



## Annual Research & Review in Biology

33(5): 1-13, 2019; Article no.ARRB.49899  
ISSN: 2347-565X, NLM ID: 101632869

# Microbial Assessment of In-door Air and Equipment Used in Banks within Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria

T. O. Olowomofe<sup>1\*</sup>, T. F. Babalola<sup>2</sup>, O. O. Oluyide<sup>3</sup> and O. Adedayo<sup>1</sup>

<sup>1</sup>Department of Microbiology, Faculty of Science, Ekiti State University, Ado-Ekiti, Nigeria.

<sup>2</sup>Department of Environmental Health Sciences, College of Health Science and Technology, Ijero-Ekiti, Nigeria.

<sup>3</sup>Department of Biomedical Engineering, College of Health Science and Technology Ijero-Ekiti, Nigeria.

### Authors' contributions

This work was carried out in collaboration among all authors. Authors TOO and TFB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TFB, OOO and OA managed the analyses of the study. Authors OOO and TOO managed the literature searches. All authors read and approved the final manuscript.

### Article Information

DOI: 10.9734/ARRB/2019/v33i530134

Editor(s):

(1) Dr. Manikant Tripathi, Department of Microbiology, Dr. Ram Manohar Lohia Avadh University, India.

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(2) Adebajo Seun Owolabi, Federal University of Agriculture, Nigeria.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/49899>

Original Research Article

Received 10 May 2019  
Accepted 16 July 2019  
Published 20 November 2019

## ABSTRACT

Banking activities which involve the use of counting machines, Automated teller machines, and exchange of naira notes play potential roles in the spread of infectious microorganisms. This study aimed at determining the microbial status of banks within Ekiti State University campus. A total of 96 samples were collected from six different banks' in-door air, ATM, counting tables and Money counting machines in Ekiti State University campus. The samples were collected both in the morning and afternoon. Bacteria and fungi were isolated from the samples using serial dilution and pour plating methods. The isolates were identified based on morphological and biochemical characterization. Susceptibility pattern of the isolates to different classes of antibiotics (Penicillins, Quinolones, Macrolides, Aminoglycosides, Fluoroquinolones and Sulfonamides) were determined using agar disc diffusion method. There was significant difference ( $p < 0.05$ ) in bacteria counts on all

\*Corresponding author: E-mail: [temitayo.olowomofe@eksu.edu.ng](mailto:temitayo.olowomofe@eksu.edu.ng), [motunde21@yahoo.com](mailto:motunde21@yahoo.com);

the equipment analyzed in all the banks except Heritage bank. Analysis of variance also revealed significant difference in the bacteria counts from the banks in the morning and in the afternoon ( $p < 0.05$ ). Bacteria and fungi isolated from the samples belonged to the genera *Staphylococcus*, *Streptococcus*, *Enterobacter*, *Klebsiella*, *Escherichia Serratia*, *Pseudomonas*, *Proteus Bacillus*, *Aspergillus*, *Alternaria*, *Mucor* and *Fusarium* where bacteria group dominated with 65% while their fungal counterparts were 35% of the total isolates. *Escherichia coli* had the highest percentage occurrence of 18.6%, followed by *Staphylococcus aureus* (15.2%) while *Proteus* sp. had the lowest occurrence (1%). The isolates exhibited resistance to Augmentin (100%), Erythromycin (100%), Amoxicillin (96%), Cotrimoxazole (96%), Chloramphenicol (86%), Streptomycin (72%) and Gentamycin (58%) while their growths were inhibited by Ciprofloxacin, Ofloxacin, Prefloxacin and Septrin. Plasmid analysis of the resistant strains showed that the isolates lack plasmids. The presence of potential pathogens in the banks and multiple antibiotic resistance displayed by the isolates constitutes risk to the public health. Hence, measures such as thorough hand washing with soap and hand sanitization after using the bank and its facilities should be emphasized.

**Keywords:** Bank facilities; plasmid analysis; antibiotics resistance; sanitizing agents.

## 1. INTRODUCTION

Banks are one of the public places people visit in recent times. Different activities within the banks have been recognized to play potential roles in the spread of infectious microorganisms. Due to free access to the bank, different people from different socio-economic levels and hygienic status visit banks on a daily basis [1]. Their activities such as use of the ATM machine, filling of tellers, exchange of Naira notes among others enhance the transmission of microorganisms within the bank. Inanimate objects are known to support viable microorganisms for a prolonged period of time [2].

Hand transmission of infection is through surfaces that require contact with human hands such as computer keyboards, door handles, mobile phones, elevator buttons. Factors such as the source and destination of surface contacts, microorganisms involved, moisture levels, pressure and friction between the contact surfaces, and inoculum size have been shown to influence the bacterial transfers between surfaces and human [3]. Many bacterial, fungal and viral pathogens could survive on inanimate objects for several months, and such pathogens could cause epidemic infections [4].

Many people are ignorant of the fact that such environmental surfaces and objects, especially those in close proximity with persons and frequently touched, pose a lot of threat to human health and is a cause for public concern. The health status of the workers and customers in the bank also influence the air quality of the banking hall. Lack of ventilation and overcrowding in the banks can increase the risk of acquiring air-borne infections. Majority of bank users are ignorant of

potential risk of acquiring infections and diseases from this route and as such do not engage in proper hygiene and hand sanitation after use [5].

In view of the fact that 80% of infections are spread through contact with contaminated hands and the increasing incidence of antimicrobial resistance by many pathogenic microorganisms, this study is aimed at carrying out a microbiological survey of banking halls in Ekiti State University to provide information on the microbial status of the banks and the health risk they pose on the public health.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Samples

Samples were aseptically collected in duplicate from In-door air, Automated Teller Machines (ATM), Money counting machines and Counting Tables of Six Banks within Ekiti State University Ado-Ekiti campus both in the morning and afternoon. Samples were collected with sterile swab stick moistened in sterile water and placed in well labeled sterile bag. Indoor samples were collected by exposing prepared media to air for 10 to 20 minutes. The exposure time was for the air microorganisms to settle gravitationally directly on the media surfaces of the plates, a method called plate sedimentation method [6]. The samples were taken to the Laboratory for microbiological analyses.

