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Variability in indigenous knowledge and practices of wood treatments against termites in the cities of Yaoundé and Douala (Cameroon) and their status

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ABSTRACT

The aim of this study was to describe the wood treatment sector in the cities of Douala and Yaoundé (Cameroon). A total of 319 semi-structured interviews were conducted. The respondents were agents of wood depots, sawmills, hardware stores, and carpentry shops. They were asked about the diversity of products used and their perception of the risks and dangers of treatments. The chemical method (40.4%) was the main means of preserving wood against termite attack according to the respondents, followed by the traditional method with 9.4%, the physical method (2.2%) and more rarely, the use of plant extract (0.3%). All the chemicals were found to be hazardous to the environment and human health, with Xylamon being classified as the most hazardous. The physical control methods and those using plant extracts were found to be not at all dangerous for human health and the environment. Notwithstanding concerns for the protection of the environment and human health, toxic and hazardous products are still predominantly used. It would be important to move towards less or non-toxic products.

Keywords: chemical control, cultural knowledge, profitability of products, toxicity of treatment

INTRODUCTION

Cameroon is among the main timber-producing countries in Africa. According to Lescuyer et al. (2017), approximately 830,000 m^3 of sawn wood is sold annually in urban marketplaces as planks, formworks, laths, and rafters. This market reportedly supports job creation and economic growth, generating at least USD 15 million in annual revenue and employing about 5,000 people in Yaoundé, Douala, and Kinshasa alone (Cerbu, 2016).

Wood products stored in depots have been known to be exposed to a number of abiotic and biotic stressors that can impact the quality and attributes of stored items (Yalcin, 2020). Climate, storage location and duration, are among the abiotic factors that can affect the quality of wood products, resulting in the lowering of their economic value (Yalcin, 2020). Stain and decay/rot fungi, bacteria, and wood-damaging insects are examples of biotic factors contributing to wood biodeterioration. In tropical and subtropical areas, termites in particular are acknowledged to be the most destructive pest of wood and wooden structures, costing billions of dollars in damage to currently used timber globally (Ahmed & French, 2008; Bedasa et al., 2015; Govorushko, 2018)

Traditionally, wood products have been protected against termites using a diversity of treatment options. Studies have indicated the benefits of boron as an insecticide and commercially used for over 200 years (Gentz & Grace, 2006). The application of repellent or non-repellent liquid termiticide, the baits systems, and the use of chromated copper arsenate (CCA) or older inexpensive organic biocides have also been reported, but environmental and disposal concerns and governmental regulations have resulted in a rapid change in treatment systems (Schultz et al., 2007).

The Ministry of Agriculture and Rural Development in Cameroon issues and periodically updates the list of authorized pesticides in the country (MINADER, 2019). However, as a result of its neighbourhood with other countries

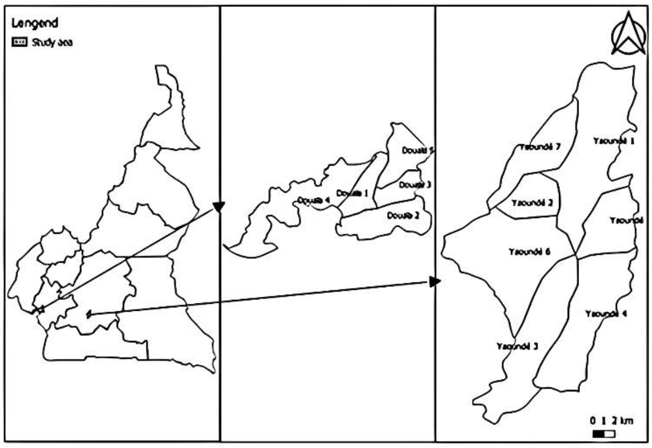

Figure 1. Map of the survey area (INC, 2015)

like Nigeria and Chad, which belong to other economic zones not applying the same phytosanitary regulations, and of the borders sometimes quite porous, users are often reported to source even unapproved and sometimes less expensive products outside the national territory.

