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An Innovative Production of a Sustainable Termite Resistance Sandcrete Block Using Jimson Weeds (*Datura stramonium*)

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Abstract: *The problem of termite attacks is very common in sub-Saharan Africa region and this makes components of building structures such as timber very vulnerable to attacks. In an attempt to effectively protect these construction materials from termite attack, it is more effective to deal with the pathway through which termites gain access into the building structures. The toxicity of available synthetic chemicals to human health and the environment calls for the use of alternative natural plants as insecticides and developed them as termite-repellent materials. One of such plants identified is Jimson weed (Datura stramonium, DS). Metal analysis was carried out on both its seeds and leaves, the seed were identified to be more acidic and repelled termites. The aqueous seed extract with 0.2 mg/l concentration was added to the potable water used to prepare sandcrete block at varying percentage. The effect of termite on the piece of wood in sandcrete blocks placed on earthen and concrete surfaces were studied. It was observed that as the percentage of Jimson extract increases, the termite activity reduces. The results showed that DS extract is found to be acidic, making it very toxic to termite. The compressive strength and water absorption of sandcrete hollow block made from DS extract increases with increasing curing time. The results showed that the Jimson weeds can effectively reduce the termite activities on the building components. It can be recommended that the extract be effectively applied after laying the foundation before laying the block walls so as to ensure long time sustainability of the whole building materials.*

Keywords: *Compressive strength, Jimson weeds, metal analysis, sandcrete block, termite.*

1. INTRODUCTION

Man, since ancient time has been in need of a comfortable housing and the choice of materials for making accommodations has evolved with time. The problem of termite attacks is very common in sub-Saharan Africa region such as Nigeria and Ghana and this makes components of building structures such as timber very vulnerable to attacks. Termite's access to a building or other construction materials is mostly by eating their way through walls. Sandcrete hollow block is one of the principal materials being used in the construction industry in Nigeria and the world over for walling units [1]-[4]. In an attempt to effectively protect these materials, it is important to deal with termite pathway.

Termites are members of the soil ecosystem and are found throughout the world, their presence is particularly noticeable in tropical and sub-tropical regions. The natural activities of termites create conditions conducive for primary production [5]. However, in some areas, their natural activities can have negative economic impacts as they attack unprotected cellulosic materials, devaluing property, thus necessitating increasing household repairs. Globally, the annual economic cost of termite damage and termite prevention is estimated in several billions [6]-[8].

The toxicity of available synthetic chemicals in the market to human health and environment has called for alternative use of natural plants, identified as insecticides which are not toxic to human health and environment. Among these plants is *DS*, (Jimson weeds) a local plant which can be found in many part of Nigeria.

Zhu *et al* [9] examined the behaviour of termites towards nootkatone isolated from vetiver oil which have been confirmed to be toxic to termites. Sbeghen *et al* [10] studied the repellent and toxic effect of essential oils of basil (*Ocimum basilicum L.*), citronella *(Cymbopogon winterianus Jowitt*), ho-sho (*Cinammomum camphora Nees and Eberm var. linalonifera*) and rosemary (*Rosmarinus officinalis L.*) on termites. Singh *et al* [11] investigated the essential oil of *amboinicous* using gas chromatography techniques and concluded that the oil extracted was insecticidal to white termites as there was 100% mortality of the termites at a dose of 2.5 x 10^{-2} mg/cm^3 for five hours exposure. Raina *et al* [12] studied the effect of orange peel extract on sub-terranean termites in the United States. The oil extract was found to contain about 92% d-limonene generally known to be toxic to insects. They also observed that termites exposed to the oil extract vapour has reduced feeding rate than controls.

