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COMPARING DURABILITY OF WOODEN PRODUCTS AGAINST MICROCEROTERMES DIVERSUS IN REGIONS OF JIROFT AND SISTAN OF IRAN

Ali BAYATKASHKOLII
University of Zabol, College of Natural Resources, Department of Paper
Wood Technology and Sciences, Zabol, Iran
Tel: 00989177153975, Fax: 00985422232600, E-mail: ali.bayatkashkoli@gmail.com, ali.bayatkashkoli@uoz.ac.ir

Batoul KAMESHKI
University of Zabol, College of Natural Resources, Department of Paper
Wood Technology and Sciences, Zabol, Iran
E-mail: batoolkameshki@gmail.com

Soltan RAVAN
University of Zabol, College of agricultural, Department of Plant Protection, Zabol, Iran
E-mail: rbayatkashkoli@yahoo.com

Mohammad SHAMSIAN
University of Zabol, College of Natural Resources, Department of Paper
Wood Technology and Sciences, Zabol, Iran
E-mail: mohammadshamsian1@hotmail.com

Abstract:
Wood-based panels are used at inside and outside of various building, and termites feed mostly from these lignocelluloses materials. The aim of present study identifies biological resistance of four wooden products that include medium density fiberboard, 3-plywood and particleboard against Microcerotermes diversus termite via field method. Degradation grading the termite attack was performed in accordance with the ASTM D 1758-06 specifications. This research was conducted in Sistan region and Jiroft for 15 months. On the base of this result, all testing samples have been degraded. Both weight loss and grading values indicated that the 3-plywood and medium density fiberboard had the lowest and highest degradation, respectively. The weight loss and grading values of wood based panel specimens against the Microcerotermes diversus attack is the same. Field observations showed that the degradation of composite specimens located at Sistan are similar to Jiroft, except of particleboard specimen degradation.

Key words: *biological resistance; wooden products; Microcerotermes diversus termites.*

INTRODUCTION

The wooden products and cellulosic industries have had considerable growth and development. The increasing consumption of wooden products that is followed by population growth, and demand extension has increased consumption of raw wood. Concerning ascending trend of consumption of wood and its products and limited wooden sources, the lack of raw wood is very evident. Wooden composites have been used extensively instead of raw woods in structural. A large amount of wood products that are in contact with soils degrade and many losses are incurred to the economy. Identification of resistant wood products against termites can be a good guide for selection of wood products in different consumptions. Studies conducted on durability of productions against termites and in field condition are limited, but studying the durability of wood and wood products in vitro has a relatively good and generally they associate with durability of woods against fungi.

Cellulose being the principal food of termites, wood and wood products such as paper, fabrics and wood structures are avidly consumed (Peralta et al. 2004). A five year test in Japan showed that softwood 3-plywood, particleboard and oriented strand board were not resistant against termites attack (Tsunoda 2008). Studies indicated that the first fracture on the glue line resulted in start of degradation of wood-based composites against biological degradations (Carll and Highley 1999; Kartal and Clausen 2001; Vick et al. 1996; Wagner et al. 1996).

The ability of white and brown rot fungi and termites to decompose MDF consisting of different wood species by measuring weight loss evaluated. MDF and wood specimens were also bioassayed against the eastern subterranean termite, Reticulitermes flavipes (Kollar) in order to determine termite resistance of the specimens. MDF specimens made from beech and mixed furnish showed decreased weight losses from termite attack after 4 weeks. However, none of the MDF specimens were resistant to termite attack. In severe conditions, the MDFs may require the incorporation of chemical biocides prior to board production for increasing the resistance of MDF to termite attack (Kartal and Green 2003). Laboratory termite resistance tests showed that all samples containing boron compounds had greater resistance against termite attack compared to untreated MDF samples. As chemical loadings increased, termite mortalities increased, and at the same time the weight losses of the samples decreased (Usta et al. 2009).

Particleboard and medium density fiberboard (MDF) panels were produced using stone pine (Pinus pinea) cones, which were mixed with either wood particles or fibers from pine and beech wood at various ratios. Specimens were also subjected to subterranean termites, Coptotermes formosanus, according to the JIS K 1571 standard test method for 3 weeks. No increased resistance was observed in the specimens exposed to the termites. In some cases, the specimens containing pinecone furnish had greater mass losses compared to the control specimens (Kose et al. 2011). Five kinds of commercially available wood-based composites (softwood plywood, hardwood plywood, medium density fiberboard, oriented strand board, and particle board) post-treated with alkaline copper quat and copper azole were exposed to decay and subterranean termite activity for three years. Both biological attacks developed with time. Untreated medium density fiberboard and particle board were highly resistant to field conditions during the 36 months. Untreated oriented strand board, hardwood plywood and softwood plywood were the least resistant composite types (Tascioglu et al. 2013).

