Biotermiticides to Protect the Soil Health

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Abstract— *Chemical termiticides are hazardous to biotic and abiotic factors in the environment and hence banned in US and European countries but are still in use in developing countries. They are applied in huge quantity reaching to potable water ways, food, and fodder and killing soil microbiological components. It has been observed from the study that these hazardous termiticides can be replaced by ecofriendly and cheap Biotermiticides made from the plant based oils. Four tree borne oils (CNSL(50-100%), Neemseed oil(10-25%), Karanj seed oil(10-25%) and Markingnut oil(10-25%) and three chemicals Chlorpyrifos(10-50%), Coppernaphthenate(10-50%) and (Boric acid(10-50%) were used in different proportions to formulate CNSL based termiticides. Specimen samples were treated and exposed to termites for 60 days. The mass loss after 60 days was noted and results were analyzed. Chlorpyrifos and Coppernaphthenate 100% have shown better termite control property than boric acid. Commercial termiticides their own might be effective against termite but except Chlorpyrifos and other two have shown not much promising results in CNSL based formulation when compared with the oil formulations. It was observed that CNSL(50-80%) + NO (10-25%) + BSL(10-25%) and CNSL(50-80%) + NO(10-25%) + KO(10-25%) formulations can act as an effective termiticides. All four oils if used 100% have shown good resistant against termites.*

Keywords— CNSL- Cashew nut shell liquid, NO- Neemseed oil, KO- Karanj oil, BSL- Bhilawan shell liquid.

I. INTRODUCTION

Termites are a group of eusocial insects of infraorder *Isoptera*, or as epifamiliy *Termitoidae* within the cockroach order *Blattodea* (Beccaloni and Paul, 2013). They are of four groups: dampwood living and feeding in very moist wood, drywood termites do not require contact with moisture or soil and subterranean termites live and breed in soil, and arboreal/mound builders. Termite mounds are commonly found in Africa, Australia, Southeast Asia, and parts of South America (Krishna, 1969; Inward et al., 2007). They are polymorphic living in colonies comprising reproductives (king, queen), soldiers and workers called castes. The queen in 'Royal Chamber' is very much bigger than the king and is capable of laying eggs at the rate of 36,000 a day for as long as 50 years. Single subterranean termite colony may contain millions of workers and may forage a distance of up to 100 m^2. (Su & Scheffrahn, 1988).

Termites help in aeration of the soil due to burrowing activities, the breakdown and release of organic matter as termites eat and digest soil, improvement of soil fertility when termite mounds, which are rich in minerals, are crushed down and incorporated into the soil, as a source of minerals for cattle who lick the mounds and as a source of protein rich food for many organisms including ants, guinea fowl and other mammals including humans (HDRA, 2001). It is also observed that termite in its natural environment; improve soil pH, organic carbon content, water content and porosity by recycling dead organics (Abdel and Skai, 2011).

Although there are some benefits of termites in soil reclamation but they are often called the **"Silent Destroyer"** as they may be secretly hiding and thriving in homes without any immediate signs of damage. About 10% of species of the termite are economically significant as pests and consume cellulose-based plant materials and destroy valuable property, documents, furniture and furnishings anything that contains cellulose, silently and swiftly, before becoming aware of the damage done. Termites also cause damage to living trees, crop plants, wooden electric poles, railway sleepers, telephone and electrical cables, etc. (Krishna and Weesner, 1970; Pardeshi et al., 2010; Mitchell, 2003; Ogedegbe and Eloka, 2015).

