SSR Journal of Engineering and Technology (SSRJET)

Volume 2, Issue 3, 2025 Journal homepage: https://ssrpublisher.com/ssrjet/ ISSN: 3049-0383
Email: office.ssrpublisher@gmail.com

Evaluation of the Impact of Dampness on Existing Buildings in Ikirun, Osun State, Nigeria

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Received: *05.06.2025* | ***Accepted:*** *30.07.2025* | ***Published:*** *31.07.2025*

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DOI: *10.5281/zenodo.16647103*

Abstract **Original Research Article**

Dampness is a very dangerous structural defects that ruins paint jobs and interior décor, promotes the growth of mould and decay, detracts from aesthetics, and endangers residents' health. This study sought to identify and document the causes, and effects associated with dampness in the existing 150 residential buildings in Ikirun, Osun State, Nigeria through a questionnaire survey in the town. A quantitative approach to data analysis was used in which the causes and effects associated with dampness were analyzed using severity index. Majority of the houses surveyed were of lateritic materials and sandcrete block walls. The findings indicated that hygroscopic salts, deteriorated skirting, excessive moisture, inadequate ventilation, inadequate DPC, building defaults, inadequate gutters, condensation, exposed wall tops, poor supervision, and noncompliance with building rules, regulations, and codes were the most serious factors linked to dampness in the floors and walls of the existing residential buildings surveyed. These identified causes are indications of the severity of the problem of dampness in existing residential buildings in Ikirun, Nigeria. Based on this study, it was recommended that all landlords ought to be required to create drainage systems around their structures and the relevant authorities should conduct inspections on a regular basis to assess the degree of adherence to the aforementioned point.

Keywords: Dampness, residential buildings, structural defects, severity index, moisture intrusion, building materials, Ikirun, Nigeria.

Citation: Olanrewaju, S. B.O., Opatade, J. A., & Alli, P. A. (2025). Evaluation of the impact of dampness on existing buildings in Ikirun, Osun State, Nigeria. *SSR Journal of Engineering and Technology (SSRJET)*, 2(3). [10-18]

1.0 INTRODUCTION

Residential building dampness assessment is an essential part of building management and maintenance since it has a direct effect on the buildings' structural soundness, indoor air quality, and occupants' general comfort (Clark et al., 2023). The deterioration of most buildings is intrinsically connected to dampness in the walls. Additionally, it makes homes seem ugly, gives off an unpleasant smell, and permanently ruins paint, plaster, and other surfaces. A very serious structural flaw, dampness ruins paintwork and interior decorations, promotes the growth of mould and decay, detracts from aesthetics, and endangers the health of residents. According to Elinwa et al. (2018), dampness is the result of water seeping through a building's walls and other components. Additionally, moisture can result in structural issues, aesthetic issues, fabric deterioration, and in certain cases, negative health implications for building occupants (Blay et al., 2019; Agyekum et al., 2017). Across the world, one of the problems affecting buildings is dampness. According to Zam et al. (2017), deterioration is caused by an excessive amount of moisture in building materials and components, which leads to unacceptably bad interior environmental conditions. Building wall dampness is closely related to the majority of building deterioration (Hollis, 2000). Additionally, it gives homes an ugly look, has a foul smell, and permanently damages paint, plaster, and other surfaces (Mbachu, 1999; Burkinshaw and Parrett, 2004; Halim et al., 2010; Hetreed, 2008; Agyekum et al., 2017). For a number of reasons, it is essential to assess how dampness affects existing structures. This includes identifying structural failures or weakness (Hyvarinen et al., 2002), preventing additional damage, and reducing the health hazards connected with mould and poor air quality. Wetness can shorten a building's lifespan, cause expensive repairs, and harm tenants' health.

Regardless of how ancient or contemporary a structure is, one of the most destructive defects that can happen is dampness penetration. It can induce fungal assault on wood, deterioration and disintegration of mortar joints, deterioration of brick and block work by soaking it, corrosion of iron and steel, and discolouration of wall surfaces. Mould grows on damp surfaces, and when mould and mites proliferate in high relative humidity environments, it is linked to poor health. According to Zam, Emilia, Karmegam, and Sapuan (2017), the prevalence of flaws and deterioration brought on by exposure to water and moisture is predicted to be between 5% and 30% in cold climates and between 10% and 60% in moderate and warm climates.