The wood has a special structure and consists of carbon, hydrogen, and oxygen and it is considered as a natural organic material, it can degrade easily by different biological degradations. Termites in their geographical limits threat building timbers, goods made from wood, paper, and dress, for special types of arable trees and plants and some types of plastics. Termites have an extensive distribution throughout the world and they damage wooden products. All wooden composites have been made by less durable woods or their coats have small holes are sensitive to attack of termites especially when they are subject to soil. Wooden materials are degraded by termites even when are apparently dried. It is important to identify wooden products resistant against termite.

OBJECTIVE

The main objective of the present research was to identify the wood-based panels resistant against termite *Microcerotermes diversus*.

MATERIAL, METHOD, EQUIPMENT

Termites and geographical distribution

The geographical range of termites is mostly in north of Africa, Middle East and southwest of Asia such as south of Iran (Kerman and Sistan & Baluchistan) and south of India. Generally, most of termites are living in tropical and rainy jungles but their activity is higher in unstable jungles and plains under cultivation meaning where there are farms. The number of species and termites will reduce rapidly outside the tropical regions or where the earth height causes reduction of temperature. Many termites are living in warm soils in the world. Some of them are hidden under the soil surface and are invisible while others have obvious mound above the land surface. Some of such nests are only few centimeters high while others are 9 m high.

Termite genus Microcerotermes diversus is living in countries such as Iran, Iraq, Kuwait, Oman, Arabia, and United Arab Emirates. This insect has been reported in provinces of Khuzestan, Boushehr, Sistan & Baluchistan, and Yazd in Iran (Habibpour 2008).

Termite genus Microcerotermes diversus

This family includes a ratio four fifth of all types of termites in the world. Concerning morphology, these are wood feeding termites and often they are living under ground or they make mounds (Epigeal nests) but a few of them will built above ground, and always connected to the ground (such as arboreal nests). Termites have very strong and abrasive parts in their mouths. They have antennas with 21-32 articulations. They have two membrane wings that are laid on their back during resting and the word isopteran is used for equality of their wings. These insects are known as isopteran and have social life and are called termites. Its head is yellowish brown, their antenna is light yellow, and their mandibles are reddish dark brown and at the top they are a bit black, the part under the front is darker than the head. Top mandibles are sharp and a bit shorter than head capsule and their shape is sickle with thin and sharp lobes. This genus is living in closed places where the air is mild and relative humidity is 50%. The light will not penetrate in mounds of termites and the amount of carbonic gas is high and the amount of oxygen is low. The temperature of colony is between 18 and 22^{0}C (Harris 1971).

Geographical position of the regions

This research was conducted at two locations for 15 months in field condition. Ghaemabad village in Sistan region located at south east of Zabol, and Miandeh is located at the south of Jiroft. Jiroft is located at the south of Kerman province of Iran in a plain in 28 degrees, 40min in north and 57 degrees, 44min in east to Greenwich noon. Jiroft climatic has changed from warm status to cold and temperate. The penetration of humidity of Indian Ocean causes torrential rain. In summer, a very warm wind (known as Hoosha and Kouhbad) blows from mountains of north and north east to Jiroft plain. The wind that sometimes lasts for 7 days reduces humidity in Jiroft. Mean precipitation is 82.0mm per year and its temperature is between 6.2 and 39.6^{0}C. Sistan is located at the north of Sistan & Baluchistan province of Iran in a uniform plain in 31 degrees, 20min in north and 61 degrees, 39min in east to Greenwich noon. Zabol has a hot and arid climate. Mean precipitation is 6.59mm per year and its temperature is between 5.9 and 49^{0}C (Iran meteorological organization).

Field test

Holes were dug with 30cm deep and 50cm diameter. Cement rings have been used inside the holes in order that the soils do not fall on the samples. Specimens were randomly placed in the bottom of the holes so that the thickness faced the ground; they were then fixed in position using metal wire. Three types of wooden products including medium density fiberboard, 3-plywood and particleboard were degraded by termite genus Microcerotermes diversus in field method. Degradation grading and evaluating against the termite attack was performed in accordance with the ASTM D 1758-06 specifications. The samples were placed in holes. Each sample was hung from the bar with wires and after putting samples in the hole, thickness of samples was in contact with the soil. They were visually observed per three months and the final observation was done after 15 months. Once specimens were positioned, the openings of the holes were covered with galvanized sheet covers. Dry weight of the primary samples before being degraded by termites has been estimated based on wet content (ISO 13061-1). At the end of the 15-month exposure, specimens were brought out of the holes to be weighted again for weight loss calculation. Weight loss of samples degraded by termites was measured based on dry weight in the last stage.