Tagbor [13] determined the anti-termitic efficacy of locally available plants such as *Thevetia peruviana* (pers) *K*., Shum *Carapa procera* DC, *Jatropha curcus L*., Cassia *nigricans* Vahl, C*ymbopogon ginganteus* (Hachst) Chiov), *Hyptis spicigera* Lam., V*etiver zizaniodes* Nash (vetiver grass) and *Chromolaena odorata* (*L*). The results showed that soil treated with pulverized materials from *T. peruviana* offered the best protection to buried stakes against damage by subterranean termites. Ajayi *et al* [14] tested ethanol extracts of *Morinda lucida* and *DS* leaves as wood preservative *in-vivo* at three different concentrations: 0.5%, 1.0% and 1.5% w/v using Basudin, an organophosphate as standard. This study reveals that the two plants have components that are potential treatment for termites. Jayashere *et al* [15] conducted a comparative study to determine the effect of roots and leaves of vetiver grass (*chrysopogon zizanicdes* L Roberty) on termites in India, they found out that the roots were more effective as they have higher mortality rate.

Therefore, the main objective of this study is to produce termite resistance sandcrete block using Jimson weed extract as an admixture to deter termite attack on building and some other construction materials. It also investigates and identify the chemical composition of Jimson weeds that makes it termite-repelling.

2. MATERIALS AND METHODOLOGY

2.1 Materials

Ordinary Portland cements (OPC) of grade 32.5 used in this study conforms with the recommendation of BS 12 [16]. The soundness and fineness of the cement were carried out in accordance to BS EN 196-3 [17] and ASTM C786/C786M-17 [18], and the values were 4.17% and 5% respectively. The initial and final setting times were carried out on the recommendation of BS EN 196-3 [17]. The results were 10 and 630 mins with 5 mm penetration.

A well-graded fine aggregate with maximum size of 4.75 mm free from deleterious materials is used. The fineness modulus of 3.02 obtained was between 2.3 and 3.1 recommended by the ASTM C136-05 [19]. The bulk density of 1730 kg/m^3, silt/clay content of about 9%, and specific gravity 2.65 were obtained. Comparing the physical properties of the aggregates used in this study with the standard requirement, it can be concluded that the fine aggregates is fit for use as sand.

2.2 Jimson Weed

The *DS* (Jimson weeds) was obtained from Fanibi area of Akure in Ondo State, Nigeria (see Fig. 1). It was traditionally recognised to be anti-termite, as termites are not found where they grow. The reason maybe because it contains termite repelling chemicals. It was processed to extract the oil in the Chemical Science Laboratory of Federal University of Technology, Akure (FUTA).

Figure 1: Jimson Weed Plant

2.3 Tests on Jimson Weed

Metal analyses were carried out on Jimson weed leaves and seeds to determine which plant part is more toxic and resistant to termite attack. Phytochemical analysis was carried out in order to determine the chemical compounds that are responsible for insecticidal and anti-termite effect.

2.3.1 Metal Analysis on Jimson Weed Leaves and Seeds

Washed seeds and leaves of *D*S were grinded into uniform powder using a Thomas-Willey milling machine. The powdered samples were kept in an air-tight polythene bags and placed in a refrigerator at 4°C until the time of analysis. For the metal analysis, samples of the Jimson weed was dry-ashed at 550°C, 1.2 g of the ash was dissolved in 10% (vol/vol) HCl, filtered and made up to 100 ml in volumetric flasks photometer using a Maizeing flame photometer.

Metal analysis of nutritionally and poisonous minerals were conducted using the atomic absorption spectrophotometer Buck Scientific 210 (AAS). From the AAS analysis, Jimson weed was discovered to contain Cu, Pb, Ni, Cr, Co, Zn, Cd, Mg, Fe, Mn, Na, K, and Ca. Phosphorus (P) content of *DS* was also determined by the Vanado Molybate method. The absorption values for the metals as obtained from the metal analysis were converted to part per million (ppm).

2.3.2 Phytochemical Analysis

This analysis was done by preparing an aqueous extract of the sample (*DS*) by soaking 100 g of dried powered sample in 200 ml of distilled water for 12 hr, the extracts were filtered using Whatman filter paper No. 42 (125). Qualitative analysis of the chemical constituents was conducted after the phytochemicals analysis; this is such that the actual percentage of the chemical compounds present could be determined. The Jimson weed samples were defatted before subjected to phytochemical analysis so as to determine the actual quantity of the chemical compounds present.