The economic losses associated with termite damage for Malaysia, India, Australia, China, Japan and the United States are 10, 35, 100, 375, 800 and 1,000 million US dollars respectively (Abdel and Skai, 2011). In Indian region about 35 species have been reported to damage about 10-25% agricultural crops and timber in buildings (Rajgopal, 2002). It is observed that due to termite attack on wheat, paddy, cotton, sugarcane, groundnut, in Punjab, Rajasthan, Delhi, Uttar Pradesh, Andhra Pradesh, Bihar and Gujarat, Madhya Pradesh, and Maharashtra faced major loss in crop production (Patel and Patel, 1954;

Chhotani, 1980; Verma et al. 2009). As many as 13 species of termite are reported to cause 30-60% destruction of buds of sugarcane in India (Roonwal, 1981) and are responsible for plant mortality (5-50%) and pod damage (46%) in groundnut (Rajgopal, 2002). Not only crops and wood but the cash, ornaments and saving documents kept in banks have been found attacked by termite in India (Indian Express News, 22 Apr 2016, TNN. Apr 5, 2008).

Chemical termiticides used to control the termite include liquid termiticides, termite baits, building materials impregnated with termiticides and wood treatments. Chemical treatments on broad base can be of two types repellent termiticide and non-repellent termiticide. These chemicals do not kill the termites; they simply deter them from entering the treated soil and building tunnels. Ex. Cypernethrin, Bifenthrin, Fenitrothion, Permethrin and Fenvalerate, Chlorpyrifos. Non-repellent chemicals do not prevent termites from tunneling; they only kill the termites upon ingestion or contact. An example is imidacloprid, Aldrin, Heptachlor, Chlordane, Coppernaphthenate, Boric acid etc. Grace, et al.,(1993) reported that the toxicity of aldrin, chlordane, DDT, dieldrin and heptachlor was observed 17,20,24,28 and 33years after treatment in Hawaii. These are applied in huge quantity in soil or poured in mounds to destroy it. These chemicals are very toxic to all the biotic factors in soil and on the earth, leading to hazardous effects and diseases. This may is one of the threats to the human existence on the earth through soil pollution.

It is necessary to search the alternative safe termiticides to the commercial hazardous chemicals damaging soil health and ultimately the environment as a whole. Therefore the study was undertaken in the College of Agricultural Engineering and Technology, DBSKKV, Dapoli on, "Development of Cashew nut shell liquid based termiticide'. The main objective of study was developing and testing cashew nut shell liquid based termiticide by using Neemseed oil, Karanj seed oil and Markingnut shell oil in different proportions and field tested for termite response.

II. MATERIALS AND METHODS

In this study four tree borne oils (Cashew nut shell liquid (CNSL), Neemseed oil, Karanj seed oil and Markingnut oil(BSL)) and three chemicals (Boric acid, Chlorpyrifos and Coppernaphthenate) were used in different proportions (Table 1). Treatment detail is shown in Table 2 and Table 3. Wood specimens (30cm long and 2.5cm diameter) of Giripushpa (*Gliricidia sepium),* were dried and weighed before the subsequent treatment. As per the treatments, CNSL based oil and chemical formulations were made. Then dry weighed specimens were treated with both the formulations by surface area application and dipping into the solution up to 10cm and room dried for 24 hrs. Then specimens were again weighed to know the percent weight of termiticide absorbed by the surface area of each wood sample. The detail experimental design of the present investigation is as shown in fig.1. Treated specimen samples were placed in the mound holes 10cm deep by breaking mound soil cap and exposed to termites up to 60 days.

TABLE 1
TREATMENT DETAILS OF THE EXPERIMENT

1	**Experiment—I** (Oil Formulation)	**Material**	**Levels (%)**
		CNSL	50,60,70,80,100
		Neemseed Oil	10, 15, 20,25,100
		Karanj seed Oil	10, 15, 20,25,100
		BSL	10, 15, 20,25,100
2	**Experiment-II** (Chemical Formulation with CNSL)	**Material**	**Levels (%)**
		CNSL	50,60,70,80,90,100
		Chlorpyriphos	10,20,30,40,50,100
		Coppernaphthanate	10,20,30,40,50,100
		Boric acid	10,20,30,40,50,100