Statistical Analysis

The descriptive statistic of mode was used to determine differences between wooden products on the basis of degradation grading. Cluster analysis was performed to find similarities and dissimilarities between treatments based on more than one property (Ada 2013). Hierarchical cluster analysis, including dendrogram and using Ward methods with squared Euclidean distance intervals, was carried out by SPSS/18 (2010). One way variance analysis was used to determine significant difference between weight losses of wooden products at the 95% level of confidence. Grouping was then made between treatments by using the least significant difference (LSD) at 95% confidence level. Fitted-line plot between weight losses versus degradation grading were performed.

RESULTS AND DISCUSSION

Climate conditions and soil properties of field sites such as Electricity conductance (EC) are shown in Table 1.

Wooden products specimens were exposed to Microcerotermes diversus termite at two regions. The first visual observation was done after three months. The evaluation was done during 5 three month periods. After visual observations, the score of degradation was recorded based on ASTM standard. Results of statistical analysis are shown in tables 2 as descriptive statistics (mode). The raw materials and adhesive of wooden products are presented at Table 2.

Results (mode) obtained from wooden products during 15 months in field condition have shown that the termites degradation is the difference at two regions, except of particleboard specimen degradation. The 3-plywood had the highest resistance against Microcerotermes diversus (Table 2). The final observation of samples in order of degradation amount is 3-plywood, particleboard and medium density fiberboard.

Table 1

Climate conditions at periods the study and soil properties are relate to Jiroft and Sistan regions

Field site	Climate parameter	Periods the study				
		May June July	**August September *October***	**Novembe r December January**	**February March April**	**May June July**
Jiroft	Average temperature	35.5	24	12	28	34
	Relative humidity	32	36	52	47	37
Sistan	Average temperature	32	30	11	39	33
	Relative humidity	27	28	49	38	27
	Soil properties					
	Type soil	pH	(EC) (ds/m)		Density (g/m3)	
Jiroft	Sandy, clay, loam	7.81	3.24		1.43	
Sistan	Sandy, loam	8.71	22.7		1.53	

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Table 2

Degradation grading of the medium density fiberboard, 3-plywood and particleboard specimens in three-month intervals exposed to Microcerotermes diversus termites at regions of Jiroft and Sistan, based on the mode descriptive statistic (results of a 15-month field test), and also properties of wooden products

Wood-based panels				**Regions**	**Symbol name**	**Grade No. Degradation of three-month periods (Mode)**				
Type	**Density (g/cm2)**	**Raw materials**	**Adhesive**							
MDF	0.77	hardwood	Urea formaldehyde	Jiroft	11	10	8	8	7	6
				Sistan	21	10	9	9	8	7
3-plywood	0.60	Poplar	Phenol formaldehyde	Jiroft	12	10	10	10	10	10
				Sistan	22	10	9	9	9	9
particleboard	0.78	Hardwood	Urea formaldehyde	Jiroft	13	10	10	8	8	7
				Sistan	23	10	9	8	8	7

Cluster analysis includes dendrogram based on the degradation grading values is shown in Fig. 1. Cluster analysis based on the degradation grading values showed that particleboard exposed to *Microcerotermes diversus* termite at Jiroft region (symbol name: 11) were clustered significantly different from the others wood-based panels. But, the weak impact of placement on the biological resistance of wooden products against Microcerotermes diversus termites is illustrated (Fig. 1). Also, the 3-plywood specimens against *Microcerotermes diversus* termites (symbol name: 12 and 22) were clustered significantly different from the others wood-based panels.

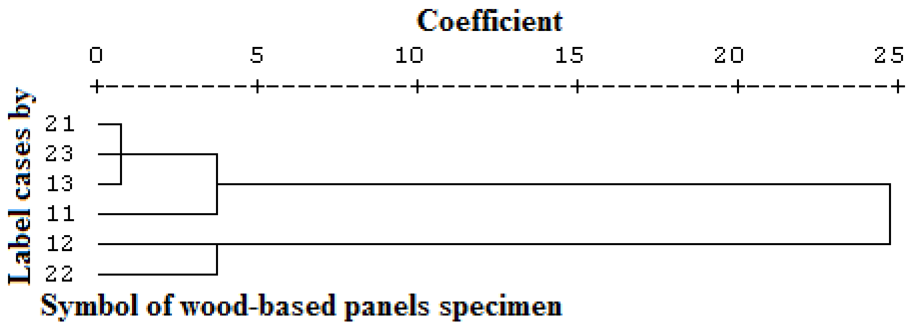

Fig. 1.
Cluster analysis of the wood-based panels based on the degradation grading values. Wooden products specimen symbol is present at Table 2.