2.4 Tests on Jimson Weed Extract

The *DS* extract were analysed using some water quality indicators such as alkalinity, pH, dissolved oxyegen, hardness, and nitrate; and compared with the Nigerian Industrial Standards (NIS) for drinking water.

2.5 Toxicity to Termites

The toxicity of Jimson weed to termites was measured in terms of number of termites that die on exposure to control (i.e., when there is 0% addition of *Datura* extract), *Datura* leaf extract and *Datura* seed extract in the laboratory. Each sample contained about 50 termites.

2.6 Sandcrete Block Production

In this study, mix ratio of 1:6 by weight of cement and sand with water-cement ratio of 0.60 was adopted for the production of block. In order to investigate the water replacement potential of *DS* extract dilution, the extract was added to the water at varying percentage of 5%, 10% 15% and 20% w/v. The percentage variations represent the amount in percentage that water was partially replaced with the *DS* extract. After thorough mixing of cement and sand with water, the mixture was then poured into the 450 mm x 225 mm x 225 mm mould, the hand ramming method was used to produce a well compacted blocks. The blocks were firstly cured by covering them with polythene material to control the surrounding moisture for the 24 hours before exposure removing coverings. These were done to prevent cracks, and allow early strength development because of the rapid rate of hydration which may lead to poor strength in the long term. Samples were then cured using the sprinkling method of curing in a controlled environment. Tests such as absorption rate and compressive strength tests were carried out on the block.

The rate of water absorption of blocks was influenced by the bond between aggregates and the cement paste, the resistance of concrete to freezing and thawing, chemical stability, resistance to abrasion and specific gravity. The water absorption rate is defined as the weight of water absorbed when the unit is partially immersed for 24 hours in water as indicated in ASTM C1763-16 [20]. Each sample of blocks was weighed in dried conditions, fully immersed in water for a period of 24 hours. After 24 hours, the wet block samples were removed and weighed.

Compressive strength test was carried out to determine the load bearing capacity of the produced sandcrete blocks. The weights and crushing load of the total number of 60 blocks were determined for 7 days, 14 days, 21 days, and 28 days respectively, that is, 3 blocks each for five different dilution percentages of 0.2 mg/L concentration of aqueous *Datura stramonium* seed extract solution in water ranging from 0 % as control, 5 %, 10 %, 15 % and 20 % at the above curing ages.

Figure 2: Produced termite resistant sandcrete blocks on earthen surface.

2.7 Tests on Termite-Resistance Blocks

Two separate studies were conducted on the termite resistant of blocke, which includes placing the block on the concrete surface and on an earthen surface (see Figures 2). The blocks were arranged side by side in areas where visible termite presence was visible. The blocks were spaced about 5 cm apart. Afara (*Terminalia ivorensis*) species of wood pieces were placed in the holes of the blocks as baits in attracting the termites to the blocks in order to assess the effectiveness of the termite resistant blocks. The set up was monitored 2 times daily for 30 days and observations on the effect of the termite on the wood pieces were noticed and recorded.

3. RESULTS AND DISCUSSIONS

3.1 Metal Analysis Results

Table 1 shows that *DS* is rich in Potassium, Magnesium, Calcium, and Sodium. The leaf has higher Magnesium constituent of 782.50 mg/g whereas seed has 773.33 mg/g. Leaf has higher Calcium, Iron, Manganese, Potassium, and Sodium concentration than seed. In contrast, Nickel, Cobalt, Cadmium and Zinc were higher in seed than in leaf. Copper proportion is the same in the seed and leaf with 5.0 mg/g. Lead and chromium were not detected in both leaf and seed.