### 2.2 Isolation Procedure

Samples collected were inoculated into sterile nutrient broths and incubated at 37°C for 24 hours. After 24 hours incubation, ten-fold serial dilution was carried out on the broths and 1 ml

of dilutions  $10^5$  and  $10^6$  were plated on sterile Eosin Methylene Blue Agar, Nutrient Agar, MacConkey agar and Potato Dextrose Agar (PDA) plates using the pour plate method. PDA plates were incubated for 72 hours at a temperature of  $37^\circ\text{C}$  while other plates were incubated at  $37^\circ\text{C}$  for 24 hours. Colonies on the plates were counted and bacterial counts were recorded in  $\text{Log}_{10}\text{CFU/ml}$ . Different fungal spores were counted as well.

### 2.3 Purification of Isolates

The primary isolates were sub-cultured on Eosin Methylene Blue Agar, Nutrient Agar, MacConkey agar and Potato Dextrose Agar (PDA) repeatedly until pure cultures were obtained.

Identification of isolates: The isolates were subjected to different tests which involved cell morphology, Gram stain, spore formation, production of oxidase, catalase, indole, fermentation of glucose, galactose, sucrose, maltose, mannitol, fructose, xylose, lactose, methyl red, Voges proskauer, motility test, urease utilization as well as growth and appearance on Simmon citrate agar and starch utilization. Identification of the isolate to the generic level followed the scheme in Bergey's Manual of Systematic Bacteriology [7].

### 2.4 Antibiotics Susceptibility Test

This was carried using protocol described by Clinical and Laboratory Standards Institute [8,9]. The disc diffusion method was used to determine the antibiotic susceptibility of the isolates on Mueller Hinton agar plates. The Isolates with Bacteria growth obtained from different ATM machine, money counting machines and counting Tables were tested by the standard disc diffusion method and were subjected to a susceptibility panel of 10 antibiotics. Isolates were first resuscitated on nutrient Agar plate, then standardized into Mueller Hinton Broth, before seeding organisms on Mueller Hinton Agar. The entire surface was seeded with the inoculum using a sterile swab and allowed to dry for 10 minutes at room temperature after which the sensitivity disc was impregnated and incubated at  $37^\circ\text{C}$  for 24 hrs. Antibiotic discs used were: Amoxyllin (25  $\mu\text{g}$ ), Ofloxacin (5  $\mu\text{g}$ ), Streptomycin (10  $\mu\text{g}$ ), Chloramphenicol (30  $\mu\text{g}$ ), Ceftriazone (30  $\mu\text{g}$ ), Gentamicin (10  $\mu\text{g}$ ), Pefloxacin (5  $\mu\text{g}$ ), Cotrimoxazole (25  $\mu\text{g}$ ), Ciprofloxacin (10  $\mu\text{g}$ ), and Erythromycin (5  $\mu\text{g}$ ). Sterile water was used as a control.

Susceptibility of the isolates to antibiotics was determined by measurement of zone of inhibition of growth around the antimicrobial disc according interpretative standards of Clinical and Laboratory Standards Institute (CLSI) guidelines. The isolates were evaluated as susceptible or resistant [8,9].

### 2.5 Plasmid Extraction Preparation

In preparation for isolates plasmid extraction, the isolates maintained on nutrient agar slants were inoculated in bijou bottles containing sterile nutrient broth and incubated for 24hrs at  $37^\circ\text{C}$  after which they were plated out on nutrient agar and incubated for another 24hrs at  $37^\circ\text{C}$  to obtain a fresh isolates growing at logarithmic stage. From each nutrient agar plate a loopful of the pure colony was inoculated each in freshly prepared nutrient broth and incubated for 24hrs before 0.5 ml each of the nutrient broth culture was dispensed in cryovials tubes containing glycerol and finally kept at  $-80^\circ\text{C}$  for preservation until when plasmid extraction was carried out [10].

### 2.6 Plasmid Extraction Using Fast and Easy Plasmid Mini-prep Kit

Five hundred micro liters (500  $\mu\text{l}$ ) of cultured bacterial cells each was harvested by centrifuging at 10,000 g for 1 min. The supernatant was discarded and the cell pellet suspended in 300  $\mu\text{l}$  of Resuspension Buffer, 2 $\mu\text{l}$  of lysozyme solution was added and mixed well by inverting several times. Incubation was done at  $37^\circ\text{C}$  for 1 hour and eventually centrifuged at 10,000 g for 1 min and the supernatant discarded. The pelleted bacterial cells were suspended in 300  $\mu\text{l}$  lysis Buffer by pipetting or vortex for 1 min.

For neutralization, 300 $\mu\text{l}$  of Neutralization Buffer (containing RNase A) was added to sample and mixed gently by inverting the tube 4-6 times without votexing and centrifuged at 10,000 g for 5min at room temperature in a micro-centrifuge. For column activation, a binding column was placed into a 2 ml collection tube where 100  $\mu\text{l}$  of Activation Buffer was added into the binding column. Centrifugation was done at 10,000 g for 30 sec in a micro-centrifuge. For Column loading, the supernatant collected was poured into the activated Binding Column by decanting or pipetting and centrifuged at 10,000 g for 30 sec. The flow-through was discarded. For column washing, the DNA loaded Binding Column was

placed into the used 2 ml tube and 500  $\mu$ l of Washing Buffer (containing Ethanol) to the Binding Column. Centrifugation was done at 10,000 g for 30 sec and the flow-through discarded. For elution, Binding Column was placed into a clean 1.5 ml microtube. 30-50  $\mu$ l Elution Buffer was added to the center of the column membrane and incubated for 1 min at room temperature and finally centrifuged at 10,000 g for 1 min to elute plasmid DNA. The ultra-pure plasmid DNA was eventually subjected to agarose gel electrophoresis [10].

## 2.7 Statistical Analysis

Data obtained from the study were analyzed using two-way analysis of variance t-test.  $P < 0.05$  was considered significant during the analysis.