In the first three months (July, August, September), the gradation only started on medium density fiberboard. Then, at the end of autumn and in the third three months (January, February, March), degradation stopped due to temperature drop at Jiroft. At the end of the third three months and start of the fourth three months (April, May, June) that is the season of mating for termites, degradation started again. On the other hand, the highest percent of degradation started from September, October, and November and stopped due to temperature reduction in December, January, and February meaning at the end of autumn and the beginning of winter and it again started at the middle of March at Sistan. In September, the samples were exited from holes for final observation after 15 months and degradation score was given to species during visual observations (Table 2).

Statistical analyses of the least significance difference shows that weight loss of wood-based panels have a significant difference between treatments at the 95% level of confidence. Percent of weight loss of composites and also, result of LSD multiple comparisons are seen in Table 3.

Table 3

The mean and standard deviation of weight loss and also, result of LSD multiple comparisons

	one-way descriptive		multiple comparisons LSD			
Symbol name of Treatment	**Mean of weight loss**	**Standard Deviation**	**(I) Treatment**	**(J) Treatment**	**(I-J) Mean Difference**	**Sig.**
11	25.128	3.725	11	12	18.032*	0.000
12	7.097	2.830		13	15.691*	0.000
13	9.438	2.983		22	18.609*	0.000
			12	21	-14.177*	0.000
21	21.273	4.396		23	-13.615*	0.000
22	6.519	3.461	13	21	-11.836*	0.001
23	20.711	1.991		23	-11.274*	0.001
			21	22	14.755*	0.000
			22	23	-14.192*	0.000

Symbol name of treatment is presented at Table 2.
Standard Error of one-way descriptive and multiple comparisons LSD are equal 1.940 and 2.709, respectively. .
*. The mean difference is significant at the .05 level.

According to results of visual degradation grading and the least significance difference of mean percent of weight loss, the resistance (from strong to weak) of samples against Microcerotermes diversus is as follows: 1-3-plywood, 2-particleboard and 3-medium density fiberboard (Tables 2 and 3). But based on results of mean percent of weight loss, the amount of degradation particleboard at Sistan is more than Jiroft. Also, both 3-plywood and medium density fiberboard that exposed the termites at region Jiroft and Sistan are the same degrade. The best biological resistant against the termites attack to wood-based panels is -plywood (Tables 2 and 3).

The correlation between the weight losses versus degradation grading indicated that these two properties were somehow related, though the R-square value was not very high (0.63 or 63%) (Fig. 2). This correlation was attributed to the fact that larger number of nibbles and visual penetration is indicative of higher degree of attack; consequently higher weight losses can be expected. The weight losses has shown the best actual degradation when compared to visual degradation grading because visual illusion. Termite attack continuously performed in the shelter an external thin coat. The coverture is known as carton. The wood composites under attack continuously degrade during visual observations. Since, the precision of visual degradation grading as Table 2 and Fig. 1 can be reduced by the carton, and the estimation of weight loss as Table 3 has the most validated. Generally, Table 3 shows that particleboards exposed to Microcerotermes diversus termite at Sistan region were LSD significantly different from Jiroft region. The different filed and experimental conditions can lead to such different results. On the other hand, the results of visual degradation grading and the least significance difference of mean percent of weight loss are show that the resistance (from strong to weak) of wood-based panel samples against Microcerotermes diversus is the same. It means that 3-plywood have the highest resistances against degradation of termites.

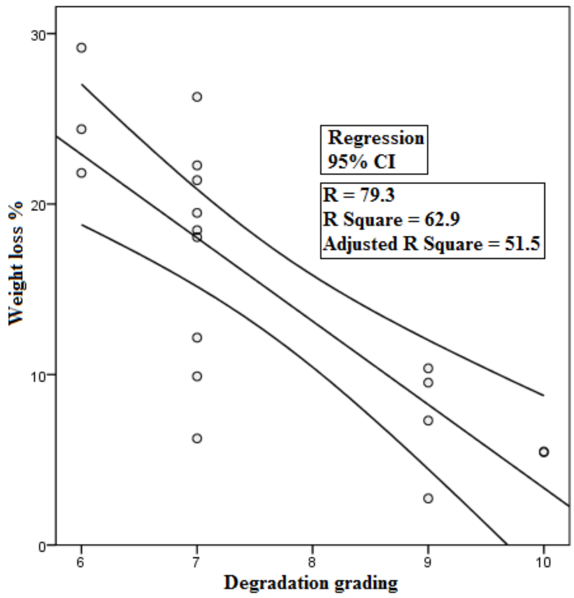

Fig. 2.
Fitted-line plot between weight losses versus degradation grading for the wood-based panels specimens.