TABLE 2
TREATMENT COMBINATION FOR OIL FORMULATION

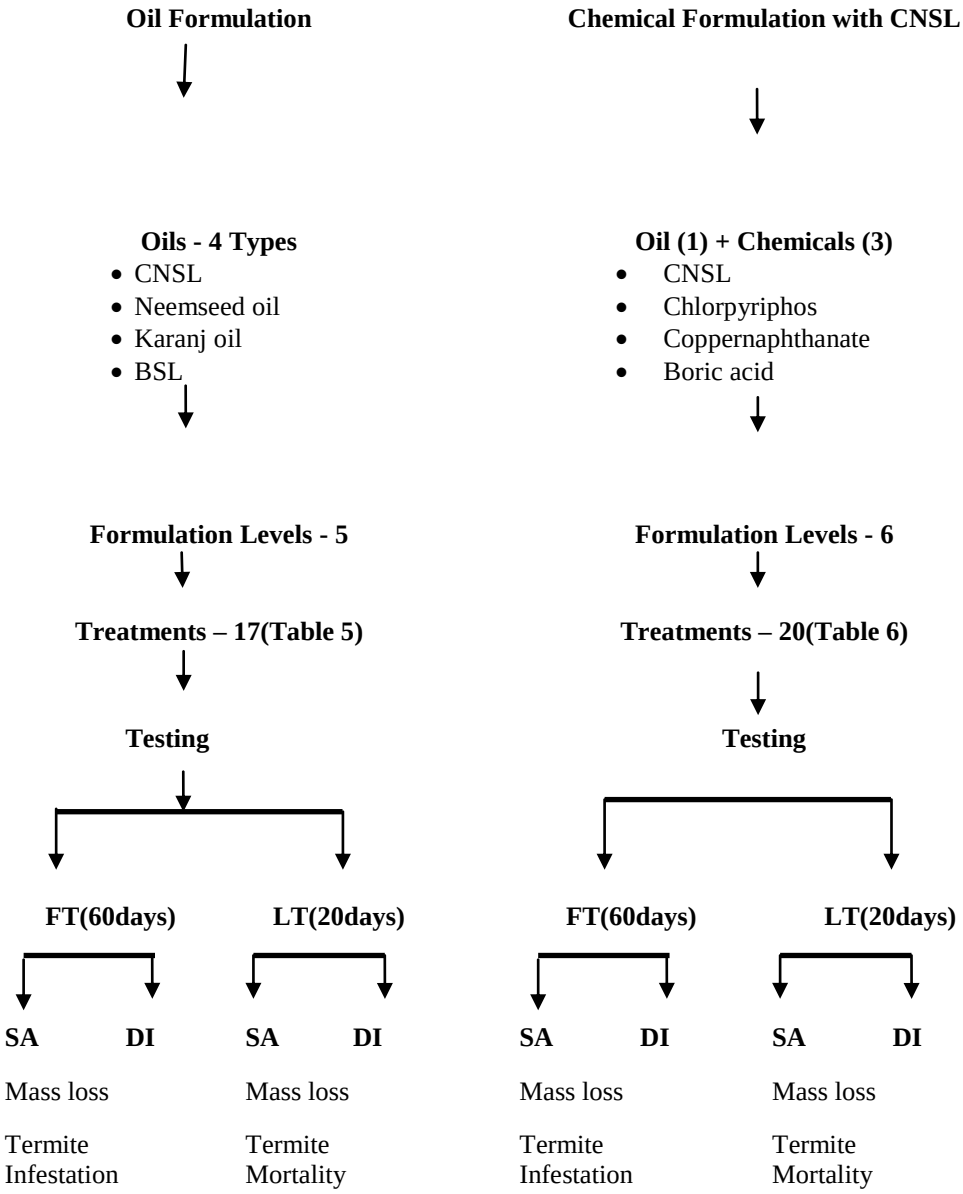
Sr. No.	Treatment	Oils			
		CNSL(%)	Neem oil (%)	Karanj oil (%)	BSL (%)
1	TO_1	100	0	0	0
2	TO_2	0	100	0	0
3	TO_3	0	0	100	0
4	TO_4	0	0	0	100
5	TO_5	80	10	10	0
6	TO_6	80	10	0	10
7	TO_7	80	0	10	10
8	TO_8	70	15	15	0
9	TO_9	70	15	0	15
10	TO_{10}	70	0	15	15
11	TO_{11}	60	20	20	0
12	TO_{12}	60	20	0	20
13	TO_{13}	60	0	20	20
14	TO_{14}	50	25	25	0
15	TO_{15}	50	25	0	25
16	TO_{16}	50	0	25	25
17	TO_{17}(Control)	0	0	0	0

(TO- Treatment of oil formulation)

TABLE 3
TREATMENT COMBINATION FOR CHEMICAL FORMULATION WITH CNSL.

