IMPACT OF AIR POLLUTION ON THE MICROBIOLOGICAL QUALITY OF READY TO EAT HAWKED FOODS SOLD AROUND A CEMENT FACTORY IN LOKOJA, NIGERIA

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ABSTRACT

Air pollution constitutes a major challenge to humans as it poses a lot of health issues. This study evaluated the effect of polluted air on ready to eat hawked foods sold around a cement factory. A total of fifteen (15) bacterial pathogens namely *Salmonella* sp., *Shigella* sp., *Bacillus* sp., *Escherichia coli, Klebsiella* sp., *Pseudomonas* sp., *Proteus* sp., *Micrococcus* sp., *Staphylococcus* sp., *Streptococcus* sp., *Streptococcus pyogenes, Enterobacter aerogenes, Bacillus* sp., *Bacillus cereus* and *Lactobacillus sp*. were isolated from air and hawked food samples. Seven (7) fungal species namely *Penicillium* sp., *Alternaria* sp., *Aspergillus niger, Aspergillus flavus, Fusarium* sp, *Rhizopus stolonifer* and *Mucor* sp. were isolated from both air and hawked food samples. Total aerobic bacteria had the highest count (7.8 × 10^1cfu/m^2/min) and *Shigella* sp. had the lowest count (3.7 × 10^1cfu/m^2/min) in the air samples. The high microbial load of these organisms in hawked food which ranges from 6.2 – 3.3 x 10^5cfu/g shows the likelihood of incidence of these organisms from air samples. For fungal species, air sample from the wall close to production line had the highest fungal count of 72 cfu/m^2/min and the air sample from the opposite side of the factory had the lowest fungal count of 52cfu/m^2/min. The correlation of the high incidence of these organisms in air and hawked ready to eat foods indicate that bioaerosols dispersed by dust from the cement factory are deposited onto exposed hawked foods. This study revealed that ready-to-eat foods

sold around the cement factory in Lokoja were highly contaminated with pathogenic bacteria and fungi which likely originated from polluted air. It is therefore recommended that continuous monitoring system should be established and pollution controls must be implemented. Government should put a policy or law to stiffen how food is been displayed in and around cement factories.

Keywords: Cement, Cement Factory, Air Pollution, Ready to Eat Hawked Foods and Microbiological Quality.

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INTRODUCTION

Cement is a binder, which reacts with carbon dioxide (CO_2) in the air independently, and can bind other materials together (Francis, 1977). During cement production, gases are released which contain particles that cause air pollution. These gases can be referred to as air pollutants. Air pollutants are mixtures of solid particles and gases in air emissions, chemicals from factories, dust, pollen and mold spores which may be suspended as particles. Some air pollutants are poisonous and inhaling them can increase the chance of health problems (Albeanu *et al*., 2004). The cement industry contributes significantly to the imbalances of the environment in particular air quality. The key environmental emissions are nitrogen oxides (NO_x), sulphur dioxide (SO_2) and grey dust (Albeanu *et al*., 2004). Cement production has detrimental environmental impacts such as airborne pollution in the form of dust, gases, noise

and vibration when operating machinery and during blasting in quarries, and damage to countryside from quarrying (Jeff and Hans, 2004).

Air serves as a mode of transport for the dispersal of bioaerosols (particles of biological origin e.g. bacteria, fungi, pollen, viruses that are important constituents of the atmosphere and could possess the potential to cause a variety of diseases in humans and animals). The composition and concentration of the microorganisms comprising the bioaerosols vary with source and their dispersal in air (Lighthart, 1994). The survival of microorganisms in air varies, though generally, fungal spores, enteric viruses and amoebic cysts are somewhat resistant to environmental stresses encountered during transport through air. Bacteria and algae are more susceptible, although bacterial endospores for example *Bacillus sp.* are quite resistant. In recent years, outdoor air quality has become an important issue, because of industrialization (Medrela-Kudar, 2003). Microorganisms present in the air originate from soil, plants, water and dispersed by dust. However, spore-forming bacteria and fungi are able to survive in bioaerosols and stay viable for a long time in the air (Dowd and Maier, 1999). Many microorganisms present in the air including viruses, bacteria, fungi, yeasts and protozoa, are associated with diseases occurring in humans, plants and animals (Dowd and Maier,1999). The most pathogenic fungi usually found in air samples are *Aspergillus niger, Aspergillus clavatus, Aspergillus avenaceus, Acremonium curvulum, Curvularia clavata, Penicillium chrysogenum, Aspergillus niger, Aspergillus flavus , Aspergillus fumigates* (Waleska, 2010)

Some pathogenic bacteria have been implicated in the air and they include *Staphylococcus epidermidis, Micrococcus lylae, Micrococcus luteus, Klebisella pneumoniae, Bacillus megaterium, Staphylococcus haemolytica, Staphylococcus saprophyticus* (Waleska, 2010).

Mancinelli and Shulls (1978) reported the incidence of the following organisms in air namely *Micrococcus, Aerococcus, Staphylococcus, Peptococcus, Peptostreptococcus, Neisseria,*

Streptococcus, Paracoccus, Pediococcus, Bacillus, Sarcina, Sporolactobacillus, Clostridium, Sporosarcina, Serratia, Pseudomonas, Leuconostoc, Xanthomonas, Lactobacillus.

Ready to eat foods are raw or cooked, hot or chilled foods that are ready for immediate consumption at the point of sale without further treatment (Tsang, 2002). Hawked foods are exposed to disease causing microorganisms in the air during vending resulting in diseases such as cholera, dysentery, typhoid fever and others. Hawked foods provide a source of readily available inexpensive nutritional meals to populations and a source of income to the vendors (Omemu *et al*., 2005). Hawked foods are often the most affordable source of ready-made meals for urban workers near their places of work. It is however, a veritable source of food borne pathogen (Abdussalam and Kaferstein, 1993). Exposed hawked foods are prone to microbial air contamination and consumption of such foods can lead to serious intoxication and health challenges. Food borne disease outbreaks linked with ready to eat foods have been associated with various food borne pathogens (Gilbreth *et al*., 2005).

