EVALUATION OF SOME ENVIRONMENTALLY FRIENDLY SUBSTANCES TO CONTROL SUBTERRANEAN TERMITES *ANACANTHOTERMES OCHRACEUS* (Burmeister, 1839) (BLATTODEA: HODOTERMITIDAE).

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ABSTRACT

To control the subterranean termites, *Anacanthotermes ochraceus* using inorganic and organic materials in Hihya, Sharkyia Governorate. Two sites were selected namely, Hihya1 and Hihya 2. Inorganic substances were assessed in Hihya1, while organic substances were assessed in Hihya2. El-Sebay cardboard traps with water were used to locate termites in Hihya and served as the control. This process was repeated thrice every other week during August and early September 2021. The inorganic materials were evaluated five times using El-Sebay traps in Hihya1 in Sept. 2021. Boric acid was the most effective substances tested with no termite in traps (0 individuals), followed by barium chloride and ammonium sulfate (50 and 150 individuals, respectively) while the least effective was potassium bromide (190 individuals) compared to control (710 individuals). Organic substances were evaluated in Hihya2, using the same procedures as in Hihya1. Thymol, citronella oil and tar oil had the highest effect on termite control while the least effective was Camphor oil (350 individuals) compared to control (1020 individuals). The latent effect for the organic substances revealed that citronella oil was the most effective while the least effective were tar oil, camphor oil and thymol. Accordingly, citronella oil and boric acid could be used as potential eco-friendly substances against termites in Hihya.

Keywords: *Anacanthotermes ochraceus,* termite control, Organic materials, Inorganic material.

INTRODUCTION

Termites are widely distributed throughout the tropical and sub-tropical regions (**Emerson, 1955; Araujo, 1970; Wood and Johnson, 1986; Eggleton, 1999)**. They feed on cellulose that exists as roll baits, litter bags, wooden baits, stake baits and corrugated cardboard or grass bags which are used to measure the relative consumption of different species of termites (**La Fage *et al.*1973; Brian, 1978; Said, 1979; Ali *et al*. 1982; Abdel-**

Wahab *et al*. 1983; Salman *et al*. 1988; El-Sebay, 1991 and El-Sherif *et al*. 2009). Different forms of traps were used to monitor foraging activity of many groups of termites such as Polyvinylchloride (PVC) collar traps, glass plates, square or roll traps of corrugated cardboard (**El-Sebay, 1991; Su *et al*. 1991; Ahmed, 1997; El-Sherif *et al*. 2009 and Abd El-Latif, 2013**). Several studies estimated the economic loss caused by subterranean termites in Aswan to reach 6 million L.E. (**El-Sebay, 2008). El-Sebay and Ahmed (2006)** estimation was about 4.3 million L.E. losses in Fayoum, and 755.110 L.E. for termites' control at North Sinai. **Engel *et al*. (2009)** found between 2,300 and 3,000 species at Siberia, Spain, Brazil, Germany, France, Croatia, Zanzibar copal and Colombian copal. *Anacanthotermes ochraceus* is the most common termite in Lower Egypt; its range extends from Cairo to the Mediterranean coast. However, it was collected from 13 Governorates (Minufia, Sharkyia, Qalyubiya, Kafr El-Sheikh, Beheira, Ismailia, Giza, Matrurh, El Fayoum and Sinai in addition to Dakhla and Kharga oasis) (**Kassab *et al*. 1960; Kaschef and El-Sherif 1971**).

Chemical insecticides e.g. chlordane, heptachlor and lindane, etc. were mostly used for controlling termites. However, the use of organochlorine pesticides was banned in most countries due to longer persistence and health hazards so organophosphates and pyrethroids replaced organochlorines (**Paul *et al*. 2018**). Organophosphorus pesticides are the most toxic to vertebrate animals (**Malhat and Nasr, 2013**); among which chlorpyrifos was considered highly toxic (**WHO, 2020**). The heavy use of chlorpyrifos leads to different damage, including environmental pollution and direct hazard to users. According to the World Health Organization, about one million accidental and two million suicidal poisonings with organophosphorus insecticides are reported per year (**Rust and Saran, 2008; Smith *et al*. 2008; Ahmed *et al*. 2014;Hassan *et al*. 2018).**

The most effective repellent oils for *Psammotermes hybostoma* were caraway, basil, camphor and tar (**Aly *et al*. 2012**). Citronella oil and lemongrass oil have antibacterial, antioxidant and termite repellent activities. Therefore, both compounds could be potential termite repellent agent (**Lima *et al*. 2013**). *Lippia gracilis* had a greater proportion of thymol

(57.24%) and methyl thymol (10.58%), the essential oils as *L. gracilis* were more toxic to the workers than to the soldiers of *Nasutitermes corniger* (Isoptera: Termitidae).

