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Certified that the project report **"Antimicrobial Silver Nanoparticle coating on Currency notes and Mobile phones using Eco-friendly Tollens process for prevention of infectious diseases"**

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Antimicrobial Silver Nanoparticle coating on Paper currency notes and Mobile phones using Eco-friendly Tollens process for prevention of infectious diseases

INTRODUCTION:

Contaminated Paper currency notes may cause a public health risk by spreading nosocomial (Hospital acquired infections) infections when simultaneous handling of food and in addition to this, also cause normal sort of contaminations in persons with immunodeficiency. Especially when banknotes recovered from hospitals may be highly contaminated by *Staphylococcus aureus*, *Salmonella* species and *Escherichia coli.* Laboratory studies revealed that methicillin-resistant *S. aureus* can easily survive on paper currency notes, whereas *E. coli*, *Salmonella* species and viruses, including human influenza virus, Norovirus, Rhinovirus, hepatitis A virus and Rotavirus, which can be transmitted through hand contact. Large-scale, 16S rRNA, metagenomic studies and culturomics have the capacity to dramatically expand the known diversity of bacteria and viruses on money and fomites [1].

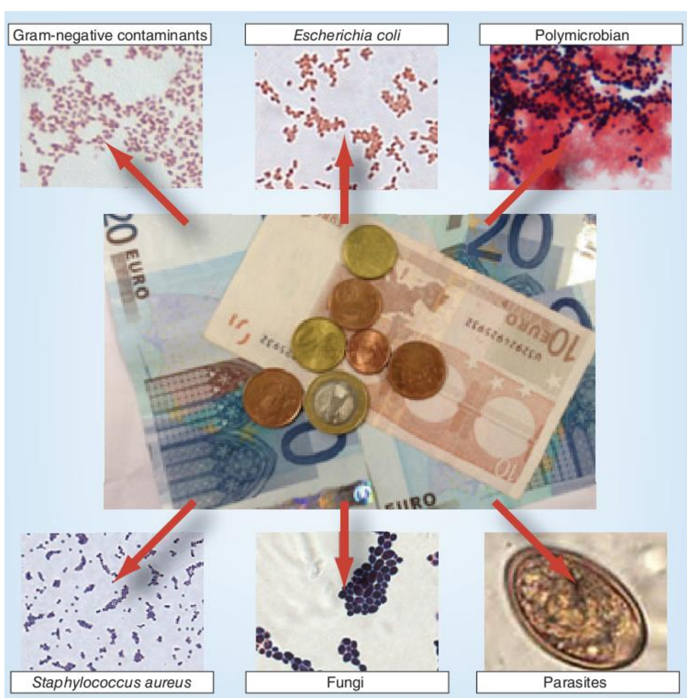


Figure 1: Depiction microbes on paper currency notes (**Courtesy:** *Future Microbiol.* (2014) 9(2), 249–261).

Similarly, constant handling of the Mobile phone by different users exposes it to an array of microorganisms, and makes it a good carrier for microbes, especially those associated with the skin resulting in the spread of different microorganisms from user to user. Because of the multifaceted benefits of the mobile phones, it is easy to overlook its hazard to health; this is against the background that many users may have no regard for personal hygiene, and the number of people who may use the same phone. Many research studies has shown that the mobile phone could be a health hazard with tens of thousands of microbes living on each square inch of the phone [2,3].

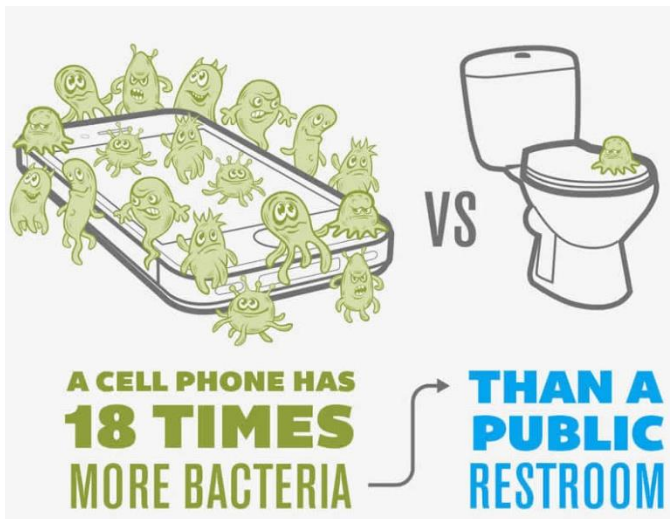


Figure 2: Depiction microbes on Mobile phones.

(**Courtesy:** https://www.phonesoap.eu/medical-professional)

However, Nosocomial infections caused by microorganisms which usually originated from hospital environments and cross-contamination due to the incorrect use of medical equipment can be prevented or reduced by replacing normal equipments with Silver nanoparticles (AgNPs) coated medical devices [4,5]. Many medical studies have revealed that silver is effective against more than 650 pathogens, having a broad spectrum of activity. Further its use in the form of Nanoparticles enhances this property up to great extent and allows its use in a wide range of applications [6, 7]. Therefore, in recent years Nano-silver is considered as one of the most viable alternatives to antibiotics because it seems to have high potential to solve the problem of multidrug resistance, which is often observed in several bacterial strains [8-10].