Contamination of hawked food has been attributed to exposure to polluted environment, poor sanitation and poor hygienic practices by the vendors (Mensah *et al*., 2002). It is therefore necessary that adequate measures be put in place to ensure that ready to eat foods sold in highly polluted areas be adequately covered and not exposed.

The aim of this work is to evaluate the impact of polluted air around Obajana cement factory on the microbiological quality of ready to eat hawked food.

MATERIALS AND METHOD

Collection of Samples

Five hawked food samples namely rice, beans, spiced meat, sugar cane and *Fura de nono* were purchased from five different local vendors around a major cement factory in Lokoja.

Each food sample was collected into a sterile polythene bag and labelled appropriately at the point of collection. Air samples were gotten using the settling plate technique. The prepared agar plates of Potato dextrose agar (PDA), Plate count agar (PCA), *Salmonella –Shigella* agar (SSA), MacConkey agar and blood agar were exposed around the cement factory. The agar plates were placed 1m above the ground and 1m away from different locations of the wall close to the production line of the cement factory for 15 min (Wallace, 2012). The samples were immediately conveyed in aseptic condition to the laboratory for analysis.

Isolation and Enumeration of Microorganisms From Hawked Food Samples

Ten grams of each of the food samples were homogenized in 90ml of sterile peptone water and stomached using a stomacher at 360rpm for 1 min, after which the homogenized samples were serially diluted to a factor of 10^{-5} (Clarence *et al*., 2009). One ml of the 10^{-5} aliquot of each food sample was used to inoculate plates of PCA, SSA, Blood agar, MacConkey agar for the isolation of total aerobic organism, *Salmonella, Shigella, Streptococcus* and coliform respectively. The plates were prepared in duplicates and incubated under aerobic condition at 37^0C for 24 - 48h. For fungi, 1ml of the 10^{-5} aliquot of each food sample was used to inoculate PDA plates and was incubated at 25^0C for 3 - 5 days. The number of colonies in each plate was counted using the Quebec colony counter (Reichert, USA) and expressed as colony forming unit per gram of sample homogenate (cfu/g) (Clarence *et al*., 2009).

Identification of Bacterial Isolates from Air and Food Samples

The bacterial isolates were identified using their colonial morphology and biochemical characteristics. The colonial morphology examined the shape, sizes, edge, optical characteristics, colony surface, colour and elevation of the test isolates as described by Fawole and Oso (2004). The biochemical tests carried out included Gram staining, endospore

staining, catalase test, citrate utilization test, starch hydrolysis test, indole test, motility test, oxidase test and sugar fermentation test.

Identification of Fungal Isolates from Air and Food Samples

The fungal isolates were identified using cultural and morphological features according to the most documented keys in fungal identification (Samson and Varga, 2007). Fungal isolates were examined using morphological characteristics such as mycelia colour, shape of hyphae and spore structure. The fungal isolates were examined microscopically using the wet mount stain method was used.

RESULTS

This study investigated the impact of polluted air around the cement factory on ready to eat hawked foods. A total of fifteen (15) bacterial pathogens were isolated from air and food samples as shown in Table 1. The following bacterial pathogens were isolated from air samples *Salmonella* sp., *Shigella* sp., *Proteus* sp., *Micrococcus* sp., *Escherichia coli, Klebsiella* sp., *Pseudomonas* sp., *Staphylococcus* sp., *Bacillus sp., Enterobacter* sp., *Streptococcus sp., Streptococcus pyogenes,* while *Lactobacillus* sp., *Bacillus cereus, Bacillus sp., Escherichia coli, Enterobacter aerogenes, Micrococcus* sp., *Staphylococcus* sp., *Proteus* sp. and *Pseudomonas* sp. were isolated from hawked food samples.

Isolates

Parameters	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B1	B2	B3	B4	F1	F2	R1	R2	SMI	SM2	SM3	SC1	SC2	SC3
Morphological characteristics	Round , Black centers, Opaque ,Flat, Wavy	Round ,Pink, Opaque, Raised ,Entire	Filamentous, Milky, Translucent, Flat, Branching	Irregular ,Pink, Raised Undulate	Round, whitish, transparent, flat, undulate,	Irregular, Cream, Flat, Undulate, Smooth	Round, pink ,Opaque, Raised, Undulate	Wrinkled, Creamy, Opaque, Raised, Entire	Irregular, Pink, Transparent,Flat, lobate	Round, Cream, opaque ,Raised, rhizoid	Round, Creamy, Opaque , Flat, undulate	Circular , Pale White Opaque, Flat ,Smooth	Round, Pink, Opaque, Raised, Entire	Filamentous, Milky,translucent, Flat, branching	Tiny , Cream, Smooth, Convex, Punctiform	Round, White, Opaque, Raised, Entire	Irregular, pink, Opaque, Flat Undulate	Irregular, Pale, White, Flat, Smooth	Round, cream, Opaque, Raised, Entire	Round, pink, opaque, flat, entire, smooth	Wrinkled , Creamy, Opaque, Raised, Entire	Round, Pink ,Opaque, Raised, Entire	Irregular, , Pink, opaque, Raised, Undulate	Round, Cream, opaque ,Raised, rhizoid,
Cellular characteristics	G-ve rod	G-ve rod	G-ve rod	G+ve rod	G-ve rod	G+ve rod	G-ve rod	G-ve rod	G-ve rod	G-ve rod	G-ve rod	G+ve rod	G-ve rod	G-ve rod	G+ve rod	G-ve rod	G+ve rod	G+ve rod	G +ve rod	G-ve rod	G-ve rod	G-ve rod	G +ve rod	G-ve rod
Spore staining	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve
Motility test	+ve	-ve	+ve	-ve	-ve	-ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	+ve	+ve	+ve	-ve	+ve
Citrate utilization	+ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	-ve	+ve
Catalase test	-ve	-ve	+ve	+ve	-ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	+ve	+ve	+ve	+ve
Indole test	-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	-ve	-ve
Oxidase test	+ve	+ve	+ve	+ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	+ve

