AGRICULTURAL AND BIOLOGICAL SCIENCES

A MYCOLOGICAL ASSESSMENT OF THE AIR QUALITY IN FLOOD-PRONE HOMES WITHIN LAFIA LOCAL GOVERNMENT AREA OF NASARAWA STATE

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Date Manuscript Received:06/04/2016 Accepted:20/12/2016 Published:December, 2016

ABSTRACT
Air quality of three hundred (300) flood prone homes was assessed for the presence of fungal spores during the rainy season between September and November, 2015. Sixty (60) randomly selected households in five council wards namely Wakwa, Makama, Gayam, Ciroma and Akurba wards were assessed using the Koch sedimentation method by gravitational settlement on Sabouraud dextrose agar (SDA). Identification of isolates followed colonial and microscopic methods. Seventy-one fungal genera and species were identified, with *Aspergillus niger* (179; 59.7%) being the most predominant. *Aspergillus niger* was most isolated in Wakwa (40; 22.3%), Makama (31; 17.3%) and Gayam (51; 28.5%) wards while *Bipolaris* sp (40; 35.4%) and *Aspergillus fumigatus* (33; 28.2%) dominated isolates in Ciroma and Akurba wards respectively. The number of isolated genera and species in the wards was in the order Akurba (51) > Makama (42) > Wakwa (38) > Ciroma (36) > Gayam (32), while total frequency were 292, 290, 283, 274 and 249 in Akurba, Wakwa, Gayam, Ciroma and Makama respectively. The highest and least mean relative humidity obtained in the study were (76.3%) and (52.5%) respectively. Statistical analysis revealed no significant differences in the mean relative humidity, number and total frequency of isolates in the wards. Homes that reared animals were more contaminated with fungal species than those that did not. The study has revealed unhealthy presence of fungal pathogens in the homes, a conducive environment for the proliferation of fungi and therefore advocates necessary actions to reduce flooding in Lafia local government area of Nasarawa State.

Keywords: *Flood, Homes, Fungi, Air quality, Relative humidity*

INTRODUCTION

Microorganisms are ubiquitous in nature and thus tend to survive in a very wide range of environmental conditions. There are however certain conditions which are considered more conducive and thus lead to increased growth and consequently their large numbers in the environment.

Fungal growth is supported mainly by oxygen and moisture (Deacon, 2005). However, water availability is considered more important as controlling it has been shown to reduce or even prevent the growth of fungi (Karch, 2008). Furthermore, there is a higher risk of mould infestation in areas with high amounts of water in the environment such as flood prone areas (Emerson *et al*., 2015; Barbeau *et a*l., 2010: Olaf and Robert, 2011), places with humid weather conditions and or seasons characterised by high relative humidity (Talley, Coley and Kursar, 2002). Indoor air in areas with high relative humidity has been shown (Henk and Olaf, 2011) to have a higher concentration of fungi when compared with air within low relative humidity areas. In accordance with this, a relative humidity of at least 70% is generally considered ideal for the proliferation of fungi in indoor air. Some studies further suggest a variation in the species of fungi isolated at different levels of relative humidity. While xerophilic fungi such as *Aspergillus penicilloides, Penicillium* sp*, Eurotium herbariorum* (Petterson and Leong, 2011) grow best at relative humidity below 85%, Mesophilic fungi (*Alternaria* sp,) and Hydrophilic fungi (Yeasts, *Chaetomium* spp*, Stachybotrys* sp*, Phoma, Herbarum* spp*, Mucor* sp, *Rhizopus* sp *)* (Park *et al.*, 2008), and (Abe, 2011) grow best at relative humidity of above 85% and 95% respectively (Snow, 1949).

The nature of the relationship between increased fungal or mould growth and high relative humidity has been described by Karch (2008), and water is considered key in the process of absorptive nutrition which is primarily employed by fungi. Here the enzymes which are necessary for the breakdown of complex substances into simpler forms that can be absorbed by the fungi, are only functional in the presence of water. Furthermore spore germination, mycellium growth and mycotoxin production is said to only occur in the presence of free water molecules within the fungal cells (Peart, 2001; Magan and Lacey, 1984).

Fungal growth in damp buildings as obtainable in flood prone areas is considered an increasing problem globally mainly due to the health and financial implications which arise from it (Andersen *et al.,* 2011).