Nanoparticles are usually a clusters of atoms, with sizes ranging between 1 and 100 nm, whereas the word “Nano” is used to indicate one billionth of a meter [11-13]. Because of the variation in the size of AgNPs, they exhibited variety of physical and chemical characteristics to that of metallic silver [14, 15].

The silver is well known for its antimicrobial activity. In Nano-metric form, silver has shown accentuated antimicrobial characteristics. Due to their nano scale size, AgNPs can enter in to cells and inhibit enzymatic systems in the respiratory chain of some bacteria and thereby alter their DNA synthesis. AgNPs, their use can be recommended as a good alternative for the control of microorganisms, with less risk of toxicity to human cells [16].

Various studies have revealed the effectiveness of AgNPs as dressings for covering burns to surgical devices and bone prostheses, and are incorporated into clothing – always with the aim of producing antimicrobial effect [17-20].

In this context, we have been used silver nanoparticles (AgNP) to coat the surfaces of both Paper currency notes and mobile phones for the prevention of microbial contamination.

RESEARCH PROBLEM:

In recent time, healthcare-associated infections are one of the most serious patient safety issues in healthcare today [21]. Most microbes are able to survive on surfaces and Paper currency note’s surfaces can act as sources of pathogen transmission if no disinfection is performed. In addition, the survival of nosocomial bacterial strains, including methicillin-resistant *Staphylococcus aureus* (MRSA), in the environment is of great interest to infection control professionals [22]. Moreover, workers who are working with food and edible products have been implicated in several outbreaks of food-borne diseases who were frequently handling contaminated paper currency notes and human occupational activities could introduce the risk of food contamination [23]. Pathogens that can infect food workers have multiple sources among them paper currency notes occupy considerable portion and contaminated workers in turn become potential sources of contamination in food processing and preparation facilities [24].

In addition to the Paper currency notes, mobile phones also act as potential non-vector causative factors for microbial contamination due to its constant contact with humans. According to many microbial studies conducted by Microbiologists reveal the combination of constant handling with the heat generated by the mobile phones creates a prime breeding platform for many microorganisms that are normally found on the skin. Staphylococci species, particularly *S. epidermidis* are which belongs to the normal flora of the human skin, respiratory and gastrointestinal tracts. 20-50% of human beings contain *S. aureus* in their nasal carriage. are also found regularly on Clothes, bed linen, and other human environments usually contains Staphylococci species [25]. *Staphylococcus aureus*, a common bacterium found on the skin and in the nasal fluids of up to 25% of healthy people and animals can cause illnesses from pimples and boils to pneumonia and meningitis, and is a close relative of methicillin Resistant *Staphylococcus aureus* (MRSA). Human hand acts as main reservoir of *S. aureus* from where it is introduced into food during preparation [26]. The hands also serve as a major vehicle of transmission of various pathogens including the enteric species [27]. *Proteus mirabilis* is one of the most common Gram-negative pathogens found in clinical specimens. It can cause a variety of community or hospital-acquired infections, including those of the urinary tract, respiratory tract, wounds and burns, bacteraemia, neonatal meningoencephalitis, empyema and osteomyelitis [28]. After *Escherichia coli, P. mirabilis* is the member of the Enterobacteriaceae most often isolated in European clinical microbiology laboratories [29] and accounting for ~3% of nosocomial infectionsin the United States [30]. Pseudomonas aeruginosa is a metabolically versatile γ-Proteobacterium, which inhabits terrestrial, aquatic, animal, human, and plant-host-associated environments [31].

To address the above issues the common utility objects like Paper currency notes and mobile phone surfaces should be disinfected regularly with broad spectrum antibiotics. These antibiotics are chemically unstable under the normal handling conditions and their efficacy will reduced significantly with time. Hence these antibiotics should be used regularly used for disinfection, which leads to evolution of multi-drug resisted microbial strains. This further ruins the public health care with diseases which will not be controlled by normal dosage of antibiotics.

To answer the above research problem innovative approach of coating Silver nanoparticles on surfaces of Paper currency notes and mobile phones has been adopted. The most applied method for AgNPs preparation is by the reduction of Ag^{+} in aqueous solution. For this purpose we have used simple Tollens process with slight modifications.

Owing to their peculiar properties Nanoparticles attracts great interest for applicative methods in many disciplines [32], among them the most advance application is in the field of biology and medicine [33]. Many metals like silver, copper, gold, magnesium etc. have been exhibited potential antimicrobial property in the form of Nano-particles and among these silver was the most efficient [34]. The antimicrobial activity of Silver nanoparticles (AgNPs) against both pathogenic fungi and bacterial strains is attracting researcher's attention in multidisciplinary applications of health care. Many bacterial strains have great intrinsic antimicrobial resistance limiting the number of effective antibiotics. Thus, metallic antimicrobial agents such as silver nanoparticles (AgNPs) are considered as potential agents to help manage and prevent infections. AgNPs can be used in several applications against bacteria which are resistant to common antibiotics or even multiresistant bacteria such as *P. aeruginosa*.

OBJECTIVES:

- The major objective of the project is to develop a protective strategy for prevention of microbial infections caused by contaminated Paper currency notes and Mobile phones using concepts of nanotechnology.
- To Design the novel synthetic strategy for coating silver nanoparticles (AgNP) on Paper currency notes and mobile phone screen using simple tollens reagent and evaluate its antimicrobial efficacy against both bacteria and fungi by microbial screening methods.

