epidermidis* (63.3%), *Staphylococcus aureus* (4.2%), *Enterococcus* (24.1%), alpha-hemolytic *streptococcus* (4.1%), *Streptococcus pneumoniae* (1.7%), *Corynebacterium* (7.5%), *Lactobacilli* (10.8%), *Klebsiella pneumoniae* (31.7%), *Enterobacter* (19.2%), *E. coli* (17.5%), *Proteus* (1.7%), *Pseudomonas aeruginosa* (0.8%), *Shigella flexneri* (0.8%) from paper money samples of one hundred twenty currency notes. Currency notes in general were bacteriologically contaminated, especially with enteric pathogens and potentially pathogens, it was thought that some measures have to be taken to reduce these ill effects.

The presence of *Staphylococcus* species on paper money could have been due to rubbing off or may be surfing from a skin flake. Pathogenic *Staphylococci* harbored either by an asymptomatic carriers or a person with a disease, can be spread by the hands or expelled from the respiratory tract. The *Staphylococci* are natural inhabitants of the animal body, which is the source of those found elsewhere. As saprophytes, *Staphylococci* are ubiquitous, being found on normal skin and in the nose, mouth and intestine as well as in the air, water, milk and sewage and on fomites. Infections occur when *Staphylococci* enter the body through breaks, cuts and abrasions in the skin [21]. *Bacillus* sp. a vast group of hardy spore forming species that live in soil and are found in the environment could also be transferred on money due to its placement on dirty surfaces or handling with dirty hands. *Bacillus* produces an emetic exotoxin capable of inducing disease in man [22]. Therefore, Bangladesh paper money play important role to disseminate several diseases. Enteric pathogens, such as *Escherichia coli*, *Vibrio* and *Salmonella* were isolated from paper-money samples obtained from meat sellers and fish sellers. The study suggests that currency notes may carry enteric pathogens. This goes a long way to reveal the poor sanitary condition of the environment as well as poor personal hygiene practices observed by most of the artisans and non artisans surveyed. These microorganisms can cause cholera, diarrhea and urinary tract infections besides skin bum and septicemia infections. Pathogens from bank notes may infect the body through scratches on the hands, or when the hand touches the mouth, nose and through unhygienic practices. Enteric pathogens such as enterotoxigenic *E. coli*, *Vibrio* and *Salmonella* have been isolated from paper money samples obtained from butchers and

fishmongers in Rangoon, Myanmar [9]. Piece of money are in permanent movement, passing in all environments that constitute a reservoir and source of various bacteria as pathogenic *Escherichia coli*, which can survive 11 days on the inert surfaces [23]. It has been established that *E.coli* 0157:H7 and *Salmonella enteritidis* can survive for up to eleven days and up to nine days, respectively on the surfaces of money coins, thus making it possible for coins to transfer bacteria to human hands [24]. *V. cholerae* is primarily an inhabitant of the aquatic environment, so water plays an important role in the transmission and epidemiology of cholera [25, 26]. *V. cholerae* can be transmitted by Paper money from fish seller, vegetable seller and food vendors as they use water frequently for different purposes.

In conclusion the present study clearly demonstrated that Bangladesh paper currency is commonly contaminated with pathogenic bacteria. This may play a significant role in the transmission of various disease. Depending on the results of this study, one suggestion may be made to peoples to improve their personal health consciousness by washing hands after handling of money notes, taking no foods even snakes after touching money notes, avoiding using saliva during counting of paper money notes, avoiding baby to handle money notes. In future more complex study using molecular methods would be required to accomplish further investigation on the antibiotic resistance pattern, plasmid profile and pathogenicity of the isolates obtained.

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