Oseni *et al* [21] shows that magnesium, calcium, iron, manganese, potassium, and sodium are nutritionally valuable minerals while nickel, cobalt, copper, Cadmium and zinc are poisonous. *DS* seed has a higher proportion of the poisonous mineral content than the *DS* leaf which implies that the *DS* seed is more poisonous and resistant to termite attack when compared to *DS* leaf.

Table 1: Percentage oxide of *D. Stramonium* leaf and seed

Metal	ppm concentration (ppm) mg/g		% oxide	
	Leaf	Seed	Leaf	Seed
Copper (Cu)	5.00	5.00	0.00079	0.00079
Lead(Pb)	-	-	-	-
Nickel(Ni)	7.50	22.50	1.27768	0.00383
Chromium (Cr)	-	-	-	-
Cobalt(Co)	38.33	64.17	0.00651	0.01089
Zinc(Zn)	35.00	35.83	0.00535	0.00548
Cadmium (Cd)	14.17	33.33	0.00126	0.00297
Magnesium(Mg)	782.50	773.33	0.32604	0.32222
Iron(Fe)	149.17	140.00	0.02671	0.02507
Manganese(Mn)	35.00	20.83	0.00637	0.00379
Sodium(Na)	4750.00	4333.33	2.06522	1.88406
Potassium(K)	10750.00	6166.67	2.75641	1.58120
Calcium(Ca)	583.33	500.00	0.14583	0.12500

3.2 Phytochemical Screening Results

Results of the phytochemical screening test (qualitative test) as shown in Table 2 shows that secondary plant metabolites; glycosides, alkaloids, phytates, oxalate, saponins, tannins, and phenolics were present while anthraquinones, and flavonoids were absent.

Quantitative analysis of the metabolites in *DS* (see Table 2) shows that phytate has the highest percentage composition followed by alkaloids, glycoside, phenols, oxalate, saponins and tannins respectively. From the table, it is observed that the higher percentage of poisonous metabolites to termites constitute to its termite resistant property.

From Table 3, the *DS* extract was very acidic as the pH value was 4.5, this is because the extract contains substances such as oxalate, total phenols, alkaloids, tannins and phytates which when react with water will reduce the pH of the water by producing H^+ (ions), some of this H^+ (ions) combine with water to form hydroxonium ion. The alkalinity value was high, this is as a result of the presence of volatile organic compound which include organic salts, organic solvents, nitrogen compound in the *D. stramonium* extract. However, dissoved oxygen, hardness, nitrite and chloride were seen higher than th recommended values.

3.3 Toxicity to Termites

The results of the *DS* toxicity to termite attack on the blocks produced with or without *DS* extract are presented in Figure 3. From the figure there were varying degrees of termite mortality when termites were exposed to different parts of Jimson weeds in the laboratory over time. It is observed that the extract from the seed causes more termite mortality over time. There was 16% mortality without extract (control). The death of the termites in the control could be as a result of suffocation, and heat. *DS* seed with 88% toxicity to termites was more resistant to termite attack compared with *DS* leaf of 70% toxicity to termites. Generally, it is observed that as the period of exposure increases the mortality also increases.

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Table 2: Phytochemical screening results

Metabolite	**Qualitative**		**Quantitative (Mean ± SDs)**
	Suspected	**Confirmed**	
Tannins	Positive	Positive	1.97±0.15 (mg/g)
Saponin	Positive	Positive	12.33±0.20 (%)
Flavonoids	Negative	Negative	-
Glycosides	Positive	Positive	22.04±0.72 (mg/g)
Anthraquinones	Negative	Negative	-
Alkaloids	Positive	Positive	28.60±0.29 (%)
Phytate	Positive	Positive	33.57±0.80 (mg/g)
Oxalate	Positive	Positive	13.06±0.58 (mg/g)
Phenolics	Positive	Positive	21.37±0.35 (%)