Borax (BX), boric acid (BA), zinc borate (ZB), or sodium perborate tetrahydrate (SPT) were tested against the subterranean termites, *Coptotermes formosanus* Shiraki. All samples containing boron compounds had greater resistance against termite attack. The highest termite mortalities were determined in the samples treated with either BA or BX (**Usta *et al.* 2009**).

The ability of termites to attack solid wood and plywood treated with ammonium sulfate (AS) was used to test the resistance of subterranean termites *Coptotermes formosanus* Shiraki under laboratory conditions. The lowest mass losses were obtained for the solid-wood and plywood specimens treated with AS (**Terzi *et al.* 2011**). **Fagbohunka *et al.* (2014)** observed that table salt is used as a lethal substance for termites due to its indirect effect, whether inhibitory or stimulant, of the crucial enzymes. It has also been found that the chloride salts such as the chlorides of barium, calcium and magnesium were more than the effect sodium salts on *Amitermes desertorum.*

The aim of the present study was to explore environmentally friendly materials for controlling termites, therefore, some organic and inorganic materials were tested.

MATERIALS AND METHODS

1-Study area:

Two field experiments were conducted, at Hihya district in Sharkyia Governorate, where *Anacanthotermes ochraceus* (family: Hodotermitidae) dominate. The first area was at distance of 100 m Hihya1, the Agricultural Society namely, Hihya1 and the second area was at distance 500 m from the Agricultural Society which namely, Hihya 2.

2-Materials tested:

A field test was conducted using some inorganic substances on *A. ochraceus* at Hihya1. While, at Hihya 2, some organic materials were tested.

The inorganic materials: barium chloride, potassium bromide, boric acid with concentration 10%. The ammonium sulfate was tested with concentration 2%. The materials were tested in the field from September 2021 until November 2021. All inorganic materials were obtained from "Alpha Chemicals Group".

The organic materials tested were 2% citronella oil obtained from "Pure Life Company". Camphor oil and thymol were obtained from "Alpha Chemicals Company Group" and tested at concentration of 2.5%. Tar oil was obtained from "All Bio Green Moroccan Cosmetics" and tested at a concentration of 2.5%. All materials were field tested from October 2022 until November 2022.

2.1 Preparation of inorganic material concentration:

A concentration of 10% was prepared from the following mineral salts: barium chloride, potassium bromide and boric acid. According to **Grace and Abdallay (1990)** the use of boric acid or barium metaborate at 10% concentration resulted in high mortality but 5% concentration was lowest mortality.

- **Barium chloride:** 30 grams were weighed then completed volume with water to reach 300 ml and distributed among 3 traps, each trap was saturated with 100 ml of the solution.
- **Potassium bromide:** 40 grams were weighed then completed volume with water to reach 400 ml and distributed among 4 traps.
- **Boric acid**: 50 grams were weighed then completed volume with hot water to reach 500 ml and distributed among 5 traps.

A concentration of 2% **ammonium sulfate** was prepared by using 10 grams of the salt then completed volume with water 500 ml and it was distributed among 5 traps. Ammonium sulfate at 2 % was successful in controlling velvetleaf (**Pratt *et al.* 2003**).

2.2 Preparation of organic material concentration:

A concentration of 2.5% was prepared from the following organic materials:

- **Thymol:** 10 gm was dissolved in 100 ml ethyl alcohol then completed volume with water to reach 400 ml (total volume 400 ml), distributed among 4 traps.
- **Camphor oil:** 10 ml was dissolved in 200 ml acetone then completed volume with water to reach 400 ml (total volume of 400 ml) distributed among 4 traps.

- **Tar oil:** 10 ml was dissolved in water and completed volume to reach 400 ml (total volume of 400 ml) then it was distributed among 4 traps.

A concentration of 2% was prepared from the citronella oil:

- **Citronella oil:** 10 ml was dissolved in 100 ml of ethyl alcohol then completed volume with water to reach 500 ml (total volume of 500 ml), then it was distributed among 5 traps.

3-Traps Preparation:

The present field study was performed using the modified El-Sebay traps (1991) consisting of corrugated cardboard roll of 12 cm. long and 5-7 cm diameter, closed from side by plastic covers. Cardboards were prepared in laboratory at Wood Borers and Termite Research Unit at PPRI, Doki-Giza. The number of traps for each experimental field was determined based on the results of the control traps (water) for each field. El-Sebay traps are preferred due to the high aggregation of termites in them and the facilitated of counting numbers of termites.