Starch hydrolysis	-ve	-ve	-ve	-ve	+ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	+ve	-ve	-ve	-ve
Sugar Fermentation Tests																							
Glucose	A+	A-	A+	A+	-	A-	A+	A-	A+	--	--	A-	A-	A-	A+	A+	A+	A-	A-	A+	A-	A+	A+	--
Maltose	--	A-	A-	--	A+	A+	A-	A-	A+	A+	A+	A+	A-	A-	A+	A+	A-	A+	A+	A-	A-	A-	--	A+
Sucrose	-+	A-	A-	--	--	A--	A+	A-	A+	A+	A+	A-	A-	A-	A+	A+	A-	A-	A-	A+	A-	A+	--	A+
Galactose	--	A-	A-	--	-+	--	A+	A+	A+	A-	A-	A-	A-	A-	A+	A+	A+	A-	--	A+	A+	A+	--	A-
Fructose	--	A-	A-	A+	A+	A+	A+	A-	A+	--	--	--	A-	A-	A-	A+	A-	--	A+	A+	A-	A+	A+	--
Most Probable Organism	*Salmonella sp*	*Shigella sp.*	*Proteus sp.*	*Micrococcus sp.*	*Klebsiella sp.*	*Streptococcus pyogenes*	*Escherichia coli*	*Bacillus sp.*	*Enterobacter sp.*	*Pseudomonas sp*	*Pseudomonas sp.*	*Staphylococcus sp.*	*Shigella sp.*	*Proteus sp.*	*Lactobacillus sp.*	*Enterobacter aerogenes*	*Bacillus cereus*	*Staphylococcus sp.*	*Streptococcus pyogenes*	*Escherichia coli*	*Bacillus sp.*	*Escherichia coli*	*Micrococcus sp.*	*Pseudomonas sp.*

Key: A1 – A10 = Isolates from air samples, B1 – B4 = Isolates from hawked cooked beans samples, F1 –F2 = Isolates from *fura de nono* samples, R1 – R2 = Isolates from hawked cooked rice samples, SM1 – SM3 = Isolates from hawked spiced meat samples, SC1 – SC3 = Isolates from hawked sugar cane samples.

A total of seven fungal species were isolated from air and food samples respectively. *Alternaria sp., Penicillium sp., Aspergillus flavus, Aspergillus niger* were isolated from air samples while *Mucor sp. Rhizopus stolonifer, Aspergillus niger,* and *Fusarium sp. were* isolated from food samples as shown in Table 2.

Table 2: Colonial and Microscopic Characteristics of Fungal Isolates.

Isolates	Sampling Location	Mycelia Colour	Type of hyphae	Spore Structure	Spore Appearance	Probable organism
OBJ A1	Air	Bluish-green	Aseptate	Conidiophores	Branched	*Penicillium* sp.
OBJ F	Fulani milk	Black	Aseptate	Sporangiosphore	Smooth, sporangium	*Mucor* sp.
OBJ A2	Air	Green	Aseptate	Conidiophores	Smooth conidiophores	*Aspergillus flavus*
OBJ A3 **OBJ SC**	Air, Sugar cane	Black Black	Aseptate Aseptate	Conidiophores Conidiophores	Condia globose Condia globose	*Aspergillus niger* *Aspergillus niger*
OBJ R1 **OBJ B**	Rice Beans	Black Black	Aseptate Aseptate	Sporangiospore Sporangiospore	Large sporangium Large sporanguim	*Rhizopus stolonifer* *Rhizopus stolonifer*
OBJ A4	Air	Black	Septate	Meiospores	Macroconidia	*Alternaria* sp.
OBJ SM **OBJ R2**	Meat Rice	Yellow Orange	Septate Septate	Condiophores Condiophores	Macroconidia Microconidia	*Fusarium* sp. *Fusarium* sp.

KEY: OBJ A1 – A4 = Air samples, OBJ B= Cooked beans, OBJ F= *Fura de nono*, OBJ SC = sugarcane, OBJ R1 – R2 = Cooked rice, OBJ SM =Spiced meat.

The bacterial count in air and hawked food samples are shown in Fig. 1 – 6. The total aerobic and coliform count in air, hawked cooked rice, hawked spiced meat, hawked sugar cane and hawked *fura de nono* were the highest as compared to other microorganisms in these samples. For hawked cooked beans, coliform had the highest count followed by *Salmonella* sp.

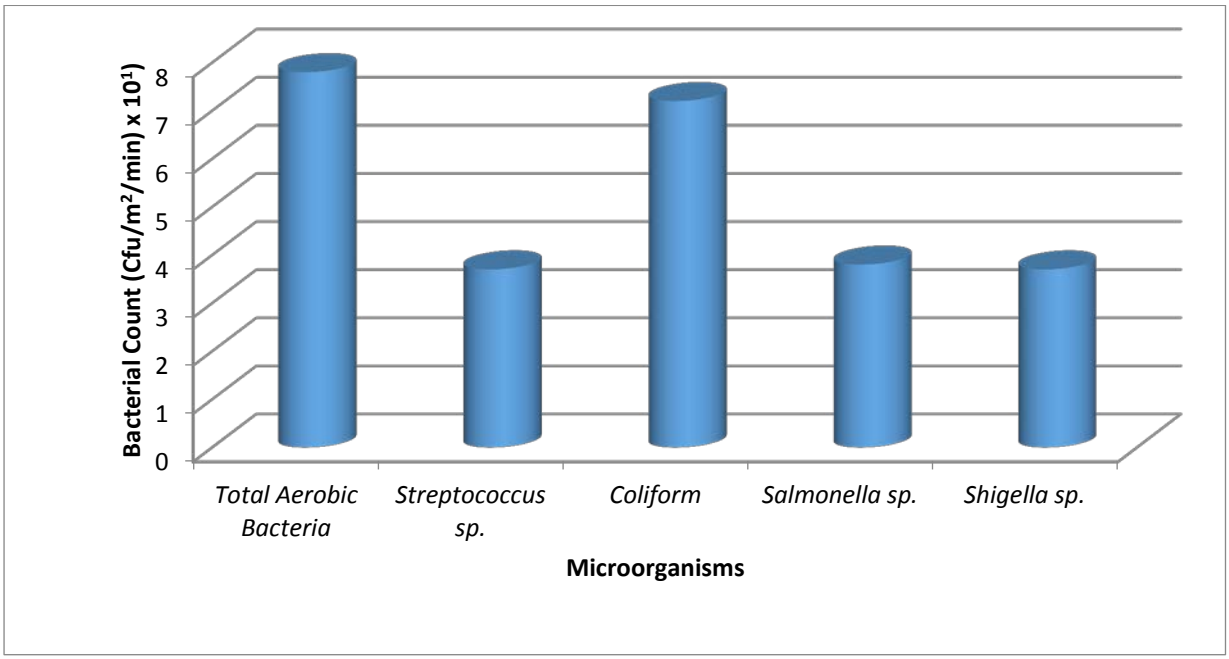

Figure 1: Bacterial Load of Air Samples (cfu/m^2/min) around Cement Factory.

