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INCIDENCE AND SEVERITY OF TERMITES ATTACK IN SAVANNAH ECOLOGICAL ZONE OF ONDO STATE, NIGERIA

Adiji A.O[1], Olaniran S.O[2], Owoyemi J.M[3], Akande S.O[4], Oriire, L.T[1], Adebisi, A.A[1], Aguda L. O[1]

[1]Department of Forest products development and Utilisation, Forestry Research Institute of Nigeria

[2]Department of Wood Biology and Wood Products, University of Goettingen

[3]Department of Forestry and Wood Technology, Federal University of Technology Akure

[4]Centre for Space Research and Advancement (CESRA), Federal University of Technology Akure

Corresponding author: adijiayodeji@gmail.com, 07038874432

ABSTRACT

Despite the increasing occurrences of termite attacks to buildings in Ondo state Nigeria, there is still limited information about the prevalence and severity of termites attack. In this study, prevalence and severity of termites attack in savannah ecological zone of Ondo state were examined with a view to providing baseline data for proper planning by wood users and builders. Field exposure test of five samples each of *Daniellia oliveri (Iya), Terminalia superba (Afara)* and *Albizia ferruginea (Ayunre)* wood in 15 locations of study area were assessed. Sample were cut into 35mm x 35mm x 35mm; oven dried, weighed and buried for assessing the severity of termite activities. The prevalence and severity of termites attack was determined with the results obtained from the ASTM D3345-17 visual rating and corresponding gravimetric weight loss data. Termite's species identification and some soil physical properties were examined in the fifteen locations and also correlation analysis was carried out to establish the relationship between parameters accessed. Six species of termite were identify in the study area namely; *Ancistrotermes cavithorax, Coptotermes intermedius, Macrotermes subhyalinus, Microtermes* species, *Odontotermes magdalenae* and *Trinervitermes geminatus* with the *Microtermes* species and *Ancistrotermes cavithorax* being prevalent and most abundant termite species in the study area. The severity of the attack shows that location (study area) 1,2,3,4,7,8,9,10,12,14 and 15 had the highest attack ranges from 45.30% to 73.90% and locations with moderate attack include location 5, 11 and 13 while location 6 have light attack with 17.78% weight loss. There exists low, very low and moderate positive and negative correlation between weight loss and some of the soil physical properties in the study area.

Keyword: Termite, identification, severity, wood deterioration, Soil particle**,**

Introduction

Wood is a green, renewable, sustainable, recyclable, locally grown and versatile material. Wood consumes lesser energy during construction than other product (Buchanan 2007; Falk 2009). It is not dimensionally stable and also easily attacked by biodegradating agents which are its major drawback. Prominent among the biodeteriorating agent is termites (Owoyemi *et al*, 2013). Termites are a social insect, living in colony. It belongs to order isopetra, the colonies perform distinct function (Daniel *et al.*, 2024). Termite is an ecosystem

engineer, which perform its role in the balance of ecosystem especially in the tropics (Jouquet *et al.*, 2006). In the course of termite performing its role in the balance of ecosystem, there exist conflict between termite and wood in service (Ssemaganda *et al.*, 2011; Owoyemi and Emmanuel, 2018, Emmanuel and Owoyemi, 2018). More than 2600 species of termites have been identified in the world in 280 genera and 80 termite species were considered serious pests, subterranean termites accounted for 38 species with differ rate of its attack worldwide, (Lee, 2002; Ahmed *et al.* 2011; Rust and Su, 2012). From the structural point of view, termite is the most serious enemy of wood. The lost incur due to termite attack on building in the world are in billions of dollar annually for repair and reconstruction with it attendance pressure on the forest estate (Su and Scheffrahn 2000; Rust and Su, 2012).