4- Statistical analysis:

Actual termite counts were statistically transferred to square roots (sqrt (count+0.5) to reduce variability within the same variable. Data was analyzed using two/way ANOVA, using Proc GLM in SAS. Data was considered significant at $p \leq 0.05$.

5- Field experiments:

<u>5.1-The First area at Hihya1:</u>

This study was conducted in an area of 80 square meters (inside residential building, not an empty space) infested with subterranean termites *A. ochraceus*. The experimental area was carefully cleaned from any cellulosic materials (superficial and partially buried debris of dead wood as stumps) to prevent any nutrient interferences with the applied trap. This study area used to test some inorganic and attractive material against subterranean termites *A. ochraceus.*

To detect termites in the study area, twenty-five traps were distributed in this area with one meter between each trap. Corrugated cardboard was immerged with water only then buried in holes (30 cm deep in the soil and 10 cm diameters) to identify infested and/or intact traps. Every two weeks, all traps are removed from holes and replaced with new traps and this process is repeated three times. The infected traps are placed in a plastic container for examination and transported to the laboratory (Plant Protection Research Institute in Dokki, Giza) to count individuals using a fine brush after every time.

5.1.1-Testing inorganic material at Hihya1:

In this field: Ammonium sulfate, barium chloride, boric acid and potassium bromide were tested from 18th September to 14th November, 2021. To evaluate these materials against *A. ochraceus*. Fifteen traps were treated with inorganic material and other traps were as a control (untreated). Every two weeks each trap was removed from the ground hole and a new trap was placed in its place with the same inorganic materials. This process was repeated five times. Each time, the infected traps were detected and transported to the laboratory for counting termites.

Six months later, on the 4th of June 2022, after leaving the previous area without any treatment. Twenty-one traps were treated with water only and placed in the same area. After two weeks these traps were removed to detect infested traps followed by counting termites to evaluate the latent effect of inorganic material on *A. ochraceus*.

5.2-The second area at Hihya 2:

This study was conducted in an area of 175 square meters (inside residential building, not an empty space) infested with subterranean termites *A. ochraceus.* This area was carefully cleaned from any cellulosic material to prevent any nutrient interference with the applied trap. This study area used to evaluate some organic material as thymol, citronella oil, tar oil and camphor oil against *A. ochraceus*.

To detect termites in the study area, twenty-eight traps were distributed in this area with one meter between each trap. Corrugated cardboard was immerged with water only then buried in holes (30 cm deep in the soil and 10 cm diameters) to identify infested and/or intact traps. Every two weeks, all traps are removed from holes and replaced with new traps and this process is repeated five times. The infected traps are placed in a plastic container for examination and transported to the laboratory (Plant Protection Research Institute in Dokki, Giza) to count individuals using a fine brush after every time.

5.2.1-Testing organic material at Hihya2:

In this field: thymol, citronella oil, tar oil and camphor oil were tested from 8th October to 5th November 2022 to evaluate the material against *A. ochraceus*. Sixteen traps were treated with organic material and other traps were as a control. Every two weeks, each trap was removed from the ground hole and a new trap was placed in its place with the same organic materials. This process was repeated three times. Each time, the infected traps were detected and transported to the laboratory for counting termites.

Two weeks later, on 19th November 2022, after leaving the previous area without any treatment. Twenty-four traps were treated with water only and placed in the same area. After two weeks, these traps were removed to detect infested traps followed by counting termites to evaluate the latent effect of organic material on *A. ochraceus*.

RESULTS

1-Determination of active termites at Hihya1:

Results illustrated in Fig. (1) that gradual increase in the detected number of termites when repeated time with wet traps which the highest number recorded at 400 individual termites on 4-Sep. followed by 300 individual termites on 21-Aug. On the other hand, the traps recorded any termite individuals in the first time (7-Aug.).

