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Full Length Research Paper

Health and safety conditions of building maintenance sites in Nigeria: Evaluating the post occupancy contaminations of timber buildings by microorganisms

I. H. Mshelgaru[1]* and O. S. Olonitola[2]

[1]Department of Building, Faculty of Environmental Design, Ahmadu Bello University, Zaria - Nigeria.
[2]Department of Microbiology, Ahmadu Bello University, Zaria - Nigeria.

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This research assessed the safety of the environmental conditions of timber buildings as maintenance sites from cultivable microorganisms under various climatic conditions in Nigeria. Several site illnesses leading to poor work and reduced productivity on construction sites have been attributed to unidentified microorganisms or their metabolites. To identify the microorganisms, bulk samples were collected on timber buildings classified as maintenance sites over the country and then identify the microorganisms available using the cultivation technique. Eight hundred and fifty nutrient and Sabouraud dextrose agar dishes were prepared. The nutrient agar dishes were incubated for 24 h at 35°C whereas those of Sabouraud dextrose agar were incubated for 72 h at 30°C. Biochemical tests were used to classify the bacteria while fungi were identified via visual and microscopic observations. The sites were highly contaminated with *Enterobacter agglomerons, Serratia liquefaciens, Enterobacter hafniae, Staphylococcus aureus, and* other species of *Enterobacter, Serratia, Klebsiela, Bacillus,* and *Micrococcus. And among* fungi *species were; Penicilium, Mucor, Geotrichum, Alternaria, Trichoderma, Rhizopus, Paecilomyces, Gliocladium, Aspergillus, Syncephalastrum, Acrosporium, Mycelia sterilia, Cladosporium, Trichothecium, Chrysonilia and Saccharomyces.* Sixty four percent of construction workers experienced symptoms of sick building syndrome while on maintenance site. The most contaminated region is the rain forest.

Key words: Microorganisms, prevalence, sick-building-syndrome, contamination, productivity.

INTRODUCTION

Construction work has been described to comprise erection, construction, extension, alteration, conversion, fit-out, commission, renovation, repair, refurbishment, disassembly or decommissioning of a structure or part of a structure (CSIR, 2001; Nigerian National Building Code, 2006) and most of the components of construction are classified as maintenance (Seeley, 1987). The work place for building maintenance operations are usually post occupied buildings. The components of such post occupied buildings tend to deteriorate either as a result of mechanical- wear and tear; or decomposition (Seeley, 1987; Richardson, 1995); or chemical decomposition; or actions of foreign biological agencies such as insects and microorganisms (Dinwoodie, 2000; Viitanen et al., 2008).

Earlier studies by Johnstone (2001), Stevens (2004) and The Canadian Center for Occupational Health and Safety (2009) focused on effects of microorganisms on building materials in Canada and U S A; and Hyvarinen (2002) sampled the microorganisms (bacteria) in water damaged building in relation to illness in Finland. The National Academies, 2004; Canadian Center for Occupational Health and Safety (2009) recorded 500 - 1,000 freely floating fungi species in the air around the buildings in Canada. This quantity increases in multiples when the building components are disturbed during maintenance. Up to 5.0×10^8 cfu/g of bacteria have been identified in building in Finland (Hyvarinen, 2002). Studying micro-organisms in relation to Nigerian timber buildings gives peculiar knowledge on indigenous timbers in dissimilar weather conditions

*Corresponding author. E-mail: hassangaru468@gmail.com, mshelgaruisa@yahoo.com. Tel.: +234 69 876540, +234 803 4512 589.

which are different from that obtainable elsewhere.

The health and safety of maintenance sites refer to the well being of the already occupied buildings viewed as workplaces for maintenance activities. Sound timber components are universally accepted as natural and sustainable materials (Nofal and kumaran, 2007) but are more susceptible to microbial attack than most building materials. The maintenance activities may require the presence of work forces from the main contractors, sub-contractors, suppliers and persons authorized to be on the site. In Nigeria, the construction manager bears the responsible on behave of his clients to provide safety procedures and practice; safe workplace (Nigerian National Building Code, 2006) and safeguard lives and physical welfare of all. Menzies and Bourbeau (1997) and Harris and McCaffer (2001) also emphasized on microbial aspects of health and safety on construction sites.