Furthermore, moist environments often have a negative impact on residents' mental health, leading to worry and sadness, especially in cases where mould or damp stains have damaged décor. In many nations, including Nigeria, moisture in all its manifestations has become a concerning issue—the most commonly reported building-related issue. Nigeria is not exempt from the issue of moisture. The issue has taken on a concerning dimension in certain residential and institutional structures across the nation, according to field studies (Stanley et al., 2020; Zakariyyah et al., 2020). The main purpose of this study was to identify the impacts associated with dampness in walls of existing residential buildings in other to find out the causes, prevention and treatment of its effects.

Explicit communications between the walls and roofs cause damp to accumulate inside the buildings. Many issues can arise from dampness in structures, such as the deterioration of bricks, blocks, and timber, inadequate insulation from cold bridging, and a higher chance of mould growth (Fisk et al., 2010). Damp is a significant problem that has affected buildings, putting occupants' lives in danger, causing health issues like asthma, causing damage to their property, and causing the building to deteriorate. However, dampness in buildings is an issue when there is a lot of moisture in the structure, like when roofs leak or when humidity levels are high. In these cases, mortar or plaster may slide off the affected wall, resulting in poor indoor air quality and respiratory illnesses for the occupants. Additionally, moist environments often have an impact on residents' mental health, leading to anxiety and despair, especially in cases where mould or damp discolouration has damaged the décor (Nicol, 2006). All types of dampness have become the most commonly reported issue with buildings, and nations like the US, UK, Australia, Denmark, Canada, Japan, Estonia, Iceland, Norway, Sweden, and Taiwan have documented the severity of the dampness issue (WHO, 2009).

2.0 LITERATURE REVIEW

Dampness can be defined as water seeping through walls and other components of a building. An excessive amount of moisture in building materials and components that leads to unsatisfactory interior environmental conditions and unfavourable motions or deterioration is another definition of it. There are various types of dampness, including capillary, equilibrium, hygroscopic, total, and potential moisture content. Dampness is the quantity of moisture content that is present in a substance.

More than 50% of all known building failures are caused by dampness, which is the most common and significant issue in structures and is most commonly cited as the primary source of building defects worldwide (Halim et al., 2012; Magaji et al., 2022). The majority of building damage is intrinsically tied to dampness. Between 0.5 and 1.5 meters above ground level is the typical upper limit for growing wetness. When rising humidity is extreme, it can cause blistering of paint and plaster damage, as well as a high tide-like stain on wall paper and other interior surfaces. Understanding moisture and its effects on buildings is necessary for accurate diagnosis and recommendation of corrective measures.

Other classifications of dampness include condensation of air moisture, penetrating dampness, internal plumbing leaks, subsurface moisture, and sources peculiar to a building. Capillary suction of moisture from the ground into porous masonry building materials, such as stone, brick, blocks, earth and mortar, causes rising dampness. These materials are best suited for building envelopes because they have a major 51% impact on the energy loads of the buildings (Ahmad, 2010; Padilla-Marcos et al., 2017). More moisture can be taken from below as the moisture evaporates from the walls inside or outer faces. The rate of evaporation and the type of wall dictate how high the moisture will rise (Elinwa et al., 2017; Zakariyyah et al., 2019). Rising dampness, penetrating dampness, condensation, and pipe leaks are the different categories of dampness sources.

Water must be present, there must be an opening for water to enter, and there must be a physical force moving the water in order for it to pass through a building enclosure. Rain, snowmelt, and soil moisture are all examples of water. Water intrusion into structures is influenced by a number of factors, including gravity, air currents, capillary suction, surface tension, kinetic energy, air pressure, and hydrostatic pressure. Permeation dampness in buildings can also result from rainwater, pipe leaks, water from horizontal directions, overflows from air conditioners or hot water systems, etc. While rising wetness may impact a building's base, these sources typically result in limited, localized pockets of dampness and degradation.

Studies by (Curtis, 2007; Fischer, 2018; Magaji et al., 2022) stated that condensation-induced dampness happens when water in a building's air condenses on a colder surface. This is typically a sign of cold patches, sometimes known as cold bridges, throughout the building (Curtis, 2007; Fischer, 2018; Magaji et al., 2022). A common consequence of excessive condensation is the growth of mould, which can pose health risks. Plaster walls may develop damp patches in unexpected locations, especially on exterior walls, and these patches frequently come and go (Burns, 2010). Mould, which is typically black in colour but can be almost any shade, is frequently found on walls, ceilings, beneath bay windows, and other surfaces where condensation occurs (Burns, 2010). When combined with excessive humidity, damp walls promote the formation of mould, which can cause health issues for residents (Wolde, 2007; Halim et al., 2010; Boulic, 2015; Mendell and Kumagai, 2017; Ye and Qian, 2017; Norbäck, 2017; Smedje et al., 2017).