In addition, in Africa, studies have reported a well-established indigenous knowledge of termite control in agricultural and forestry sectors (Bhardwaj & Tomar, 2018; Dokurugu et al., 2012; Hassan & Nasiru, 2020). However, in Cameroon, despite the importance and growing market of wood products in major cities like Douala and Yaoundé, the perception and practice of wood treatment against termite attacks by vendors and some users have so far not been investigated.

This study aimed to assess the local knowledge and practice of wood treatment against termites in the cities of Yaoundé and Douala (Cameroon). It reports the diversity of products used, the perception of actors involved as well as a risk and hazard assessment of the treatments.

STUDY SITES AND METHODS

Study Site

The study was conducted between November 2020 and April 2021 in the cities of Douala and Yaoundé. These cities were selected because of their high concentration of wood processing units.

Yaoundé is the capital city of Cameroon. It is located in the semideciduous rainforest zone, between 3°90 north latitude and 11°50 east longitude (**Figure 1**). Yaoundé records an average of 1,564.7 mm/year of rainfall and the average annual temperature is estimated at 23.5 °C and the annual thermal amplitude at 2.4 °C (Abossolo et al., 2015). The climate is of equatorial type with four seasons:

1. long dry season extending from mid-November to mid-March,
2. short rainy season between mid-March to mid-June,
3. short dry season from mid-June to mid-August, and
4. long rainy season from mid-August to mid-November.

In this city, it rains on average 153 days a year.

Douala is a coastal city located at the Gulf of Guinea. The climate is of the Cameroonian type, which is highly humid and equatorial, with two seasons. A dry season extending between December and February and is a wet season between March and November. The average temperature is 26.4 °C. Each year, Douala receives about 4,000 mm of rainfall (Maffo et al., 2019).

Data Collection

A survey was conducted in the two cities to gather information on the local knowledge and practice of wood treatments against termites. The target informants were of owners and employees of sawmills, hardware stores, joineries, and wood depots. The sampling of respondents was non-probabilistic and followed random routes taken in these two cities following the methods of (Bayol et al., 2012; Hiolhiol, 2020; Mélingui et al., 2018). The interviews were conducted in French, using a questionnaire. Information gathered from respondents included gender, age, professional category, level of education, knowledge of termite control methods, wood preservation methods against termites, environmental and economic considerations of the products used, hazard classes for each termite control method, and cost-effectiveness (ratio of quantity, yield and price).

Table 1 show a summary of the socio-demographic profile of the respondents.

Table 1. Socio-demographic profile of respondents

Characteristics	Locality (%)		Total	
	Douala	Yaoundé	100.0%	n=319
Gender				
Male	89.3	64.3	70.8	226
Female	10.7	35.7	29.2	93
Age				
<20	9.5	4.3	5.6	18
20-30	15.5	10.4	19.1	61
31-40	47.6	26.0	31.7	101
41-50	23.8	44.3	38.9	124
51-60	1.2	4.3	3.4	11
>60	2.4	0.9	1.3	4
Professional categories				
Wood depot agents	22.6	53.6	45.5	145
Sawmill agents	7.1	4.3	5.0	16
Hardware store agents	13.1	10.2	11.0	35
Carpentry agents	57.1	31.9	38.5	123
Professional experience				
0-5	20.6	6.8	10.3	33
6-10	29.8	16.6	20.0	64
11-15	20.2	23.4	22.7	72
16-20	21.4	17.9	18.8	60
>20	8.3	35.3	28.2	90
Education level				
None	10.7	17.4	15.7	50
Primary	4.8	21.7	17.2	55
Secondary	59.5	42.6	47.0	150
University	25.0	18.3	20.1	64