One way to change this narrative is to have the baseline information about termites activities in the area of construction and the use of right building design and technology (Adiji *et al.*, 2022). It has been established that builders and developer build without prior knowledge on termite activities of the area to build and even use wood without wood treatment in Nigeria and this is leading to constant replacement or repair of wooden structures (Owoyemi *et al*, 2022a). Previous work has reported the presence of termite and its severity in Ondo state in some locations (Adiji and Owoyemi 2015; Owoyemi *et al*, 2022a; Owoyemi *et al*, 2022b). Therefore, this work focused on the comprehensive assessment of termite prevalence and severity of termite attack in the savannah ecological zone of Ondo State, with a view to providing baseline information on the activities of termite for proper planning for pre-construction and remedial approach for management of termites.

Materials and Methods

Study Area

This study was carried out in Ondo State, Nigeria (Fig. 1). It lies between latitude 5^{o} $45^{'}$ and 8^{o} $15^{'}$ North and longitude 4^{o} $45^{'}$ and 6^{o} $15^{'}$ East of the tropics. The State is bounded in the North-West by Ekiti State, West-Central by Osun State, South-East by Ogun State, South-East by Delta State and in the South by Atlantic Ocean. The climate is tropical with two distinct seasons, the rainy season, (April-October) and dry season (November – March) with slight variations from year to year. The annual rainfall varies from 1,150mm in the northern parts to 2,000mm in the southern area; the State generally enjoys luxuriant vegetation. The vegetation consists of coastal forest and mangrove swamp forest in the south, moist lowland forest, and the forest savannah in the north (ODSG, 2010). The State has a surface area of approximately 15,317 square kilometres, which represents 1.66% of the total surface area of Nigeria (Adeyinka and Olugbamila, 2016).

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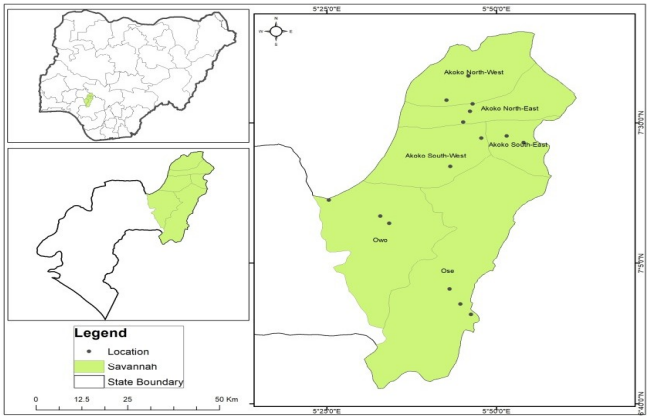


Figure 1: Map showing locations of study

Sampling and plot selection

Sites Selection

A hard copy of the Ondo state Savannah ecological zone map was obtained from the Ministry of Land and Physical Planning of Ondo state. The map was scanned, digitized, and geo-referenced at the Center for Space Research and Application (CESRA) FUTA using ArcGIS software. The map was divided into grids of regular points which were numbered serially after which; fifteen randomly selected points were obtained and exported to the geo-referenced map to ascertain their exact locations coordinate in the zone.

The georeferenced map of the zone also superimposes the boundary layer for plot sampling. After the plot sampling, a reconnaissance survey ground-truthing) was carried out to assess the ground conditions of each location before the establishment of the timber graveyard in each of these selected locations (Table 1). Timber graveyards were situated within school premises selected within each location, after due approval from the Ministry of Education, Ondo State. Siting of the test sites within the school premises is to ensure the safety of the exposed wood samples.