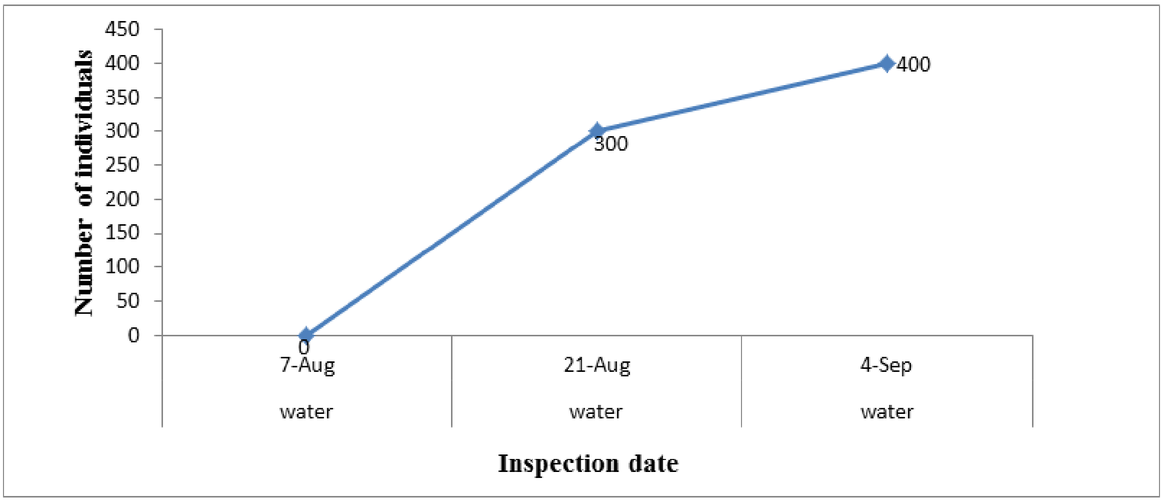

Fig. (1): Determination of the activity of *A. ochraceus* at Hihya1 in Sharkyia Governorate, in 2021.

1.1-The relation between some weather conditions on active termite at Hihya 1:

Data recorded in Table (1) revealed that the effect of decreased of average temperature and soil temperature led to a gradual increase in termite individuals which were recorded as 0, 300 and 400 termite individuals. On the contrary, there was an increase in the average relative humidity.

Results of statistical analysis demonstrated that the correlation between termite individuals and some weather factors as R.H.% was positively significant different and soil temperature was negatively significant different, while it was insignificant different with air temperature.

Table (1): Effect of temperature, relative humidity and soil temperature on *A. ochraceus* at Hihya1 in Sharkyia Governorate, in 2021.

Date	Tested Material	Number of Individuals	Temperature Average (°C)	Average Relative Humidity (%)	Soil Temperature Average (°C)
7-Aug	control	0	40.36	45.48	31.07
21-Aug	control	300	40.76	47.71	30.23
4-Sep	control	400	36.95	52.68	28.99
Pearson correlation "r"			-0.169	0.261	-0.279
p-value			0.154	0.026	0.017

Means with the same letter are not significantly different at $p \leq 0.05$.

1.2-Effect of some inorganic material:

The results presented in Table (2) showed that a significant different drops in the activity of termites was recorded in tested boric acid followed by the same effect were barium chloride and ammonium sulfate and the insignificant different was potassium bromide. The total number of termites recorded was 50,150 and 190 individual termites compared to the control 710 individuals.

Table (2): Evaluation of some inorganic material on the activity of *A. ochraceus* at Hihya1 in Sharkyia Governorate, in 2021.

TESTED MATERIAL	18-SEP		30-SEP		14-OCT		30-OCT		14-NOV		TOTAL NUMBER OF TRAPS	TOTAL NO.OF TERMITES	MEANS
	No.of traps	No.of termites	No.of traps	No.of termites	No.of traps	No.of termites	No.of traps	No.of termites	No.of traps	No.of termites			
Control	5	40	6	100	6	120	9	200	10	250	36	710	19.72[a]
Ammonium sulfate	5	150	3	0	3	0	3	0	3	0	17	150	8.82[abc]
Potassium bromide	–	–	4	50	4	60	4	50	4	30	16	190	11.88[ab]
Barium chloride	–	–	3	50	3	0	3	0	3	0	12	50	4.17[bc]
Boric acid	5	0	5	0	5	0	5	0	5	0	25	0	0[c]
"F" value													3.62
p-value													0.0045

Means with the same letter are not significantly different at $p \leq 0.05$.

1.3-Latent effect of some inorganic material:

Results illustrated in Figure (2) showed that the latent effect of used inorganic material on *A. ochraceus* was strong and extended up to six months. Treatments of boric acid, barium chloride and ammonium sulfate had the highest latent effect as their traps didn't record any termite individuals while the lowest latent effect was potassium bromide compared to control.