Sr. No.	Treatment	CNSL (%)	Chlorpyrifos (%)	Coppernaphthanate (%)	Boric acid (%)
1	TC_1	100	0	0	0
2	TC_2	0	100	0	0
3	TC_3	0	0	100	0
4	TC_4	0	0	0	100
5	TC_5	90	10	0	0
6	TC_6	90	0	10	0
7	TC_7	90	0	0	10
8	TC_8	80	20	0	0
9	TC_9	80	0	20	0
10	TC_{10}	80	0	0	20
11	TC_{11}	70	30	0	0
12	TC_{12}	70	0	30	0
13	TC_{13}	70	0	0	30
14	TC_{14}	60	40	0	0
15	TC_{15}	60	0	40	0
16	TC_{16}	60	0	0	40
17	TC_{17}	50	50	0	0
18	TC_{18}	50	0	50	0
19	TC_{19}	50	0	0	50
20	TC_{20}(Control)	0	0	0	0

(TC - Treatment of chemical formulation with CNSL)



FT - Field Test
LT - Laboratory Test
SA - Surface area application
DI - Dipping into solution

FIG.1 FLOW DIAGRAM OF EXPERIMENTAL DESIGN.

After 60 days wood specimens were removed from the termite mounds and weighed to know the mass loss by termite attack which was calculated as below.

Mass loss (ML%)

The termite attack to the specimen samples placed on the mound will be quantified by calculating the weight after 60 days.

$$ML(\%) = \frac{[M_1 - M_2]}{M1} X\ 100 \quad (1)$$

Where, M_1 and M_2 are initial (before exposure) and final (after exposure) weight (g) of the wood sample (EN 118, 2005).

TABLE 4
MASS LOSS OBSERVED IN OIL FORMULATION TREATMENTS

Sr. No.	Treatment (CNSL:NO:KO:BSL)	Surface Application	Dipping
		Wt.Loss %	Wt.Loss %
T1	100:0:0:0	5.37	3.46
T2	0:100:0:0	0.00	4.44
T3	0:0:100:0	0.00	0.00
T4	0:0:0:100	5.90	3.56
T5	80:10:10:0	0.00	0.000
T6	80:10:0:10	0.00	0.000
T7	80:0:10:10	10.16	6.21
T8	70:15:15:0	0.00	0.00
T9	70:15:0:15	0.00	0.00
T10	70:0:15:15	7.56	4.23
T11	60:20:20:0	0.00	0.00
T12	60:20:0:20	0.00	0.00
T13	60:0:20:20	5.07	0.00
T14	50:25:25:0	0.00	0.000
T15	50:25:0:25	4.44	0.00
T16	50:0:25:25	0.00	2.69
T17	0	19.94	38.94

III. RESULTS AND DISCUSSION

In the oil formulation experiment, from surface application treatments it was observed that specimens of T_2, T_3, T_5, T_6, T_8, T_9, T_{11}, T_{12} T_{14}, T_{16} were not attacked by termite, where as among rest of the treatments specimens of T_7 was attacked causing highest mass loss 10.16% and in treatment T_{15} it was lowest i.e 4.44% as against control treatment T_{17} in which the mass loss was 19.94%. In the same experiment with specimens dipping in formulation, specimens of treatments T_3, T_5, T_6, T_8, T_9, T_{11}, T_{12}, T_{13}, T_{14}, T_{15} were not attacked by termite, whereas among rest of the treatments specimens of T_7 was attacked causing highest mass loss 6.2% and in treatment T_{16} it was lowest i.e. 2.69%, as against control treatment T_{17} in which the mass loss was 38.94%.