## 3. RESULTS AND DISCUSSION

It was observed in this study that banks and their equipment are contaminated with different species of microorganisms. Total Bacteria and Total Coliform counts revealed that the ATM, counting machines, counting Tables and Indoor air of these banks harbored considerably high bacteria and fungal counts. Several studies have reported the contamination and colonization of inanimate objects such as door handles, plastics, faucets, phones, money, fabrics, plastics and other fomites by bacteria [11,12,13,14,15] which is also responsible for the spread of various bacterial infections [16].

Different bacteria counts were observed in the banks and their facilities (Table 1). Total bacteria count, total coliform count and total *E. coli* count in samples collected in the morning was significantly different ( $p < 0.05$ ) from that of the afternoon samples. Similarly, the banks also differ significantly in their bacteria counts ( $p < 0.05$ ). Highest bacteria count was recovered from the ATM in all the banks while the in-door air had the lowest bacteria count. Although significant difference ( $p < 0.05$ ) was observed on the bacteria counts in all the equipment analyzed in all the banks except Heritage bank. Variability of bacteria count among the banks could be due to factors such as level of hygiene, construction, number of users, location of ATM. Higher bacteria count recorded at UBA ATM could be because it is located outside where it receives contamination from the environment compared to banks where their ATM are confined in a space. Higher counts recorded in the afternoon could be

due to increase in the people visiting the banks thereby making contact with this equipment. This also could have contributed to bacteria count of the indoor air which increased in the afternoon. Some of the banks are crowded in the afternoon, as such the air conditioner will not be as cool as it is in the morning thereby making the environment conducive for microbial growth. Release of pathogens from diseased individuals into the air and the transfer to healthy persons is inevitable in banks especially when all windows and doors are locked. As shown in Table 1 there was increase in the indoor air bacteria counts in the afternoon across all the banks. It could be inferred that the density of population in the banks contributed to rise in the counts. Similarly, increased use of the counting machine in counting money in the afternoon accounts for the rise in the bacteria counts in all the banks. Microbial contamination of naira notes could be from several sources such as atmosphere, during storage, usage, handling or production [17]. Daily transactions have made the naira to pass through many hands and pathogens become imposed on them before they are finally deposited in banks.

Different bacteria and fungi belonging to the genera *Staphylococcus*, *Streptococcus*, *Enterobacter*, *Klebsiella*, *Escherichia Serratia*, *Pseudomonas*, *Proteus Bacillus*, *Aspergillus*, *Alternaria*, *Mucor* and *Fusarium* were isolated from the banks (Table 2). Previous findings have revealed the presence of similar bacteria genera on surfaces and objects [18,19]. Enteric bacteria usually live in the intestinal tracts of animals and humans, some are pathogenic, causing disease and food poisoning in humans. However, there isolation from the banks could be attributed to poor hygiene practices. Their fungal counterparts have also been reported to inhabit the soil and air [20], hence can be found on several surfaces [21].

The percentage distribution of the isolates showed bacteria had considerably higher frequency of occurrence (65%) compared to that of the fungi (35%). This agrees with the findings of Iquo et al. [22] who reported fewer fungi than bacteria from ATM. *Escherichia coli* had the highest percentage occurrence of 18.6%, followed by *Staphylococcus aureus* (15.2%). *Enterobacter* sp. and *Klebsiella* sp. had relatively high percentage occurrence of 12.1% and 8.4% respectively (Fig. 1). *S. aureus* was the most abundant (28.57%) bacterial isolate followed by *E. coli* (21.43%) in a similar study by

