Study of Antibacterial effects on Indian Currency

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1 **Abstract**

Indian currency is the official currency of India. With the advancement of science and technology several modes of cashless transaction have been introduced to our country but still a large section of our society is dependent on the transaction through currency notes. The composition of the Indian currency generally comprises of cotton rags, balsam and parts of silk for the purpose of security threads. These currency notes are a hidden threat to us as they transmit bacteria, virus and fungus through touch and gets transmitted from one person to another. An Indian note changes hands in an average of 500 times a day therefore increasing the chances of contaminating the currency getting high and the transmission of harmful diseases through this currency also increases. When these highly contaminated Indian currencies comes in contact with the human touch it results in the transmission of harmful bacteria into the humans therefore causing several bacteria prone diseases such as food poisoning diarrhoea Gonorrhoea, meningitis, ulcers, and several other diseases. Therefore, it is important to make the Indian currency antibacterial.

The main focus of the study is to develop an antibacterial chemical agent which comprises of certain natural as well as chemical components as a solution which will be used to activate the antibacterial properties of the natural fibres present in the currency. Several investigations were carried out on how the natural ingredients that is of lemon extracts, industrial vinegar and ginger extract would act on the surface of the currency notes. Bleach was used to chlorinate the note as the fibroin fibres gets activated of the silk thread when chlorine treatment is done and it kills about 99.9% of the bacteria including E. coli and S. aureus. The application of the natural extracts on the surface of the currency showed specific changes as it was instantly more clear than previous condition. The acidic and the antibacterial properties of the natural ingredients used, makes the currency note bacteria free as well as dirt free for a certain period of time which is a notifiable change. The treated currency were seen to be preventing the growth of bacteria for a certain period of time because of the activation of antibacterial properties of silk fibres due to the application of chlorine on silk and also the application of natural ingredients therefore preventing the growth of bacteria by persisting on the outer surface of the currency.

Keywords: Indian currency; Antibacterial property of Indian currency; Surface coating on currency

1. **Introduction**

India is an evolving country both in terms of digitalization and overall development. Among the different forms of digitalization, the cashless economy is of great concern all over the world. India is also moving towards the cashless economy to transform India into a digitally

driven society and knowledge economy. The necessity of implementing a cashless economy in our country is to capture black money and undeclared assets. Recent COVID pandemic has necessitated and boosted the cashless transactions in our society. But usually, India has been a cash driven economy here the currency notes are being circulated millions of times among innumerable number of people per day.

The notes being circulated so many times raises the question of microbial contamination among humans through the currency. Especially in these tough times of pandemic where everything is advised to be contactless to avoid the deadliest effects of CORONA virus, the cash-based mode of transaction is one such thing where contact must be made in-order to complete the transaction therefore raising a probability of contamination by currency.

A study of identifying microbes were carried out on 24 currency notes out of which all were contaminated with bacteria. The results showed that the currency notes that were collected from the open market as well as from the hospitals were contaminated with pathogenic microorganisms. The S. aureus contamination was found more in the notes collected from the hospitals than in the open market [Sunil et. al., (2020)]. As a result, various people come in contact with the bacteria everyday due to the transaction of currency notes. Therefore, leading to various types of diseases and bacterial infections.

Previously various processes had been undertaken to resolve the problem. Several studies had been conducted on the currency notes in various countries. In countries like Australia and New Zealand washable notes are introduced so that the lifespan of the currencies is not compromised while washing the notes [Girma et. al., (2015)]. But it is not possible in our country like India as the main composition of Indian currency includes 100% cotton with certain portion of silk for security thread purposes. Washing it is in not an option. Also, ultraviolet light can be used to disinfect the notes while being handed out in the banks [Girma et. al., (2015)]. But the longevity of the UV Rays is very less, and UV rays are just passed to check the security thread of the note therefore making it partially antibacterial that too for a very short period of time. [Source: Reserve Bank of India]. This present study differs from all the previous works mainly because of one significant point and that is to make the entire currency note antibacterial for a certain period time, an idea upon which no study has been done yet.

The main objective of research is to achieve a solution which will create a coating on currency notes so that it prevents the growth of microorganisms for a certain period of time.