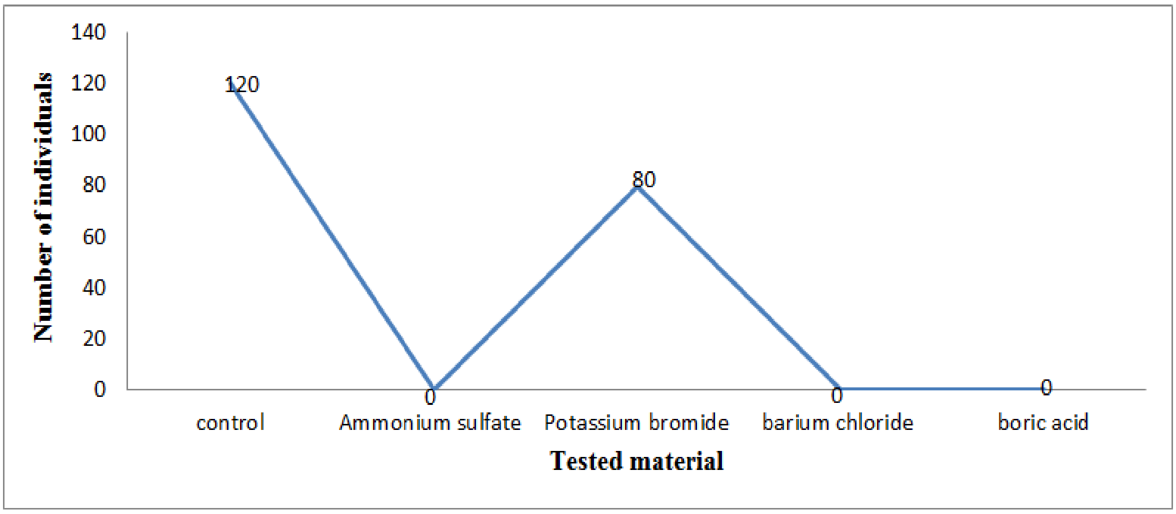

Fig. (2): Latent effect of some inorganic material after six months on *A. ochraceus* at Hihya1 in Sharkyia Governorate, in 2022.

2- Determination of the activity of termites in the second area at Hihya2 (Sharkyia Governorate):

The results obtained from Hihya 2 followed the same trend as Hihya1. Figure (3) illustrated a gradual increase in termite individuals as 20, 60, 80, 90 and 120 termite individuals were recorded, respectively.

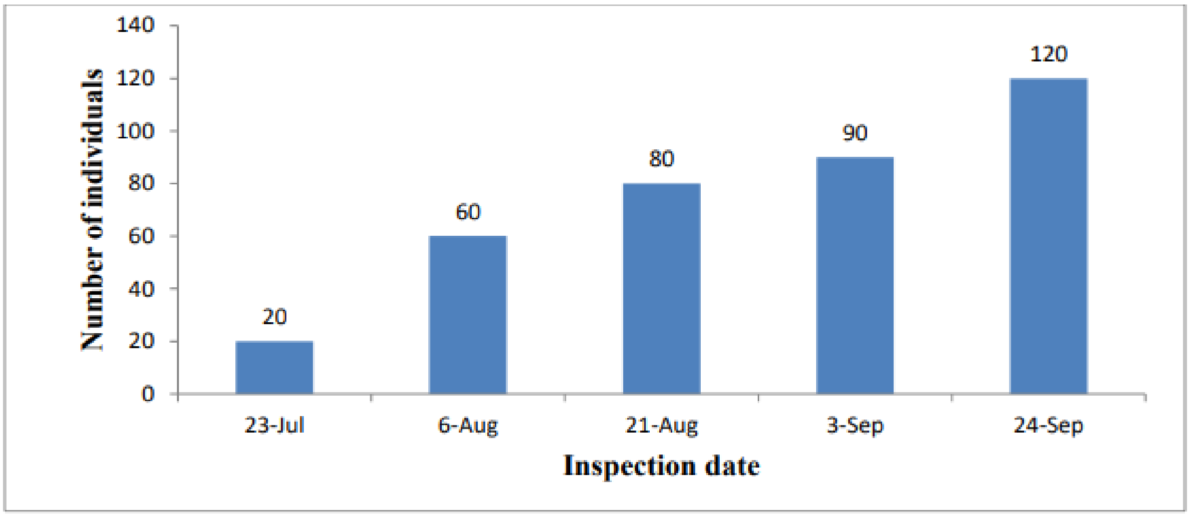

Fig. (3): Distribution of *A. ochraceus* in study area at Hihya2 in Sharkyia Governorate, in 2022.