Table 1. Bacterial and fungal counts from Banks in Ekiti State University Campus

| Banks         |                  | Morning (9.00 am)                               |   |   | Afternoon (3.00 pm)                             |   |   | Total fungal count |
|---------------|------------------|---|---|---|---|---|---|--------------------|
|               |                  | Total bacteria count (Log <sub>10</sub> CFU/ml) | Total Coliform count (Log <sub>10</sub> CFU/ml) | Total <i>E. coli</i> count (Log <sub>10</sub> CFU/ml) | Total bacteria count (Log <sub>10</sub> CFU/ml) | Total Coliform count (Log <sub>10</sub> CFU/ml) | Total <i>E. coli</i> count (Log <sub>10</sub> CFU/ml) |                    |
| Access Bank   | ATM              | 3.81±1.35                                       | 4.53±1.08                                       | 4.33±1.27   | 5.22±1.14                                       | 4.71±1.47                                       | 3.54±1.39   | 4±0.02             |
|               | Counting Machine | 2.50±0.58                                       | 2.33±0.35                                       | 2.12±0.46   | 4.17±0.54                                       | 3.04±0.45                                       | 3.33±0.38   | 2±0.02             |
|               | Counting Table   | 2.10±0.34                                       | 1.78±0.58                                       | 1.56±0.49   | 3.27±1.12                                       | 2.43±0.57                                       | 2.88±1.02   | -                  |
|               | Indoor air       | 1.23±0.08                                       | 1.11±0.05                                       | 1.04±0.06   | 2.14±0.03                                       | 2.29±0.03                                       | 1.49±0.05   | -                  |
| Wema Bank     | ATM              | 6.46±1.58                                       | 4.09±1.67                                       | 3.21±1.42   | 7.03±1.82                                       | 6.88±1.55                                       | 5.71±1.07   | 4±0.03             |
|               | Counting Machine | 4.73±0.64                                       | 4.15±0.53                                       | 2.74±0.68   | 5.86±1.22                                       | 4.97±1.11                                       | 3.88±0.89   | 4±0.03             |
|               | Counting Table   | 2.95±0.67                                       | 2.24±0.76                                       | 2.43±0.72   | 5.58±0.65                                       | 5.06±0.76                                       | 4.91±0.78   | 2±0.02             |
|               | Indoor air       | 2.89±0.04                                       | 2.51±0.06                                       | 2.66±0.12   | 3.29±0.15                                       | 2.77±0.09                                       | 1.84±0.08   | 3±0.02             |
| First Bank    | ATM              | 3.93±1.47                                       | 4.12±1.23                                       | 3.43±1.59   | 6.17±1.43                                       | 5.34±1.39                                       | 4.17±1.56   | 4±0.05             |
|               | Counting Machine | 2.54±0.68                                       | 2.33±0.49                                       | 2.13±0.54   | 4.27±0.46                                       | 4.38±0.66                                       | 4.08±0.63   | -                  |
|               | Counting Table   | 2.22±0.67                                       | 2.08±0.76                                       | 2.14±0.82   | 4.77±0.69                                       | 4.59±0.65                                       | 4.37±0.53   | -                  |
|               | Indoor air       | 2.27±0.08                                       | 1.02±0.07                                       | 1.11±0.06   | 3.71±0.08                                       | 2.55±0.04                                       | 2.10±0.09   | 2±0.02             |
| Heritage Bank | ATM              | 4.18±1.03                                       | 3.52±1.33                                       | 2.61±1.54   | 6.59±1.68                                       | 4.04±1.45                                       | 3.05±1.36   | 5±0.03             |
|               | Counting Machine | 3.12±1.34                                       | 3.01±1.12                                       | 2.08±0.09   | 5.74±1.55                                       | 4.55±1.44                                       | 3.22±1.18   | 3±0.01             |
|               | Counting Table   | 2.9±0.76  | 2.87±0.53                                       | 2.11±0.58   | 4.90±0.65                                       | 4.39±0.48                                       | 3.17±0.69   | -                  |
|               | Indoor air       | 2.12±0.08                                       | 2.15±0.09                                       | 1.48±0.07   | 2.81±0.08                                       | 2.86±0.05                                       | 2.03±0.08   | -                  |
| UBA Bank      | ATM              | 7.51±1.16                                       | 6.02±1.38                                       | 5.09±1.37   | 8.86±1.32                                       | 6.56±1.22                                       | 4.08±1.09   | 5±0.02             |
|               | Counting Machine | 3.15±0.10                                       | 2.49±0.35                                       | 2.14±0.45   | 5.04±1.21                                       | 4.75±1.46                                       | 4.16±1.29   | 3±0.02             |
|               | Counting Table   | 3.27±0.49                                       | 3.04±0.56                                       | 2.85±0.65   | 4.05±0.38                                       | 4.09±0.49                                       | 3.82±0.43   | -                  |
|               | Indoor air       | 2.18±0.08                                       | 2.05±0.05                                       | 1.89±0.04   | 3.77±0.07                                       | 3.23±0.06                                       | 2.21±0.05   | 2±0.03             |
| ECO Bank      | ATM              | 5.12±1.33                                       | 4.08±0.05                                       | 3.31±0.04   | 7.71±0.04                                       | 6.55±0.03                                       | 4.77±0.06   | 4±0.02             |
|               | Counting Machine | 2.83±0.84                                       | 2.55±0.67                                       | 1.23±0.76   | 5.59±0.57                                       | 4.29±0.78                                       | 3.24±0.66   | -                  |
|               | Counting Table   | 2.44±0.34                                       | 2.39±0.48                                       | 1.45±0.50   | 4.74±0.62                                       | 3.23±0.68                                       | 3.10±0.58   | -                  |
|               | Indoor air       | 2.17±0.06                                       | 2.10±0.05                                       | 1.58±0.08   | 3.26±0.08                                       | 3.12±0.08                                       | 2.16±0.07   | 2±0.01             |

(-): No growth; Values are the mean and standard deviation of two replicates

**Table 2. Bacteria and fungi isolated from collected samples**

| <b>Banks</b>  |                  | <b>Bacteria</b>  | <b>Fungi</b>   |
|---------------|------------------|--|--|
| Access Bank   | ATM              | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> , <i>Klebsiella areogenes</i> and <i>E.coli</i>  | <i>Aspergillus fumigatus</i> , <i>Aspergillus niger</i> , <i>Fusarium oxysporum</i>  |
|               | Counting Machine | <i>E.coli</i> , <i>Enterobacter</i> sp. <i>Proteus</i> sp. <i>Serratia</i> sp.   | <i>Aspergillus niger</i>   |
|               | Counting Table   | <i>Staphylococcus aureus</i> , <i>Pseudomonas</i> sp. and <i>Bacillus</i> sp.  | No growth  |
| Wema Bank     | Indoor air       | <i>Klebsiella</i> sp. <i>Bacillus</i> sp.  | No growth  |
|               | ATM              | <i>Enterobacter aerogenes</i> , <i>Proteus</i> sp., <i>Serratia</i> sp. , <i>Pseudomonas</i> sp., <i>Streptococcus</i> sp and <i>E.coli</i>                          | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>Mucor</i> sp. <i>Alternaria</i> sp.  |
|               | Counting Machine | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> , <i>Klebsiella areogenes</i> and <i>Streptococcus</i> sp.   | <i>Mucor</i> sp., <i>Penicillium</i> sp. <i>Aspergillus niger</i>  |
|               | Counting Table   | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogenes</i> , <i>Klebsiella</i> spp. and <i>E.coli</i>  | <i>Mucor</i> sp.   |
| First Bank    | Indoor air       | <i>Serratia</i> spp. <i>S.aureus</i> , <i>Streptococcus</i> spp., <i>Klebsiella areogenes</i> and <i>E.coli</i>  | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>A. flavus</i> , <i>Mucor</i> sp.   |
|               | ATM              | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> , <i>Klebsiella</i> spp., <i>Bacillus</i> spp. and <i>E.coli</i>   | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>A. flavus</i> ,  |
|               | Counting Machine | <i>E.coli</i> . <i>Serratia</i> spp., <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> and <i>Klebsiella</i> spp.   | No growth  |
|               | Counting Table   | <i>Staphylococcus aureus</i> , <i>Proteus</i> spp., <i>Enterobacter</i> sp. and <i>Klebsiella</i> spp. .   | No growth  |
| Heritage Bank | Indoor air       | <i>Staphylococcus aureus</i> , <i>Staphylococcus</i> spp., <i>Enterobacter aerogens</i> , <i>Klebsiella</i> spp. and <i>Bacillus</i> spp.                            | <i>Aspergillus flavus</i>  |
|               | ATM              | <i>E.coli</i> , <i>Staph. aureus</i> , <i>Pseudomonas</i> sp. <i>Staphylococcus</i> sp., <i>Enterobacter aerogens</i> , <i>Klebsiella</i> sp. and <i>Proteus</i> sp. | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>A. flavus</i> , <i>Alternaria</i> sp. <i>A. nidulans</i> , <i>Fusarium oxysporum</i> |
|               | Counting Machine | <i>Serratia</i> sp, <i>Enterobacter aerogens</i> , <i>Klebsiella</i> spp. and <i>E.coli</i>  | <i>A. niger</i> , <i>Penicillum</i> sp., <i>Mucor</i> sp.  |
|               | Counting Table   | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> , <i>Klebsiella areoginenes</i> and <i>Bacillus</i> sp.  | No growth  |
|               | Indoor air       | <i>Streptococcus</i> spp. , <i>Proteus</i> sp., <i>Klebsiella</i> spp. and <i>E.coli</i>   | <i>Aspergillus niger</i> , <i>Mucor</i> sp.  |