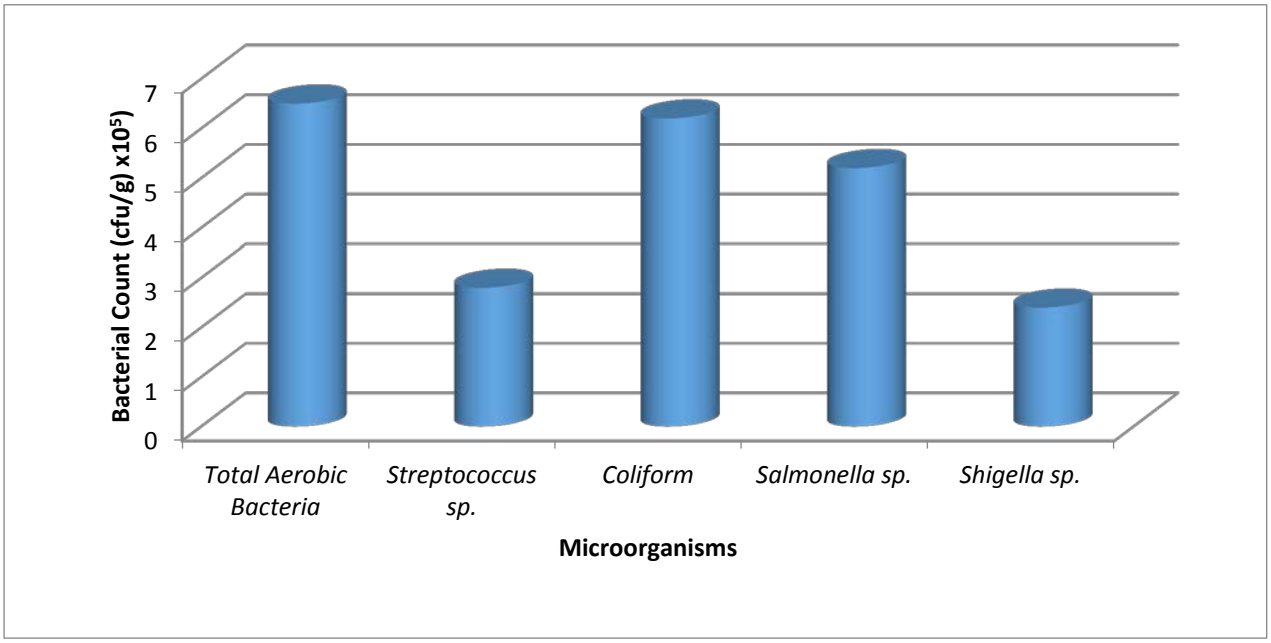

Figure 2: Bacterial Load in Hawked Cooked Rice Samples (cfu/g).

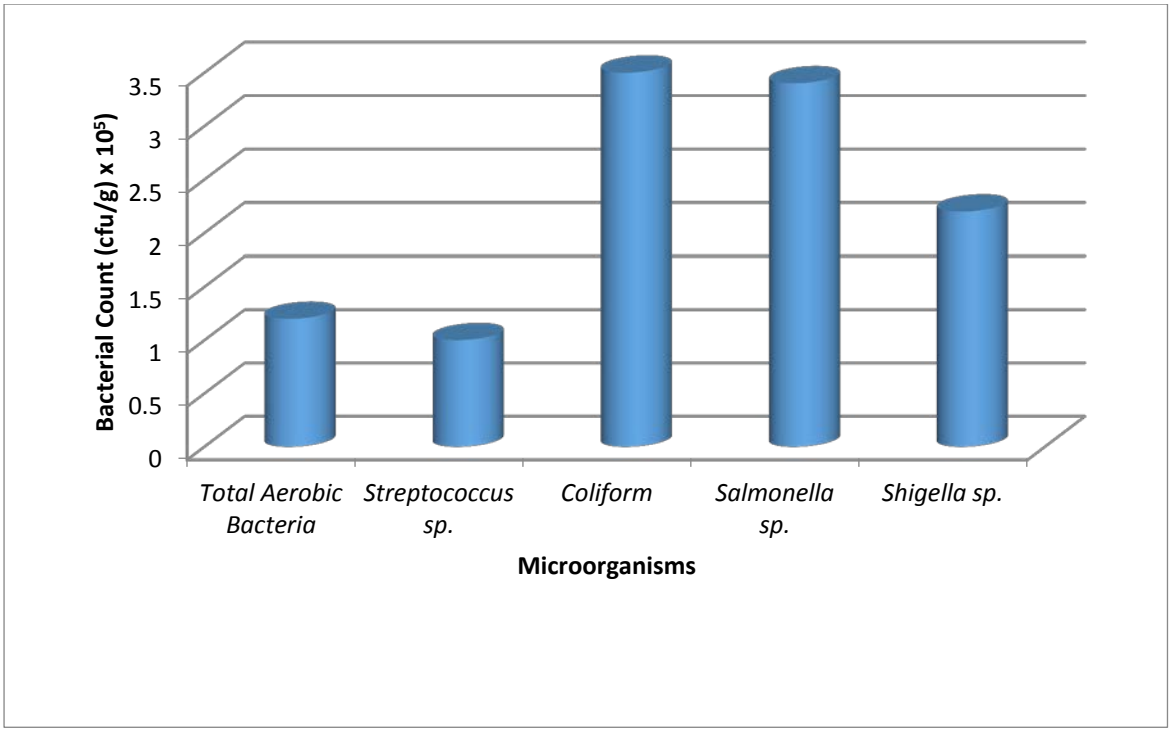

Figure 3: Bacterial Count of Hawked Cooked Beans Samples (cfu/g).

