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Bacterial Profile of Indoor Air of Kebbi State University of Science and Technology, Aliero, Kebbi State, Nigeria

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**ABSTRACT**

*Bacteriological analysis of indoor environment was carried out in some strategic indoor environments cutting across four different locations in Kebbi State University of Science and Technology, Aliero, Nigeria with the view to isolate and identify bacteria present in the indoor air. A total of twenty samples were collected during the course of this study, out of which five samples were collected from each of the locations (Classrooms, Minimarkets, Hostels and Staff quarters). All samples were collected using settling plate methods. Enumeration of bacteria was carried out using the standard plate count; and the results revealed that the Student hostel harbored more bacteria ( $1.08 \times 10^2$  cfu/aqi) when compared with other locations. Staff quarters had the least bacterial counts ( $3.0 \times 10^1$  cfu/aqi). A total of six bacteria were identified which include *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus* spp, *Bacillus* spp, *Klebsiella* spp, *Micrococcus* spp and *Escherichia coli*. Considering the fact that some of the isolated bacteria are associated with gastrointestinal tract infections (i.e. *E. coli* and *Bacillus subtilis*) and also respiratory tract infections (i.e. *Klebsiella* spp.), this may constitute a great health hazards to the populace.*

**Key words:** Bacteriological, Health, Hazard, Indoor, Air, and Quality

**INTRODUCTION**

Indoor air quality is one of the most significant factors affecting the health and wellbeing of people. Annals of Agricultural and Environmental Medicine (ACGIH, 1995), reported that people inhale  $10\text{m}^3$  of the air every day and spend between 80-95% of their lives indoors. The air inhaled by people is abundantly populated with microorganisms which form so-called

bioaerosol. Bioaerosol is a colloidal suspension, formed by liquid droplets and particles of solid matter in the air, whose components contain or have attached to them fungal spores, viruses, conidia and bacterial endospores (ACGIH, 1995).

Possible sources of biological contamination of indoor air includes: people, organic dust, various materials stored in the building and the air flowing from the

ventilation and air conditioning systems. Microorganisms may affect the general health of people who live in such places. Indoor air quality is rapidly becoming an environmental concern because a significant number of people spend most of their time in a variety of different indoor environment. This indoor environment includes but is not limited to homes, offices, hotels, restaurants, Government buildings, factories, Warehouses and vehicles including cars, planes, buses and trains (Holmes *et al.*, 1987).

The findings of epidemiological research indicate that exposure to high concentrations of microbes in the air frequently leads to allergies, asthma, hay fever, pneumonia and many other health side effects. Infectious biological factors such as fungal spores and mite are involved in sick building syndrome, a complex situation in which occupants experience a variety of symptoms and becomes generally unwell, recovering only when they cease to frequent the building (ACGIH, 1995).

Other symptoms of health problem caused by biological pollutants include sneezing, watery eyes, coughing and shortness of breath, dizziness, lethargy, fever and digestion problems (Fisk, 2001). Many allergic reactions caused by biological allergens occur immediately after exposure; other allergic reactions are the result of previous exposures that a person may not have been aware of as a result people who have noticed only mild allergic reactions or no reactions at all may suddenly find themselves very sensitive to a particular allergen. Children, elderly people and people with breathing problems and lung diseases are particularly susceptible to these diseases. Airborne bacteria are the causes of many

nosocomial and community acquired infections. The most implicated in this regard are the airborne gram-positive cocci (e.g.: *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, coagulase negative *Staphylococci*, *Enterococcus faecium*, and *Enterococcus faecalis*). Some of the most serious non-nosocomial infections are those caused by airborne Gram – positive *Bacilli* (e.g. *Bacillus anthracis*).

In view of the health hazard associated with the indoor air within the public buildings, regular monitoring of the indoor air quality becomes a paramount issue in order to safeguard the health of the populace. This study is therefore aimed at identifying the bacteria associated with the indoor environment within the study area with the view to create awareness on the dangers/health hazard associated with such bacteria.

## MATERIALS AND METHODS

### *Collection and processing of samples*

Samples were collected using the passive sedimentation method in 150mm diameter Petri-dishes containing nutrient agar (NA) media. A total of five samples each were collected from four different locations (i.e. student hostels, classrooms, and minimarket and staff quarters). All samples from air were collected by the plate settling method (Pelczar, 1985). The plates were exposed at different locations in each of the indoor environments for 20minutes each. The plates were positioned 2m high-roughly human respiration height close to an open window. All plates were then incubated at 37°C for 24-48 hours. The colonies developed were counted using colony counter (Fawole and Oso, 1998).

### Isolation of bacteria

Different colonies observed from different culture plates after 24-48 hours were selected and further sub cultured on nutrient agar using streak plate technique. The pure cultures were inoculated into sterile nutrient agar slants and incubated at 37°C for 24 hours. The slants were kept in the refrigerators for further analysis.

