Survival of Some Pathogenic Bacteria in Current Currency Paper in Mosul City

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Abstract. Currency is one of the most frequently passed items in the world. It used every day and every way, and it could act as an important vehicle for cross-contamination. This research was aimed to determine how long pathogenic bacteria can survive on currency paper, four pathogenic bacteria including E. coli, Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis were provided according to laboratory standard methods. Sterile pieces of currency paper were inoculated with the pathogenic bacteria and the survival of bacteria was tested over seven days. The results showed that all tested bacteria differed in time of survival and this survive according to environmental conditions, the type of bacteria and the mode of its resistance, but they were stable and still cultivable after seven days. The second part of this research was to design a simple experimental model to check the efficacy of germicidal and attempted to use ultraviolet light radiation to evaluate the inhibitory effect of most pathogenic microorganisms on currency as a disinfectant. The results revealed that UV is an effective tool, so we recommend using it as a disinfectant for currency.

Keywords: Current Currency Paper, Resistance, Pathogenic Bacteria

1. Introduction

Globally, the currency is one of the items most frequently passed from hand-to-hand in the world. A paper currency that is transferred from one hand to another may be contaminated with many microorganisms causing diseases, especially dealing with not cleaned hands, or that kept in unclean surroundings [1].

Transmission of bacteria to humans depends on the role of many environmental agents and some materials serving as vehicles. Microorganisms are known to spread via air, water, food, etc. Contamination by pathogenic microorganisms can be a source of transmitting bacteria is of many public health concerns as contaminated materials [2]. Microbial contaminations may occur either directly (contact from hand-to-hand) or indirectly (from food or other objects). These routes are essential to health, especially in many countries where the frequency of infection is a public indication of local hygiene and levels of environmental sanitation [3].

Currency is accomplished by persons of different health and hygienic standards and is stored under personal cleanliness environmental conditions. Its commodities exchanged for goods on a large scale and services in most countries worldwide [4], and its very important to human life as it facilitates the needs. Although the paper notes of currency which is used by many people increase the possibility as an environmental vehicle for the transmission of potentially pathogenic microorganisms i.e., bacteria and fungi, they are transferred from hand to hand and may cause contamination with many diseases. So, Paper currency presents a wider risk to public health [5]. Since infectious disease can prevalent through contact with fomites, the currency may play a role. In contact with fomites, the bacteria have been shown
to be transmitted from person to person. It can be contaminated routinely and commonly passed among individuals during cough by droplets, touching sneezing, with previously contaminated hands or other materials and placement on an unclean surface. It is commonly handled by different categories of people during a transaction [6].

In many parts of the developed countries, there is a common belief that the synchronized dealing with food and currency contributed to the injury of food-related to public health [7]. The currency in which pathogenic bacteria might survive as an often-ignored reservoir for intestinal disease [8]. Currency paper provides a large surface area as the breeding ground for pathogens [9]. Other attitudes such as wetting the fingers with saliva or unclean water to lubricate fingers in counting money.

Over the past two decades, noted data indicated that concurrent handling actually was a cause of intermittent foodborne-illness and survival of bacteria on currency in the United States [10], India [11], Egypt [12], China [8]. In Egypt a study confirmed that 65% of currency contain bacteria like Staphylococcus & Klebsiella [13], others reported that most likely contamination are environmental bacteria, such as gram-positive flora (especially Bacillus spp.) and those found in human normal skin flora such as Staph. aureus [14], while many other studies from the United States reported that contamination of currency via the presence of bacteria like E. coli, Klebsiella [15].

UV light sterilization is an eco-friendly environmental method of eliminating bacteria, moulds, fungi and viruses without producing harmless by-products or using chemical disinfection. The UV-A range includes wavelengths from 315-400 nanometre which have the least amount of energy.

Paper currency like all other materials inevitably becomes contaminated over time. Disinfection is the process of elimination of most pathogenic microorganisms on an inanimate object.

Many studies were aimed to isolate and identify bacteria and fungi on money, but there are no local studies that represent the survival of pathogenic bacteria on a currency paper for many days. So, the study aims to determine and investigate the survival of some pathogenic bacteria on current currency paper in Mosul city and evaluate the effectiveness of UV light on the contaminated currency.

2. Materials and Methods

2.1. Preparation of currency samples:
The old currency paper used in this study was obtained from different shops in Mosul city. The one-centimetre square was cut from the currency papers and put in vials (12 pieces in each vial) then sterilized by autoclave for 15 min. in 121°C.

2.2. Bacterial Strains
Four types of pathogenic bacteria were obtained from the Bacterial Strains Bank Unit in Biology Department / College of Science / Mosul University / Mosul / Iraq.

Those types were preserved in Brain Heart Infusion (BHI) with 10% glycerol, then it was refreshed overnight in tryptic soy broth (TSB) and suspensions were prepared after that their growth was adjusted to 1×10^8 CFU/ml by using McFarland standard tubes.