Table 3: Physicochemical analysis of *d. stramonium* extract

Parameter	**1st Trial**	**2nd Trial**	**3rd Trial**	**Average Value**	**NIS regulatory limits**
pH	4.50	4.46	4.55	4.50	6.5 – 8.5
Dissolved Oxygen (mg/l)	6.91	6.91	6.71	6.83	6.0
Hardness (mg/l)	140.00	158.00	140.00	146.00	150.00
Chloride (mg/l)	3750.00	3800.00	3750.00	3766.67	250.00
Nitrate (mg/l)	45.00	44.00	41.50	43.50	50.00
Alkalinity (mg/l)	335.00	360.00	290.00	328.33	200

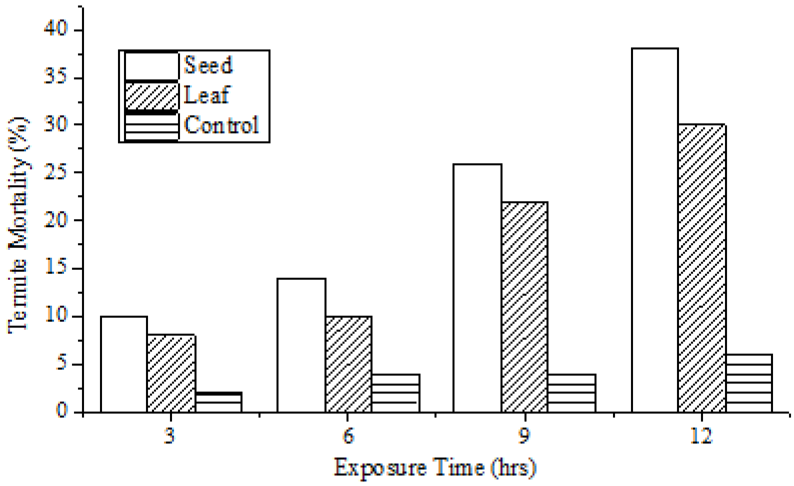

Figure 3: Relationship between termite mortality and exposure time.

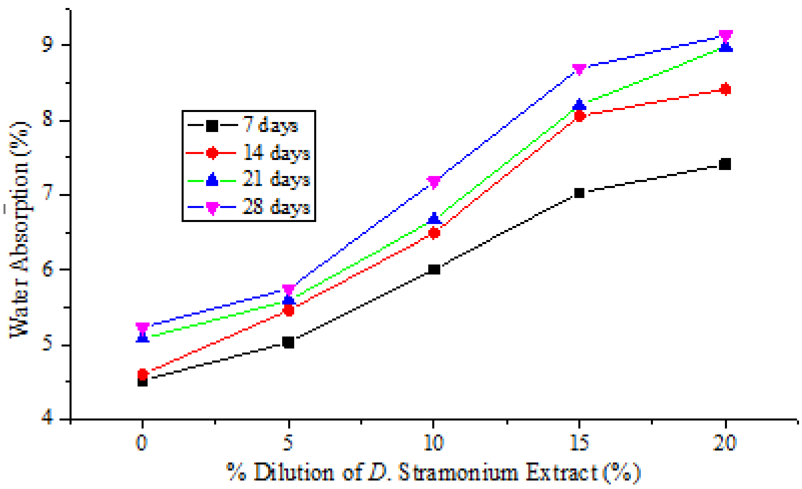

Figure 4: Relationship between water adsorption ratio and *DS* extract.

3.4 Water Absorption Results

The water absorption result for the blocks produced with *DS* extract are presented in Figure 4. The water absorption values for the blocks produced with control and with all percentages of *DS* extract were less than 12% specified by Nigerian Industrial Standard [22]. The water absorption values range from 4.52% at 0% dilution percentage of *DS* extract to 7.41% at 20% dilution percentage of *DS* extract after 7 days, 4.60% at 0% dilution percentage of *DS* extract to 8.42% at 20% dilution percentage of *DS* extract after 14 days, 5.08% at 0% dilution percentage of *DS* extract to 8.99% at 20% dilution percentage of *DS* extract after 21 days and 5.23% at 0% dilution percentage of *DS* extract to 9.14% at 20 % dilution percentage of *DS* extract after 28 days. The result showed that blocks produced with *DS* extract complied with Nigerian Industrial Standard (NIS 2004). The control blocks in this study is similar to commercial blocks. The fact that sandcrete blocks produced without *DS* extract (commercial) not resistant to termite's attack are not to be ignore. Finally, it is observed that the blocks absorb more water as the percentage of *DS* extract and curing age increase.