### Characterization and identification of isolates

The bacterial isolates were characterized and identified based on colonial morphology, cultural characteristics and biochemical tests. These biochemical tests include: Gram's staining, coagulase test, catalase test, vogues - Proskauer tests, indole tests, carbohydrate fermentation test, methyl red test, sodium azide test, starch hydrolysis tests as described by Cheesbrough, (1998);

Cowan, (1974) and Cruikshank *et al.*, (1973). The colonial morphology of the isolates was examined and characteristic colonies were identified and compared with those of known taxa described by Cheesbrough, (1998).

### RESULTS

The bacterial load of air samples collected from four different locations in Kebbi State University of Science and Technology Aliero is presented in Table 1. There was significant difference ( $p > 0.05$ ), between the bacterial load of the indoor air within the student hostel compared to the staff quarters. But there was no significant difference ( $p < 0.05$ ) among the three locations (i.e. Staff quarters, Classrooms and Minimarket). The results were subjected to statistical analysis using Analysis of Variance (ANOVA).

**Table 1:** Bacterial load of air samples

Sample location	Bacterial load (cfu/aqi)
Students' hostel	$1.08 \times 10^2 \pm 6.1 \times 10^{1b}$
Staff quarters	$3.0 \times 10^1 \pm 1.2 \times 10^{1a}$
Classrooms	$8.7 \times 10^1 \pm 4.8 \times 10^{1ab}$
Minimarket	$6.3 \times 10^1 \pm 3.0 \times 10^{1ab}$

### Frequency of occurrence of bacteria

The prevalence of most of the bacteria found in the various indoor environments varied. The student hostels contained more bacterial load than the staff

quarters, classrooms, and the minimarket. *Staphylococcus* species were more frequently isolated, followed by *Micrococcus* species. *Escherichia coli* had the lowest number.

**Table 2:** Frequency of occurrence of bacteria

Bacteria	Frequency of occurrence	Percentage occurrence (%)
<i>Staphylococcus aureus</i>	9	23.8
<i>Staphylococcus epidermis</i>	4	10.0
<i>Streptococcus</i> species	3	8.0
<i>Micrococcus</i> species	7	18.0
<i>Bacillus</i> species	7	18.0
<i>Escherichia coli</i>	2	6.3
<i>Klebsiella</i> species	6	15.9
<b>TOTAL</b>	<b>38</b>	<b>100.0</b>

## DISCUSSION

The study revealed that the hostels harbored more bacteria ( $3.0 \times 10^1$  cfu/aqi) as shown in Table 3.1 than all other indoor environments. This could be attributed to the large population of people living in close proximity as compared to other locations. The prevalence of the organism found in the indoor environments varied. For example, the hostel and the classrooms harbored more bacteria species than the staff quarters and minimarkets. Gram positive bacteria were more frequently isolated in the air. This may be due to the fact that they survive under dry conditions fairly well and may remain alive in the dust for long period of time. Also, gram positive bacteria are in general more resistant to drying than gram-negative bacteria due to their thicker and more rigid cell wall as reported by Madigan et al., (2004). *Staphylococcus aureus* was most frequently isolated compared to other isolated bacterial species. The prevalence of this organism may be attributed to the predominance of the organism in nature. *Staphylococcus aureus* is widely distributed in the environment and the primary habitats are the skin of man from where these organisms are easily transferred to the environmental surfaces.

The high prevalence of *Staphylococcus aureus* (23.8%) in this study (Table 3.2) should be viewed seriously as the organisms is responsible for pyogenic infections. The organisms produce several endotoxins. The toxic products of these species are classified as blood cell toxins (Hemolysines and the Leukocidins), intestinal toxins and epithelial toxins. The hemolysin for example lyses red blood cells by disrupting their membranes and the leukocidins damage cell membranes of neutrophils and macrophages, also the white blood cells causing them to lyses. Some strains produce exotoxins called enterotoxins that act upon the gastrointestinal tracts of humans. A few strains produce the exfoliative toxins (Nolan and Beaty, 1976; Talaro and Talaro, 2002). *S. epidermidis* is not as invasive or toxic as *S. aureus*. It can also cause endocarditis, bacteremia, and Urinary Tract Infections (Singleton, 1999).

*Micrococcus* species were also isolated. They are not pathogenic and are normal inhabitants of the human body as reported by (Madigan et al., 2004). They are essential in keeping the balance among the various microbial flora of the skin. They are found in many other places in the

environments including water, dust and soil. *Micrococcus* can grow well in the environment with little water or high salt concentrations. Most are mesophiles, some like *Micrococcus antarcticus* (found in Antarctica) are psychrophiles. Also, *Micrococci* have been isolated from human skin, animal and dairy products, and beer. *M. roseus*, *M. denitricans*, *M. colpogenes* and *M. flavus* are found in the dust of air, soil, marine water and on the skin/skin glands/skin gland secretions respectively (Brooks et al., 2001; Patterson, 1996; Raina, 2000). In other studies, conducted by Ryan and Ray, (2004), they stated that it can be difficult to identify *Micrococcus* as the cause of an infection, since the organism is normally present in skin as micro flora and the genus is seldom linked to disease. In rare cases, death of immune compromised patients has occurred from pulmonary infections caused by *Micrococcus*. *Micrococci* may be involved in other infections, including recurrent bacteremia, septic shocks, septic arthritis, endocarditis meningitis and cavitating pneumonia (Immunosuppressed patients).