The issue of dampness is widespread. Most of the time, it happened without warning during periods of intense rain. The presence of undesired moisture in a residential or commercial building's structure is known as dampness, and it mostly affects older structures. It can be caused by condensation inside the building or by water overflowing from the exterior. Mould growth, unhealthy structures, and poor indoor air quality are all significantly influenced by moisture in buildings. According to Prowler (2011), a significant percentage of damp issues in buildings are brought on by ambient climate-dependent elements such condensation and rain penetration. A building's exterior is not the only thing that can be harmed by dampness. It can cause harmful humidity, encourage the decomposition of wood, and cause plaster and brickwork to deteriorate (Oliver, 2017).

The unwanted moisture encourages the growth of certain fungi in wood, which can lead to mould or rot and ultimately sick building syndrome. When there is a lot of moisture from structural issues like leaky roofs or excessive humidity levels, mould can grow on practically any surface. A building's ability to stay dry, or damp-proof, is one of its most crucial needs. All things considered, if this need is not met, the building may become unsanitary for the residents and hazardous from a structural standpoint since moisture fosters the growth of certain disease-causing bacteria and damages the building. Damp in building can occur naturally when the foundation of a building is not well treated with the appropriate material which may lead to rising damp.

When the materials inside a structure are so wet that they harm the materials and visible mould grows, the building is said to have a dampness effect or problem. According to Hall (2011), structural damage caused by moisture poses a real risk to the structure's ability to function and permeates the structure's fabric over an ambiguous period of time. This damage is usually characterized by isolated areas of damp or submerged wall/ceiling finishes. weak construction, inadequate protection, broken pointing, weak eaves, insufficient gutters or cracked roofing tiles can all contribute to dampness in a building.

However, we should be aware that there are other ways that dampness might arise, including condensation, rain penetration, increasing wet, and humidity. The three main factors that facilitate water infiltration through a structure enclosure are the simultaneous presence of water, an aperture that allows water to enter, and the physical ability to move the water. Damp is defined by Hindawi (2011) as a level on a building's outside envelope that is susceptible to moisture impacts brought on by the pooling, splashing or impinging of (typically) rainwater at the intersection of a horizontal surface and the vertical wall surface, which is most frequently near the wall base. According to Jean Batina and René Peyrous (2018), condensation occurs when water vapour inside a structure migrates outward through air development or diffusion through a permeable structure fabric to a surface inside the structure cavity that is below the dew point. That surface could be fibrous, like glass wool insulation, or smooth, like sheet metal.

A cold surface that collects vapour absorbs the heat from vaporization, slightly increasing its temperature. As a result, condensation may occur more quickly on metal frames and more slowly on insulating materials. Interstitial condensation may go undetected, and if the fabric of the structure was not designed to allow moisture to evaporate from the interior, it may become trapped and jeopardize the structure's integrity and longevity as well as the health of its occupants. However, this issue is particularly common in buildings with inadequately insulated walls. It usually appears in similar places and consistently causes damage like moisture in a property. Explicit communications between the walls and roofs cause damp to accumulate inside the buildings. One of the main problems affecting the walls of structures in Ikirun, Osun State, is moisture. In addition to putting occupants' lives in danger and contributing to health issues like asthma (Wolde, 2007; Halim et al., 2010; Boulic, 2015; Mendell and Kumagai, 2017; Ye and Qian, 2017; Norbäck, 2017; Smedje et al., 2017), dampness also damages and deteriorates buildings. Nevertheless, the issue of damp in buildings arises when there is excessive moisture in the structure, such as from leaky roofs or high humidity levels, which can cause plaster or mortar to slide off the impacted wall, resulting in poor indoor air quality and respiratory illnesses for residents.