A wide range of Fungi have been isolated from indoor air of houses in flood prone areas and the sources of these organisms are suggested to vary from soil, human or animal, or plant waste and accumulated dust which find their way into indoor air as aerosols and air which moves from the external surroundings (Yasin and Almouqatea, 2010; King and Auger, 2002).

While some of these fungi do not pose a threat to health, a larger number of them are pathogenic. Previous studies (Gravesen *et al*., 1999; Andersen *et al*., 2011) which sampled indoor air of flood prone homes show the most commonly isolated fungi to include *Penicillium* sp*, Aspergillus* sp*,* and *Cladosporium* sp. Others are *Trichoderma* sp, *Paecilomyces* sp*, Stachybotrys* sp*, Alternaria* sp (Khan and Karrupayil, 2012).

The documented health implications of fungi in relation to flooded environments which have included water bone disease outbreaks, wide spread fungal skin infection just to mention a few have therefore necessitated this study in the flood prone areas of Lafia, Nasarawa state.

MATERIALS AND METHOD

The study was conducted in Lafia local government area, which also doubles as the capital of Nasarawa state. Lafia lies between latitude $8^0$25'40" to $8^0$34'15"North and longitude $8^0$24'25" to $8^0$38'19"East in the Guinea savannah region of Northern Nigeria (Nuhu and Ahmed, 2013). Wards within the local government area that experience flooding were identified and selected for the study, namely Wakwa, Makama, Gayam, Ciroma and Akurba wards. These wards experience extensive yearly flooding majorly during the rainy season which last all through the rainy period.

Sixty (60) houses were randomly selected in each of the five (5) council wards, making a total of three hundred houses. Air sampling was done using the Koch sedimentation method by gravitational settlement. Three petri dishes containing Sabouraud Dextrose Agar (Micro Masters) supplemented with chloramphenicol at 16ug/ml were placed on flat surfaces and exposed to air in the sitting room, bedroom and bathroom of each house for at least 10 minutes, covered and incubated at room temperature for 3 – 5 days.

The bedrooms and bathrooms sampled had no vents or windows except the entrance doors while some of the sitting rooms had only a window and the entrance door with no vents.

The relative humidity of the room was also read using a wet and dry temperature hygrometer, and the mean relative humidity calculated.

Isolates were identified using macroscopic characteristics on the growth medium as well as

micromorphological characteristics such as shape, size and arrangement pattern of spores and other vegetative structures of the isolates, aided by identification keys (G.S. de Hoog *et al.,* 2014, Atlas of Clinical Fungi, version 4.0). Following incubation, isolates were mounted in lactophenol cotton blue stain and viewed using a light microscope.

Data collated were analyzed using SPSS version 20 (IBM Corp., Armonk, New York). Simple means, percentages and frequencies were computed. Means were compared using Chi square ($\chi 2$) test.

RESULTS AND DISCUSSION

Seventy-one (71) fungal genera and species were identified as contaminants of air in the sampled homes (Table 1). *Aspergillus niger* (59.7%) was the most predominant isolate, followed by *Aspergillus fumigatus* (39.0%) and *Bipolaris* sp (37.7%). Species of *Aspergillus* were more frequently isolated in the sampled areas than other genera of fungi. Similarly, five (5) genera had a frequency of 3 (1.0%), six (6) had a frequency of 2 (0.7%) while twenty two (22) genera and species had a frequency of 1 (0.3%), the lowest occurring isolates of the study.

The frequency and distribution of each isolate in the respective wards was as presented in Table 2. While some of the genera and species had high frequencies of occuarrence in some of the wards, the frequency of occurrence and distribution of others were low. *Aspergillus niger* the most dominant isolate, was most isolated in Gayam, Wakwa and Makama wards with a frequency of 51 (28.5%), 40 (22.3%) and 31 (17.3%) respectively. *Bipolaris* sp was the most dominant isolate in Ciroma ward with a frequency of 40 (35.4%). *P. maneffei, A. nidulans and P. decumbens* were isolated only in Wakwa ward, whereas *Cladosporium* sp*, A. minisclerotigenes, A. tamarii, A. wentii and R. stolonifera* were all isolated only in Makama ward.