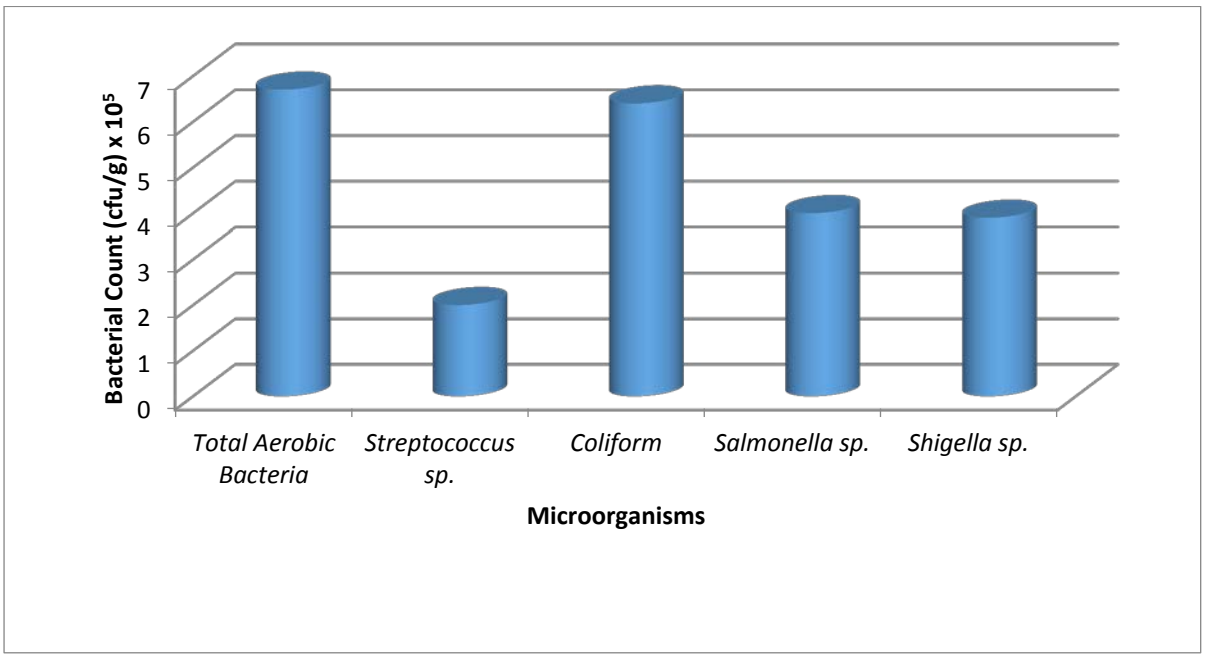

Figure 4: Bacterial Count of Hawked Spiced Meat Samples (cfu/g).

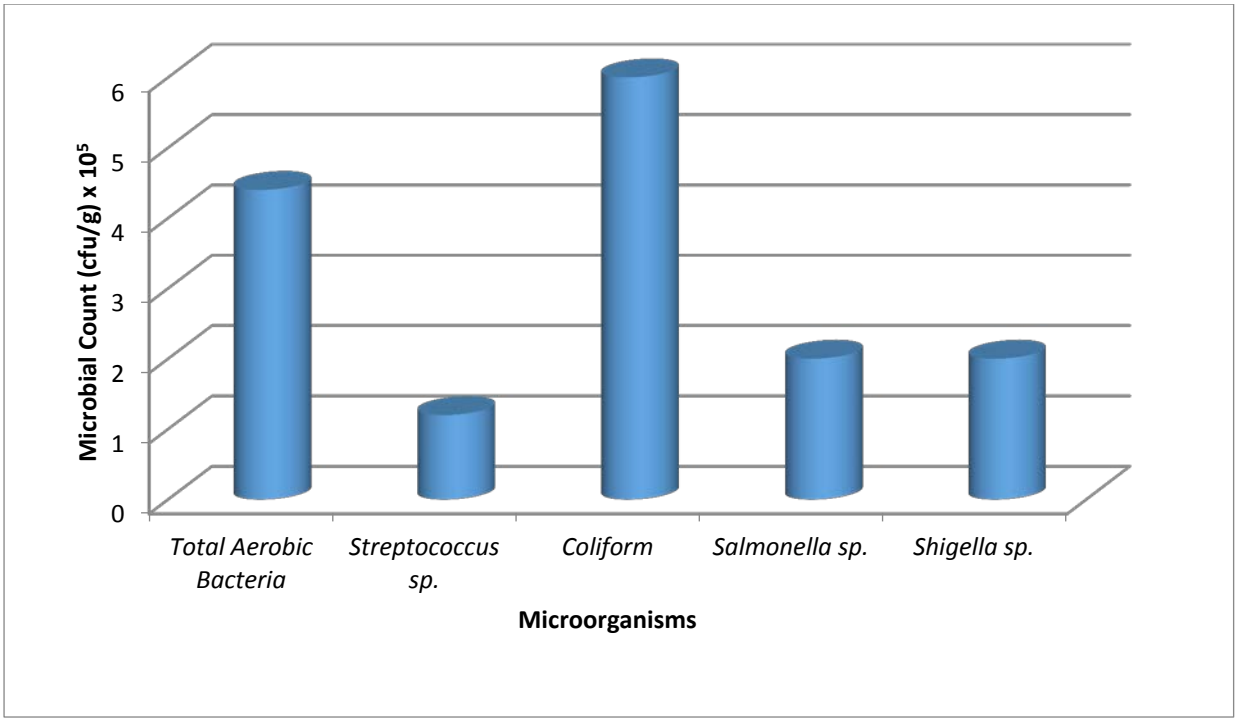

Figure 5: Bacterial Count of Hawked Sugar Cane (cfu/g).