Table 1: Study locations

Locations	LGA	Latitude (°)	Longitude (°)
1	Owo	07.27098	005.42209
2		07.20206	005.57002
3		07.22324	005.54837
4	Ose	07.00694	005.71858
5		06.96226	005.74489
6		06.93193	005.77075
7	Akoko	07.56677	005.71062
8	Northwest	07.63850	005.76460
9		07.55581	00577508
10	Akoko	07.37018	005.71991

11	Southwest	07.45510	005.79623
12	Akoko	07.46133	005.85832
13	Southeast	07.44196	005.90019
14	Akoko	07.53417	005.76828
15	Northeast	07.50237	005.75206

Sample Preparation

The site sampling and plot selection were carried out with the use of a georeferenced Ondo state Map obtained from the Center for Space Research and Application (CESRA) FUTA using ArcGIS software. The sample stakes used as bait for this study were obtained from Daniellia oliveri(Iya), Terminalia superba (Afara) and Albizia ferruginea (Ayunre) wood known for its moderate susceptibility to termite attack.

The wood species were obtained from sawmill located in Oka Akoko and Akure. The wood sample were converted using mixed conversion in the workshop of the Department of Forestry and Wood Technology Federal University of Technology Akure into 35 x 35 x 450mm in accordance with ASTM D3345-08.2008 (1995). Five (5) sample of each of the wood species (35 x 35 x 450mm) were obtained, making fifteen (15) wood samples for each of the location of the study in the fifteen (15) locations, totaling two hundred and twenty five (225) wood samples in all. All samples were neatly sawn to avoid rough edges, labeled for easy identification and weighed using a weighing balance (green weight). The samples were then oven dried at 103±2 ^{o}C until a constant weight was achieved. The dry-weight density of the samples was determined and classified as high (>550 kg/m^3), medium (450 to 550 kg/m3), or low (<450 kg/m^3).

Field test

Field-exposure tests of the wood samples to termites were carried out at the 15 locations. The study sites were cleared and sprayed with wood shavings to induce termite activity. Samples for each of the three wood species were buried at a depth of 225 mm in a grid with a spacing of 100 by 100 mm. The exposure test ran from 13 December 2021 through 13 December 2022, which was a transition period from the rainy to the dry season. The samples were assessed weekly using a visual rating according to the American Society for Testing Materials Standard D-3345-74 (ASTMD1980) (table 2).

Table 2: Visual Assessment of Wood Samples for Termite Attack

Nature of Termite Attack	Rating
Sound, surface nibbles permitted	10
Light attack	9
Moderate attack with bore holes	7
Heavy attack	4
Failure	0

The experiment was terminated after 52 weeks and the percentage weight loss was determined

$$\% \, Weight \, Loss = \left(\frac{W_1 - W_2}{W_1}\right) \times 100 \quad \text{..... (1)}$$

Where: W_1 is oven dried weight, W_2 is weight after termite attack (in grams).

Termite identification

Termite identification was performed by collecting worker and soldier termites from the infested wood sample from each of the study area using a plastic insect specimen bottle filled with 10ml of 80 % ethanol. Internal morphology was carried out after enteric valve armature of the termites were removed, dissected, and fixed in alcoholic Boun's fluid, after which they were dehydrated in dioxane and observed under a scanning electron microscope.The identification of termites was carried out at Centre for Termites Research, Identification and Management, Department of Biology, Federal University of Technology, Akure.

Soil Properties Determination

Physical properties of the soil from the study areas (bulk density, moisture content, and particle size) were determined in July 2014 by collecting three soil samples per study location. Samples were collected at a depth of 0 to 15 cm and 15 to 30 cm following standard laboratory procedures as this will show the level of termites infestation, present and past activities termites in the soil.

Experimental Design and Data Analyses

The experimental design used for the research is Randomized Complete Block Design (RCBD) with 15 selected locations constituting the treatment and the wood species constituting the block. The data obtained from the fieldwork was analyzed using the Statistical Package for Social Sciences (SPSS) version 21. Descriptive statistics of the investigated variables were obtained, while analysis of variance (ANOVA) (a = 0.05) was carried out to determine if there were significant differences in the investigated variables as observed in the fifteen (15) selected locations and the wood species, the mean separation was carried out using Duncan New Multiple Range Test (DMRT) where a significant difference is observed and correlation analysis was carried out to establish the relationship between parameters accessed.