The mean relative humidity was in the order Makama (90.5%) > Akurba (87.7%) > Wakwa (87.4%) > Ciroma (83.8%) > Gayam (76.3%). Akurba ward had the highest number of isolated genera and species, followed by Makama (42; 59.2%), Wakwa (38; 53.5%), Ciroma (36; 50.7) and Gayam (32; 45.1) wards respectively. The total frequency of isolated genera and species was highest in Akurba ward (292) and least in Makama ward (249) respectively. Chi square test however did not reveal any significant difference between the mean relative humidity ($p = 0.05$), the number of isolates and total frequency of isolates in the respective wards. However, relative humidity was found to affect the number or frequency of the isolates in each of the wards.

Farming activity was found to affect the total frequency of isolates (Table 4). Animal farming or rearing of animals (815; 58.6) had the highest total frequency of isolates, while houses engaged in crop farming (43; 3.1%) had the least total frequency. Houses not engaged in any form of farming activity had more isolates (401; 28.9%) than those engaged in crop farming alone (43; 3.1%) and a mixture of both crop and animal farming (128; 9.2%)

Table 1: Frequency of fungal isolates in the five wards

Isolates	Frequency (n = 300)	Percentage (%)
A. niger	179	59.7
A fumigatus	117	39.0
Bipolaris sp	113	37.7
Mucor sp	68	22.7
P. chrysogenum	67	22.3
A. flavus	67	22.3
T. rubrum	57	19.0
A. terrus	56	18.7
T. mentagrophytes	51	17.0
Rhizopus sp	49	16.3
S. schenckii	41	13.7
A. corymbifera	34	11.3
T. violaceum	33	11.0
T. harzianum	31	10.3
C. lunata	30	10.0
P. griseofulvum	28	9.3
F. solani	27	9.0
C. krusei	25	8.3
A. altanata	24	8.0
T. verrucosum	23	7.7
P. digitatum	23	7.7
A. aborescens	23	7.7
A. restrictus	22	7.3
F. oxysporum	18	6.0
A. oryzae	17	5.7
R. minuta	16	5.3
A. sydowii	15	5.0
T. tonsurans	14	4.7
S. cerevisae	12	4.0
Scopulariopsis sp	11	3.7
A. versicolor	10	3.3
A. clavatus	7	2.3
P. maneffei	6	2.0
Botrytis sp	5	1.7
A. acidus	5	1.7
A. parasiticus	4	1.3
M. nanum	4	1.3
Nigrospora sp	3	1.0
A. nidulans	3	1.0
P. decumbens	3	1.0
P. purpurogenum	3	1.0
Stemphylium sp	3	1.0
A. carbonarius	2	0.7

Table 1: Frequency of fungal isolates in the five wards *-continued*

Isolates	Frequency (n = 300)	Percentage (%)
Phialophora sp	2	0.7
R. oryzae	2	0.7
Chrysonilia sitophila	2	0.7
Phoma sp	2	0.7
Aureobasidium pullulans	2	0.7
M. audouinii	1	0.3
Ulocadium alternaria	1	0.3
Cladosporium sp	1	0.3
A. minisclerotigenes	1	0.3
A. tamarii	1	0.3
A. wentii	1	0.3
R. stolonifera	1	0.3
Cryptococcus laurentii	1	0.3
Talaromyces sp	1	0.3
Trichophyton sp	1	0.3
E. floccosum	1	0.3
Scedosporium sp	1	0.3
Rhizomucor sp	1	0.3
Paecilomyces sp	1	0.3
Eurotium sp	1	0.3
Syncephalostrum sp	1	0.3
Exserohilum sp	1	0.3
Talaromyces trachyspermus	1	0.3
Geotricum sp	1	0.3
A. glaucus	1	0.3
M. ferrugineum	1	0.3
P. glabrum	1	0.3