Observation results have shown that the Microcerotermes diversus termite penetrates in cross-section. Also, the degradation of particleboard specimens exposed to Microcerotermes diversus termite at Jiroft and Sistan is significantly difference. Particleboard has the most penetrate of Microcerotermes diversus termite in cross-section when it is put at Sistan region.

The medium density fiberboard specimen has the lowest degrade especially at Jiroft (Tables 3). The order of resistance against the attack of termites to wooden products is 3-plywood, particleboard and medium density fiberboard (Tables 2 and 3). Wooden composites of the 3-plywood are the most resistant samples against termites. The glue line on both sides of kernel layer prevents from attack of termites.

Published data showed that glue can be ply as composites protection against the biological degradations attack (Carll and Highley 1999; Kartal and Clausen 2001; Vick et al. 1996; Wagner et al. 1996). Before glue line hardening, the adhesive penetrate in the wood surface. The glue acts as a toxin (due to formaldehyde) against termites. The depth of glue penetration is considerable at 3-plywood because of thin layers, and it prevents of termites attack. Generally, the covered surface with adhesive reduces when component of wood-based panels is finer. Subsequently, the weighing value of adhesive increases, but glued surfaces of particles reduce. Therefore, the adhesive amount of fiberboard per unit area is less than 3-plywood and particleboard, and fiberboard is more degraded by termites. Kose and et al. (2011) revealed that have not significant difference between fiberboard and particleboard against termite genus Coptotermes formosanus in laboratory. Wood-based panels consist about of 8-12% resin. Wooden products are often made from urea formaldehyde and melamine formaldehyde glues. Formaldehyde is a gas with a strong odor. It is reason that 3-plywood has greater resistance against Microcerotermes diversus termite attack compared to particleboard and MDF samples.

Wood polymer of medium density fiberboard is hydrolyzed and hemicelluloses decompose for polymerization and attachment to hydrocarbons. Also, Lignin is decomposed to finer parts that are used as composites fillers. For this reason, medium density fiberboard is a good feeding source for termites. Experimental studies indicate that medium density fiberboard is weekly act against termite degradation and it has more degraded than composites other (Kartal and Green 2003; Kose et al. 2011). The acidity of wood may increase by oxidation of the extractives and hydrolytic degradation of the wood components. (Choon and Roffael 1990; Nawawi et al. 2001). The acidity of wood is caused mainly by free acids and acidic group such as hydrolysable acetyl groups of wood. The cellulose and hemicellulose contribute to the wood acidity (Fengel and Wegener 1989). The wood acidity has an influence on the wood digestion by termite. Changes in environmental condition are causes of varied wood acidity (Sadeghifar et al. 2010).

Termite penetrates in cross-section of wood-based panels, easily. The composites thickness is covered with type laminates. Composites can be protecting with laminate. Termite penetrates through a very small hole that created at this coating. The thin skin will hide attack of termite. Medium density fiberboard is combination of wooden lingocellulosic fibers. In fact, wood chips are changed into separated fibers. Their lignin and hemicelluloses are soft and often degradable. Separation of fibers occurs in medium density fiberboard and extractive materials of fiberboard reduce in manufacture process. Cellulose is very palatable for termites. As a result, medium density fiberboard is a good feeding source for termites.

CONCLUSIONS

Studies conducted on biological resistant of productions against termites as in field condition are limited. Wood-based panels were not resistant against termites attack. The ability of Microcerotermes diversus termites to decompose medium density fiberboard, 3-plywood and particleboard by measuring weight loss and visual degradation grading evaluated. According to results of visual degradation grading and the least significance difference of mean percent of weight loss, the resistance of samples against Microcerotermes diversus is as follows: 1-3-plywood, 2-particleboard and 3-medium density fiberboard. The 3-plywood has the highest resistance against termite attack. Observation results during 15 months in field condition have shown that the termite degradation is the same at two regions, except of particleboard specimen degradation. Adhesive such as formaldehyde can be ply as 3-plywood protection against the biological degradations attack. Separation of fibers occurs in medium density fiberboard and extractive materials of fiberboard reduce in manufacture process. There, wood components is hydrolyzed and attachment to hydrocarbons. Their lignin and hemicelluloses are soft and often degradable. Also, the wood acidity increase by oxidation of the extractives and hydrolytic degradation of the wood components. For this reason, medium density fiberboard is a good feeding source for termites.

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