World Health Organization (WHO, 2009) identified ten common moisture issues in buildings: leaks and spills from plumbing, groundwater or rainwater seeping through building envelopes, condensation, capillary suction water licking through porous foundation materials, poorly vented or unvented swimming pools, inadequate ventilation system dehumidification, use of wet materials during construction, infiltration of warm or moisturized outdoor air, inadequate drainage due to air conditioning. The main source of moisture issues in buildings is leaks. Water seeping through building envelopes, including the roof, windows, doors, and ceiling, leads to several moisture problems. Building moisture issues, particularly in basements, are caused by bad design, the environment, subpar craftsmanship, and ventilation issues.

Controlling dampness is essential to any building's correct operation. In addition to protecting the structure, its mechanical systems, and its contents from physical or chemical damage, controlling moisture is crucial for preventing negative health impacts on occupants. However, a lot of people believe that dampness issues are unavoidable because they are so prevalent in buildings. According to Alfano et al. (2006), rain penetration from the wall can be prevented by creating cavity walls or sufficient wall thickness. The exposed wall faces should be of high quality, have a low capacity to absorb water, and be covered with cement plaster. In a similar vein, Hutton (2011) said that among other things, lowering moisture creation, enhancing background heat, and ventilating cold surfaces can all help manage condensation.

3.0 RESEARCH METHODOLOGY

The study used a comprehensive strategy to investigate moisture, including destructive, nondestructive, and visual assessment. The visual examination was carried out by looking at the surrounding environment, examining the wet areas, and physically determining the reasons for the moisture based on the building's symptoms. Furthermore, the building's exteriors—roofing, rainwater gutters, etc.—were inspected for any evident flaws from both street level and higher access. Additionally, the interior of the structure was inspected to identify any dampness-affected areas. Some of the moist locations found by ocular observation are depicted in **Figure 1**

a) Peeling of paints b) Dampness shown marks on basements

Figure 1: Affected areas of building identified during visual assessment

A well-organized one hundred and fifty (150) questionnaires were administered on residents in selected residents in Ikirun of Osun State in order to assess the effects of dampness on existing building in Ikirun, Osun State, Nigeria but one hundred and ten (110) equivalent to (73%) were retrieved while 40 questionnaires equivalent to (27%) were not returned. The data collated were presented in tabular form and simple statistical tools were used for the analysis to include percentage among other methods.

Data sourced from various professionals within the built environment within the resident of the area of study in Ikirun, Nigeria were analyzed using arithmetic mean and ranking by descending value methods of statistical analysis. The data retrieved was analyzed with descriptive statistic of mean. The response categories in the questionnaire were scored using a four point rating scale as shown in the instrument for data collection above. The frequency of each categories of response was multiplied by score value of the response alternative.

For average to get decision rule; $\frac{4+3+3+1}{4} = 2.50$

All items with mean score less than 2.50 were rejected while every item with mean score above 2.50 and above was accepted. For assessment purpose, mean score was used to assess the effects of dampness on existing building in Ikirun, Osun State, Nigeria and to suggest possible remedial actions and results were ranked from which conclusions were deduced. In computing the arithmetic mean, the following formula was used:

Mean score = $\frac{\sum w_i f_i}{\sum f_i}$

Where $\sum w_i$ = the summation of the weights.

$\sum f_i$ = the summation of responses

The factors were measured by using the Likert scale involving rating on interval scale of 4 and 1 which was developed for application in social sciences and management researches for quantification of qualitative variable were used, namely:

4 represent "Strongly Agreed (SA),"
3 represent "Agreed (A),"
2 represent "Disagree (DA),"
1 represent "Strongly Disagree (SD)."

IV. Data presentation and analysis

This research work was based on three main possible contributory effects of dampness on existing building which were subsequently identified and scored within the identified factors.

Table 1: Respondents' Gender

Gender	Frequency	Percentage (%)
Male	70	63.64
Female	40	36.36
Total	**110**	**100**

Table 1 above revealed data analysis related to the respondents' gender who responded to the instrument distributed. 150 copies of questionnaire were distributed and one hundred and 110 were retrieved. It comprised 70 males which represented 64% and 40 females represented 37%.

Table 2: Respondents' profession

Profession	Frequency	Percentage (%)
Architect	25	22.73
Builder	40	36.36
Engineer	30	27.27
Estate Surveyor	10	9.09
Quantity Surveyor	5	4.55
Total	**110**	**100**

Table 2 above revealed analysis of data related to the respondents' profession who responded to the instrument distributed. Among which builders were 40 represented 36%, engineers were 30 represented 27%, architects were only 25 represented 23%, estate surveyors were 10 represented 9%, while quantity surveyors were 5 represented 5%.