The deteriorations due to microorganisms lead to emissions of Microbial Volatile Organic Compounds (MVOC's), dust mites, and allergens and so on that result to assorted health problems because the metabolites or the mere presence of the microorganisms have been associated to health effects (Nofal and kumaran, 2007). With the exception of the first and the last items, the rest are mainly caused by microorganisms, basically, bacteria and fungi. Pinchin Environmental Mississauga head office (2009) reported that the presence of any fungus is a potential for causing Sick Building Syndrome (SBS) and other forms of illnesses. In 1998, asthma associated with mould deteriorated dwellings costs between 11 and 35 million Euros and other moisture-related respiratory diseases cost between 12 and 23 million Euros Europe. It was also reported that in 2005, insurance companies paid out $2.5 billion in mould-related claims in Canada (Environmental and Energy study Institute, 2009; The National Academies, 2004; Canadian Center for Occupational Health and Safety, 2009). Mouldy buildings also present serious health risks to occupants and construction employees (World Health Organization, 2003; Stevens, 2004; Environmental and Energy study Institute, 2009). The consequences of the activities of the microorganisms on the performances of the work forces are enormous and can lead to reduced productivities, absenteeism and increased hospital bills.

MATERIALS AND METHODS

The study population was divided into four regions along the Sudan savanna, Guinea Savanna, Rain forest, and Swampy rain forest regions, guided by weather and climatic elements, such as temperature, rainfall, atmospheric humidity, and proximity to the sea (Bradford and Kent, 1994). The settlements within each region were selected based on local conditions and assumed manner of distributions of species of timbers used in building stocks available.

Bulk samples were collected on deteriorated timber samples from building components that showed visible signs of deteriorations as identified by a microbiologist. Eight hundred and fifty samples were aseptically collected and transferred into labeled airtight polythelene bags. Additional information relating to the function of building, the the part building from which sample was taken, and age of buildings were also collected. The samples were sealed in sterile containers before transportation to laboratory.

Structured SBS questionnaire was administered to employees on sites to investigate their perceptions of the presence of these micro-organisms and their metabolites when carrying out maintenance work in these buildings. Hundred and fifty questionnaires were distributed in each of the four zones to employees selected at random taking into account the microclimates of each study location. The questionnaire focused on information that was related to symptoms or ailments that were associated with presence of the identified microorganisms, MVOCs and microbial toxins. Maintenance operatives come into direct contact with high concentrations of each of these items before they are dispersed into the air. The effect of microbial toxins which are not airborne and cannot be detected easily by sampling the indoor air quality was also assessed by the perceptions sampling.

Cultivation of microorganisms

Nutrient agar (NA); Sabouraud dextrose agar (SDA) and triple sugar iron (TSI) Agar were used as the culture media. The media were prepared according to manufacturers' specifications and were sterilised at 121°C for 15 min. Stocks of one gramme in 10 ml of distilled water were prepared for each sample. The stocks were thoroughly shaken to dislodge microorganism cells into the water before dilution. The dilution of 10^{-3} and 10^{-5} were inoculated onto each labeled SDA and NA plates and evenly spread over the entire surface of the media using a sterile glass rod spreader. The NA plates were incubated at 37°C for 24 h while the SDA plates were incubated at room temperature for 72 h. Observations for colony developments were recorded on daily basis and when the growths matured, distinct colonies were counted and identified and characteristic colonies were transferred to slants containing 20 ml of media to generate pure cultures. Magnifying electronic counter was used to count bacterial and fungal colonies.

Identifications and classification of microorganisms

Fungi

Visual observations and observations through light microscopes were the main techniques used to identify the fungi. Dissection and light microscopic observations paid attentions to characteristic growth morphology and the presence and nature of conidia, septa, conidiophore, appendage, hyphae, texture, catenation, and colour features.

Bacteria

Gram-staining: Characteristic colonies grown on NA were obtained by pin inoculators and streaks of colonies were made on clean glass slides, stained by means of crystal violet, fixed with Lugols iodine and decolourised with 95% ethanol. Slides were counter-stained with diluted carbol fuchsin solution dried and observed under an oil immersion at a magnification of ×100. Bacteria isolates were classified according to their shapes and how they responded to the staining. Gram-positive cocci were classified as either isolated spherical or bundled spherical for the purpose of biochemical test.

Biochemical tests

Biochemical test of Triple Sugar Iron (TSI) comprising, glucose – 0.1%, lactose - 1%, and sucrose - 1% was used on some isolates.

Table 1. Mean concentrations of bacteria on sites in the Sudan savanna and Guinea savanna.