The results indicate that synergistic effect of oils in treatments CNSL +Neemseed oil + Karanj oil and CNSL +Neemseed oil + BSL has positive effect on termite control in both surface application and dipping treatments of oil formulation experiment. It is clear that presence of Neemseed oil with CNSL stands more effective against termite attack.

In the chemical formulation experiment from surface application treatments it was observed that specimens of T_2, T_5, T_8, T_{10}, T_{11}, T_{17} were not attacked by termite, where as among rest of the treatments specimens of T_4 was attacked causing highest mass loss 79.13% and in treatment T_3 it was lowest i.e 4.43%, as against control treatment T_{20} in which the mass loss was 85.40%. In the same experiment with specimens dipping in formulation, specimens of treatments T_2, T_3, T_8, T_{10}, T_{11}, T_{12}, T_{14}, T_{17} were not attacked by termite, whereas among rest of the treatments specimens of T_4 was attacked causing highest mass loss 73.56% and in treatment T_5 it was lowest i.e. 4.84%, as against control treatment T_{20} in which the mass loss was 87.73%.

In chemical formulation treatments it is observed that specimens from treatments CNSL with boric acid were highly attacked in comparison to other treatments whereas only one treatment with Chlorpyrifos was attacked by termite, may be because of its repellent nature. Boric acid is slow poison, it shows its effect after ingestion, and hence the specimens treated with it might be attacked more but after effect is unknown. Coppernaphthenate treated specimens were attacked by termite unevenly with increase in its proportion with CNSL it might be because of synergistic effect.

TABLE 5
MASS LOSS IN CHEMICAL FORMULATION TREATMENTS

Sr. No.	Treatment (CNSL:CF:CN:BA)	Surface Application	Dipping
		Wt.Loss %	Wt.Loss %
T1	100:00:00:00	58.49	35.81
T2	0:100:00:00	0.00	0.00
T3	0:00:100:00	4.43	0.00
T4	0:00:00:100	79.13	73.56
T5	90:10:00:00	0.00	4.84
T6	90:00:10:00	48.62	5.69
T7	90:00:00:10	40.43	9.33
T8	80:20:00:00	0.00	0.00
T9	80:00:20:00	21.09	30.81
T10	80:00:00:20	0.00	0.00
T11	70:30:00:00	0.00	0.00
T12	70:00:30:00	20.84	0.00
T13	70:00:00:30	15.27	5.01
T14	60:40:00:00	0.00	0.00
T15	60:00:40:00	11.63	0.00
T16	60:00:00:40	66.92	47.89
T17	50:50:00:00	0.00	0.00
T18	50:00:50:00	30.65	6.17
T19	50:00:00:50	19.71	40.20
T20	00:00:00:00	85.40	87.73

CNSL- Cashew nut shell liquid, CF- Chlorpyrifos, CN- Coppernaphthenate, BA- Boric acid

IV. CONCLUSION

From the results it can be concluded that Chlorpyrifos and Coppernaphthenate 100% have shown better termite control property than boric acid. Commercial termiticides individually are effective against termite but except Chlorpyrifos, other two have shown not much promising results in CNSL based formulation when compared with the oil formulations. It can also be concluded that CNSL (50-80%) + NO (10-25%) + BSL(10-25%) and CNSL(50-80%) + NO(10-25%) + KO(10-25%) formulations can act as an effective termiticide. All four oils if used 100% have shown good resistant against termites. Results of oil formulations are near about and better than the chemical formulations.

It is found from this study that a Biotermiticide i.e. Cashew nut shell liquid based oil formulation termiticide has a potential to act as an alternative to the commercial termiticides in the market. Also it will help to reduce the harmful effects and cost required for chemical formulations and to maintain the health of soil microbiology.

REFERENCES

[1] Abdel, G. and S. Edwards, 2011. Termite Damage to Buildings: Nature of attacks and preventive construction methods. *Am. J. of Engg and Applied Sciences,* 4(2): 187-200.