REVIEW OF LITERATURE:

- Nosocomial infections caused by contaminated Paper currency notes have a significant impact on public health in recent time. According to the studies conducted by ***Emmanouil Angelakis et al***.[1] stated that that contaminated money and coins are a public health risk when associated with the simultaneous handling of food, and Paper currency may spread nosocomial infections. We have highlighted the potential for banknotes and coins to carry bacteria and fungi, as well as their potential capacity to spread infectious agents. In addition, banknotes and monetary coinage can act as potential reservoirs for antibiotic-resistant bacteria, such as MRSA.

- Similarly mobile phones also act as non vector factors for cross-contamination. ***Saeed Banawas et al.***[35] reported that the cell phones of healthcare workers can be contaminated by a wide range of bacteria including multidrug resistance bacteria. Bacteria may be readily able to adhere to the surface of mobile phones, and the heat emitted by the cell phone enhances bacterial growth and these bacteria can then be transferred to one person to another. Another study conducted by **Raghavendra Rao Morubagal et al**.[36] also revealed the presence of pathogenic bacteria on Mobile phones which are capable of causing infections when dealt with health care associates.
- **R. Salomoni et al.** [16] in their study explained the antibacterial activity of AgNPs especially multidrug resistant strains of *Pseudomonas aeruginosa* which are common pathogens in nosocomial infections.
- According to study conducted by **K. M. Alananbeh et al**.,[37] AgNP have been possess potential antifungal activity against various fungal strains like *Aspergillus* sp. i.e. *A. niger* and *A. terreus*. The gradual growth reduction was clear in both *Aspergillus* species with the increase in concentration of the AgNP.
- ***Yadong Yin et al.*** [38] reported a simple and convenient procedure based on the Tollens process for the preparation of silver nanoparticles with a relatively narrow distribution in size in the range of 20–50 nm. These silver particles could be easily prepared either as stable aqueous dispersions or as decorative coatings on microspheres and surfaces.
- ***Gayatri Dhulappanavar et al.*** [39] reported an eco-friendly synthesis of AgNP using Lemon fruit juice (*Citrus limon L.*) as a reducing and stabilizing agent.
- According to study conducted by **Padma S Vankar** and **Dhara Shukla** [40] showed that Antimicrobial finish on fabric provided durable textile finish on cotton and silk fabric. The Preparation of silver nanoparticles (AgNP) have been carried out biosynthetically using aqueous extract of Lemon leaves *(Citrus limon)* which acts as reducing agent and encapsulating cage for AgNP.
- Polymer nanocomposites containing metal nanoparticles have attracted a great interest due to their unique chemical and physical properties. “Green” chemistry promotes application of natural fibers in such structures, among them cellulose is one of the most

frequently used. However, cellulose fabrics have ability to absorb moisture, so under certain conditions of humidity and temperature they can be subjected to microbial attack. One of the most popular and best known antibacterial agents is silver, which serves as a potential antibacterial material acting against an exceptionally broad spectrum of bacteria including activity against antibiotic-resistant bacteria. **Dagmara K. Chmielewska et al.**[41] revealed in their studies that Silver nanoparticles (Ag NPs) were grown at the cellulose fibers surface by direct reduction of $AgNO_3$ with electron beam (EB) application.

- **E. Smiechowicz et al.** [42] reported the enhanced antibacterial activity of nanocomposite cellulose fibers of Lyocell type modified with nanosilver particles and nanosilica.

RESEARCH METHODOLOGY:

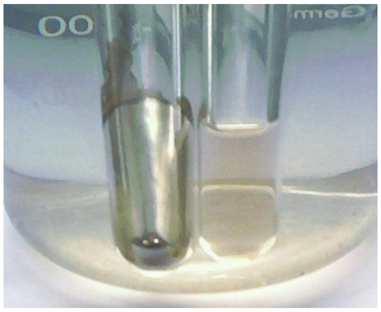
Nanotechnology deals with various structural aspects of matter having dimensions of the order of a billionth of a meter. Based on the size, Nano-materials are usually intermediate between macroscopic solid materials and of atomic and molecular systems. Specific physical, chemical and biological properties of Nano-materials make them dissimilar from the macroscopic bulk materials. These properties of Nano-particles provide us the scope of multiple applications in advance research to day to day life.

Based on the size, morphology, physical and chemical properties NPs (Nano-particles) were categorized into different types namely ceramic nanoparticles, carbon-based nanoparticles, metal nanoparticles etc. Among these Metal based Nps have shown multifaceted applications. Metal nanoparticles are prepared from metal precursors. These nanoparticles can be synthesized by chemical, electrochemical, or photochemical methods. In chemical methods, the metal nanoparticles are obtained by reducing the metal-ion precursors in solution by chemical reducing agents. These have the ability to adsorb small molecules and have high surface energy. In the present study we use nanotechnology to answer the research problem, i.e. to design antimicrobial protective layer on Paper currency notes and mobile phone surfaces for prevention of microbial contamination. For this we have chosen AgNP because of its significant antimicrobial activity, AgNP have several merit over normal antibiotics which includes long period of effectiveness and will not initiate drug resistance among the microbial strains.

In the present study we have used very simple Tollens process which is used to identify aldehyde functional group in the organic chemistry.