Species	Colony forming units per gramme (CFU /G)							
	Sudan savanna				Guinea savanna			
	Borno	Kano	Sokoto	Yobe	Adamawa	FCT	Kaduna	Plateau
Serratia species	-	-	-	-	5.000×10^{2}	-	-	2.020×10^{4}
S. liquefacians	-	6.750×10^{4}	1.650×10^{4}	-	1.054×10^{5}	3.000×10^{3}	8.400×10^{3}	4.680×10^{4}
Micrococcus	7.900×10^{4}	7.760×10^{4}	2.480×10^{4}	1.151×10^{5}	4.057×10^{5}	5.370×10^{4}	2.137×10^{5}	1.848×10^{5}
Staphylococcus aureus	-	1.970×10^{4}	-	-	-	4.200×10^{3}	-	-
Enterobacter spp	-	1.000×10^{2}	-	-	-	-	-	-
Klebsiela spp	-	1.300×10^{4}	-	-	4.200×10^{3}	-	-	-
Bacillus spp	2.199×10^{4}	1.028×10^{5}	2.591×10^{5}	6.680×10^{4}	9.670×10^{4}	1.573×10^{5}	3.840×10^{4}	1.261×10^{5}
E. agglomerons	1.540×10^{4}	1.750×10^{5}	-	7.400×10^{3}	2.870×10^{4}	6.800×10^{3}	2.700×10^{3}	3.780×10^{4}

Isolate inoculants were stabbed into TSI medium and incubated at 35°C for 24 h. The TSI test examines the possibility of the organisms to ferment the three sugars. Inoculants were streaked on the surface of slants and stabbed three times into the butt and incubated at 35°C for 24 h before recording the reactions. The reactions were either one or two or three of the sugars being fermented. Some reactions were accompanied by evolvement of gasses and hydrogen sulphate. The ability of the organisms to produce catalase enzymes were also tested by dipping isolates into a solution of one millimeter of a 3% hydrogen peroxide. Rapid evolvement of bubbles of gas as a result of breakdown of the hydrogen peroxide into oxygen and water by catalase enzyme was an indication of positive catalase test reaction. In the coagulase investigation, human plasma diluted with normal saline (10:1) was used. Half ml of the solution were added to nutrient broth and incubated at 37°C for 24 h. Signs of clotting of the broth which signified positive reactions were compared against already set controls (positive and negative) which served as guides. To distinguish whether the organisms were aerobic or anaerobic, the carbohydrate fermentation experiment was carried out using semi solid medium containing glucose and sucrose. Productions of acids in course of reactions were interpreted as either oxidative or fermentative, that is anaerobic and aerobic respectively, depending on whether the reaction took place on the surface or below the surface of the medium.

Investigations on gram-positive organisms for motility were conducted via observation of broth of cultured organisms under an oil immersion at magnification of ×100. Vigorous movements of the microorganisms in random directions signified positive motility. In indole assessment, the red colour in Kovac's and layer of alcohol solution indicated positive reactions while negative reactions retained normal yellow colour. The ability of the organisms to utilize citrate was tested on Simmon's citrate medium in which conversion of the green coloured medium to blue indicated positive citrate utilization test. Biochemical experiments of Methyl Red and Voges Proskauer using methyl red reagent and 1 ml of 40% potassium hydroxide and 3 ml of a 5% solution of K-naphthol in absolute ethanol were conducted. Reactions of bright red colour signified positive indicated methyl red test while development of pink colour that latter changed to crimson was positive Voges Proskauer test.

Assessments of employees' perceptions of effects of microorganisms

Six hundred structured SBS questionnaires were administered to maintenance employees on these sites to assess their perceptions of the effects of the microorganisms. Attentions were given to common symptoms of sick building syndromes such as headache, watery eyes, irritated eyes, nausea or dizziness, fatigue, wheezing, congested or runny nose, chest tightness, itching, sneezing, and allergies in cases of peculiar illnesses such as asthma within the periods spent on the sites.

RESULTS

Bacteria contaminations

Table 1 shows the concentrations of bacteria species and genera on the maintenance sites in the eight study locations in the Sudan and Guinea savanna regions.

Table 2 shows the concentration of different species and genera of bacteria in maintenance sites in six study locations in the Rain forest and the Swampy rain forest regions.

Fungi contaminations

Table 3 shows the concentrations of fungi on maintenance sites in the Sudan and Guinea savanna regions.

Table 4 shows the concentration of different fungi genera in six study locations in the Rain forest and Swampy rain forest regions.