| <b>Banks</b> |                  | <b>Bacteria</b>  | <b>Fungi</b>   |
|--------------|------------------|--|--|
| UBA Bank     | ATM              | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> ,<br><i>Klebsiella areoginenes</i> and <i>E.coli</i>   | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>A. flavus</i> ,<br><i>Fusarium oxysporum</i> |
|              | Counting Machine | <i>Streptococcus</i> spp., <i>Staphylococcus aureus</i><br><i>Enterobacter aerogens</i> , <i>Bacillus</i> spp. <i>Klebsiella</i> spp.<br>and <i>E.coli</i> | <i>Mucor</i> sp.   |
|              | Counting Table   | <i>Enterobacter</i> sp., <i>Pseudomonas</i> spp., <i>Klebsiella</i> spp.<br>and <i>E.coli</i>  | No growth  |
|              | Indoor air       | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> ,<br><i>Klebsiella</i> spp. and <i>Bacillus</i> spp.   | <i>Fusarium oxysporum</i>  |
| ECO Bank     | ATM              | <i>Staphylococcus aureus</i> , <i>S. aureus</i> , <i>Serratia</i> spp.<br><i>Klebsiella</i> spp. and <i>Pseudomonas</i> spp.                               | <i>Aspergillus fumigatus</i> , <i>A. niger</i> , <i>A. flavus</i> ,                              |
|              | Counting Machine | <i>Enterobacter aerogens</i> , <i>Klebsiella</i> sp. and <i>Proteus</i> sp.  | No growth  |
|              | Counting Table   | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> ,<br><i>Klebsiella aerogenes</i> and <i>E.coli</i>   | No growth  |
|              | Indoor air       | <i>Staphylococcus aureus</i> , <i>Enterobacter aerogens</i> ,<br><i>Klebsiella</i> sp. and <i>Bacillus</i> sp.   | <i>A. niger</i>  |

Onuoha and Fatokun [18]. Prevalence of *E. coli* is indicative of possible faecal contamination [23,24]. This could also be an indicator of poor hygienic practices by bank users. *Staphylococcus aureus* is a major component of the normal flora of the skin and nostrils, which probably explains its high prevalence as contaminant, and it can easily be discharged by several human activities, like sneezing, talking and contact with moist skin (Itah and Ben, [25]. A work on Automated teller machines in Ebonyi State, Nigeria carried out by Akoro et al. [26] showed that *Staphylococcus aureus* are ubiquitous and can be found on several exposed surfaces.

The antibiotic susceptibility test showed that the bacteria isolates showed multiple resistance to antibiotics (Table 3). The bacterial isolates showed resistance to Augmentin (100%), Erythromycin (100%), Amoxicillin (96%), Cotrimoxazole (96%), Chloraphenicol (86%), Streptomycin (72%) and Gentamycin (58%). This is similar to the report of Saadabi et al. [27] that all the bacteria isolated showed 100% resistance to Augmentin and Amoxicillin 87.5% resistance to Chloraphenicol and 50% resistance to Cotrimazole, Ceftriazone and Gentamycin respectively. However, the bacteria were susceptible to Ciprofloxacin, Ofloxacin, Prefloxacin, Tarivid, Seprin and Sparfloxacin which was in correlation with report by Jane-Francis et al. [28] who reported that bacteria are susceptible (100%) to

Ofloxacin, Ceftriaaxone, Vancomycin and Penicillin.

*Staphylococcus aureus* had the highest multiple antibiotic resistance compared to other bacteria. It showed 100% resistance to Amoxicillin, 92% resistance to Gentamycin, 92% resistance to Augmentin and 83% resistance to Erythromycin, Stretomycin, Contramozole, Chloramphenicol. This corroborates the work of Emikpe and Oyero, [29] who reported that organisms isolated from Nigerian naira notes were resistant to first line antibiotics. Another study by Awe et al. [30] revealed that *S. aureus* showed resistant to all the antibiotics tested.

The plasmid profile carried out showed the absence of plasmid bands on the agarose gel which indicated that resistance of organism to antibiotics was not plasmid mediated. It has been reported that genes coding for resistance could be located on the chromosomes [31,32]. The results of this study provides a baseline information on the contamination status of banks, banking equipment and incidence of antibiotic resistance among the bacteria isolates in banks within Ekiti State University Campus. The contamination of banks by pathogenic organisms suggests the possibility of their transmission to humans through the use of the facility. Hence, there is need for routine cleaning and disinfection of the banks and their equipment to eliminate these pathogens that could pose public health hazard.