Risk and Hazard Assessment of the Products Used

The chemicals cited in this study were identified by their trade names and their active ingredients using the reference list of the Ministry of Agriculture and Rural Development (MINADER, 2019). The hazard classes were grouped into two parts, namely, the human health hazard classes, which include

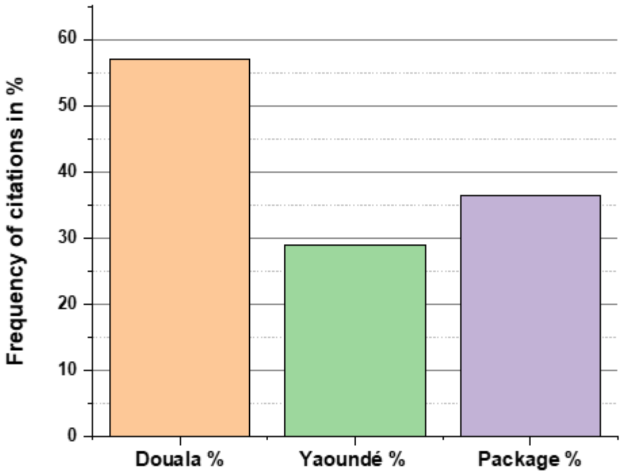

Figure 2. Level of knowledge of termite control method in the study sites (Source: Authors' own elaboration, using Origin 2019 software)

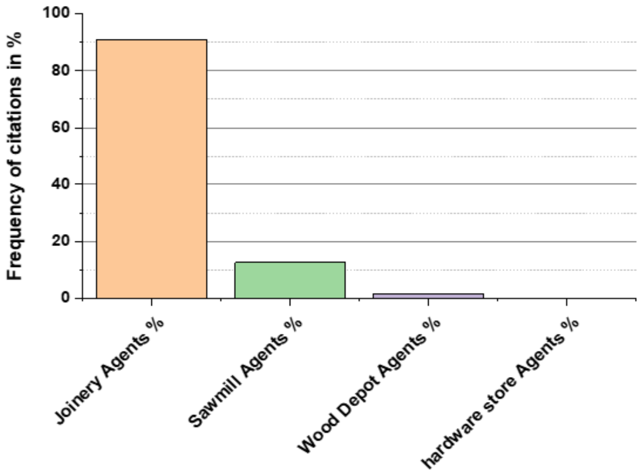

Figure 3. Knowledge of termite control systems among respondent groups (Source: Authors' own elaboration, using Origin 2019 software)

acute toxicity, skin and eye irritation, skin sensitivity, germ cell mutagenicity, carcinogenicity, reproductive toxicity, exposed organ toxicity, and aspiration hazard; and the environmental hazard classes, which highlight hazards to the ozone layer and the aquatic environment. The chemicals listed are derived from a classification of pesticides, (I) for insecticides (kills, destroys insects) and (F) for fungicides (kills, destroys parasitic fungi) (ILO/UITA 2004).

Data Analysis

Data were analyzed using IBM SPSS statistics 20.0 software. Simple descriptive statistics were used to calculate frequencies (f_i) of each of response following the formula (1). Mean (M[n]) and standard deviation (SD) for quantitative variables were also computed following the formulas (2) and (3), respectively. The χ^2 test was used to compare the different frequencies. The different tests were considered at the 5.0% probability level. The graphs were produced using Origin 2019 software.

$$f_i = \frac{n_i}{N} \quad (1)$$

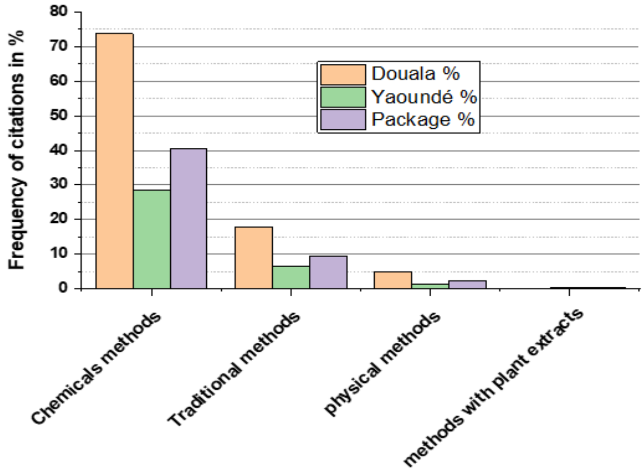

Figure 4. Main termite control method used in the study sites (Source: Authors' own elaboration, using Origin 2019 software)