Table 2: Frequency and distribution of isolates in each ward

Isolates	Frequency in each ward				
	Wakwa (%)	Makama (%)	Gayam (%)	Ciroma (%)	Akurba (%)
A. niger	40 (22.3)	31 (17.3)	51(28.5)	32(17.9)	25(14.0)
A. fumigatus	32 (27.4)	16 (13.7)	23(19.7)	13(11.1)	33(28.2)
Bipolaris sp	4 (3.5)	12 (10.6)	26 (23)	40(35.4)	31(27.4)
Mucor sp	15 (22.1)	14 (20.6)	18(26.5)	12(17.6)	9 (13.2)
P. chrysogenum	18 (26.9)	15 (22.4)	14(20.9)	9 (13.4)	11(16.4)
A. flavus	27 (40.3)	17 (25.4)	6 (9.0)	5 (7.5)	12(17.9)
T. rubrum	21 (36.8)	7 (12.3)	9 (14.0)	15(26.3)	6 (10.5)
A. terrus	8 (14.3)	12 (21.4)	10(17.9)	9 (16.1)	17(30.4)
T. mentagrophytes	9 (17.6)	8 (15.7)	14(27.5)	10(19.6)	10(19.6)
Rhizopus sp	13 (26.5)	7 (14.3)	6 (12.2)	13(26.5)	10(20.4)
S. schenckii	15 (36.6)	4 (9.8)	5 (12.2)	7 (17.1)	10(24.5)
A. corymbifera	7 (20.6)	6 (17.6)	10(29.4)	8 (23.5)	3 (8.8)
T. violaceum	14 (42.4)	5 (15.2)	6 (18.2)	3 (9.1)	5 (15.2)
T. harzianum	2 (6.5)	8 (25.8)	9 (29.0)	7 (22.6)	5 (16.1)
C. lunata	11 (36.7)	2 (6.7)	1 (3.3)	5 (16.7)	11(36.7)
P. griseofulvum	1 (3.6)	7 (25)	8 (28.6)	3 (10.7)	9 (32.1)
F. solana	1 (3.7)	3 (11.1)	3 (11.1)	13(48.1)	7 (25.9)
A. altanata	1 (4.2)	4 (16.7)	3 (12.5)	6 (25.0)	10(41.7)
T. verrucosum	8 (34.8)	0 (0)	7 (30.4)	0 (0)	8 (34.8)
P. digitatum	4 (17.4)	2 (8.7)	3 (13.0)	7 (30.4)	7 (30.4)

Table 2: Frequency and distribution of isolates in each ward *-continued*

Isolates	Frequency in each ward				
	Wakwa (%)	Makama (%)	Gayam (%)	Ciroma (%)	Akurba (%)
A. aborescens	0 (0)	8 (34.8)	3 (13.0)	5 (21.7)	7 (30.4)
A. restrictus	1 (4.5)	6 (27.3)	10(45.5)	3 (13.6)	2 (9.1)
C. krusei	1 (4.0)	9 (36.0)	10(40.0)	4 (16.0)	1 (4.0)
F. oxysporum	0 (0)	3 (16.7)	5 (27.8)	6 (33.3)	4 (22.2)
A. oryzae	5 (29.4)	0 (0)	0 (0)	12(70.6)	0 (0)
R. minuta	1 (6.2)	5 (31.2)	7 (43.8)	1 (6.2)	2 (12.5)
A. sydowii	1 (6.7)	4 (26.7)	4 (26.7)	5 (33.3)	1 (6.7)
T. tonsurans	7 (50.0)	1 (7.1)	0 (0)	4 (28.6)	2 (14.3)
S. cerevisae	1 (8.3)	4 (33.3)	4 (33.3)	2 (16.7)	1 (8.3)
Scopulariopsis sp	2(18.2)	1 (9.1)	2 (18.2)	5 (45.5)	1 (9.1)
A. versicolor	0 (0)	3 (30.0)	0 (0)	2 (20.0)	5 (50.0)
A. clavatus	0 (0)	4 (57.1)	3 (42.9)	0 (0)	0 (0)
P. maneffei	6 (100)	0 (0)	0 (0)	0 (0)	0 (0)
T. schoenleninii	2 (33.3)	0 (0)	0 (0)	1 (16.7)	3 (50.0)
Botrytis sp	0 (0)	3 (60.0)	0 (0)	2 (40.0)	0 (0)
A. acidus	0 (0)	5 (100)	0 (0)	0 (0)	0 (0)
A. parasiticus	0 (0)	3 (75.0)	1 (25.0)	0 (0)	0 (0)
M. nanum	0 (0)	2 (50.0)	1 (25.0)	1 (25.0)	0 (0)
Nigrospora sp	1 (33.3)	1 (33.3)	0 (0)	0 (0)	1 (33.3)
A. nidulans	3 (100)	0 (0)	0 (0)	0 (0)	0 (0)
P. decumbens	3 (100)	0 (0)	0 (0)	0 (0)	0 (0)
P. purpurogenum	0 (0)	0 (0)	0 (0)	0 (0)	3 (100)
Stemphylium sp	0 (0)	0 (0)	0 (0)	2 (66.7)	1 (33.3)
A. carbonarius	1 (50)	0 (0)	0 (0)	0 (0)	1 (50)
Phialophora sp	1 (50)	0 (0)	0 (0)	0 (0)	1 (50)
R. oryzae	1 (50)	1 (50)	0 (0)	0 (0)	0 (0)
Chrysonilia sitophila	0 (0)	1 (50.0)	0 (0)	0 (0)	1 (50.0)
Phoma sp	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)
Aureobasidium pullulans	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)
M. audouinii	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Cladosporium sp	0 (0)	1(100)	0 (0)	0 (0)	0 (0)
A. minisclerotigenes	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
A. wentii	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
R. stolonifer	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
Cryptococcus laurentii	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)
Trichophyton sp	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
E. floccosum	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Scedosporium sp	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Rhizomucor sp	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Paecilomyces sp	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Eurotium sp	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
Syncephalostrum sp	0 (0)	0 (0)	0 (0)	0 (0)	1(100)
Exserohilum sp	0 (0)	0 (0)	0 (0)	0 (0)	1(100)
Talaromyces trachyspermus	0 (0)	0 (0)	0 (0)	0 (0)	1(100)
Geotricum sp	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
A. glaucus	0 (0)	0 (0)	0 (0)	0 (0)	1(100)
M. ferrugineum	0 (0)	0 (0)	0 (0)	0 (0)	1(100)
P. glabrum	0 (0)	0 (0)	0 (0)	0 (0)	1(100)