Result and discussion

Termite identification

Table 3 present the results of termite identification for this study, it revealed that six (6) termite species namely *Ancistrotermes cavithorax, Coptotermes intermedius, Macrotermes subhyalinus, Microtermes species, Odontotermes magdalenae, Trinervitermes geminatus* were identified within the study area with the *Microtermes species* and *Ancistrotermes cavithorax* being prevalent and most abundant termite species. It was observed that *Microtermes species, Ancistrotermes cavithorax* and *Odontotermes magdalenae were* identified in 7, 4 and 3 locations respectively. Furthermore, in some locations more than one termites species were identified, *Macrotermes subhylinus and Microtermes species* were present in location 1 while location 6 shows that *Trinervitermes geminatus and Microtermes species* were also identified. This corroborates Harris (1971) and Akande (1992) who submitted that termite species are widely present across vegetation zones in Nigeria. It also agreed

with Adiji *and Owoyemi (*2015) and Owoyemi *et al (*2017), that different species of termite is present in Ondo State and *Macrotermes subhylinus and Microtermes species* been the most destructive termites species.

Table 3: Termites species in the locations of study

Location No	Termite species					
	A. cavithorax	***C. intermedius***	***M. subhyalinus***	***M. spp***	***O. magdalenae***	***T. geminatus***
Location 1	-	-	+	+	-	-
Location 2	-	-	-	+	-	-
Location 3	+	-	-	-	-	-
Location 4	+	-	-	-	-	-
Location 5	-	-	-	+	-	-
Location 6	-	-	-	+	-	+
Location 7	-	-	-	-	+	-
Location 8	-	+	-	+	-	-
Location 9	-	-	-	+	-	-
Location 10	-	-	-	+	-	-
Location 11	-	-	-	-	+	-
Location 12	-	-	+	-	-	-
Location 13	+	-	-	-	-	-
Location 14	-	-	-	-	+	-
Location 15	+	-	-	-	-	-

Where ‘‘+’’ means presence and ‘‘–’’ means absence

Soil properties and correlation with termite severity

The result of the soil analysis is presented in figure 2 to 5. The result revealed that location 11 and 10 had the highest and the lowest percentage moisture content of 22.89% and 8.18% respectively. The result of the bulk density shows that location 2 and 5 had the highest and lowest value of 1.83 gcm^3 and 1.19gcm^3 respectively. The result of particle size 0-15cm depth revealed that location 7, 14 and 11 had the lowest value of 57.85%, 14.33 % and 0.97 % for sand, clay and slit respectively, while location 14, 12 and 7 had the highest value of 84.85%, 31.27% and 14.97% for sand, clay and slit respectively.

Also the result revealed Location 8, 14, 15 was classified as Sandy Loam while the remaining other locations was classified as Sandy Clay Loam. Furthermore, the result of particle size of 15-30cm depth, the result showed that location 14, 11 and 1 had the highest value of 84.85%, 29.27% and 23.29% for sand, clay and slit respectively while location 12, 8 and 14 had the lowest value of 55.85%, 12.17% and 13.27 % for sand, clay and slit respectively. The result also shows that all the locations were classified as Sandy Clay Loam except location 1 which is

classified as Sandy Loam. The result of the correlation between the soil properties and weight loss revealed that there is a low positive correlation association between Weight loss and soil bulk density (0.37) which implied that an increase in weight loss lead to increase in soil bulk density, vice versa. Owoyemi et al. (2017) found similar outcomes in their study conducted in the Akure metropolitan, reporting greater bulk density values in Akure with a corresponding higher termite attack rate in comparison to other study locations. Additionally, research has demonstrated that the bulk densities of termite-modified soils are typically higher than those of the surrounding soils.