$$M(n) = \frac{1}{n}\sum_{i=1}^{k} n_i m_i \quad (2)$$

$$SD = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i - (M(x))^2} \quad (3)$$

RESULTS

Knowledge and Awareness on Termite Control Methods

In this study, almost all respondents (97.8%) claimed to have knowledge about wood treatment methods against pests. However, less than half (36.4%) had specific knowledge of wood treatments against termite attacks. The level of awareness of termite control methods was higher in Douala (57.1%) than Yaoundé (28.9%) (**Figure 2**). The inter cites difference was significant (χ^2=21.276, p<0.001).

With respect to occupational categories, carpentry agents almost all used wood treatment methods against termites (91.1%). Low use of these methods was reported among sawmill agents (12.5%) and among wood storage agents (1.4%) (**Figure 3**). Hardware store agents had no knowledge about (0.0%). A significant difference was observed between occupational categories regarding the use of termite control methods (χ^2=259.629, p<0.001).

Main Termite Control Methods Used by Respondents

A total of four termites control methods were recorded in the city of Yaoundé and three in the city of Douala. In general, the chemical method is the most used method with a frequency of 40.4%, followed by the traditional method with 9.4%, the physical method (2.2%) and more rarely, the use of plant extract (0.3%).

In the city of Douala, the termite control methods used by timber sale agents include the chemical method (73.8% of respondents), the traditional method (17.9% of respondents) and the physical method (4.8% of respondents).

In the city of Yaoundé, respondents mainly use the chemical method (28.5%) followed by the traditional method

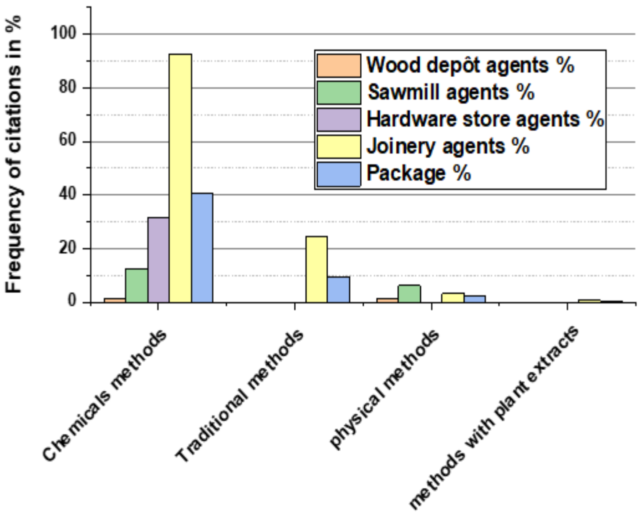

Figure 5. Variation of termite control methods amount respondent groups (Source: Authors' own elaboration, using Origin 2019 software)

(6.4%) and the physical method (1.3%). The very use of plant extract was rarely reported (0.4%) (**Figure 4**).

Termites control methods varied among professional categories. The carpentry agents used mostly the chemical method (92.7%), followed by the traditional method (24.4%), then the physical method (3.3%) and a minority use plant extracts (0.8%). Wood depot agents and sawmill agents mainly use the chemical method (1.4% and 12.5%, respectively) and the physical method (1.4% and 6.2%, respectively). The hardware store agents reported only the chemical method with a proportion of (31.4%). A significant difference was observed between occupational categories and the control methods used (χ^2=237.596, p<0.001). Carpentry agents reported a significantly higher level of use of the chemical method against termites than did wood yards, sawmills, and hardware stores agents (**Figure 5**).