The coating will persist on the upper layer of the note preventing the growth of microorganisms especially bacteria therefore preventing contamination through notes. Lime peel extract (citric acid) is used for its powerful antibacterial properties to prepare the solution along with alcohol for maximum effectiveness against E-Coli among others [Ali et. al., (2017)][15][16][17][18]. Vinegar was added it was composed of 0.1% concentration of acetic acid along with chloride to get antibacterial effect 100% on E - Cobe, S.aureas and around hundred percent antibacterial activity against E coli. It can be used as a natural substitute for antimicrobial drugs [Entani et. al., (1998)][9][10][11][12][13][14]. Ginger was also added because of its components zingiberene and Alpha curcumene. Antibacterial activity was tested against S aureus and E coli. The results showed that some electrophoretic bacteria cell proteins bands disappeared with increase in GEO concentration. The metabolic activity of bacteria was also decreased [Rahmani et. al., (2014)] [6][7][8].

. **Experimental**

2.1 *Materials and Methods*

The main aim of our research is to prepare a disinfectant solution which will make the Indian currency notes antibacterial for a certain period. The raw materials used for the preparation of the desired disinfectant solution includes lemon extract that contains citric acid which is proved to be of great use to make products antibacterial in nature. The solution also consists of industrial vinegar for acetic acid and ginger for its antibacterial qualities and for its strong aroma. Iso propyl alcohol was also incorporated in trace amount so that when added to the solution it doesn’t persist on the surface of the notes and dry up quickly and for its antibacterial nature. Methylene blue was used for identifying E. coli that presents on the surface of the currency notes. Industry made Geoline has also been added for its ability to activate the antibacterial properties of chlorine.

The disinfectant solution has been incorporated with several natural as well as chemical components to make the solution capable of killing the bacteria as well as preventing the growth of microorganisms for a certain period of time. The solution comprises of lime extract, raw ginger juice and industrial vinegar as part of the natural components. Industry made Geoline was added in measured proportions due to the presence of sodium hypochlorite which activates the natural antibacterial quality of silk. Lastly, traces of iso-propyl alcohol were added so that the solution doesn’t persist on the surface of the currency note for long period and make it wet. The nature of the solution is that of a colourless liquid with a strong

aroma and the pH of 4-5 approximately which when sprayed on currency creates an antibacterial coating.

2.1.1 *Lime Extract Preparation*

Lime extract is an essential part of the disinfectant solution that has been made. The lime juice was extracted from fresh lemon slices. The juices were squeezed into a glass petri dish and to remove any kind of pulp that may have been mixed with the juice, the lime juice was passed through the filter paper to get the actual fresh lime extract and it was stored in a clean air-tight container for further use.

2.1.2 *Ginger Extract Preparation*

Ginger juice was extracted from raw and fresh ginger. The raw ginger was cut into pieces and was shredded into much smaller pieces with a help of a clean and sterilised shredder. The shredded pieces are then taken in a clean petri dish and with the help of a filter paper the juices are extracted from those pieces and kept in an air-tight container for further use.

2.1.3 *Main Solution Preparation*

The main disinfectant solution was prepared by mixing of all the natural and chemical components in measured proportions. The lime extract and the ginger extract that was prepared from fresh lime and ginger respectively were kept in a petri dish and measured proportions were taken with the help of a syringe. Measured proportion of vinegar and iso-propyl alcohol were mixed together and were kept in an air tight test tube. For the chlorination purpose Zeoline and water were combined to get the desired results. All of these ingredients were mixed together thoroughly to get our required solution.

2.2 *Characterization Techniques*

Microscope was the main equipment used to identify and the study the various microbes present in the currency notes as well as the effect of the antibacterial solution on those microbes. The microscope which was used for this purpose was manufactured by NEBOLAB INDIA. The specific objective lens used for this purpose were of magnification 100/1.25OIL 160/0.17, 40/0.65 160/0.17, 10/0.25 160- and the eyepiece used were of zoom WF10x/20 and WF15x/15. Methylene blue was used in order to identify the gram-negative bacteria i.e., E. coli. It was manufactured by LOBA CHEMIE PVT.LTD. The specifications are of MF MW absorption maxima.

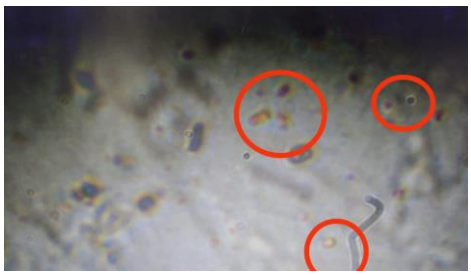
2.3 *Culture Preparation*

The culture was prepared from notes that have been already used multiple times in-order to get the best results. A note was taken and few drops of normal water was given on the surface of the currency notes. A clean ear bud was taken and samples were scraped from the outer surface of the currency notes and were put in the slide. The sample was then mixed with measured proportions of methylene blue solution and was covered with a slide cap and then put to test under the microscope. Different magnifications of the microscope were taken into account in identifying the bacteria present in the sample.