2.1-The relation between some weather factors as temperature, relative humidity and soil temperature on termite numbers:

Results presented in Table (3) proved that the temperature average and soil temperature recorded reverse relationship with termite individuals.

The statistical analysis showed that the correlation between termite individuals and some weather factors as air temperature and soil temperature were negative significant different, while it was a negative insignificant different with R.H. %.

Table (3): Effect of temperature, relative humidity and soil temperature on *A. ochraceus* at Hihya2 in Sharkyia Governorate, in 2022.

Date	Tested Material	Number of Individuals	Temperature Average (°C)	Average Relative Humidity (%)	Soil Temperature Average (°C)
23-Jul	water	20	29.12	69.68	30.43
6-Aug	water	60	28.88	72.88	30.51
21-Aug	water	80	28.67	74.21	29.73
3-Sep	water	90	27.31	72.24	29.73
24-Sep	water	120	27.18	71.66	29.41
Pearson correlation "r"			-0.189	-0.110	-0.212
p-value			0.026	0.201	0.012

2.2-Effect of some organic material:

From the data recorded in Table (4) it is worth to mentioning that all tested organic material had a significant different effect on the activity of *A. ochraceus* except the camphor oil which recorded an insignificant different effect compared to the control.

Table (4): Evaluation of some organic material on activity of *A. ochraceus* at Hihya2 in Sharkyia Governorate, in 2022.

Tested Material	8-OCT		22-OCT		5-NOV		Total Number of Traps	Total Termite Individuals	Mean
	No. of traps	No. of termites	No. of traps	No. of termites	No. of traps	No. of termites			
Control	11	100	11	400	11	520	33	1020	30.91[a]
Thymol	4	0.0	4	0.0	4	0.0	12	0.0	0.0[b]
Citronella oil	4	0.0	4	0.0	4	0.0	12	0.0	0.0[b]
Tar oil	4	0.0	4	0.0	4	0.0	12	0.0	0.0[b]
Camphor oil	4	300	4	50	4	0.0	12	350	29.17[a]
"F" Value									4.50
p-value									0.0027

Means with the same letter are not significantly different at $p \leq 0.05$.

2.3-The latent effect of some organic material:

Results demonstrated in Fig. (4) showed that the latent effect of tested organic material after two weeks. The highest latent effect was citronella oil followed by thymol, but the lowest latent effect was tar oil and camphor oil compared to the control.

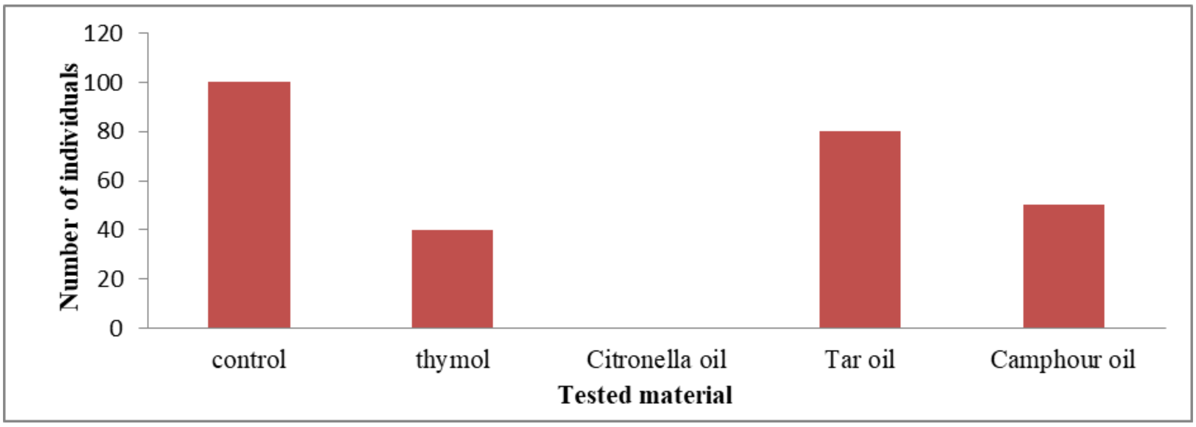

Fig. (4): Effect of some organic material after two weeks on the activity of *A. ochraceus* at Hihya2 in Sharkyia Governorate, in 2022.

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3-Comparison studies between the effect of both organic and inorganic material against activity of *A. ochraceus*:

As presented in Table 5, there was a significant difference among all tested organic and inorganic material and the mean number of termites collected. Boric acid was the most effective on termite activity. Boric acid was the most effective inorganic material while citronella oil, thymol and tar oil were the most effective organic materials. However, no significant differences were observed with potassium bromide and camphor oil.