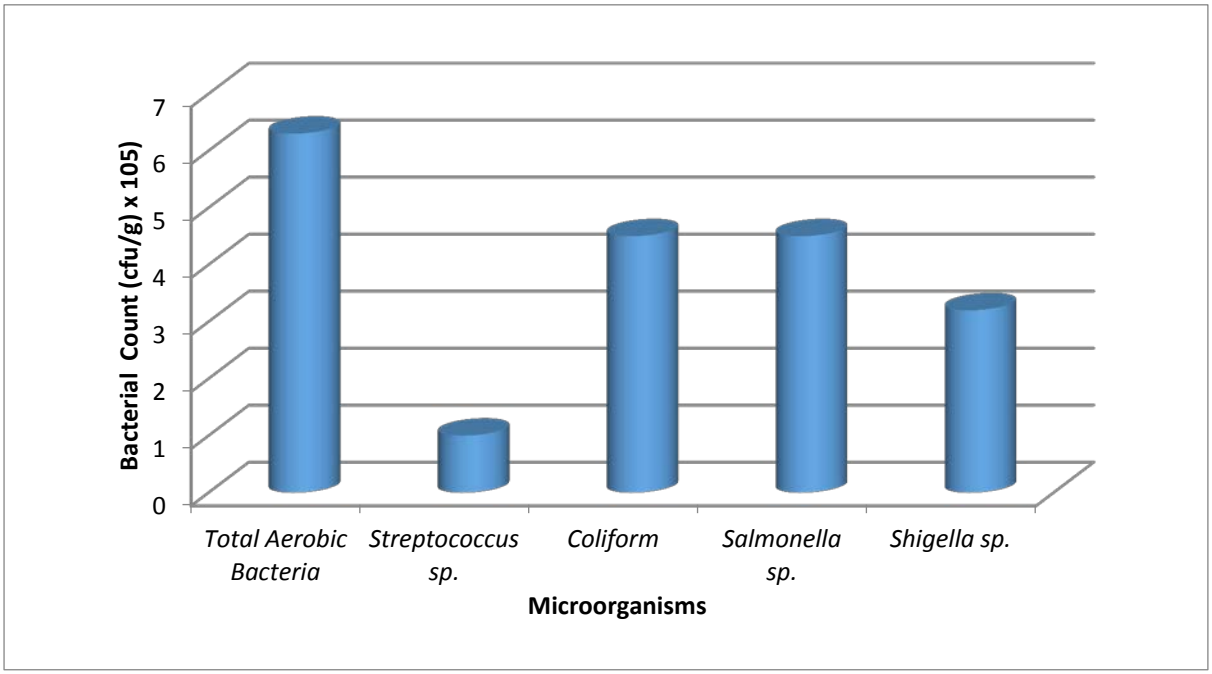

Figure 6: Bacterial Count of *Fura de Nono* samples (cfu/g).

Air and cooked rice had the highest percentage occurrence for *Streptococcus* sp. (15.2 and 18.8% respectively). The percentage occurrence of total aerobic bacteria was highest in air (31.6%) and spiced meat (33.4%). The occurrence of coliform was highest in sugar cane (38.2%) followed by spiced meat (30.4) however their occurrence in air was low (23.0%). The percentage occurrence pattern of *Salmonella* sp. and *Shigella* sp. were very similar. Cooked beans had the highest percentage occurrence (24.8%; 22.6%) followed by fura de nono (22.3%; 18.2%) as shown in Table 3.

Table 3: Percentage Occurrence of Microorganisms in Air and Food Samples

Microorganism	**% Occurrence of Microorganisms in Air and Food Samples**					
	Air	Cooked rice	Cooked beans	Sugar cane	Spiced meat	*Fura de nono*
Streptococcus sp.	15.2	18.8	10.6	8.0	9.8	6.1
Total aerobic bacteria	31.6	23.9	23.4	22.8	33.4	28.9
Coliform	23.0	23.7	28.6	38.2	30.4	24.5
Salmonella sp.	15.1	19.8	24.8	15.5	15.5	22.3
Shigella sp.	15.1	13.8	22.6	15.5	10.9	18.2

The air samples taken close to the production line had the highest fungal count while the air samples from the opposite side of the factory had the lowest fungal count as is reflected in Table 4.

Table 4: Fungal Count of Air Samples

Fungal Isolates	Fungal Count (cfu/m^2/min)
OBJ A_1	**72**
OBJA_2	**61**
OBJ A_3	**55**
OBJ A_4	**52**

KEY:
OBJ A_1-Air sample from the wall close to production line
OBJA_2 -Air sample from the factory main gate
OBJ A_3 -Air sample from the factory second gate
OBJ A_4 -Air sample from the opposite side of the factory

TABLE 5: Fungal Count in Food Samples

Food Samples	Fungal Count (cfu/g)
Cooked Rice	6.0×10^5
Cooked Beans	8.0×10^5
Spiced Meat	4.0×10^5
Sugar Cane	5.3×10^5
Fura De Nono	5.2×10^5

DISCUSSION

The impact of polluted air around the cement factory on ready to eat hawked foods were investigated and the result indicated that the microorganisms incident in the air also occurred

in the food samples and this shows that the presence of these organisms could be attributed to deposition of bioaerosols from the polluted air dispersing the organisms on the hawked foods. The most prevalent organism found in the air was aerobic bacteria including *Bacillus* sp. This bacterium isolated from both air and food samples are known as spore formers. The spores are able to survive in harsh conditions for decades or even centuries, when the spores are inhaled, digested, or come in contact with a skin lesion on a host they may become reactivated and multiply rapidly (Hudson *et al.,* 2006). *Bacillus cereus* found in food samples may be due to contamination from aerial spores carried in the air (Rajkowski and Bennett, 2003). The spores can survive normal cooking as they are heat resistant spore. This organism is associated with the production of toxin causing diarrheal and emetic illness as a result of food poisoning.

The high aerobic count could be as a result of contamination via dust, aerosols settling on the exposed ready to eat hawked food due to improper covering of food which allows the settlement of bioerosols and dust. Coliforms had the highest count in sugar cane and in beans and this could be attributed to the impure water sprayed on the sugarcane while hawking while for beans, it could be due to the proximity of the site of purchase to the production site where air pollution occurs as a result of emission from the factory. Beans having the needed nutritional requirement could serve as a suitable medium for bacterial and fungal growth. Coliforms are indicator organisms; their presence in ready-to-eat foods portrays possible danger. (Mudgil *et al.*, 2004; Tambeker *et al.*, 2008).