CONCEPT:

Tollens' reagent is usually used to determine the presence of aldehyde functional group on aliphatic, aromatic and carbohydrate (reducing sugars) moieties, it will also gie positive test with some alpha-hydroxy ketones which can tautomerize into aldehydes. The reagent is prepared from aq.silver nitrate solution, ammonia and some sodium hydroxide (to maintain a basic pH of the reagent solution). It was named after its discoverer, the German chemist Bernhard Tollens [43]. A positive test with Tollens' reagent is indicated by the precipitation of elemental silver, often producing a characteristic "silver mirror" on the inner surface of the reaction vessel.



This reagent is freshly prepared in the laboratory for immediate use due to its short shelf life and easily decomposes hence it is not commercially available. Commonly the preparation involves two steps. First a few drops of dilute sodium hydroxide are added to some aqueous 0.1 M silver nitrate. The HO^- ions convert the silver aquo complex form into silver oxide, Ag_2O, which precipitate from the solution as a brown solid:

$$2\ AgNO_3 + 2\ NaOH \rightarrow Ag_2O\ (s) + 2\ NaNO_3 + H_2O$$

In the next step, sufficient aqueous ammonia is added to dissolve the brown silver(I) oxide. The resulting solution contains the $[Ag(NH_3)_2]^+$ complexes in the mixture, which is the main component of Tollens' reagent. Sodium hydroxide is reformed:

$$Ag_2O\ (s) + 4\ NH_3 + 2\ NaNO_3 + H_2O \rightarrow 2\ [Ag(NH_3)_2]NO_3 + 2\ NaOH$$

Aldehydes/Reducing sugars are easily oxidized by mild oxidizing agents such as Ag^+. The silver mirror test is the reaction of a sample with a solution containing silver-ammonia complex ions. When this reagent oxidizes the aldehyde, the silver ions are reduced to metallic silver, which forms a black precipitate, and if the test tube is clean, a silver mirror on the test tube. The overall reaction is as follows:

$$2Ag\ (NH_3)_2^+ + 2OH^- + R-\overset{\overset{\displaystyle O}{\|}}{C}-H \longrightarrow 2Ag_{(s)}\ \text{(silver mirror)} + R\text{-}COO^- + NH_4^+ + 3NH_3 + H_2O$$

MATERIALS:

Silver nitrate (AgNO3; > 99.5% purity), Sodium hydroxide, D-Glucose anhydrous were purchased from SD fine (India). All chemicals were of analytical reagent grade and were used without further purification. Other chemicals used in this project extracted from natural sources.

METHODS:

Preparation of silver nanoparticles (AgNP):

A mixture of 5ml 0.001M $AgNO_3$ and 5ml 0.001M NaOH solution mixed to form turbid precipitated solution. To this, aqueous ammonia was slowly added to make clear solution of Tollens reagent, followed by the addition of 5ml 0.001M glucose solution. The mixture is taken in 10ml vials and immersed in a sonication bath for one hour for synthesis of AgNP. These aqueous dispersions of silver nanoparticles were also very stable and no sedimentation formed even after being stored for a longer periods. The solution of AgNP was then diluted to 2, 3, 4 folds with de-ionized water.

Coating of AgNP on Paper currency notes:

The Paper currency notes initially cleaned with cotton wool to remove dust and dirt particles and then AgNP solution sprayed on it uniformly an swapped with cotton wool dipped in dilute Lemon fruit juice (*Citrus limon L.*) as it stabilized the AgNP on Paper currency notes and also reduces any traces of Ag^{+} ions left over [40]. The AgNP plausibly deposited on cellulose fibers of Paper currency notes which provide firm binding.

Coating of AgNP on Mobile phone Screen:

Coating of AgNP on mobile phone screen (tempered glass) is difficult as Polyethylene terephthalate (PET) or Thermoplastic polyurethane (TPU) which provided smooth surface over which adsorption or binding of AgNP is not possible. Therefore we opted a innovative approach, in which Bio-film of orange peel extract was initially coated over mobile phone screen. The bio-film cross-linked with polymeric material of screen and provides a transparent texture. Upon this layer AgNP solution sprayed uniformly and wiped with cotton wool dipped in dilute Lemon fruit juice (*Citrus limon L.*) for stabilization of nanoparticles.

Characterization of AgNP:

The AgNP samples collected by scratching AgNP treated Paper currency notes were characterized by using Scanning electron microscope (SEM). Morphology of the samples was studied using a scanning electron microscope with a detector of back-scattered electrons (SEM-BSE) equipped with an energy dispersive spectrometer (EDS) which allows to determine precisely elemental composition of materials. Samples for SEM-BSE were prepared according to the standard procedure, fixed with conductive glue and covered with a thin gold layer. The thermal investigation of cellulose fibers with silver particles was carried out with Q 500 TGA (T. A. Instruments) from 30 to 600°C at a heating rate of 10°C per min, under a constant flow (60 ml/min) of nitrogen gas.

Antimicrobial Screening:

The efficacy of AgNP was tested by Antimicrobial Screening on both bacterial (Gram positive and Gram negative strains) and fungal species.