This phenomenon can be attributed to the increased compaction of the soil caused by termite saliva and fecal products (Ali *et al.*, 2013; Jurgenrius *et al.*, 1999; Owoyemi *et al.*, 2017); as such, termite activity can be reliably detected in these soils. The result also shows that, there is a very low positive correlation association between weight loss and soil moisture content (0.12), which implied that an increase in weight loss lead to increase in soil moisture content, and vice versa. Increases in soil moisture generally result in an increase in termite activity because termites need adequate moisture content levels to ensure longer tunneling distances and larger coverage areas. However, these increases must not impede or limit the termites' freedom of movement (Ali *et al.*, 2013; Arab & Costa-Leonardo, 2005; Wong & Lee, 2010). The result further revealed that there is low negative correlation association between Weight loss and sand at the depth of 15-30cm (-0.39), which implied that an increase in weight loss lead to decrease in percentage sand at the depth of 15-30cm, and vice versa. Furthermore, the result shows that there is very low negative correlation association between Weight loss and clay at the depth of 15-30cm (-0.27), which implied that an increase in weight loss lead to decrease in percentage clay at the depth of 15-30cm, and vice versa.

The result also shows that there is moderate positive correlation association between Weight loss and silt at the depth of 15-30cm (0.64),which implied that an increase in weight loss lead to increase in percentage silt at the depth of 15-30cm, and vice versa. The result also revealed that there is a low negative correlation association between weight loss and sand at the depth of 0-15cm (-0.41), which implied that an increase in weight loss lead to decrease in percentage sand at the depth of 0-15cm, and vice versa. The result also shows that there is a low negative correlation association between weight loss and clay at the depth of 0-15cm (-0.05), which implied that an increase in weight loss lead to decrease in percentage clay at the depth of 0-15cm, and vice versa. The result also revealed that there is moderate positive correlation association between weight loss and silt at the depth of 0-15cm (0.66), which implied that an increase in weight loss lead to increase in percentage silt at the depth of (0-15cm), vice versa.

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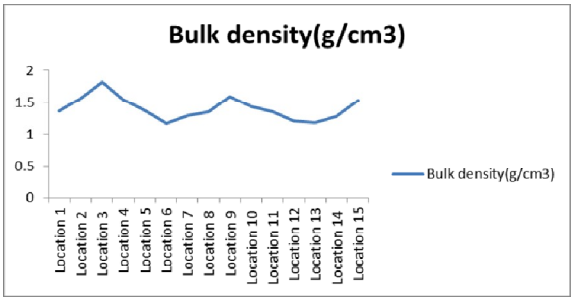


Figure 2: Soil Bulk density (g/cm^3)

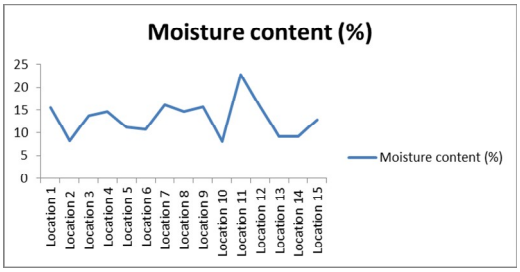


Figure 3: Soil Moisture content (%)