E. coli, Staphylococcus sp., *Bacillus cereus, Shigella* sp. *Salmonella* sp. and *Pseudomonas* sp. were isolated from the ready to eat foods indicating poor sanitary control and practices. These organisms are known food borne pathogens and opportunistic pathogens that have been implicated in food borne disease outbreaks (Mudgil *et al.*, 2004;Oranusi *et al.*, 2006; 2007; Tambeker *et al.*, 2008).

Escherichia coli is a normal flora of the human and animal intestine and has been identified as a leading cause of food borne illness all over the world. Although some *E. coli* are harmless, enterohaemorrhagic *E. coli* (EHEC) are capable of producing one or more toxin and a particular serotype O157:H7 have been associated with haemorrhagic colitis, haemolytic uraemic syndrome and thrombotic thrombocytopaenic purpura. Also enterotoxigenic *E. coli* (ETEC) is associated with traveler's diarrhea. The isolation of *E. coli*, may be as a result of poor environmental conditions due to dust, bioaerosols, contamination of the water and poor hygiene practices.(Talaro and Talaro, 2006; Mboto *et al*., 2012). *Shigella, Salmonella* and *Pseudomonas* sp. were isolated from the ready to eat foods indicating poor sanitary control and practices. These organisms are known food borne and opportunistic pathogens that have been implicated in food borne disease outbreaks (Mudgil *et al.*, 2004; Oranusi *et al.*, 2006; 2007; Tambeker *et al.*, 2008). *Shigella* sp. is of concern because this bacterium is the causative agent of bacillary dysentery in most developing countries today, which could be fatal in children if not diagnosed and treated on time. *Salmonella* are commonly associated with gastrointestinal infections as a result of eating contaminated food. They cause the disease condition known as salmonellosis and typhoid fever. *Klebsiella* sp. and *Pseudomonas* sp. are associated with respiratory tract infection and if left untreated could be life threatening both in children and adult (Abe *et al.*, 2012).

Streptococcus sp, has been frequently associated with acute sore throat (Adams and Moss, 2008). The presence of *Staphylococcus* sp. may be due to human contamination after production. This could be from direct human contact such as fingers or indirectly through additives or utensils. The organism is associated with endotoxin characterized by short incubation period (1-8h), violent nausea, vomiting and diarrhea.

The presence of *Mucor* sp, *Penicillium* sp., *Aspergillus niger*, *Aspergillus flavus*, *Fusarium* sp. *and Rhizopus stolonifer* in the food sample is not surprising as they are dispersed in the

form of spores which is abundant in the environment and can be introduced through dust and soil (Apinis, 2003). Their presence in these food samples is of serious public health concern as these fungi have all been implicated with the production of mycotoxin (Makun *et al*., 2009). The toxigenic strains *of Aspergillus flavus* have been known to produce aflatoxin, a potent hepatoxic and carcinogenic agent (Uraiah and Ogbadu, 1980). *Aspergillus niger* is known to produce protocathenic and oxalic acid which are toxic metabolites (Avedesh and Prakash, 1988). The fungal species isolated from the air sample were *Alternaria* sp., *Penicillium* sp., *Aspergillus* niger, *Aspergillus flavus*, *Alternaria* sp. *Aspergillus* sp. and *Penicillium* sp. are known as causative agents of fungal allergies they play a vital role in respiratory allergies (Agarwal and Gupta, 2011).

The percentage occurrence of microorganisms in air and food samples shows the correlation between air pollution and bioaerosol settling on exposed ready to eat hawked foods. Total aerobic count and *Streptococcus* sp. were highest in air samples and these could be the source for contamination of the hawked foods that had high incidence of these organisms.

The fungal count in air sample by the wall close to the production line was the highest which could be as a result of dispersal of bioaerosols aided by dust during production.

The fungal count in all food samples showed that cooked beans had the highest fungal count which could be as a result of beans having the needed nutritional requirement and thus serving as a suitable medium for fungal growth.

CONCLUSION

The incidence of pathogenic microorganisms in air in the hawked food indicates that these ready to eat food samples did not meet the bacteriological quality standard (WHO, 2007).

The findings of this study revealed that hawked ready-to-eat foods sold around the cement factory in Lokoja were highly contaminated with pathogenic bacteria and fungi and this could

be attributed to the polluted air within the vicinity of where the foods are hawked. This implies that these ready-to-eat foods are viable source of various diseases. Some of these diseases could spread and acquire epidemic status which poses serious health hazards. Therefore to ensure the safety of the foods, producer and hawkers must maintain a clean environment, minimize contact with the food samples after production and also maintain a high level of personal hygiene. It is therefore recommended that continuous monitoring systems and pollution controls be implemented in cement factories so as to minimize human health risk due to cement dust exposure. Government should also put a policy or law to stiffen how food is been displayed in and around factories. There is the need for establishment of national legislation that would restrict sales of ready to eat hawked food in strategic locations to reduce the level of contamination of food products.

REFERENCES

Abdulsalam, M. and Kaferstein, F.K.(1993). Safety of Street Foods. *World Health Forum* 14: 191 -194.

Abe, A.S., Inuwa, B., Abbas, H., Sule, A.M., Mohammed, H.A. and Gero, M.(2012). Identification and Characterization of Bacteria Air Pathogens from Homes in Zaria Metropolis. *International Journal of Science and Technology*, 2(7): 443 - 445.

Adams, M.R. and Moss, M.O.(2008). *Bacterial Agents of Food-borne Illness in Food Microbiology*, 3rd ed., The Royal Society of Chemistry, Cambridge,UK, p. 182-269.

Agarwal, R. and Gupta, D.(2011). Severe Asthma and Fungi: Current Evidence. *Medicine and Mycology*. 49(1): 150-157.