Antibacterial activity:

Inoculums of bacterial strains were prepared by using Nutrient broth (pH 7.2) and for antibacterial screening the agar medium was sterilized by autoclaving at 120ºC for 15 min. The Petri plates and pipettes were sterilized by dry heat in a hot- air oven at 150ºC for 1 hr. About 20 mL of the molten agar medium was poured in each of sterilized Petri plates .The microorganisms employed in this study were one gram positive bacteria; Staphylococcus aureus (MTCC – 96) and one gram negative bacteria, Pseudomonas aeruginosa (MTCC – 424). The inoculum was standardized at 1*106 CFU/ml comparing with turbidity standard (0.5 MacFarland tube). The AgNP solutions with different concentrations (standard, 2, 3, 4 fold dilutions) were spray uniformly over sterilized whatman filter paper followed by wiping with cotton wool dipped in dilute Lemon fruit juice. This paper was cut into 5 mm discs and were screened in vitro for their antibacterial activity by the cup-plate agar diffusion method [44]. The auto calved Nutrient broth media Inoculation of *Pseudomonas aeruginosa* (gram-negative) and *Staphylococcus aureus* (gram-positive) were Incubate over night at 37º C in shaker for Bacterial growth. From this 0.3ml of bacterial culture was taken and inoculated by using spreader on freshly prepared auto calved agar plates. After drying of plate prepared AgNP 5 mm sample discs were kept on microbial plate along with positive controls Norfloxacin for Staphylococcus and Pseudomonas strains. After overnight incubation at 37º C in BOD incubator zone of inhibition is measured by measuring scale. The zone of inhibition (in mm) was compared with standard drugs.

Antifungal activity:

Sclerotium rolfsii inocculam was inoculated to the freshly prepared sterilized Potato Dextrose Broth and allowed for fungal growth. After the growth of fungus, inoculum was added to the sterilized PDA plates for anti fungal Activity. Further, 5 mm AgNP discs were prepared by using whatman filter paper as discussed above. The Inoculation of *Sclerotium rolfsii* fungal strain which were obtained from MTCC in autoclaved PDB media and incubate for 3-4 days at 30º C in shaker for fungal growth. From that 20 µl of Fungal culture was taken and inoculated by inoculation loop on freshly prepared autoclaved agar plates. Different 5 mm AgNP discs were kept on microbial plate along with antifungal agent as a control i.e. Ketoconazole. These plates were incubated for 5-6 days at 30º C in BOD incubator and zone of inhibition (in mm) is measured by measuring scale.

RESULTS AND DISCUSSIONS:

(Data Analysis-Findings)

It is evident from SEM-BSE micrographs of AgNP–cellulose composites (**Fig-3**) obtained for 0.001M concentrations of the applied $AgNO_3$ solution that the silver nanoparticles present on the surface of cellulose fibers of Paper currency notes. The size and shape of the silver particles varies from 20nm to 50nm. Whereas the scratched material of mobile phone screens also confirmed the presence of AgNP with size and shape of the silver particles varies from 15nm to 50nm. (**Fig-4**)

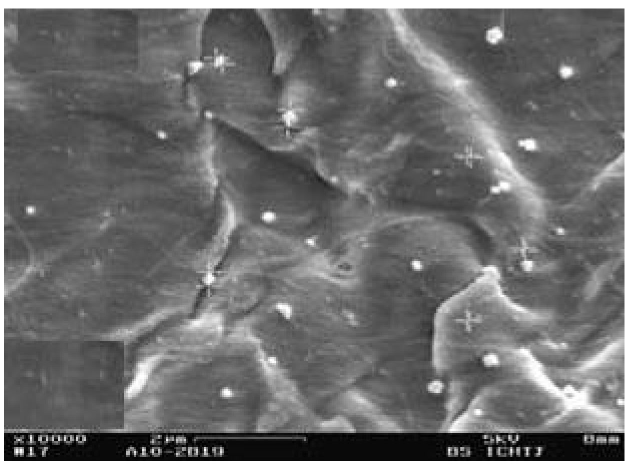


Figure 3: SEM image of AgNP distributed on cellulose fibers of Paper currency notes.

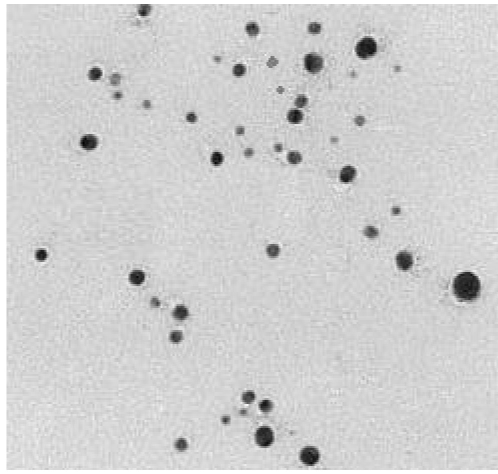


Figure 4: SEM image of AgNP in scratched material of AgNP-coating of Mobile phone screen.

From the anti-microbial studies it is evident that the AgNP treatment on Paper currency notes and cell phone screens provide potential antimicrobial barrier against both bacteria and fungi. The *in vitro* antimicrobial (anti-fungal & anti-bacterial) results are tabulated in Table 1.