Diversity of chemicals methods used for wood treatment

We identified 28 chemicals used against termites (**Table 2**). The most used product is xylamon (44.85%), followed by xylophene (28%) and pyriforce (27.1%). In the city of Douala, we have identified 20 products among which xylamon is the most used (41.2%), followed by xylophene (30.2%) and pyriforce (17.5%). In the city of Yaoundé, we identified 16 products of which the most used were xylamon (48.5%), pyriforce (36.7%) and imprebois (29.7%). However, a significant difference was observed between localities regarding the products used (χ^2=52.719, p<0.001). The use of chemical products was significantly higher in the city of Douala than in Yaoundé (**Figure 6**).

In terms of occupational categories, carpentry agents identified the majority of products (16), followed by hardware store agents (10), then sawmill agents (seven) and finally timber depot agents (two). The carpentry agents identified 17

Table 2. Chemical methods used against termites by category in the cities of Douala & Yaoundé

No	Chemical products	Active substance	WDA (%)	SW (%)	HSA (%)	CA (%)
1	XYLAMON	Cyperméthrine+permethrine	50.0[+]	0.0	71.4	39.8
2	XYLOPHENE	Cyperméthrine+propiconazole+tebuconazole+IPBC	0.0	0.0	37.3	26.1
3	PYRIFORCE	Chlorpyriphos-ethyl	0.0	0.0	0.0	39.0
4	ARSENIC SALT	Arsenic	0.0	0.0	0.0	8.9
5	WASTE OIL	ND	0.0	0.0	0.0	13.8
6	RESISTOL	Monoéthanolamine+oléate de potassium	0.0	0.0	31.5	0.0
7	IMPREBOIS	Plomb	0.0	0.0	22.9	17.8
8	MAXPRO	Bifenthrine	0.0	0.0	0.0	5.7
9	MAXYL	Xamos+D.C.O.I.T	0.0	0.0	5.8	8.0
10	XYLOMAX	Zylometazolin-hydrochlorid	0.0	0.0	11.5	0.0
11	KOTSCIAGE	IPBC+Bifenthrine+D.C.O.I.T+benzalkonium	0.0	0.0	2.9	4.8
12	CRESYL	Methoxy+propanol+alcool éthylique+oléate de sodium+chlorocresol +linéoleic acid, sodium salt+phenyl phénol	0.0	0.0	5.8	0.8
13	SARPAGRUM AF200T	Propiconazole+IPBC+thiacloprid	50.0	0.0	0.0	0.8
14	MAXYL TSE+	Bifenthrine+propiconazole	0.0	25.0	0.0	0.0
15	PROPICONAZOLE	Propiconazole	0.0	25.0	0.0	0.0
16	PREVENTOL HS 12	Diclorovinil+dimetilciclopropancarbossilato+di-ciano-fenossi+fluorobenzile	0.0	25.0	0.0	0.0
17	CARBENDAZIM	Carbendazim	0.0	25.0	0.0	0.0
18	CYPERMETHRINE	Cypermethrine	0.0	25.0	0.0	0.0
19	BIFENTHRINE	Bifenthrine	0.0	25.0	0.0	0.0
20	IPBC	Iodo-propynyl butylcarbamate	0.0	25.0	0.0	0.0
21	RESIN	Résin	0.0	0.0	2.9	0.0
22	SINOFORCE	Chlorpyrifos-ethyl	0.0	0.0	0.0	1.6
23	CYPERCAL	Cyperméthrine	0.0	0.0	0.0	0.8
24	LAMIDACOT	Lambda cyhalothrine	0.0	0.0	0.0	0.8
25	REGENT	Fripronil	0.0	0.0	0.0	0.8
26	XYLOCLAIR	ND	0.0	0.0	2.9	0.0
27	HYDRO-ACIDE	Acide	0.0	0.0	0.0	0.8
28	COCOA Extra 35 EC	Acétamiprid+lambda-cyhalothrine	0.0	0.0	0.0	0.8