3.5 Compressive Strength

The results of the compressive strength of the sandcrete blocks made from *DS* extract mixed with water at various dilution percentages are shown Figure 5. The result indicates that the compressive strength increases with the increasing curing age. It is observed that both 10% and 20% replacement satisfied the minimum strength requirement of 3.40 N/mm^2 at 28 days as stipulated by Nigerian Industrial Standard [22]. The result showed that sandcrete blocks produced with *DS* extract at 10% - 20% are termite resistant and still complied with Nigerian Industrial Standard. This is an added advantage when compared to the control (commercial) blocks.

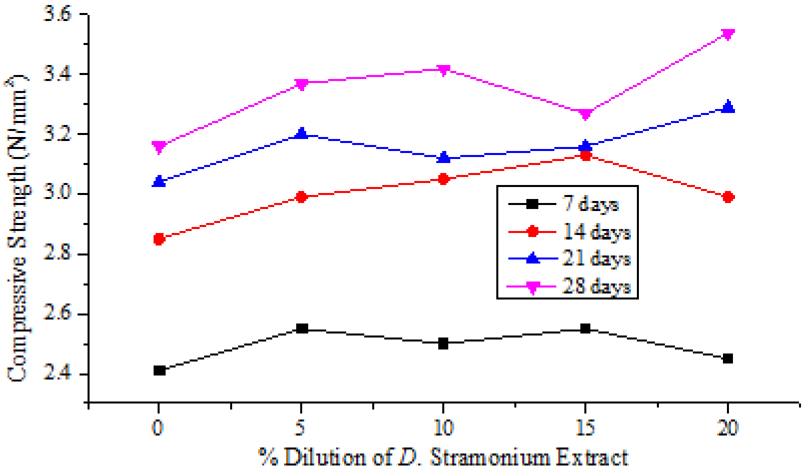

Figure 5: Relationship between compressive strength and *D. stramonium* extract

3.6 Termite Control Analysis

The results of the study on the effectiveness of the sandcrete blocks with *DS* extract are presented in Tables 4 and 5. The observations were made over the period of 30 days in which the observation was made twice daily (morning and evening). From the tables, it is observed that as the observation period and the percentage replacement of *DS* extract increases, the less impact the termite have over the wood. Also from the tables, *not affected* (*NA*) indicates that there is no sign of termite activity on the wood piece in the sandcrete blocks, *mildly affected* (*MA*) indicates that, less than 50% of the total surface area of the block was visibly affected with no sign of muds on the blocks. *Affected* (*A*) indicates that, more than 50 % of the total surface area of the wood piece was affected with little sign of muds effect on the blocks, and *seriously affected* (*SA*) indicates muds covered almost the interior surface area of the sandcrete blocks.

4. CONCLUSION

Termite attack is a serious problem to households in Nigeia. Termites pose serious challenges to wood and construction materials. This research has shown the anti-termitic capabilities of Jimsom weed (*DS*) in the production of termite resistant sandcrete blocks. Therefore, it can be concluded that:

i. *DS* seed contains a higher percentage of nickel, copper, cobalt, cadmium and zinc than *DS* leaf;
ii. *DS* seed contains a higher percentage of poisonous chemical compound such as oxalates, saponin and phytate. The phytate content with the highest percentage of 33.57% plays a dominant role in determining its termite resistant property;
iii. *DS* extract is very acidic, making it very toxic to termites and thereby eliminating the effect of termites to structural members;
iv. The compressive strength of sandcrete hollow block made from *DS* extract increases with increasing curing age;
v. The 28 days compressive strength of 3.42 N/mm^2 and 3.54 N/mm^2 for the sandcrete hollow block made from 10% - 20% dilution percentages respectively are above the minimum 28 days compressive strength of 3.40 N/mm^2 stipulated by