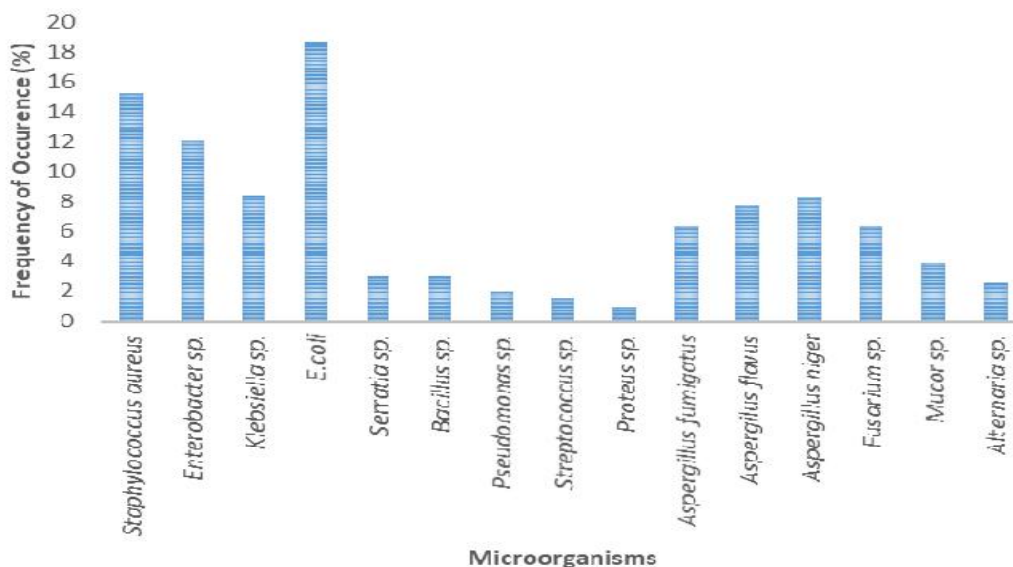


Fig. 1. Percentage distribution of Microorganisms isolated from Banks in EKSU campus



Table 4. Antibiotic susceptibility pattern of bacteria isolates from Banks in Ekiti State University Campus