Prevalence of microorganisms on maintenance sites in Nigeria

Figure 1 compares the mean Prevalence of microorganisms on logarithm reference on maintenance site in the country. The fourteen study stations corresponds with state areas in the four major and significant vegetational regions.

Table 5 shows percentage response of maintenance employees to symptoms of SBS working in timber building across the zones. These symptoms were reported to cease and not experienced as much when carrying out

Table 2. Mean concentrations of bacteria on sites in the Rain forest and Swampy rain forest.

Species	CFU/G					
	Rain forest			Swampy rain forest		
	Anambra	Ondo	Oyo	Delta	Lagos	Rivers
Serratia species	2.500×10^5	1.850×10^6	2.600×10^5	-	-	5.500×10^5
Serratia liquefacians	-	-	1.700×10^5	1.400×10^5	4.260×10^6	-
Enterobacter hafniae	2.610×10^6	1.320×10^6	-	2.450×10^6	-	9.800×10^5
Micrococcus	1.650×10^7	4.840×10^6	3.345×10^7	8.240×10^6	1.797×10^7	1.734×10^7
Staphylococcus aureus	4.260×10^6	2.200×10^5	4.970×10^6	1.700×10^5	3.900×10^5	3.650×10^6
Enterobacter species	5.000×10^4	5.000×10^4	6.000×10^4	1.100×10^5	-	-
Klebsiela species	-	5.300×10^5	9.300×10^5	1.800×10^5	5.000×10^4	5.100×10^5
Bacillus species	1.000×10^7	3.700×10^6	1.026×10^8	6.210×10^6	1.270×10^6	1.621×10^7
Enterobacter agglomerons	3.840×10^6	8.200×10^5	2.800×10^5	2.090×10^6	6.530×10^6	2.790×10^6

Table 3. Mean concentrations of fungi on sites in the Sudan savanna and Guinea savanna.

Fungi species	CFU/G							
	Sudan savanna region				Guinea savanna region			
	Borno	Kano	Sokoto	Yobe	Adamawa	FCT	Kaduna	Plateau
Acremonium	3.00×10^2	-	-	3.00×10^2	-	-	-	2.00×10^3
Alternaria	8.70×10^3	5.30×10^3	5.50×10^3	1.50×10^3	1.05×10^4	6.50×10^3	9.80×10^3	1.10×10^4
Aspergillus	2.87×10^4	2.90×10^3	8.40×10^3	1.10×10^3	5.20×10^3	1.90×10^4	4.60×10^4	3.56×10^4
Chrysonilia	-	-	4.00×10^2	-	-	1.80×10^3	1.50×10^3	-
Cladosporium	-	-	-	-	-	-	2.34×10^4	-
Geotrichum	-	-	-	-	1.20×10^3	1.00×10^2	-	1.40×10^3
Gliocladium	2.20×10^3	1.00×10^3	-	2.100×10^3	-	-	9.00×10^2	1.23×10^4
Mucor	1.30×10^3	-	5.00×10^2	3.00×10^2	-	6.00×10^2	6.80×10^3	-
Mycelia sterilia	7.00×10^2	3.60×10^3	7.00×10^2	8.00×10^2	3.00×10^2	4.00×10^3	5.00×10^2	1.40×10^3
Paecilomyces	-	-	-	-	1.00×10^3	1.30×10^3	-	-
Penicillium	-	-	-	-	-	-	1.00×10^2	8.00×10^2
Rhizopus	1.00×10^2	-	2.00×10^2	-	1.00×10^3	-	3.00×10^2	2.00×10^2
Saccharomyces	1.10×10^3	2.00×10^3	3.00×10^2	1.90×10^3	-	-	-	1.40×10^3
Streptomyces	-	-	-	-	1.30×10^3	-	5.30×10^3	8.70×10^3
Syncephalastrum	7.00×10^2	-	-	-	-	-	-	-
Trichoderma	-	3.00×10^2	-	-	-	-	7.00×10^2	-
Trichothecium	-	-	-	5.20×10^3	-	-	-	-
Yeast	2.30×10^3	3.90×10^3	6.00×10^2	2.60×10^3	3.20×10^3	3.00×10^3	7.90×10^3	1.75×10^4
Unidentified	7.00×10^2	6.50×10^2	2.00×10^1	5.40×10^2	3.64×10^2	3.00×10^2	1.00×10^3	5.10×10^3

operations in non timber structures.