(NIS 2004) thereby making the *DS* extract appropriate for this purpose.

vi. The best dilution percentage for making sandcrete hollow block is 20% dilution percentage as its 28 days compressive strength of 3.54 N/mm^2 is above the minimum 28 days compressive strength of 3.4 N/mm^2 stipulated by Nigerian Industrial Standard [22].

vii. The result showed that sandcrete blocks produced with *DS* extract are termite resistant and still complied with Nigerian Industrial Standard [22].

This research work has provided more information on *DS* which can be used as toxins to termite's attack in the construction industry and proffered a cheaper alternative in *DS* which is readily available and applicable in the Nigerian environment compared to other plant extracts that are not easily accessible in this part of the world.

It is seen that; it is quite economical to introduce the use of *DS* extract as a whole into the Engineering industry as it has been done in the field of sciences. The extract should also be effectively utilized at the sub-structure level in building technology and other engineering constructions aimed at overall increased compressive strength of the structure. This extract should be effectively applied after laying the foundation before laying the block walls so as to ensure long time sustainability of the whole building most especially in areas where termite attack is menace for instance in Akure and its environs.

Table 4: Effect of termites on the wood piece and sandcrete blocks on earthen surface

Days	Control	Percentage replacement of DS extract			
		5%	10%	15%	20%
1	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA
3	MA	NA	NA	NA	NA
4	MA	NA	NA	NA	NA
5	A	NA	NA	NA	NA
6	A	NA	NA	NA	NA
7	SA	MA	NA	NA	NA
8	SA	MA	NA	NA	NA
9	SA	MA	NA	NA	NA
10	SA	MA	NA	NA	NA
11	SA	MA	NA	NA	NA
12	SA	MA	NA	NA	NA
13	SA	MA	NA	NA	NA
14	SA	MA	NA	NA	NA
15	SA	MA	NA	NA	NA
16	SA	MA	NA	NA	NA
17	SA	MA	NA	NA	NA
18	SA	MA	NA	NA	NA
19	SA	MA	NA	NA	NA
20	SA	MA	NA	NA	NA
21	SA	MA	NA	NA	NA
22	SA	MA	MA	NA	NA
23	SA	MA	MA	NA	NA
24	SA	MA	MA	NA	NA
25	SA	MA	MA	NA	NA
26	SA	MA	MA	MA	MA
27	SA	MA	MA	MA	MA
28	SA	MA	MA	MA	MA
29	SA	MA	MA	MA	MA
30	SA	MA	MA	MA	MA

Table 5: Effect of termites on the wood piece and sandcrete blocks on concrete surface

Days	Control	Percentage replacement of DS extract			
		5%	10%	15%	20%
1	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA
7	MA	NA	NA	NA	NA
8	MA	NA	NA	NA	NA
9	MA	NA	NA	NA	NA
10	MA	MA	NA	NA	NA
11	MA	MA	NA	NA	NA
12	NA	MA	NA	NA	NA
13	MA	MA	NA	NA	NA
14	MA	MA	NA	NA	NA
15	A	MA	NA	NA	NA
16	A	MA	NA	NA	NA
17	A	MA	NA	NA	NA
18	A	MA	NA	NA	NA
19	A	MA	NA	NA	NA
20	A	A	NA	NA	NA
21	SA	A	NA	NA	NA
22	SA	A	NA	NA	NA
23	SA	A	NA	NA	NA
24	SA	A	NA	NA	NA
25	SA	A	NA	NA	NA
26	SA	A	NA	NA	NA
27	SA	A	NA	NA	NA
28	SA	A	NA	NA	NA
29	SA	A	NA	NA	NA
30	SA	A	NA	NA	NA

NA: Not Affected; MA: Mildly Affected; A: Affected; SA: Seriously Affected

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