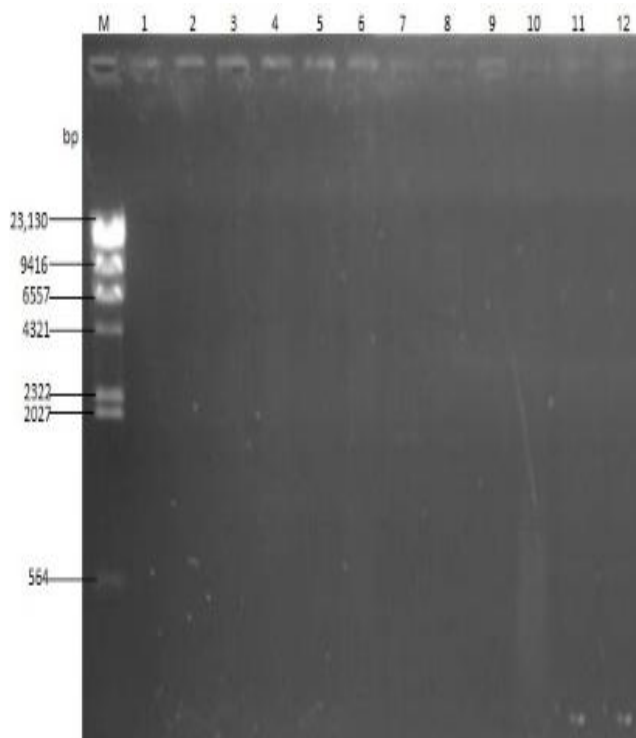
| Isolates' odes | Isolates                      | Zone of inhibition (mm) for antibiotic susceptibility test |       |        |        |        |        |        |       |       |        |        |
|----------------|-------------------------------|--|-------|--------|--------|--------|--------|--------|-------|-------|--------|--------|
|                |                               | AMX  | AU    | PEF    | ERY    | CN     | SXT    | CH     | CPX   | COT   | OFL    | STR    |
| A1             | <i>Escherichia coli</i>       | 0(R)   | 02(R) | 20 (S) | 0 (R)  | 11(R)  | 10(R)  | 05(R)  | 22(S) | 13(R) | 23(S)  | 07 (R) |
| A2             | <i>Enterobacter aerogenes</i> | 08(R)  | 02(R) | 25 (S) | 10 (R) | 21 (S) | 20(S)  | 12 (R) | 21(S) | 10(R) | 20 (S) | 10 (R) |
| H3             | <i>Klebsiella aerogenes</i>   | 10(R)  | 05(R) | 28 (S) | 07 (R) | 23(S)  | 25 (S) | 09 (R) | 20(S) | 12(R) | 21 (S) | 10 (R) |
| W4             | <i>Pseudomonas sp.</i>        | 08(R)  | 10(R) | 25 (S) | 0 (R)  | 21(S)  | 10(R)  | 17(S)  | 12(R) | 11(R) | 11(R)  | 15 (I) |
| E5             | <i>Serratia sp</i>            | 11(R)  | 11(R) | 20 (S) | 0 (R)  | 20 (R) | 20(S)  | 08 (R) | 11(R) | 08(R) | 20 (S) | 18 (S) |
| H9             | <i>Escherichia coli</i>       | 04(R)  | 12(R) | 10 (R) | 03 (R) | 10(R)  | 10 (R) | 11 (R) | 10(R) | 12(R) | 11 (R) | 10 (R) |
| U11            | <i>Escherichia coli</i>       | 0(R)   | 12(R) | 10 (R) | 10 (R) | 11 (R) | 10(R)  | 12 (R) | 11(R) | 12(R) | 10 (R) | 10 (R) |
| W13            | <i>Enterobacter aerogenes</i> | 10(R)  | 10(R) | 20 (S) | 0 (R)  | 21(S)  | 22(S)  | 09(R)  | 22(S) | 18(S) | 25(S)  | 22 (S) |
| U14            | <i>Klebsiella aerogenes</i>   | 12(R)  | 10(R) | 20 (S) | 0 (R)  | 21(S)  | 18(S)  | 18(S)  | 24(S) | 13(R) | 18(S)  | 18 (S) |
| A16            | <i>Serratia sp</i>            | 10(R)  | 05(R) | 25 (S) | 10 (R) | 10(R)  | 20 (S) | 03 (R) | 20(S) | 15(I) | 21 (S) | 23 (S) |
| F18            | <i>Enterobacter aerogenes</i> | 11(R)  | 05(R) | 26 (S) | 12 (R) | 14 (I) | 23(S)  | 08 (R) | 11(R) | 12(R) | 20 (S) | 10 (R) |
| H20            | <i>Serratia sp</i>            | 10(R)  | 10(R) | 25(S)  | 0 (R)  | 21(S)  | 21(S)  | 12(R)  | 22(S) | 10(R) | 28(S)  | 25 (S) |
| F21            | <i>Escherichia coli</i>       | 11(R)  | 10(R) | 10 (R) | 0 (R)  | 11 (R) | 10(R)  | 13 (R) | 11(R) | 12(R) | 20 (S) | 09 (R) |
| H22            | <i>Escherichia coli</i>       | 10(R)  | 11(R) | 10 (R) | 0 (R)  | 23(S)  | 10(R)  | 05(R)  | 12(R) | 05(R) | 23(S)  | 0 (R)  |
| H23            | <i>Escherichia coli</i>       | 05(R)  | 12(R) | 10 (R) | 03 (R) | 11 (R) | 11(R)  | 03 (R) | 11(R) | 0(R)  | 20 (S) | 0(R)   |
| A24            | <i>Klebsiella aerogenes</i>   | 10(R)  | 12(R) | 20 (S) | 10 (R) | 15(I)  | 10 (R) | 09 (R) | 10(R) | 12(R) | 24 (S) | 16 (I) |
| A25            | <i>Escherichia coli</i>       | 11(R)  | 10(R) | 20 (S) | 10 (R) | 21(S)  | 20(S)  | 03(R)  | 12(R) | 10(R) | 13(R)  | 09 (R) |
| A26            | <i>Serratia sp</i>            | 18(S)  | 03(R) | 22 (S) | 12 (R) | 11 (R) | 20(S)  | 18 (S) | 21(S) | 12(R) | 26 (S) | 10 (R) |
| E28            | <i>Enterobacter aerogenes</i> | 12(R)  | 0(R)  | 21(S)  | 10 (R) | 21(S)  | 22(S)  | 12(R)  | 22(S) | 05(R) | 23(S)  | 25(S)  |
| A29            | <i>Escherichia coli</i>       | 09(R)  | 0(R)  | 10 (R) | 05 (R) | 11 (R) | 10(R)  | 12 (R) | 11(R) | 08(R) | 20 (S) | 11 (R) |
| W30            | <i>Enterobacter aerogenes</i> | 10(R)  | 12(R) | 20(S)  | 12 (R) | 10(R)  | 20 (S) | 16 (I) | 20(S) | 11(R) | 21 (S) | 22(S)  |
| H32            | <i>Escherichia coli</i>       | 11(R)  | 10(R) | 20 (S) | 10 (R) | 13 (R) | 11 (R) | 12 (R) | 18(S) | 0(R)  | 20 (S) | 10 (R) |
| E33            | <i>Escherichia coli</i>       | 10(R)  | 0(R)  | 18 (S) | 10 (R) | 12 (R) | 10(R)  | 15 (I) | 20(S) | 0(R)  | 23 (S) | 10 (R) |
| E34            | <i>Enterobacter aerogenes</i> | 15(I)  | 11(R) | 18(S)  | 10 (R) | 10 (R) | 21(S)  | 18(S)  | 22(S) | 03(R) | 23(S)  | 20 (S) |
| H36            | <i>Serratia sp</i>            | 11(R)  | 06(R) | 20 (S) | 10 (R) | 18 (S) | 11 (R) | 12 (R) | 21(S) | 13(R) | 20 (S) | 22 (S) |
| W38            | <i>Pseudomonas sp.</i>        | 12(R)  | 10(R) | 23(S)  | 10 (R) | 10 (R) | 21(S)  | 12(R)  | 12(R) | 11(R) | 23(S)  | 12 (R) |
| H39            | <i>Escherichia coli</i>       | 11(R)  | 12(R) | 20 (S) | 10 (R) | 13 (R) | 11 (R) | 12 (R) | 21(S) | 10(R) | 10 (R) | 10 (R) |
| U40            | <i>Escherichia coli</i>       | 10(R)  | 12(R) | 21 (S) | 10 (R) | 12 (R) | 10(R)  | 11 (R) | 20(S) | 09(R) | 21 (S) | 10 (R) |
| F41            | <i>Klebsiella aerogenes</i>   | 12(R)  | 10(R) | 23(S)  | 10 (R) | 15 (I) | 21(S)  | 06(R)  | 22(S) | 04(R) | 23(S)  | 08 (R) |
| E42            | <i>Serratia sp</i>            | 16(I)  | 03(R) | 20 (S) | 10 (R) | 13 (R) | 11 (R) | 08 (R) | 25(S) | 11(R) | 20 (S) | 25(S)  |
| A43            | <i>Serratia sp</i>            | 18(S)  | 0(R)  | 21 (S) | 10 (R) | 18 (S) | 10(R)  | 17 (I) | 22(S) | 10(R) | 18 (S) | 20(S)  |