Table 3: Relationship between relative humidity and frequency of isolates

Ward	Mean relative humidity (%)	Total number of isolated genera and species (%)	Total frequency of isolates
Wakwa	87.4	38 (53.5)	290 (20.9)
Makama	90.5	42 (59.2)	249 (17.9)
Gayam	76.3	32 (45.1)	283 (20.4)
Ciroma	83.8	36 (50.7)	274 (19.7)
Akurba	87.7	51 (71.8)	292 (21.0)

$\chi 2 = 20.000$, $p = 0.220$ ($p>0.05$)

Table 4: Relationship between frequency of isolates and type of farming activity

Isolates	Farming activity				
	None (%)	Animal (%)	Crop (%)	Animal and crop (%)	Total(%)
A. niger	50 (27.9)	109(60.9)	4 (2.2)	16 (8.9)	179 (100)
A. fumigatus	29 (24.8)	70 (59.8)	4 (3.4)	14 (12.0)	117 (100)
Bipolaris sp	41 (36.3)	57 (50.4)	2 (1.8)	13 (11.5)	113 (100)
Mucor sp	20 (29.4)	39 (57.4)	3 (4.4)	6 (8.8)	68 (100)
P. chrysogenum	16 (23.9)	44 (65.7)	2 (3.0)	5 (7.5)	67 (100)
A. flavus	15 (22.4)	41 (61.2)	2 (3.0)	9 (13.4)	67 (100)
T. rubrum	16 (28.1)	34 (59.6)	2 (3.5)	5 (8.8)	57 (100)
A. terrus	20 (35.7)	27 (48.2)	1 (1.8)	8 (14.3)	56 (100)
T. mentagrophytes	12 (23.5)	32 (62.7)	3 (5.9)	4 (7.8)	51 (100)
Rhizopus sp	14 (28.6)	27 (55.1)	1 (2.0)	7 (14.3)	49 (100)
S. schenckii	12 (29.3)	25 (61.0)	2 (4.9)	2 (4.9)	41 (100)
A. corymbifera	9 (26.5)	22 (64.7)	2 (5.9)	1 (2.9)	34 (100)
T. violaceum	8 (24.3)	22 (66.7)	2 (6.1)	1 (3.0)	33 (100)
T. harzianum	12 (38.7)	16 (51.6)	2 (6.5)	1 (3.2)	31 (100)
C. lunata	11 (36.7)	15 (50.0)	2 (6.7)	2 (6.7)	30 (100)
P. griseofulvum	5 (17.9)	21 (75.0)	0 (0.0)	2 (7.1)	28 (100)
F. solana	7 (25.9)	18 (66.7)	1 (3.7)	1 (3.7)	27 (100)
A. altanata	8 (33.3)	11 (45.8)	0 (0.0)	5 (20.8)	24 (100)
T. verrucosum	4 (17.4)	16 (69.6)	1 (4.3)	2 (8.7)	23 (100)
P. digitatum	9 (39.1)	13 (56.5)	0 (0.0)	1 (4.3)	23 (100)
A. aborescens	10 (43.5)	13 (56.5)	0 (0.0)	0 (0.0)	23 (100)
A. restrictus	7 (31.8)	13 (59.1)	1 (4.5)	1 (4.5)	22 (100)
C. krusei	11 (44.0)	14 (56.0)	0 (0.0)	0 (0.0)	25 (100)
F. oxysporum	8 (44.4)	8 (44.4)	0 (0.0)	2 (11.1)	18 (100)
A. oryzae	6 (35.3)	8 (47.1)	2(11.8)	1 (5.9)	17 (100)
R. minuta	2 (12.5)	13 (81.2)	0 (0.0)	1 (6.2)	16 (100)
T. tonsurans	2 (14.3)	9 (64.3)	1 (7.1)	2 (14.3)	14 (100)
S. cerevisae	3 (25.0)	9 (75.0)	0 (0.0)	0 (0.0)	12 (100)
Scopulariopsis sp	2 (18.2)	8 (72.7)	0 (0.0)	1 (9.1)	11 (100)
A. versicolor	1 (10.0)	6 (60.0)	0 (0.0)	3 (30.0)	10 (100)
A. clavatus	2 (28.6)	4 (57.1)	0 (0.0)	1 (14.3)	7 (100)
P. maneffei	0 (0.0)	5 (83.3)	0 (0.0)	1 (16.7)	6 (100)
T. schoenleninii	1 (16.7)	3 (50.0)	0 (0.0)	2 (33.3)	6 (100)
Botrytis sp	1 (20.0)	3 (60.0)	0 (0.0)	1 (20.0)	5 (100)
A. acidus	2 (40.0)	3 (60.0)	0 (0.0)	0 (0.0)	5 (100)
A. parasiticus	1 (25.0)	3 (75.0)	0 (0.0)	0 (0.0)	4 (100)