DISCUSSIONS

Contaminant microorganisms (fungi and bacteria) are generally higher on the maintenance sites that are located where relative humidity and rain fall is relatively higher at the Rain and the Swampy rain forest regions (Figure 1). The difference that exists between the contaminations of sites in the dry regions of Sudan and Guinea savanna and the wetter regions is an indication that there has not been enough moisture in the dry regions for microorganisms to flourish and multiply. The contamination by moulds on these sites are fairly even on the buildings in the Rain forest and Swampy rainforest regions and also with another degree of contaminations for building both in the Sudan and Guinea savanna in the drier and hotter regions. On the other hand, the contaminations by yeast staggered from the Sudan savanna to the Swampy rain forest. The yeast contaminations increase with degree of wetness. Nofal and Kumaran (2007)

Table 4. Mean concentrations of fungi on sites in the Rain forest and Swampy rain forests.

Fungi species	CFU/G					
	Rain forest region			Swampy rain forest		
	Anambra	Ondo	Oyo	Delta	Lagos	Rivers
Acremonium	1.800×10^5	1.000×10^4	2.000×10^4	-	-	4.800×10^5
Alternaria	1.900×10^5	3.300×10^5	2.200×10^6	5.700×10^5	-	1.380×10^6
Aspergillus	1.290×10^6	1.470×10^6	3.040×10^6	2.010×10^6	8.970×10^6	2.340×10^6
Cladosporium	5.000×10^4	-	-	-	-	-
Geotrichum	2.400×10^5	-	5.800×10^5	-	1.600×10^5	2.400×10^5
Gliocladium	1.600×10^5	-	5.000×10^4	1.700×10^5	-	4.000×10^4
Mucor	2.800×10^5	1.200×10^5	-	1.300×10^5	8.000×10^4	3.100×10^5
Mycelia sterilia	3.000×10^4	-	1.900×10^5	-	2.600×10^5	1.000×10^4
Paecilomyces	9.000×10^4	8.000×10^4	8.000×10^4	-	-	-
Penicillium	7.000×10^4	1.700×10^7	-	5.000×10^5	7.200×10^5	3.000×10^5
Rhizopus	3.000×10^4	3.000×10^4	2.700×10^5	6.100×10^5	-	8.000×10^4
Saccharomyces	-	4.000×10^4	4.400×10^5	1.600×10^5	3.000×10^4	4.000×10^4
Streptomyces	-	-	1.200×10^5	2.300×10^5	2.200×10^5	5.000×10^4
Syncephalastrum	-	1.000×10^5	-	6.000×10^4	1.800×10^5	3.000×10^4
Trichoderma	-	4.000×10^4	4.900×10^5	-	-	-
Trichothecium	-	7.000×10^4	6.000×10^4	7.000×10^4	-	4.000×10^4
Yeast	4.400×10^5	2.400×10^5	1.800×10^5	8.700×10^5	2.000×10^5	2.700×10^5
Unidentified	2.000×10^4	1.100×10^4	3.100×10^4	8.000×10^4	4.200×10^5	5.800×10^4