[2] Beccaloni, George; Eggleton, Paul. 2013. "Order Blattodea" . *ZOOTAXA*. Zhang, Z.-Q., ed. Animal Biodiversity: An Outline of Higher-level Classification and Survey of Taxonomic Richness(Addenda 2013) 1 (3703): 46–48. doi:10.11646/zootaxa.3703.1.10.

[3] Chhotani, O. B., 1980. Termite pests of Agriculture in Indian region and their control. Tech. Monograph., 4: 1-84.

[4] HDRA, 2001. The organic organization of United Kingdom published a Booklet,'Termite Control'.

[5] Indian Express News, Ahmedabad, Fri,22 Apr 2016.Termites eat up Rs. 1 lakh in bank locker.

[6] Inward D., G. Beccaloni, P. Eggleton. 2007. Death of an order: a comprehensive molecular phylogenetic study confirms that termites are eusocial cockroaches.Royal Society Pub. Biology Letters. .DOI: 10.1098.

[7] EN 118. 2005. *European Committee for Standardization*. Wood preservatives- determination of toxic values action against Reticulitermes species (European Termites): 17-118. http://www.epa.gov/pesticides/op/chlorpyrifos/efedrra1.pdf.

[8] J. K. Grace, J. R. Yates, M. Tamashiro and R. T. Yamamoto. 1993. Persistence of organochlorine insecticides for Formosan subterranean termite(Isoptera: Rhinotermitidae) control in Hawaii. J. Econ. Entomol. 86(3): 761-766.

[9] Krishna, K. 1969. Introduction. In Biology of termites. A book edited by K. Krishna and F. M. Weesner, 1: 1–17. New York: Academic press, xiii + 598 pp.

[10] Krishna, K. and F. M. Weesner, 1970. Taxonomy, Phylogeny and Distribution. In: Biology of Termites. Academic Press, New York,: 643.

[11] Michael J. B., D. G. Wujek, F. L. Thomas, Jr., G. A. Lyon, T. Matsumoto, A. S. Robertson. 2000.Methods and apparatuses for monitoring or controlling pests (Especially Termite). US 6016625 A.

[12] Ogedegbe, A. B.O. and E. V. Eloka. 2015. Biodiversity of Termites on Farmlands in Local Government (Ugoniyekorhionmwon, Orhionwmon) Area, Edo State, Nigeria. *Int. J. Pure Appl. Sci. Technol*., 27(2): 65-76.

[13] Pardeshi, M. and B. A. K. Prusty, 2010. Termites as ecosystem engineers and potentials for soil restoration. Curr. Sci., 99: 11-11.

[14] Patel, G.A. & H.K. Patel, 1954. Seasonal incidence of termite injury in the northern parts of the Bombay State. Indian 1. Entomol., 15(4) : 376-378.

[15] Rajagopal, D. 2002. Economically important termite species in India. *Sociobiology*, 40: 33-46.

[16] Roonwal, M.L., 1981. Termites of Agricultural Importance in India and their Importance. In: Progress in Soil Biology and Ecology in India, Veeresh, G.K. (Ed.). University of Agricultural Science, Hebbal, Bangalore, : 253-265.

[17] Su, N.Y. and R. H. Scheffrahn. 1988. Foraging population and territory of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in an urban environment. *Sociobiology*, 14: 353-359.

[18] TNN. Apr 5, 2008, 01.19 AM , IST. Tamil Nadu News.Termites eat up cash, FDs in bank locker.

[19] Varma, M., S. Sharma and R. Prasad. 2009. Biological alternatives for termite control: A review. *Int. Biodeteriration and Biodegration*, 63: 959-972.

[20] US EPA, 2000. Reregistration eligibility science chapter for chlorpyrifos. Fate and environmental risk assessment chapter.

[21] U.S. Geological Survey. Circular 1225. Reston, VA: USGS; 1999. The quality of our nation's waters – nutrients and pesticides. http://water.usgs.gov/pubs/circ/circ1225/.