2.4 *Results and Discussions*

The solution when applied on the surface of the currency notes shows instant and notifiable changes when placed under the microscope. When the solution first comes in contact with the culture, the colony of the microbes got scattered and separated from each other therefore breaking the clusters.

FIGURE-1



(1.1)

(1.2)

Figure (1.1) shows the culture before the application of the solution. The marked portion indicates the presence of E. coli and S. aureus including other microbes.

Figure (1.2) shows the culture after applying the solution. All the microbes are dead and it is creating a layer to prevent the growth of the microorganism for a given period of time.

With the increase in time the separation also increases therefore making the bacteria weak in nature. After the 6^{th} minute mark, the microbes were studied and the random movement stopped and it moved with the flow of the solution applied. The microbes were found to be dead and the growth of the microbes were prevented for the time frame of 16 minutes 02 seconds and 33 milliseconds. The solution formed a resistance layer to prevent the growth of any kind of bacteria like E. coli and S. aureus and killing the living microbes therefore

making the currency note antibacterial in nature for 16 minutes 02 seconds and 33 milliseconds. When applied on the notes, specific changes were observed, for instance the cleansing of the outer layer of the notes and the aroma of a fresh gingery like substance.

Figure – 2

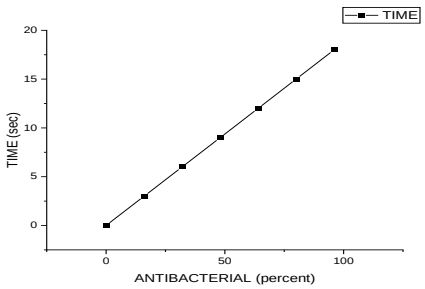
(2.1) (2.2) (2.3)

Figure (2.1) shows the cluster of microbes being attached to the culture before the application of the solution.

Figure (2.2) shows the cluster of microbes being detached from the culture after few minutes of the application of the solution and the marked portion indicates the microbes losing its power to persist on the culture.

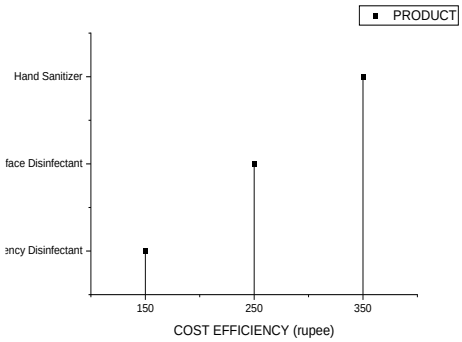
Figure (2.3) shows the cluster dying and moving out of the frame after applying the solution.

Graph – 1:



Here the graph has been drawn to show the effect of the antibacterial solution on the currency note with respect to time.

Graph - 2:



Here in this graph the comparison has been drawn among hand sanitizers, surface disinfectant and the prepared currency disinfectant to show the cost efficiency among them.

Table 1: Comparison between currency disinfectant and sanitizer/surface disinfectant

Currency Disinfectant	**Sanitizer/surface disinfectant**
1) pH – **4.5 to 5**	pH – 6.5 to 7
2) Colourless in nature	Colourless/coloured in nature
3) Odour – Limy Fresh	Odour - Alcoholic
4) No Side Effects on Human skin	May show Side Effects
5) Shows little antibacterial activity on human skin	Shows up to 99 percent of antibacterial activity on human skin
6) Shows more than 95 percent antibacterial activity on currency note	Not tested on currency notes
7) Has a longevity of time period more than 15 minutes.	Not tested on currency notes

8)	Composed of All Natural Ingredients	Composed of both Natural as well as Chemical components.
9)	When applied, cleans the outer surface as well as the inner layers of the currency note	When applied, it damages the currency note.

This table shows the difference between the currency disinfectant with any other standard surface disinfectant or hand sanitizer. The main objective behind this table is to show the improved qualities this currency disinfectant is showing when applied on the solution.

3. **Acknowledgement**

We the authors of this paper do hereby acknowledge the effort put in by Indian Institute of Chemical Engineers (IICHE) to help us do the necessary study to write this paper. We would also like to thank all the members and teachers of IICHE involved to help us with any kind of solutions to our problems.

4. **Conclusion**

The study shows the result that there is the presence of many contaminating microbes most of which can be destroyed with the studied solution. Moreover the solution also persisted on the layer therefore making the note antibacterial itself for the given period of time. Thus this can be concluded that when the solution applied, the note can be safe from the bacterial contamination for quite a period of time. Further studies can help with more distinguishable improvements in the near future.

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