Note. [+]The values represent percentage of respondents who identified a chemical; ND: Not defined; WDA: Wood deposit agents; SW: Sawmill workers; HAS: Hardware store agents; & CA: Carpentry agents

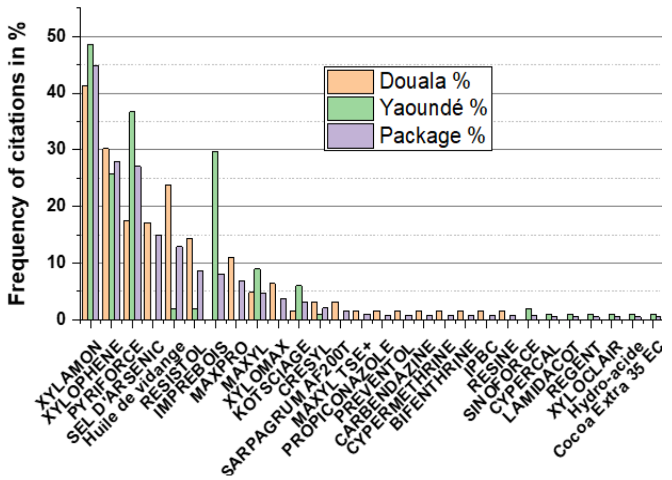

Figure 6. Chemicals methods used against termites in the cities of Douala & Yaoundé (Source: Authors' own elaboration, using Origin 2019 software)

chemicals of which xylamon (39.8%), pyriforce (39.0%), and xylophene (26.1%) were the most common. Hardware store agents identified ten types of chemical products that can be used against termites, the most common being xylamon (71.4%), xylophene (37.3%), and resistol (31.5%). The sawmill agents recorded seven products, the most important of which were maxyl TSE+, propiconazole, and proventol HS 12 (25.0% each). Wood depot agents identified two products, sarpagrum F200T and xylamon (50.0% each). A significant difference was observed between occupational categories regarding chemicals (χ^2=237.596, p<0.001). The percentage of chemical citations was higher in carpentry agents than in hardware store, sawmills, and wood storage agents (**Table 2**).

Physical methods used against termites for wood treatment

We have identified two physical methods used for the treatment of wood against termite attack. The most common method is heat treatment (4.7%), followed by drying (2.0%), which consisted of making a device under cover, stacked horizontally and spaced by pins of any section and all resting on concrete or cement dice; the drying is carried out according to the standards or not. Each city practices one type of physical treatment method. In Douala, heat treatment is used with a frequency of (4.7%). The drying of wood was only recorded in the city of Yaoundé with a frequency of citation of (2.0%). (**Figure 7**).

The analysis by professional categories showed that the carpentry agents listed the two physical methods (heat treatment and drying) of wood treatment. Heat treatment is the most common method for wood storage agents (33.3%), while sawmill agents only recorded heat treatment (25.0%) and joinery agents mainly recorded drying (1.6%) (**Figure 8**).

Traditional methods used for wood treatment against termites

We identified one traditional treatment (ash), used to treat wood against termite attacks. The results of the traditional products show that only the city of Yaoundé uses it through ash (9.9%). However, there is a significant difference between localities in the location of some products (χ^2=9.562, p<0.002).