Table 3: Respondents' year of experience

Year of experience	Frequency	Percentage (%)
1-5	24	21.82
6-10	44	40.00
11-15	32	29.09
16-20	10	9.09
Total	**110**	**100**

Table 3 above revealed analysis of data related to the respondents' year of experience. Among the copies of questionnaire retrieved, respondents with experience ranges between 1-5 years were 24 represented 22%, respondents with experience ranges between 6-10 years were 44 represented 40%, respondents with experience ranges between 11-15 years were 32 represented 29% and respondents with experience ranges between 16-20 years were 10 represented 9%.

Table 4: Respondents' qualification

Qualification	Frequency	Percentage (%)
WASCE O/L	12	10.91
ND	25	22.73
HND/BSc/B.Eng/B.Tech	50	45.45
MSc/M.Eng/M.Tech	15	13.64
PhD	8	7.27
Total	**110**	**100**

Table 4 above revealed analysis of data related to the respondents' qualification. Respondents with HND/BSc/B.Eng/B.Tech were 50 represent 45%, ND were 25 represented 23%, MSc/M.Eng/M.Tech were 15 respondents 14%, WASCE O/L were 12 represents 11% and PhD were 8 represents 7%.

Table 5: Respondents' marital status

Marital status	Frequency	Percentage (%)
Single	38	34.55
Married	72	65.45
Total	**110**	**100**

Table 5 above revealed data analysis related to the respondents' marital status who responded to the instrument distributed. Among 110 copies of questionnaire retrieved comprised 38 singles which represented 35% and 72 married represented 65%.

Table 6: Causes of dampness in existing building

S/N	Factors	Mean	Remarks
1.	Excess moisture	3.96	Agreed
2.	Poorly heated homes	2.40	Disagreed
3.	Poor ventilation	2.88	Agreed
4.	Inadequate DPC	3.80	Agreed
5	Building defaults	3.32	Agreed
6	Inadequate gutters	2.16	Disagreed
7.	Condensation	3.48	Agreed
8.	Exposed tops of walls	3.24	Agreed
9.	Lack of good supervision	3.76	Agreed
10.	Non-compliance to building rules, regulation and codes	3.00	Agreed

Table 6 showed the mean response of respondents to the causes of dampness in existing building. The respondents agreed with items 1, 3, 4, 5, 7 to 10 which were excess moisture, poor ventilation, inadequate DPC, building defects, inadequate gutters, condensation exposed tops of walls, and lack of good supervision. These positive responses were verified from the fact that the scores fell between 2.50 - 4.00 as established by the cut off mark while the negative response which only include poorly heated homes and inadequate gutters in serial number 2 and 6 which was also established from the fact that the mean scores was less than 2.50.

Table 7: Effects of dampness on existing building

S/N	Effects of dampness on existing building	Mean	Remarks
1.	Growth of termites	3.88	Agreed
2.	Breeding of mosquitoes and unhealthy living conditions	3.16	Agreed
3.	Wall decoration and painting damage	3.84	Agreed
4.	Floor coverings damage	3.08	Agreed
5	Building unable to carry dead load and imposed load	2.72	Agreed
6	Building is weak	3.68	Agreed
7.	Building unable to withstand vibration	3.08	Agreed
8.	Building unsafe to inhabit	2.12	Disagreed
9.	Building is exposed to continuous repairs and checks	3.40	Agreed
10.	Building is liable to collapse at any time	3.64	Agreed

Table 7 showed the mean response of respondents to the effects of dampness on existing building. the respondents agreed with items 1 to 7 and 9 to 10 which were growth of termite, breeding of mosquitoes and unhealthy living conditions, wall decoration and painting damage, floor coverings damage, building unable to carry dead load and imposed load, building weakness and unable to withstand vibration, it exposes building to continuous repairs and checks and it exposes building to collapse at any time. These positive responses were verified from the fact that the scores fell between 2.50 - 4.00 as established by the cut off mark while the negative response which only included making a building unsafe to inhabit in serial number 8 which was also established from the fact that the mean scores was less than 2.50.