Table (5): The comparison effect between some organic and inorganic material against ***A. ochraceus***

TYPE OF MATERIAL	THE TREATMENT	MEAN
The inorganic material	Ammonium sulfate	8.824[cb]
	Potassium bromide	11.875[ab]
	Barium chloride	4.167[cb]
	Boric acid	0.0[c]
The organic material	Thymol	0.0[c]
	Citronella oil	0.0[c]
	Tar oil	0.0 [c]
	Camphor oil	29.167[a]
value"F"		6.66
value-*p*		0.0001

3.1-Comparison studies between the latent effect of both organic and inorganic material against the activity of *A. ochraceus*:

The results in Fig. (5) showed that citronella oil exhibited the most latent effects represented organic material like boric acid, barium chloride and ammonium sulfate as inorganic materials. On the contrary, potassium bromide possessed the lowest latent effect followed by tar oil, camphor oil and thymol.

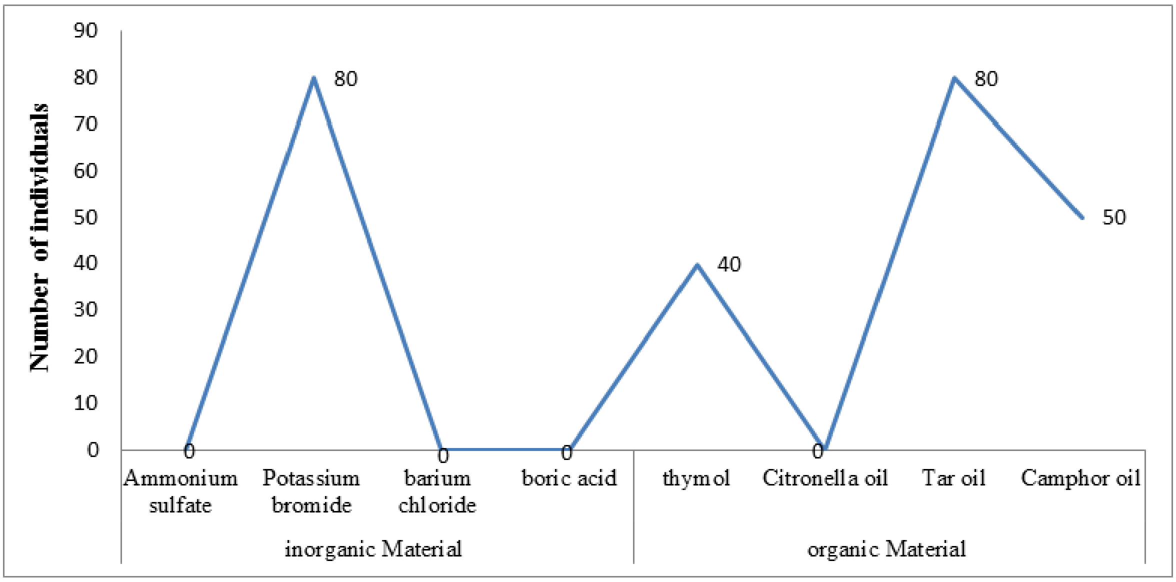

Fig. (5): The comparison of the latent effect between organic and inorganic material on the activity of *A. ochraceus.*

DISCUSSION

Termites are known to live in the soil as subterranean pests so the results of gradually increasing in termite activity in both area studies (Hihya1 and Hihya2) with the repeated time and putted wet traps, may be due to termite not being accustomed to the presence of food in this place. The results agreed with those obtained by **EL Bassiony and Ahmad (2011)** who reported that the food consumption for the examined termites recorded high rates were extended more than 6^{th} weeks and this was followed by an increase in the number of termites.

The relation between some weather factors on termite numbers:

The obtained results proved that the correlation of positive significant different with relative humidity and soil temperature while insignificant different with air temperature may be due to the nature of insect living. Results obtained in the present investigation was similar to those obtained by **Thabit *et al*. (2019)** who found that relative R.H.% had a positive significant correlation on foraging activity (r =0.585), while mean temperature has a negative significant correlation (r = -0.735).

Effect of some inorganic materials:

The obtained results proved that boric acid is the most effective on termite activity followed by ammonium sulfate and barium chloride. The results in the present investigation are similar to those obtained by **Kardl (2001)** who found that the treatment with boric acid increased the mortality of subterranean termites (Isoptera: Rhinotermitidae). Also, **Terzi *et al.* (2011)** explained that the ability of termites to attack solid wood and plywood treated with ammonia compounds such as ammonium sulfate (AS) was subjected to termite resistance tests using the subterranean termites *Coptotermes formosanus* Shiraki under laboratory conditions. The lowest mass losses were obtained for the solid wood and plywood specimens treated with AS.