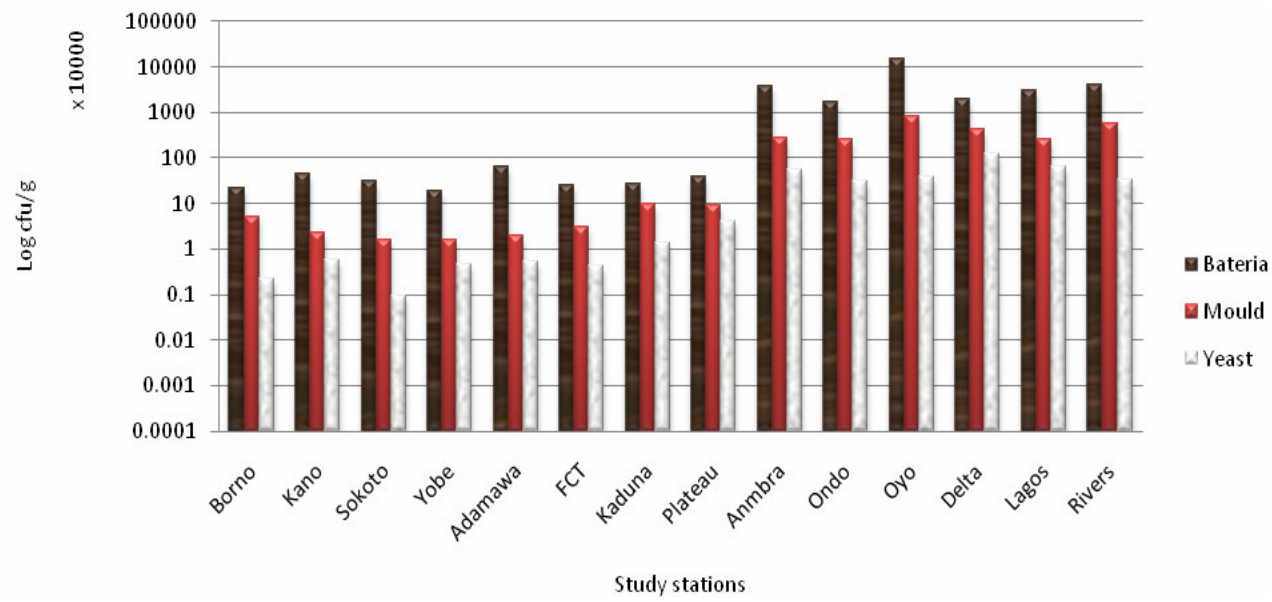

Figure 1. Mean prevalence of microorganisms on logarithm reference of ten

cited that the intensity of mould damage on timber in building are different because of the differences in weather and occupants' living habits and timber species and a concentrations of 5.0×10^8 cfu/g of bacteria have been identified in building materials in Europe (Hyvarinen, 2002).

Contaminations of maintenance sites in the Sudan savanna region

There is high contamination of bacteria on maintenance sites within the Sudan savanna region. The highest frequency of contamination by bacteria is in the Kano area

Table 5. Responses to symptoms of some Sick Building Syndromes on maintenance sites.

Frequency of symptoms	Offensive odour	Dry or Sore throat	Dryness of skin	Eye irritation	Running nose	Stuffy nose	Difficulty in breathing	Chest tightness	Flu like symptoms	Headache	Dizziness	Nausea	Drowsiness	Lethargy	Aches in arms	Chest pain	Inability to concentrate	Irritation	Hysteria	Stress	Allergies	Skin rashes	Total percentage
	Percentages																						
Always	26	32	4	13	5	2	17	4	5	25	12	10	7	10	16	9	15	42	36	33	4	3	15.00
Often	13	11	4	0	6	5	9	16	4	11	16	27	18	13	37	15	5	2	3	13	3	0	10.50
Sometime	45	33	55	65	33	48	40	50	47	42	31	39	45	37	22	43	36	30	27	41	28	19	38.91
Never	16	24	37	22	56	45	34	30	44	22	41	24	30	40	25	33	44	26	34	13	65	78	35.59

followed by Sokoto area, while Borno and Yobe have almost the same level of contamination (Table 1). Moulds contaminate sites higher in Borno but in Kano, Sokoto and Yobe the contamination is low. The yeast contaminants are virtually negligible except for Kano and Yobe where traces of slightly significant contaminations can be seen. There are more moulds on the sites from Borno area than in any of the other three sample sites.

Contaminations of maintenance sites in the Guinea savanna region

Bacteria contamination is more severe on maintenance sites located in Adamawa and Plateau areas of the Guinea savanna subregion. Maintenance sites in the Federal Capital Territory (FCT) and Kaduna zones are relatively less contaminated by bacteria. Sites in Kaduna and plateau areas are more highly contaminated by moulds compared to those in Adamawa and Federal Capital Territory (Table 3). Yeast which is not so common in some locations in this region highly contaminates buildings in the plateau area but the contamination is very minimal within the Federal Capital Territory.

Contaminations of maintenance sites in the rain forest region

Tables 2 and 3 compares the contaminations of maintenance sites in the three study areas with microorganisms. Sites in the Oyo area are mostly contaminated with bacteria species whereas the contaminations in the Anambra and Ondo areas are lower. Contaminations of buildings by moulds in the region are much more severe in the Oyo area than in the other two subregions of Anambra and Ondo. The high rain fall in the warm region contributes to the existence and survival of some more species of mould and bacteria that were not found in the Sudan and Guinea savanna regions. Yeast contaminants are relatively very low on all sites over the region.

Contaminations of maintenance sites in the swampy rain forest region

The sites within this region show high contaminations of different species of bacteria. The sites located at the Delta subregion are less contaminated with bacteria whilst those in the River areas were highly dominated (table 2 and 3). The levels of bacterial contaminations around Lagos area were slightly less than those in the Rivers zone. Mould contaminants are more on sites within the River area followed by those at Delta and then Lagos subregion. Yeast contaminations are significantly higher in the Delta area only.