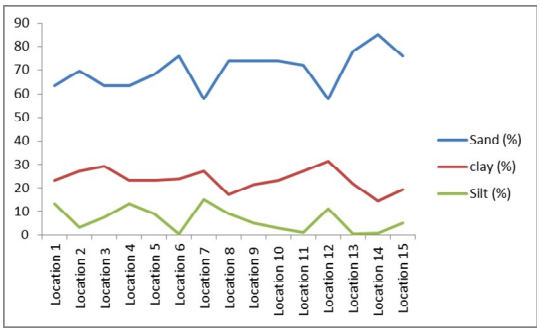


Figure 4: Particle size 0-15cm

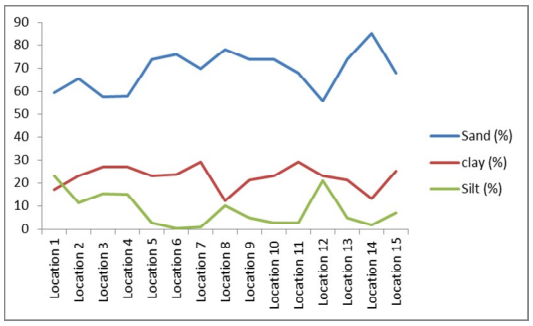


Figure 5: Particle size 15-30cm

Severity of termite activities in the study location

The result of analysis of variance for weight Loss across the locations shows that there is significant difference (table 4). That is the rate of attack of termites to wood species differs from each other and likewise the location, this could be because different species of termite identified in the area of study. It's an evidence of termites presence in all the location of study with varies severity of attack in the locations.

Furthermore, *A. ferruginea* had the least weight loss of 12.57% followed by *T. superba* with 65.28% while *D. oliveri* had the highest weight loss of 70.68% (table 5). This corroborated the finding of Owoyemi *et al* (2022a), Owoyemi *et al* (2022b) and Adiji and Owoyemi (2015) that rate of weight loss due to termites attack is the function of the density of the wood species, that is the higher the density of wood the lesser the weight loss and lower the density of wood the higher the weight loss. The studies revealed that *Daniellia oliveri (Iya) and Terminalia superba (Afara)* in the medium density class was heavily attack by termites and *Albizia ferruginea (Ayinre)* in the high density class was slightly attacked. The result agreed with the classification of wood density by Owoyemi and Olaniran (2014), high density >700kg/m^3, medium density > 450kg/m^3, < 450kg/m^3.Medium and low density wood is highly prone to attack and should not be used without treatment. According to Ogunsanwo (2023), woods are differently endowed in terms of their resistance to attack by bio-deteriorating agents. This could be as a result of the composition of the wood intrinsic properties, level of maturation, position along axial and radial planes of wood as well as the

level of deposition of metabolic toxic waste chemicals in the wood.

The studies also revealed that Location 1,2,3,4,7,8,9,10,12,14 and 15 had the highest attack ranges from 45.30% to 73.90% and locations with moderate attack include location 5, 11 and 13 while location 6 light attack with 17.78% weight loss (table 6, figure 6 and figure 7). With the rate of the severity of the termite established in this study, area with moderate and light attack could experience heavy attack. This study affirmed that different species of termites present in location study contribute to different rate of termites attack across the location. This agreed with the finding of Owoyemi *et al*. (2022a), Owoyemi *et al*. (2022b) and Adiji and Owoyemi (2015), that different species of termite is present in Ondo State and *Macrotermes subhylinus* and *Microtermes* species been the most destructive termites species.

Table 4: ANOVA for Weight Loss across the locations

Source	Df	SS	MS	F	P
Locations	14	79839.72	5702.84	10.40	0.000
Wood species	2	154563.83	77281.91	140.99	0.000
Error	208	114005.22	548.10		
Total	224	348408.77			

Table 5: Duncan multiple range test for weight loss based on the different wood species

Wood species	Weight Loss (%)
A. ferruginea	12.57b
T. superba	65.28a
D. oliveri	70.68a

Table 6: Duncan multiple range test for weight loss based on the different locations

Locations	**Weight Loss (%)**
Location 6	17.78e
Location 11	19.42e
Location 5	27.46de
Location 13	28.99de
Location 10	35.64cd
Location 2	45.30c
Location 9	48.08bc
Location 15	50.10bc
Location 7	61.71ab
Location 12	63.23ab
Location 14	63.31ab