2.3. Test of bacterial survivability on currency paper:
For each bacterial type, 12 currency paper pieces were pollinated with 0.25 ml suspension of bacteria and leaf to dry at room temperature for 2-3 days under sterilized condition. Immediately after drying, one piece of paper was immersed with 10 ml of normal saline (NS). 0.1 ml of undiluted sampling solution and 0.1 ml from each of 1:10 and 1:100 dilutions in NS were plated onto nutrient agar then incubated at 37°C for 24-48 hours, after incubation, the colonies were counted. Samples were stored, under standard room conditions (23°C). They were then cultured daily and the colonies were counted after 1,2,3,4,5 and 7 days to screen the bacterial growth and survival.
2.4. Evaluation of Ultraviolet light as germicidal:
A sample of paper currency was used to evaluate the potential of UV light to disinfect and sterilize by using a UV lamp for irradiation of the currency (36-watt gel curing TIADI UV LAMP JD 818) Figure 1. The currency was examined for bacterial contamination before and after disinfection to determine the bacterial count. Before exposure prepared sterile cotton swab with 1% peptone water were used for sampling, which was cultured in a broth of brain heart infusion separately and incubated for 15 minutes, using the standard loop, the sample was plated onto nutrient agar and incubated at 37°C for 24 hrs. After exposure, the currency was put in UV equipment for 15, 30 and 60 minutes and the experiment of culturing were repeated.

![Figure 1: UV lamp using to disinfect the currency paper](image)

3. Results and Discussion
Currency may be hurt too many various environments at a relatively high frequency. The Microbial contamination may be inherited either directly (hand-to-hand contact) or indirectly by food or other objects [1].

The results of this study revealed that the four pathogenic types of bacteria under study as shown in Figure 2 which were survive on currency paper for 7 days intervals with differences in length of survival depending on environmental room condition and the type of bacteria, but were stable on currency paper and still cultivable after 7 days with different rates as shown in Figure 3.

The initial number of bacteria in the inoculum was \(2.7 \times 10^7\) CFU/ml, corresponding to a total of 7.43 log10/ml organisms. There was a notable wide range in the resistance of different organisms under study. *Bacillus subtilis* was the most resistant to room conditions and the reduction rate was 4.6 logs \(10\) after seven days, while *E. coli* cannot survive for more than seven days and was reduced by 1.4 logs \(10\) only after seven days, other organisms including *Staph. aureus* and *Pseudomonas aeruginosa* were reduced...
by $2.4 \log_{10}$ and $3.4 \log_{10}$ in respectively (see Figure 3). Therefore, currency paper was unclean within the test period and was considered still an important source of infection.

With increasing in time to U.V bacterial growth decrease, at 60 minutes a complete inhibition of bacterial growth was established (see Figure 4).

**Figure 2:** Showing growth of the fourth pathogenic bacteria under study

**Figure 3:** Survival of some pathogenic bacteria on currency paper over time
**Figure 4:** showing bacterial growth on nutrient agar before and after exposure to UV
1. Before exposure, 2. After 15 min, 3. After 30 min, 4. After 60 min

*Bacillus* spp. is a spore-forming bacteria, widespread in the environment, it extremely tolerates heat and dryness, it may become contact with money through food, soil, clothing, and hand of users [16].

Our results also showed that *Pseudomonas aeruginosa* was more survived than *Staph. aureus* and *E. coli* (see Figure 5). This common opportunistic bacterium can cause many diseases in humans and it can cause nosocomial infections [17]. It found in soil, water, and most man-made environments and it has the ability to develop resistance to antibiotics rather rapidly. This type of bacteria can grow on minimal media and present a great challenge in the environments [18].

*Figure 5: Percentage reduction of pathogenic bacteria after different days*

Also, *Staph. aureus* is one of the commonest bacteria found on many surfaces like money. This bacterium was the most predominant among the important bacteria that cause serious diseases and food poisoning in humans and usually has developed resistance to conventional antibiotics [19]. It can spread
by hand to hand during contact. Currency can be contaminated previously during coughing, sneezing, touching with unclean hands or other materials and placement of different surfaces [3].

*E. coli* is a serious hazardous pathogenic bacterium that can cause many diseases to humans e.g. diarrhoea intestinal tract diseases, skin bum infections, septicaemia and it can contaminate drinking water [19]. This bacterium can infect the body through some injuries on the hands, and when hands touch mouth, nose and through unhygienic practices [20]. The physical condition of the currency paper. From the results of this study, we can conclude that sometimes currency could be an important source of contagion and serious to of health, and it's an important source of transmission of many diseases while it is contaminated with different pathogenic bacteria. So, a caution related to the refinement of individual hygiene and good currency handling practice such as washing hands duly before eating and avoiding using saliva during counting currency to decrease the hazard of infection.

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