Table 1. Antimicrobial activity (Zone of inhibition in mm) of different samples (Different dilutions)

Entry	Sample	*P. aeruginosa*	*S. aureus*	*S.rolfsii*
1	Standard	7	8	9
2	2-fold dilution	7	6	8
3	3-fold dilution	6	5	2
4	4-fold dilution	2.5	2.5	2
5	5-fold dilution	2.5	2.5	2
6	Control [a]	11	15	5

[a] Controls: Norfloxacin for *S. aureus,* and *P.aeruginosa* and Ketoconazol for *S.rolfsii.*

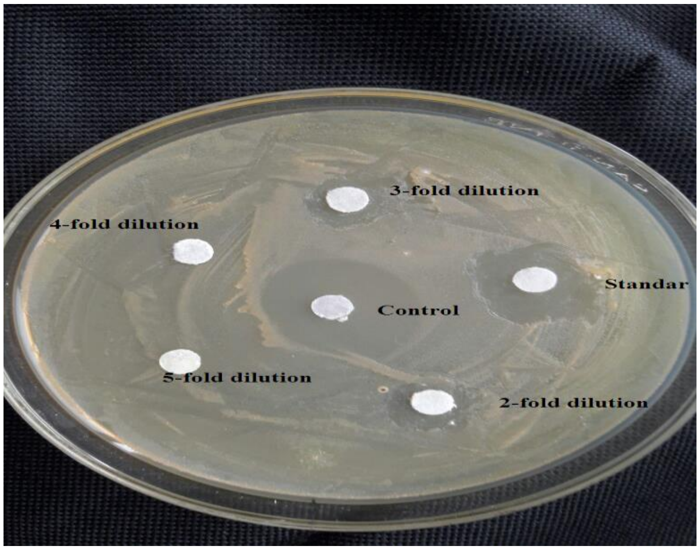


Figure5. Antimicrobial activity (Zone of inhibition in mm) against *P.aeruginosa.*

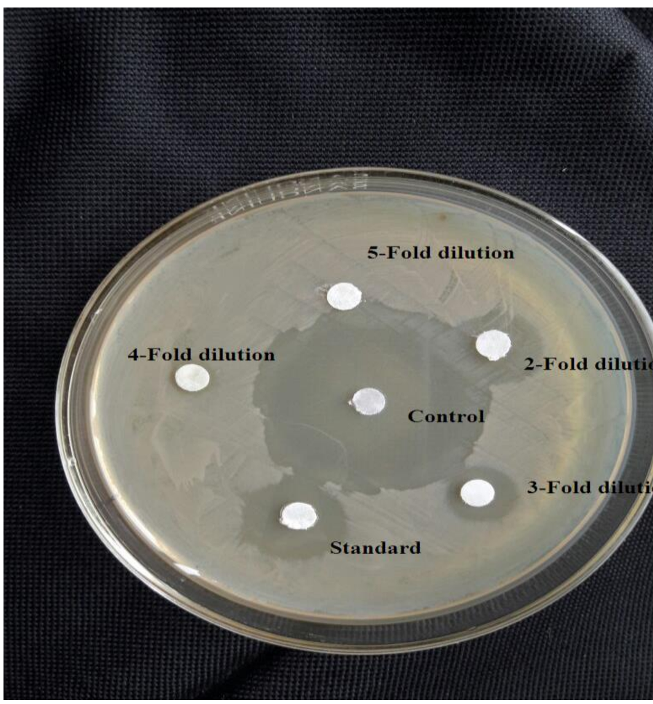


Figure 6. Antimicrobial activity (Zone of inhibition in mm) against *S. aureus.*

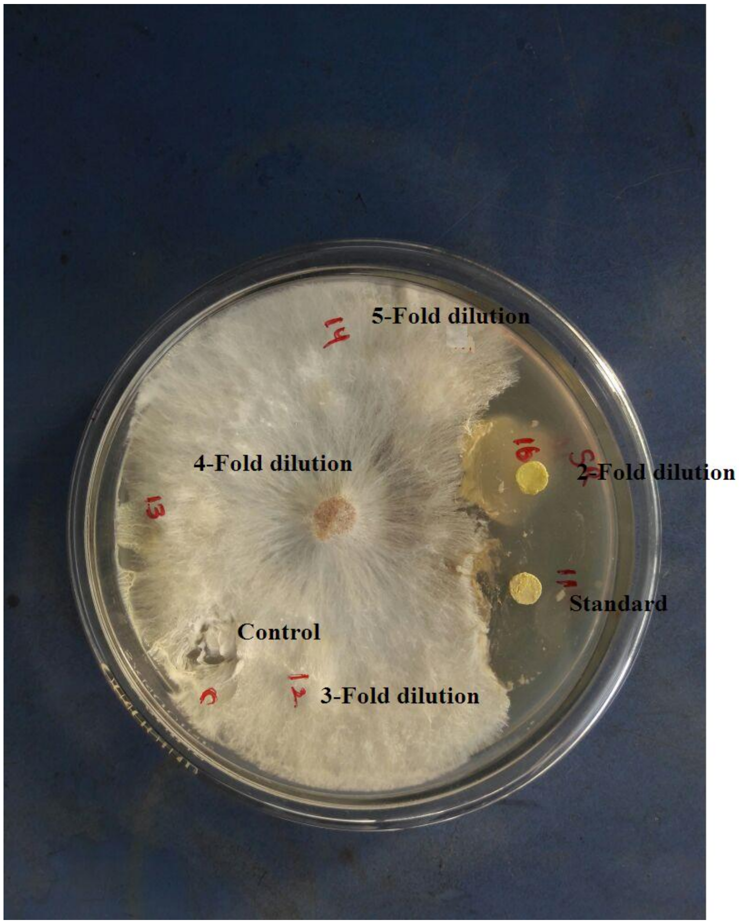


Figure 7: Antimicrobial activity (Zone of inhibition in mm) against *S.rolfsii.*

The presence of definite zone of inhibition surrounding the disc indicated antimicrobial activity. All the samples have shown Excellent to good antibacterial activity against both Gram positive bacteria and Gram negative bacteria compared to the standard antibiotic Norfloxacin. The samples up to 3-fold dilutions have shown excellent activity but beyond that (4 and 5-fold dilutions) antibacterial activity drastically decreased. Whereas, anti-fungal activity of the AgNP samples showed more potentiality compared to standard antifungal agent Ketoconazol especially for standard and 2-fold diluted AgNP samples.