Location 1	68.78a
Location 4	68.95a
Location 8	69.98a
Location 3	73.90a

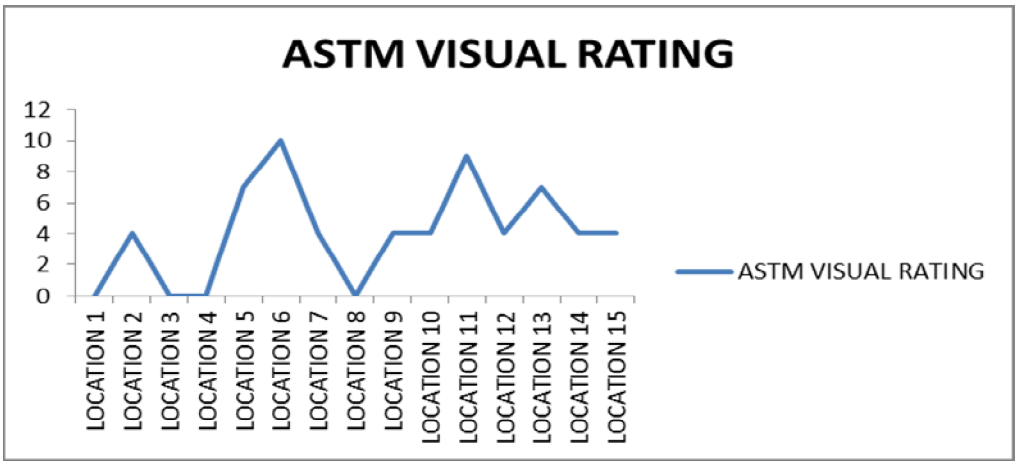


Figure 6: ASTM visual rating for location study

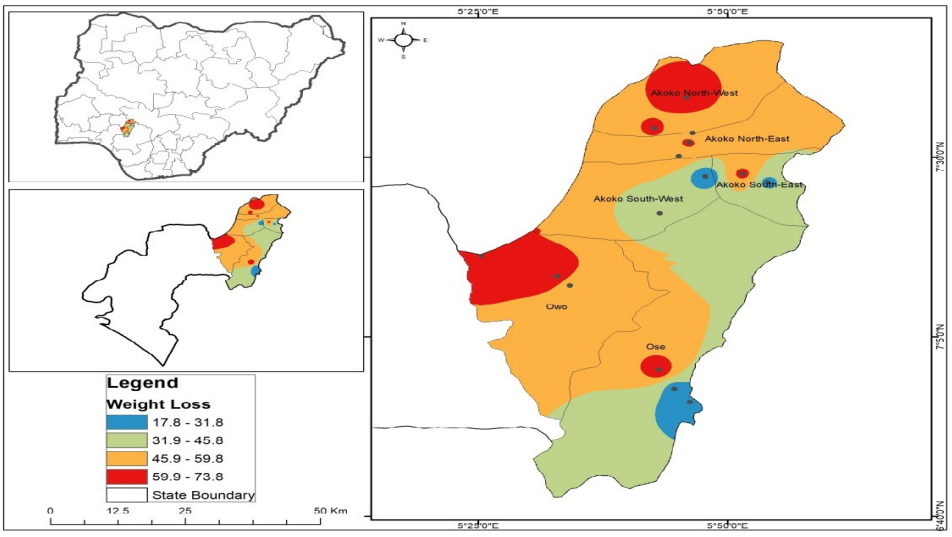


Figure 7: Termite severity probability map

Conclusion

The study has affirmed the presence of termites activities in the savannah ecological zone of Ondo state with *Microtermes species* and *Ancistrotermes cavithorax* been prominent with it aggressive foraging

activities in the ecological zone. Also, the different in the species of termites in most of the location contribute to the different rate of weight loss in all the location of study. The study further established that soil physical properties contribute to rate of termite infestation in build environment. This study therefore serves as guide in pre-constructional and remedial approaches for building in termites management. It is therefore recommended that these activities should be carried out periodically like every five years as termite move from one location to another searching for food and establishing new colony as evidenced in the periodic swarming activities of winged termites, which could make area with low risk of termite attack such as Ose, Akoko Southwest and Akoko southeast Local government Area could move high risk area.

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