Albeanu, G.M., Popentiu, F and Thyregod, P.(2004). Computer Aided Statistical Modeling and Optimization for Pollution Control in Cement Plants. *African Journal of Microbiology Research*, 3(1): 60-65.

Apinis, A.E. (2003). Mycological Aspects of Stored Grain and Bio-deterioration of materials. *Applied Science*, 2(12): 493-498.

Avedesh, N. and Prakish, O.(1968). Toxic metabolites of *Aspergillus niger* and its role in onions and disease. *Indian phytopathology* 21(2): 217- 220.

Clarence, S. Y., Nwinyi, C. O. and Chinedu, N. S. (2009). Assessment of Bacteriological Quality of Ready to Eat Food (Meat pie) in Benin City Metropolis, Nigeria. *African Journal of Microbiology Research*, 3(6): *390-395.*
Dowd, S. C. and Maier R.M.(1999). *Aeromicrobiology and Environmental Microbiology*, 4th ed., Academic Press. p. 350 - 376.

Fawole, M.O and Oso, B.A (2004). *Laboratory Manual of Microbiology*, Spectrum books limited, Ibadan, Nigeria. p. 78 - 79.

Francis, A.J. (1977). *The cement industry, 1796 – 1914: A history by Francis Arthur James Newton Abbot*, North Pomfret publisher. p. 319 - 323.

Gilbreth, S. E., Call, J. E., Wallace, F. M., Scott, V. N., Chen, Y., and Luchansky, J. B. (2005). Relatedness of *Listeria monocytogenes* isolates recovered from selected ready-to-eat foods and listeriosis patients in the United States. *Applied and Environmental Microbiology,* 71: 8115 -8122.

Hudson, J.A., Daniel, R.M. and Morgan, H.W. (2006). Acidophilic and thermophilic *Bacillus* strains from geothermally heated Antarctic soil. FEMS, 60(3): 279- 282.

Jeff, G. and Hans, P. (2004). Assessment of Environmental Impact of the Holcim cement Dundee plant, Ecology centre, Retrieved October 13, 2007 http://www.wbsed.org viewed (20/06/2014).

Lighthart, B. and Stetzenbach, L.D. (1994). Distribution of Microbial Bioaerosols, In *Atmospheric Microbial Aerosols: Theory and Applications*, 5th ed. Chapman and Hall, New York, p. 68–98.

Mancinelli, R.L. and Shulls, W.A. (1978). Airborne Bacteria in an Urban Environment. *Applied Environmental Microbiology*, 35, p.1095 - 1101.

Makun, H. A., Gbodi, T. A., Akanya, O. H., Salako, A. E. and Ogbadu, G. H.(2009). Health Implications of Toxigenic Fungi found in Two Nigerian Staples: Guinea Corn and Rice. *African Journal of Food Science*, 3(9): 250-256.

Medrela –Kuder, E. (2002). Seasonal variations in the occurance of culturable airborne fungi in outdoor air in cracow. *International biodeterioriation and Biodegradation,* 52, p. 203 - 205.

Mboto, C.I., Agbo B. E., Ikpoh, I.S., Agbor, R.B., Udoh, D.I., Ambo, E. E. and Ekim, M.A. (2012). Bacteriological Study of Raw Meat of Calabar Abattoir with Public Health and Veterinary Importance. *Journal of Microbiology and Biotechnology Research Gate.* 2(4):529-532.

Mensah, P., Yeboah-Manu, D., Owusu., D. K, Ablordey A. (2002). Street foods in Accra Ghana: how safe are they? *Bulletin of World Health Organization*, 80, p. 546–554.

Mudgil, S, Aggarwal D and Ganguli A.(2004). Microbiological Analysis of Street Vended Fresh Squeezed Carrot and Kinnow – Mandarin juices in Patiala city, India. *Internet Journal of safety*, 3, p. 1-3.

Oranusi, S., Galadima, M., Umoh, V.J. and Nwanze, P.I. (2007). Food safety evaluation in boarding schools in Zaria, Nigeria using the HACCP system. *Scientific Research and Essay*, 2(10):426-433.

Oranusi, U.S. and Braide, W.*(2006*). A Study of Microbial Safety of Ready-To-Eat Foods Vended On Highways: Onitsha-Owerri, South East Nigeria. *International Research Journal of Microbiology*, 3(2): 66-71.

Omemu, A.M., Edema, M.O. and Bankole, M .O.(2005). Bacteriological assessment of Street vended ready-to-eat (RTE) salad in Lagos, Nigeria. *Nigerian Journal of Microbiology*, 19 (1): 497-504.

Rajkowski, K.T and Bennett, R.W (2003). *Bacillus cereus In* International Handbook of food borne Pathogens. M. D. Miliotis and J. W. Bier, 5th ed. Marcel Dekker, Inc. New York, p. 40 -51.

Samson, R.A. and Varga, J.(2007). Aspergillus Systematic in the Genomic Era .*CBS studies Mycology*, 2(5):59 – 62.

Talaro, K.F. and Talaro, A.E. (2006). *Foundation in Microbiology*. W. M. C. Brown Publisher, Dubuque. p.781-783.

Tambekar, D.H., Gulhan, S.R., Jaisingkar, R.S., Wangikar, M.S., Banginwar, Y.S, and Mogarekar M.R. (2008). Household Water Management: A Systematic Study of Bacteriological Contamination between Source and Point-of-Use. *American-Eurasian Journal of Agricultural and Environmental Science*, 3(2): 241-246.

Tsang, D. (2002). Microbiological Guidelines for Ready to Eat Food. *Road and Environmental Hygiene Department*, p.115-116.

Uraiah, M. and Ogbadu, G.(1980). Incidence of Aflatoxin in Nigeria Sorghum. *Microbios, 23*(10) :139 -142.

Wallace, D. (2012). *Air Sampling and Monitoring techniques.* 5th ed., Academic Press. p. 43- 52.

Waleska, D.M. (2010). Evaluations of the Presence of Some Pathogenic Microorganisms in the Air and on the Surface of Facilities of the Caguas Gymnastic Club, 1(5): 108 -111.

World Health Organization (2007). Food Safety and Food Borne Illness. Available at http://www.who.int/mediacentre/factsheets . Accessed (30/6/2014).