This benign process is completely eco-friendly as the chemicals used are non-hazardous and extracted from natural sources. moreover the procedure of coating AgNP is very economical as each 500 Rs Paper currency note or Mobile phone screen needed 20 pisa only.

CONCLUSION:

From the current project it is clear that AgNP coating on Paper currency notes and Mobile phone screens by using innovative modified Tollens process provide an excellent protection against microbial contamination which will be fatal in nosocomial infections caused by microorganisms in hospitals when contaminated Paper currency notes and Mobile phones handled by healthcare associates. The problem of cross contamination will be serious in patients with immunodeficiency disorders like HIV/AIDS or patients who were underwent organ transplantation to whom usually immune-depressant drugs were given. The outlook of the projects also opens new avenue for public health care aspects especially in situations where multidrug bacterial strains like *mycobacterium tuberculi* evolved by excessive use of antibiotics. The process is very convenient, ecofriendly and economical to scale up for bulk usage.

SUGGESTIONS:

Further studies should investigate the combination of AgNPs and antibiotics against resistant hospital strains for the development of new materials and substances for medical application. As "***prevention is better than cure***" the following suggestions were made basd on this project:

- The paper currency notes should be printed with inks impregnated with the AgNP.
- Automatic Teller Machines (ATM) should be reloaded with AgNP suspension for spraying on used Paper currency notes.
- The interiors of hospitals to be painted with AgNp impregnated paints to prevent Nosocomial infections and to keep the intensive care units (ICU) hygiene and sterile.
- To prevent contagious diseases like swine flu, the public transport utilities like buses and metros to be coated with AgNP impregnated paints.
- The mobile phone screen guards to be manufactured with AgNP incorporated polymers.

ACKNOWLEDGEMENTS:

We are thankful to Ciencia Life sciences, Hyderabad, India for providing bacterial and fungal strains for antimicrobial screening.

ABBREVIATIONS

rRNA	Ribosomal ribonucleic acid
AgNP	Silver Nano-particles
DNA	Deoxyribonucleic acid
MRSA	Methicillin-resistant Staphylococcus aureus
EB	Electron beam
SEM	Scanning electron microscope
BSE	Back-scattered electrons
EDS	Energy dispersive spectrometer
MTCC	Microbial Type Culture Collection
PDA	Potato Dextrose Agar
PDB	Potato Dextrose broth
BOD	Biochemical oxygen demand
HIV	Human immunodeficiency virus
AIDS	Acquired immune deficiency syndrome

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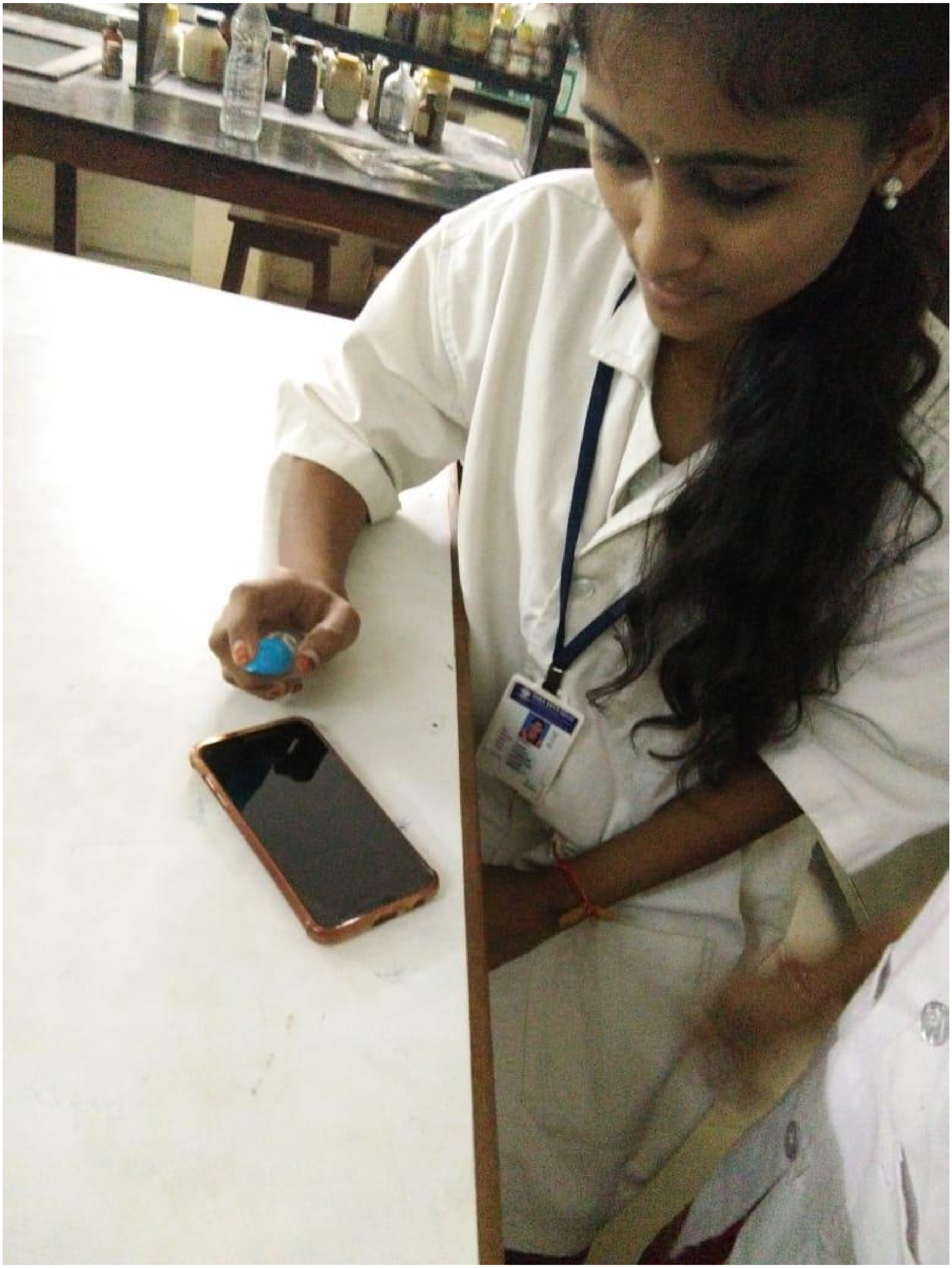