| Isolates' odes | Isolates                      | Zone of inhibition (mm) for antibiotic susceptibility test |       |        |        |        |        |        |       |       |        |        |
|----------------|-------------------------------|--|-------|--------|--------|--------|--------|--------|-------|-------|--------|--------|
|                |                               | AMX  | AU    | PEF    | ERY    | CN     | SXT    | CH     | CPX   | COT   | OFL    | STR    |
| H46            | <i>Enterobacter aerogenes</i> | 10(R)  | 0(R)  | 22 (S) | 10 (R) | 12 (R) | 10(R)  | 20 (S) | 24(S) | 10(R) | 21 (S) | 10 (R) |
| E47            | <i>Escherichia coli</i>       | 11(R)  | 10(R) | 23(S)  | 10 (R) | 10 (R) | 21(S)  | 11(R)  | 22(S) | 12(R) | 23(S)  | 04(R)  |
| W48            | <i>Pseudomonas sp.</i>        | 12(R)  | 05(R) | 23(S)  | 10 (R) | 10 (R) | 21(S)  | 05(R)  | 24(S) | 08(R) | 23(S)  | 10 (R) |
| E50            | <i>Klebsiella aerogenes</i>   | 10(R)  | 10(R) | 20 (S) | 10 (R) | 15 (I) | 10(R)  | 05 (R) | 20(S) | 04(R) | 21 (S) | 15(I)  |
| H6             | <i>Staphylococcus aureus</i>  | 15(I)  | 10(R) | 19 (S) | 11(R)  | 10 (R) | 11 (R) | 09 (R) | 28(S) | 08(R) | 26 (S) | 21(S)  |
| 7H             | <i>Streptococcus sp.</i>      | 18(S)  | 04(R) | 23 (S) | 11 (R) | 20 (S) | 10(R)  | 17 (I) | 22(S) | 10(R) | 18 (S) | 20(S)  |
| A8             | <i>Bacillus sp.</i>           | 12(R)  | 10(R) | 24 (S) | 11 (R) | 12 (R) | 11(R)  | 22 (S) | 22(S) | 12(R) | 24 (S) | 11 (R) |
| E10            | <i>Staphylococcus aureus</i>  | 15(I)  | 08(R) | 20 (S) | 12 (R) | 13 (R) | 11 (R) | 10 (R) | 25(S) | 11(R) | 20 (S) | 21(S)  |
| E12            | <i>Bacillus sp.</i>           | 20(S)  | 09(R) | 25 (S) | 10 (R) | 20 (S) | 11(R)  | 15 (I) | 22(S) | 13(R) | 19 (S) | 22(S)  |
| A15            | <i>Streptococcus sp.</i>      | 10(R)  | 05(R) | 21 (S) | 10 (R) | 11 (R) | 13(R)  | 21 (S) | 24(S) | 12(R) | 21 (S) | 10 (R) |
| H17            | <i>Staphylococcus aureus</i>  | 17(I)  | 10(R) | 22 (S) | 13 (R) | 13 (R) | 12(R)  | 09 (R) | 25(S) | 11(R) | 20 (S) | 23(S)  |
| E19            | <i>Bacillus sp.</i>           | 23(S)  | 08(R) | 22 (S) | 14 (R) | 19 (S) | 11(R)  | 17 (I) | 22(S) | 13(R) | 26 (S) | 20(S)  |
| E27            | <i>Streptococcus sp.</i>      | 11(R)  | 10(R) | 24 (S) | 12 (R) | 10 (R) | 13(R)  | 21 (S) | 21(S) | 10(R) | 23 (S) | 10 (R) |
| F31            | <i>Bacillus sp.</i>           | 15(I)  | 13(R) | 25 (S) | 11 (R) | 10 (R) | 12 (R) | 05 (R) | 22(S) | 11(R) | 20 (S) | 20(S)  |
| A35            | <i>Bacillus sp.</i>           | 19(S)  | 10(R) | 20 (S) | 13(R)  | 20 (S) | 11(R)  | 16 (I) | 20(S) | 10(R) | 18 (S) | 18(S)  |
| E37            | <i>Staphylococcus aureus</i>  | 13(R)  | 10(R) | 21 (S) | 10 (R) | 12 (R) | 13(R)  | 22 (S) | 20(S) | 10(R) | 21 (S) | 10 (R) |

Key – AMX-Amoxicillin, AU-Augmentin, COT-Cotrimoxazole, PEF- Pefloxacin, ERY-Erythromycin, CN-Gentamycin, SXT-Septrin, CH-Chloramphenicol, SP-Spafloxacin, CPX- Ciprofloxacin, CRO-Cotrimoxadole, OFL-Ofloxacin, STR-Streptomycin; A=Access Bank, E=Eco Bank, H=Heritage Bank, W=Wema Bank, F= First Bank and U= UBA Bank

**Table 4. Class, types, number and percentage of resistant and susceptible antibiotics**

| Class of antibiotics | Type of antibiotics     | Number and percentage of resistance | Number and percentage of susceptibility |
|----------------------|-------------------------|-------------------------------------|---|
| Penicillins          | Amoxycillin (25 µg)     | 48(96%)                             | 2(4%)                                   |
|                      | Augmentin (30 µg)       | 50(100%)                            | -                                       |
| Quinolones           | Ciprofloxacin (10 µg)   | 11(22%)                             | 39(78%)                                 |
| Macrolides           | Erythromycin (5 µg)     | 50(100%)                            | -                                       |
| Aminoglycosides      | Gentamycin (10 µg)      | 29(58%)                             | 21(42%)                                 |
|                      | Streptomycin (30 µg)    | 36(72%)                             | 14(28%)                                 |
|                      | Chloramphenicol (30 µg) | 43(86%)                             | 7(14%)                                  |
| Fluoroquinolones     | Ofloxacin (5 µg)        | 5(10%)                              | 45(90%)                                 |
|                      | Pefloxacin (5 µg)       | 5(10%)                              | 45(90%)                                 |
| Sulfonamides         | Cotrimoxazole (25 µg)   | 48(96%)                             | 2(4%)                                   |
|                      | Septrim (30 µg)         | 16(32%)                             | 34(68%)                                 |



**Plate 1. Plasmid profile of the resistant bacteria isolates from different bank**  
*M: Marker; 1-12: Resistant bacteria isolates*

#### 4. CONCLUSION

The research has revealed the presence of pathogenic bacterial and fungal species in the banks and banks facilities examined. Microorganisms like *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus sp.*, *Klebsiella spp*, *Aspergillus fumigatus*, *Aspergillus flavus* isolated from these banks are recognized as causative agents of infectious diseases. Multiple resistance to antibiotics

displayed by these isolates present public health concern. Measures to ensure that transfer of infections through this route is eradicated are exigent. Bank users should also be furnished with information on the presence of pathogens in banks and the risk of acquiring infections through the use of this facility. Routine disinfection of the banks and its equipment should be strictly adhered to. Hand washing exercise should also be encouraged after use.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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