*Streptococcus* species were also isolated. The genus streptococcus comprises of a wide variety of both pathogenic and commensal bacteria which are found to inhabit a wide range of host, humans, horse, pigs and cows. Within the host *Streptococcus* are found often to colonize the mucosal surfaces of the mouth, nares and pharynx. However, in certain circumstances they may also inhabit the skin, heart or muscle tissue, intestine and upper respiratory tracts of humans (Fischetti, 1995; Franklam, 2002). Pathogenic *Streptococcus* of man includes; *S. pyogenes*, *S. pneumoniae* and *S. faecalis*. However,

many species are non-pathogenic. Among the pathogenic hemolytic *streptococci*, *S. pyogenes*, or group A *Streptococci* has been implicated as the etiologic agent of acute pharyngitis, impetigo rheumatic fever, scarlet fever, glomerulonephritis, invasive or necrotizing fasciitis (the flesh-eating bacteria infections), toxic shock syndrome, tonsillitis and upper respiratory infection. Some other *streptococci* species are responsible for many cases of bacterial pneumonia, meningitis, endocarditis, erysipelas as reported by Brooks et al., (2001) and Patterson, (1996).

*Streptococcus pneumoniae*, also called *pneumococcus*, is an important human pathogen that causes pneumonia, sinusitis, otitis media, and meningitis. Fecal *Enterococcal* species occur in great numbers in the bowel and cause urinary tract infections and endocarditis. *S. mutans*, belonging to the viridans species inhabits the mouth and contributes to tooth decay. Among the lactic specie, *S. lactis* and *S. cremoris* are used in commercial starters for the production of butter, cultured milk, and certain cheeses.

*Bacilli* species were also isolated from the indoor environment. The organism produces endospores. The majorities are motile by means of peritrichous flagella, and the spores of these organisms are common in soil and dust of the air and enable the organism to procreate in the environment (Lennet, 1985). For many years most, air borne *bacillus* species were dismissed as harmless contaminants with weak to non-existing pathogenicity. However, infections by these species are increasing reportedly in immunosuppressed patients and in drug addicts who do not use sterile needles and syringes. An important contributing factor is that spores are abundant in the environment

and the usual methods of disinfection and antiseptics are powerless to control them (Talaro and Talaro, 2002).

*Klebsiella* species were also isolated. *Klebsiella* is a genus of non-motile, gram negative bacteria with a prominent polysaccharide capsule. *Klebsiella* species are ubiquitous in nature. It inhabits the intestines (GIT) of humans and animals. It is important for normal health and function, it can also be found in respiratory and urogenital tracts of normal individuals. It is an opportunistic pathogen. *Klebsiella* species is one of the major causes of nosocomial infections. Also, *Klebsiella* species is well known in the environment and can be cultured from soil, water and vegetables (Brooks *et al.*, 2001; Precott *et al.*, 1999; Rayan and Ray, 2004). Colonization can lead to chronic lung infections with which the species is associated. Infection by this organism is promoted by the large capsule, which prevents phagocytosis. Some strains also produce toxins. Less serious infections caused by this organism is bronchitis. Others are nosocomial pneumonia, meningitis, bacteremia, wound infections and urinary tract infections (Nester *et al.*, 2003).

*Escherichia coli* were the least isolated. These are gram negative bacilli. *E. coli* is one of the many species of bacteria living in the lower intestines of animals, known as gut flora. When located in the large intestine, it assists with waste processing, vitamin K production and food absorption. Some strains have been isolated from the edge of hot springs. The *E. coli* strain o157:h7 is one of hundreds of strains of the bacteria that cause illnesses in human. *E. coli* can generally cause infections such as infantile diarrhea, travelers' diarrhea and extra-intestinal infections such as urinary

tract infections, meningitis, peritonitis, mastitis, septicemia and gram-negative pneumonia (Madigan *et al.*, 2004; Nester *et al.*, 2003; Talaro and Talaro, 2002).

## CONCLUSION

All indoor air environments studied harbored different species of bacteria including *Staphylococcus aureus*, *S. epidermidis*, *Streptococcus* species, *Micrococcus* species, *Bacillus* species, *Klebsiella* species and *Escherichia coli*. Bacterial numbers in the hostels were higher ( $3.0 \times 10^1$  cfu/aqi) than those in other locations ( $3.0 \times 10^1$ ;  $8.7 \times 10^1$  and  $6.3 \times 10^1$  cfu/aqi for staff quarters, class rooms and minimarket respectively) and the bacteria species were those associated with human bodies.

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