Table 8: Solutions to dampness in existing building

S/N	Factors	Mean	Remarks
1.	Improve heating and insulate the walls	3.72	Agreed
2.	Use condensed mould to remove moist from wall	2.84	Agreed
3.	Improve ventilation through windows and doors	3.08	Agreed
4.	Sand fill round the building	2.72	Agreed
5	Pressure grouting or cementation	2.82	Agreed
6	Apply exterior waterproofing coats on external walls	3.36	Agreed
7.	Comply with building regulations and codes	3.16	Agreed
8.	Construct the building with quality Materials	3.24	Agreed
9.	Carry out site investigation before the construction	3.28	Agreed
10.	Use raft foundation with DPC for the building	3.24	Agreed

Table 8 showed the mean response of respondents to the control measures of dampness on existing building. The respondents agreed with items 1 to 10 which were to improve heating and insulate the walls, use of condensed mould to remove moist from walls, improving ventilation through windows and doors, sand fill round the building, pressure grouting or cementation, apply exterior waterproofing coats external walls, compliance with building regulations and codes, construct the building with quality materials, carry out site investigation before the construction and use raft foundation with DPC for the building. These positive responses were verified from the fact that the scores fell between 2.50 and 4.00 was established by the cut off mark.

DISCUSSION OF FINDINGS

Table 6 showed the average amount of respondents said that excessive moisture or rain penetration, inadequate ventilation, inadequate DPC, architectural flaws, inadequate gutters, condensation, and exposed wall tops were among the reasons why the building was damp. These answers were consistent with the observation made by Prowler (2011), who verified that a significant percentage of damp issues in buildings are brought on by ambient climate-dependent factors like as condensation and rain penetration.

The respondents' average response about the impact of moisture on existing buildings was shown in **Table 7**. Among the things that the respondents agreed upon were termite development, mosquito breeding, unhealthy living conditions, damage to wall decorations and paintings, damage to floor coverings, ongoing maintenance and inspections, and building collapse. These answers were consistent with (Oliver, 2017). research, which found that moisture in buildings causes more harm to their look by causing masonry and plaster to deteriorate, encouraging the decomposition of wood, and producing hazardous condensation. World Health Organization (WHO, 2009) documented a number of frequent moisture issues in buildings, such as plumbing spills and leaks, groundwater or rainwater seeping through the façade, etc.

Table 8 displayed the average answer from the participants to the moisture control methods for the current building. In order to comply with building regulations and codes, the respondents agreed to improve ventilation through windows and doors, use condensed mould to remove moisture from walls, apply exterior waterproofing coats to exterior walls, sand fill around the building, pressure grout or cementation, build the building using high-quality materials, conduct site investigation prior to construction, and use raft foundation with DPC for the building. These encouraging answers supported the findings of Alfano et al. (2006), who believed that exposed wall faces should be of high quality, have a low capacity to absorb water, and be covered with cement plaster. They also believed that rain penetration from the wall could be prevented by creating cavity walls or sufficient wall thickness. The replies also concurred with Blay et al. (2019), who claimed that among other things, lowering moisture creation, enhancing background heat, and ventilating chilly surfaces can all help manage condensation.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

One of the main causes of building decay is dampness, which also has a detrimental effect on residential buildings, shortening their lifespan and putting the lives of building residents in jeopardy. According to the results of the survey, there is moisture in certain structures, including residential ones. This research report suggests that in order to prevent moisture or any building fault, the professionals concerned should avoid variables such as inadequate ventilation and DPC systems from the pre-construction, construction, and post-construction stages. In order to extend the lifespan of a building and its occupants, certain treatment procedures are required. Building dampness has an impact on occupant health, structural integrity, and energy efficiency. Promoting the use of damp-proof building materials, improving techniques to prevent the entry of moisture during construction, and raising knowledge of the negative health effects of dampness are the main goals of solutions to managing dampness (Agyekum et al., 2013; Agyekum et al., 2013; Agyekum & Ayarkwa, 2014). Blay et al., 2019). Therefore, everyone in the nation should realize that it is their duty to stop the consequences of this problems.

5.2 Recommendations

Based on the findings of this research and a review of previous research, the following recommendations were made:

i. All landlords ought to be required to create drainage systems around their structures.
ii. The relevant authorities should conduct inspections on a regular basis to assess the degree of adherence to the aforementioned point.
iii. To discuss the impacts of building dampness on building inhabitants and the building itself, workshops and seminars should be held using the media and all other accessible channels.

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