The results for ammonium sulfate were consistent with **Muwawa *et al*. (2016)** who tested several concentrations of ammonium sulfate (5%, 10%, 15% and 20%) on termite gut bacteria (*Macrotermes* and *Odontotermes* spp.) and found that bacteria had the least growth at all ammonium sulfate concentrations, especially using concentrations higher than 15%. Also, the results obtained were consistent with **Fagbohunka *et al.* (2014)** who observed that table salt could be used as a lethal substance for termites because it's indirect effect, whether inhibitory or stimulant, on the crucial enzymes. It has also been found that the effect of chloride salts such as the chlorides of barium, calcium and magnesium is more than the effect of NaCl on *Amitermes desertorum.*

Effect of some organic materials:

The present data clarified that citronella oil was the most effective material, but camphor oil was the least effective on termite activity. The results obtained are in disagreement with **Aly *et al*. (2012)** who found that camphor oil on *Psammotermes hybostoma* affects the percentage of the individuals caught in treated traps (0.0 %). However, the results are in agreement with tar oil registered the percentage of the individuals caught in treated traps (0.0 %). Also, results confirm the finding **Lima *et al*. (2013)** who reported that the *Lippia gracilis* had a greater proportion of thymol (57.24%) that was followed by methyl thymol (10.58%). The essential oil as *L. gracilis* was more toxic to the workers than to the soldiers, as observed by the mortality ratio of workers relative to the soldiers on *Nasutitermes corniger*. The current results are consistent with **Park *et al*. (2015)** who indicated that citronella oil and lemongrass oil have antibacterial, antioxidant and termite repellent activities. Therefore, both compounds could be potential termites- repellent reagents.

CONCLUSION

The organic materials that are the most effective in controlling termites were citronella oil, thymol and tar oil, whereas the most effective of inorganic materials were boric acid, barium chloride and ammonium sulfate. So the organic and inorganic materials used in the present investigation could be used to inhibit termite activity.

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تقييم بعض المواد الصديقة للبيئة لمكافحة النمل الأبيض تحت الأرضي

***Anacanthotermes ochraceus* (Burmeister, 1839) (Blattodea:Hodotermitidae).**

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المستخلص

تم إجراء هذا العمل لمكافحة النمل الأبيض الجوفي *Anacanthotermes ochraceus* باستخدام المواد العضوية وغير العضوية في ههيا بمحافظة الشرقية. تم اختيار موقعين هما ههيا 1 وههيا 2. تم تقييم المواد غير العضوية في ههيا 1، بينما تم تقييم المواد العضوية في ههيا 2. تم استخدام مصائد الكرتون السباعي بالماء لتحديد موقع النمل الأبيض في هيهيا كما عملت أيضًا كعنصر مقارنة. تكررت هذه العملية ثلاث مرات كل أسبوعين خلال أغسطس وأوائل سبتمبر 2021. تم تقييم المواد غير العضوية خمس مرات باستخدام مصائد السباعي في ههيا 1 في سبتمبر 2021. كان حمض البوريك هو أكثر المواد فعالية التي تم اختبارها مع عدم وجود النمل الأبيض في المصائد (0 فرد)، يليه كلوريد الباريوم وكبريتات الأمونيوم (50 و150 فردًا على التوالي) بينما كان أقلها فعالية هو بروميد البوتاسيوم (190 فردًا) مقارنة بالمجموعة المقارنة (710 فردًا). تم تقييم المواد العضوية في ههيا 2، باستخدام نفس الإجراءات المستخدمة في ههيا 1.كان للثايمول وزيت السترونيلا وزيت القطران أعلى تأثير في مكافحة النمل الأبيض بينما كان أقل فعالية هو زيت الكافور (350 فردًا) مقارنة بالمجموعة المقارنة (1020 فردًا). كشف التأثير الكامن للمواد العضوية أن زيت السترونيلا كان الأكثر فعالية بينما كان أقل فعالية هو زيت القطران وزيت الكافور والثايمول. وعليه، يمكن استخدام زيت السترونيلا وحمض البوريك كمواد صديقة للبيئة محتملة ضد النمل الأبيض في ههيا.

الكلمات المفتاحية: *Anacanthotermes ochraceus*، مكافحة النمل الأبيض، المواد العضوية، المواد غير العضوية