Effects of microorganisms on construction employees and occupants

The highly dominant species of microorganisms encountered are generally ubiquitous and have been reported to be saprophytic, pathogenic, and allergenic *Aspergillus*; is the highest contaminant and its species are known to have serious health effects including in sick building syndrome, odour, mycotoxins. They also cause health and safety risks, lack of comfort and disturb well being of employees. Concentrations of microorganisms in indoor air qualities of buildings that contain deteriorating materials such as timber are very much higher than in ones without deteriorating materials (Ellringer et al., 2000).

The quantity and the general trend of microbial contamination obtained in this study which vary from one location to another but increases from the Sudan savanna in the northern part of the country to the swampy rain forest in the south. Most of the contaminations in the Sudan and the Guinea savanna are less than those obtained by Hyvarinen, (2002) in Finland but the value from the rain forest and the swampy rain forest are much higher. The differences are likely due to environmental differences as well as the type of building materials studied. Since moulds are the major degradants of building materials, as reported by Ellringer et al. (2000); Lebow and Highley (2009) their presence and prevalence are of great concern (Sustainable world, 2009). They are threats to timber buildings as well as the health of employees and occupants.

Bacterial contaminants will also pose some health threats on sites. The highest contaminants of bacterial genera are *Baccilus* and *Micrococcus* located in the Rain forest and Swampy rain forest regions. The *Enterobacter* specie had the least contamination and was found in the Sudan savanna region. The bacterial contaminations steadily increase also from the savanna region to the swampy rain forest region closest to the ocean. Since moisture is one of the fundamental requirements for growth, buildings in the areas of higher annual rain fall and relative humidity showed more intensive contaminations than those situated in the dry and low relative humidity Sudan and Guinea savanna regions in the northern part of the country. The species such as *Enterobacter hafniae, Staphylococcus aureus, Enterobacter,* and Klebsiela present in the Rain and Swampy rain forest*s were* not frequently encountered in the Sudan and Guinea savanna sub region. In addition, Viitanen *et al*; (2008) reported that species of bacteria found in building are responsible for biocorrosion of many different materials, smell, and health problems, especially at relative humidity greater than 97% and temperature between -5 to 60°C. Lebow and Highley (2009) demonstrated that the two greatest influences on regional biodeterioration hazard are temperature and moisture and this explains why concentrations of micro-organisms are much higher in the wetter and warmer southern zones.

The perception of the symptoms of microorganisms proved the presence of the identified microorganisms and the likelihood of them causing the assumed health hazards on the maintenance sites. Analyses of the perceptions test on Table 5 suggested 64% of maintenance employees experienced symptoms related to microorganisms, metabolites, mycotoxin and microbial related particulates while working on timber building sites. Symptom of nausea, irritation, headache, stress, sensing offensive odour, and dry throats were among the major complaints scored higher than what was reported by London hazard centre (1990) on peoples perception on indoor environments. The difference is as a result of the fact that microorganisms concentrations are higher in biodeteriorating buildings than non biodeteriorating ones and this level increases during maintenance work involving renovation, refurbishment, rehabilitation, revitalisation and deconstruction; decreasing back to baselines in few months after work and removal of the deteriorating materials (Ellringer et al., 2000). Only 21% experience skin rashes and 36% were allergenic when in contact with the deteriorating timbers.

SUMMARY

Maintenance sites in the Rain forest regions were more contaminated than those in the dry hot Sudan and Guinea savanna regions. There are higher contaminations of bacteria on sites in Kano, Adamawa, Oyo and Rivers. Mould contaminations are high on Borno, Kaduna, Plateau, Oyo and Rivers sites. The sites located at the Rain forest and Swampy rain forest areas were most endangered because of higher contaminations than those at the Sudan and Guinea savanna regions in the northern part of the country. This invariably indicates that maintenance sites in timber buildings in the southern zones are experiencing more health hazards than those in the northern zones.

Conclusion

The main microorganisms that inhabit timber on the maintenance sites in Nigeria are bacteria and fungi species. The dominant mould genera were *Aspergillus* and *alternaria* and have been reported by Berry et al., 1995; Cooley et al., 1998 and Doctor Fungus, 2009 to be both saprophytes and pathogenic. This means that the timbers serve as substrate on which they survive to impairment of health and well beings of employees. The usually reported resultant effects have been allergens, health problems, and sick-building-syndrome among others.