M. nanum	2 (50.0)	1 (25.0)	1(25.0)	0 (0.0)	4 (100)
Nigrospora sp	1 (33.3)	1 (33.3)	0 (0.0)	1 (3.33)	3 (100)
A. nidulans	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)	3 (100)
P. decumbens	0 (0.0)	3 (100)	0 (0.0)	0 (0.0)	3 (100)
P. purpurogenum	0 (0.0)	1 (33.3)	0 (0.0)	2 (66.7)	3 (100)
Stemphylium sp	1 (33.3)	1 (33.3)	0 (0.0)	1 (33.3)	3 (100)
A. carbonarius	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (100)
Phialophora sp	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (100)
R. oryzae	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (100)
Chrysonilia sitophila	2 (100)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100)
Phoma sp	0 (0.0)	1 (50.0)	0 (0.0)	1 (50.0)	2 (100)
Aureobasidium-pullulans	0 (0.0)	1 (50.0)	0 (0.0)	1 (50)	2 (100)
M. audouinii	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
Ulocadium alternaria	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Cladosporium sp	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
A. minisclerotigenes	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
A. tamarii	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
A. wentii	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
R. stolonifer	0 (0.0)	0 (0.0)	1 (100)	0 (0.0)	1 (100)
Cryptococcus laurentii	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Talaromyces sp	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Trichophyton sp	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
E. floccosum	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
Scedosporium sp	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
Rhizomucor sp	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
Paecilomyces sp	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Eurotium sp	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Syncephalostrum sp	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
Exserohilum sp	1 (100)	0 (0.0)	0 (0.0)		0 (0.0)
Talaromyces trachyspermus	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
Geotricum sp	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)
A. glaucus	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
M. ferrugineum	0 (0.0)	1 (100)	0 (0.0)	0 (0.0)	1 (100)
P. glabrum	0 (0.0)	0 (0.0)	0 (0.0)	1 (100)	1 (100)
TOTAL	**401 (28.9)**	**815(58.6)**	**43 (3.1)**	**128 (9.2)**	**1387 (100)**

This study was designed to assess the mycological quality of air in flood prone homes and in achieving this, the fungal contaminants in the homes were identified, the relative humidity and its effect on fungal density was determined, and the relationship between farming activities and the occurrence of the fungal isolates was also determined.