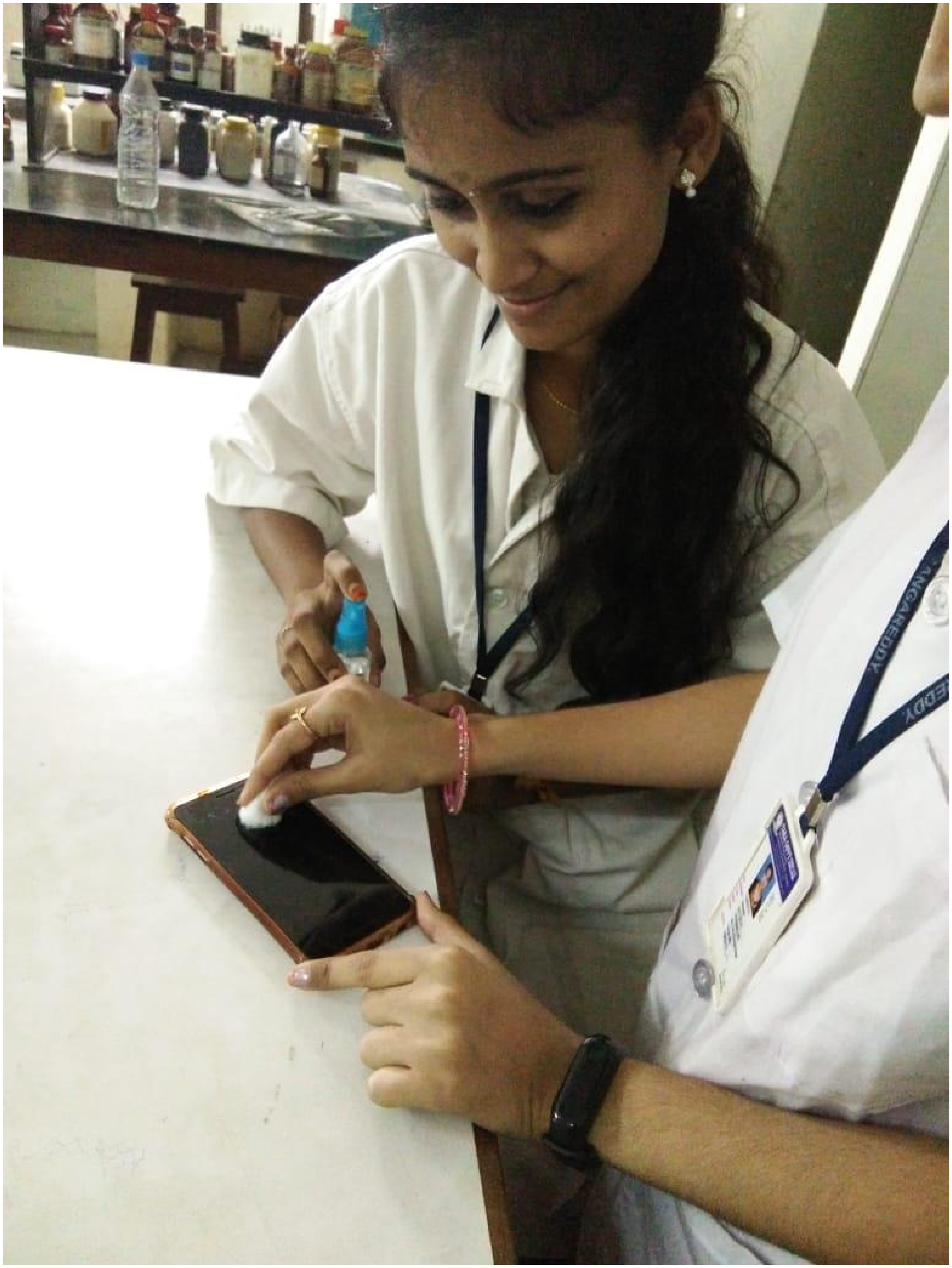


Eubacteria

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For Academic and Scientific Cooperation
Ciencia Life Sciences, Hyderabad
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