Therefore, with the presence of the timber inhabiting

microorganisms on maintenance sites, employees and even tenants of these post occupied buildings likely to be debilitated (Centers for disease control and prevention, 2009). This may lead to discomfort, absenteeism and lost of productivity on these sites.

REFERENCES

Berry R, Boxall J, Crump D (1995). Health Hazards of Building Materials. Building issues. Lund Univ., Lund Centre for Habitat studies.

Bradford M, Kent AK (1994). Understanding Human Geography: people and their changing Environment. Oxford Univ. press, Ibadan Nigeria.

Canadian Center for Occupational Health and Safety (2009). Biological Hazards, Indoor Air quality- Moulds and Fungi www.ccohs.ca. More Moulds in the Home www.uoguelph.ca.

Centers for disease control and prevention (2009). Building Environmental Health Capacity. National Centers for Environmental Health Services.

Cooley DJ, Wong WC, Jumper CA, Straus DC (1998). Correlation between the Prevalence of certain Fungi and Sick Building Syndrome. Occupat. Environ. Med. 55: 579.

CSIR (2001). Agenda 21 for Sustainable Construction in Developing Countries. First discussion document, version 2. Prog. for sustainable human settlements. Boutek, S. Africa.

Dinwoodie JM (2000). Timber: Its Nature and Behaviour. Second edition, published by E & FN Spon. 11, New Fetter lane, London.

Doctor Fungus (2009). Environmental and Industrial Infestation: Homeowners and Mould FAQ Summary, Environmental Moulds in the Home FAQ, Assessment for Environmental Moulds, Disease due to Environmental Moulds, and Sick Building Syndrome. www.doctofungus.org

Ellringer PJ, Boone K, Hendrikson S (2000). Building Materials used in Construction can affect indoor Fungal levels greatly. J. Am. Ind. Hyg. Assoc. 61: 895-899.

Environmental and Energy Study Institute (2009). Buildings and Health. Shefali Ranganathan. Washington DC, U S A. www.eesi.org.

Harris F, McCaffer (2001). Modern Construction Management 5th edition. Blackwell Science Limited. A Blackwell Publishing Company Editorial Office Osney Mead Oxford UK.

Hyvarinen AM (2002). Charactering Moisture Damaged Buildings – Environmental and Biological Monitoring. Public Nat. Public Health Inst. Univ. Kuopio, Finland pp. 27-61.

Johnstone IM (2001). Periodic Refurbishment and Reductions in National Costs to Sustain dwelling Services. Construction Manage. Econ. 19: 97-108.

Lebow S, Highley T (2009). Regional Biodeterioration Hazards in the United States. Forest Products Laboratory, U.S. Dept. Agric., Madison.

London Hazard Centre (1990). Sick Building Syndrome: causes, effects and control. Interchange Studios, Hempstead Town Centre, London UK.

Menzies D, Bourbeau J (1997). Building Related Illness, N. Engl. J Med. 337: 1524-1531.

Nigerian National Building Code (2006). National Building Code. First edition Lexis Nexis Butterworth, Fed. Rep. Nigeria. Abuja Nig.

Nofal M, Kumaran MK (2007). Durability Assessment of Wood-frame Construction Using the Concept of Damage-functions. Durability Assessment of Wood-frame Construction. Inst. Res. Construction, Nat. Res. Council Canada, Ottawa, Canada

Pinchin Environmental Mississauga head office (2009). Mould Contamination in Buildings Q/A www.pinchin.com

Richardson BA (1995). Remedial Treatment of Buildings. Second edition. Butterworth-Heinemann Ltd oxford.

Seeley IH (1987). Building Maintenance. Second edition. Published by Macmillan press limited London

Stevens D (2004). Fungi in the Domestic Environment and Community Settings-association with health problems Washington DC, USA.

The National Academies (2004). Damp Indoor Spaces and Health. Board on Health Promotion and Disease Prevention, Inst. Medicine. www.books.nap.edu.

Viitanen H, Ritschkoff A, Ojanen T, Salonvaara M (2008). Moisture conditions and biodeterioration risk of building materials and structure. VTT Building and Transport FIN VTT.

World health organization (2003). Manual for Laboratory Identification and Antimicrobial Susceptibility testing of Bacteria pathogens of Public health importance in the developing world. WHO Geneva Switzerland.