A total of 71 fungal species were isolated from the 300 homes sampled in the study. The large number of fungi isolated is clearly an indication that the prevailing environmental condition in these homes largely favours and encourages fungal proliferation. The high number of fungal contaminants observed in this study could be attributed to elevated moisture levels and the presence of suitable substrates such as damp paints, walls and furniture. Similar studies by Emerson *et al.* (2015) and Barbeau *et al*. (2010) also

reported a high number of fungi in air of houses in areas where flooding occurs.

Among the fungal species isolated, *Aspergillus niger* (59%) and *Aspergillus fumigatus* (39.0%) were found to be the most frequently occurring. This could be as a result of the *Aspergillus* sp being the most common type of fungi in the environment. A. niger which was the most isolated is regarded as the most abundant species of *Aspergillus* in nature and their ability to grow in environments with very little nutrients available could also be responsible for their high occurrence in the study (Chehri, 2013). The equally high occurrence of *A. fumigatus* could be as a result of the organism being the most temperature tolerant among the species.

It has the ability to tolerate temperatures between 20^{o}C and 55^{o}C. They cause infections in humans more often than any other *Aspergillus* species. Other isolates with relatively high frequencies include *Bipolaris* sp (37.7%), Mucor sp (22.7%) and *Penicillium chrysogenum* (22.3%). The high incidence of *Aspergillus* sp and *Penicillium* sp observed in this study, agrees with a previous report by Khan and Karrupayil (2012). Other fungal species isolated in this study have also been reported in similar studies (Barbeau *et al.*, 2010; Khan and Karrupayil, 2012; Emerson *et al.*, 2015). The high occurrence of *Bipolaris* sp in this study is considered an important finding because of its pathogenic nature. Hence, its occurrence in large quantities in indoor air poses a major threat to the health of individuals. Other important pathogens isolated in this study are the dermatophytes *Epidermophyton floccosum*, *Tricophyton* sp and *Microsporum* sp which cause superficial or subcutaneous infections of the hair, skin and nails including Tinea (ringworm) and onychomycosis (Gupta *et al.*, 2005; Seddon, 1997). The presence of these pathogens in the study area clearly calls for the need for measures to control flooding so as to safeguard the health of inhabitants.

Farming activities have been reported to affect the number and types of fungi occurring in a particular environment (Swer, Dkhar and Kayang, 2011). This study has observed a relationship between farming activity, and the frequency and type of isolates in the various wards. The high frequency of isolates associated with animal farming in this study may not be unrelated to the fact that resultant materials such as animal dung and feed serve as substrates for the growth of fungi. A relatively high frequency of fungal isolates was observed in houses engaged in neither crop nor animal farming. The reason for this may not be farfetched as it was observed during sampling that harvested farm products such as grains were stored in most of the homes. This practice could have served as reservoirs and substrates for fungi such as *Aspergillus* sp and *Penicillium* sp, commonly found on stored grains. It is worthy of note that *Aspergillus flavus* is a common contaminant of maize grains which produces the highly potent aflatoxin known to affect the health of man and animals.

CONCLUSION

Results of this study have revealed a high incidence of fungal contamination in houses prone to flooding, due to prevailing environmental conditions which favour the growth of various fungal populations. A number of the fungal contaminants isolated in the study have been reported to be pathogenic to humans. These findings therefore stress the need for adequate measures to control flooding in the affected areas so as to safeguard the health and wellbeing of the populace.

ACKNOWLEDGEMENT

The authors are grateful to the Tertiary Education Trust Fund (TETFUND) for providing the research grant used for this study, and the management of Federal University Lafia, for the support and encouragement given while the study lasted.

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