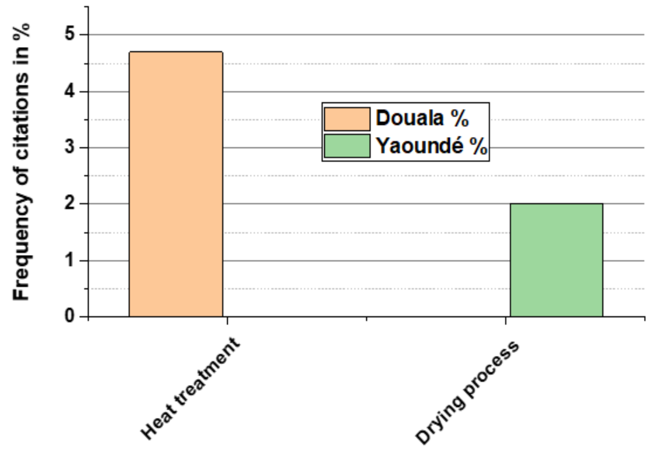

Figure 7. Physical methods used in the cities of Douala & Yaoundé (Source: Authors' own elaboration, using Origin 2019 software)

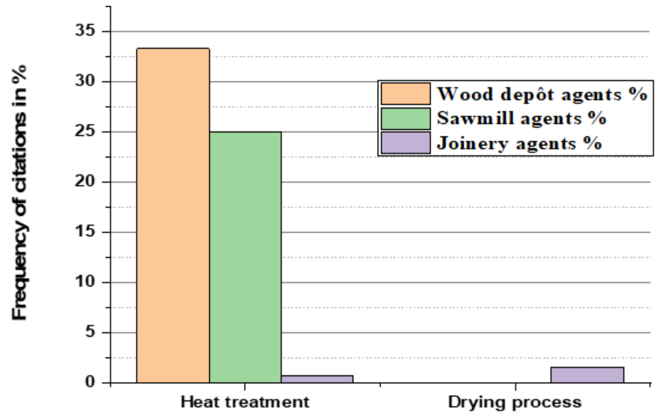

Figure 8. Physical methods used by professional categories in the cities of Douala & Yaoundé (Source: Authors' own elaboration, using Origin 2019 software)

Table 3. Traditional methods used against termites for wood treatment

Traditional treatments	Localities		Professional categories
	Douala %	Yaoundé%	Joinery agents %
Ash	0.0	9.9	8.1

The percentage of citation of traditional methods is significantly higher in Yaoundé than in Douala (**Table 3**).

For the professional categories, only carpentry agents identified this type of treatment products, with a single census of ash (8.1%). A significant difference was observed between professional categories regarding traditional products (χ^2=52.767, p< 0.001). The percentage of citation of traditional products was higher among carpentry agents than among hardware, sawmill and wood depot agents (**Table 3**).

Hazard Classes of Wood Treatment Products

Human health hazard classes of treatment products

We identified 28 wood treatment products as dangerous to human health. All of the chemical products were identified as dangerous by the professional categories in Douala and Yaoundé. Xylamon is the most dangerous chemical (12.3%), followed by pyriforce (11.3%) and xylophene (7.5%). The

Table 4. Human health hazard classes of wood treatment products

No	Product	AT	DI	OI	SS	GM	C	RT	TEO	DS	Total
1	XYLAMON	3.98+	1.45	1.16	0.79	0.58	0.79	0.94	2.17	3.91	12.33
2	PYRIFORCE	3.26	1.02	0.94	0.94	0.94	0.94	0.94	2.03	2.47	11.30
3	XYLOPHENE	1.74	0.65	0.65	0.65	0.72	0.65	0.65	1.52	2.32	7.51
4	MAXYL	0.72	0.72	0.72	0.65	0.58	0.58	0.72	0.44	0.51	5.21
5	IMPREBOIS	1.52	0.51	0.36	0.36	0.36	0.44	0.44	0.58	1.60	4.75
6	KOTSCIAGE	0.58	0.44	0.58	0.51	0.51	0.58	0.15	0.15	0.65	3.55
7	CRESYL	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.36	3.52
8	RESISTOL	0.58	0.36	0.44	0.36	0.36	0.44	0.44	0.44	0.44	3.46
9	XYLOMAX	0.44	0.36	0.44	0.44	0.44	0.44	0.44	0.44	0.44	3.46
10	WASTE OIL	0.73	0.22	0.29	0.29	0.22	0.29	0.29	0.29	0.73	2.69
11	MAXPRO	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.22	2.34
12	ARSENIC SALT	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.80	1.25
13	SARPAGRUM AF200T	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	1.18
14	COCOA EXTRA 35 EC	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.17
15	HYDRO-ACIDE	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.17
16	SINOFORCE	0.07	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.10
17	CYPERCAL	0.07	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.10
18	LAMIDACOT	0.07	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.10
19	XYLOCLAIR	0.07	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.07	1.10
20	REGENT	0.07	0.15	0.07	0.15	0.15	0.15	0.15	0.15	0.15	1.03
21	BIFENTHRINE	0.07	0.07	0.07	0.15	0.15	0.15	0.15	0.15	0.15	0.96
22	MAXYL TSE+	0.07	0.07	0.07	0.15	0.15	0.07	0.15	0.15	0.15	0.89
23	CYPERMETHRINE	0.07	0.07	0.07	0.15	0.15	0.07	0.15	0.15	0.15	0.89
24	RESINE	0.07	0.07	0.07	0.07	0.07	0.15	0.15	0.07	0.15	0.74
25	PROPICONAZOLE	0.07	0.07	0.07	0.15	0.07	0.07	0.07	0.07	0.07	0.66
26	PREVENTOL HS 12	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.59
27	CARBENDAZIM	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.59
28	IPBC	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.59

Note. +The values represent percentage of respondents who identified a danger to human health from treatment method; AT: Acute toxicity; DI: Dermal irritation; OI: Ocular irritation; SS: Skin sensitization; GM: Germline mutagenicity; C: Carcinogenicity; RT: Reproductive toxicity; TEO: Toxicity to exposed organs; & DS: Danger by suction

physical method, traditional method and the plant extract method were not identified as hazardous to human health. (**Table 4**).

Environmental hazard classes of treatment products

We identified 29 wood treatment products as environmentally hazardous. All chemicals and traditional products were identified as environmentally hazardous by the professional categories in Douala and Yaoundé.

Xylamon is the most dangerous chemical (20.1%), followed by pyriforce (15.0%) and xylophene (10.4%). The traditional product (ash) with a frequency of 3.2% ranks seventh among the environmentally hazardous products. The physical method and the plant extract method were not identified as environmentally hazardous (**Table 5**).

Table 5. Environmental hazard classes of wood treatment products

No	Products	Danger to environment (%)		Total (%)
		DAE	DOL	
1	Xylamon	14.44+	5.61	20.05
2	Pyriforce	10.96	4.01	14.97
3	Xylophène	6.15	4.28	10.43
4	Imprébois	5.61	1.17	6.78
5	Waste oil	2.67	0.80	4.47
6	Maxyl	1.07	2.41	3.48
7	Ash	2.67	0.53	3.20
8	Résistol	1.60	1.34	2.94
9	Xylomax	1.34	1.60	2.94
10	Arsenic salt	0.27	2.67	2.94

Table 5 (continued). Environmental hazard classes of wood treatment products

No	Products	Danger to environment (%)		Total (%)
		DAE	DOL	
11	Kotsciage	1.17	1.07	2.24
12	Crésyl	1.34	1.60	1.94
13	Maxpro	0.80	1.07	1.87
14	Sarpagrum AF200T	0.53	0.53	1.06
15	Sinoforce	0.27	0.53	0.80
16	Cypercal	0.27	0.53	0.80
17	Maxyl TSE+	0.27	0.53	0.80
18	Propiconazole	0.27	0.53	0.80
19	Preventol HS 12	0.27	0.53	0.80
20	Carbendazim	0.27	0.53	0.80
21	Cyperméthrine	0.27	0.53	0.80
22	Lamidacot	0.27	0.53	0.80
23	Regent	0.27	0.53	0.80
24	Xyloclair	0.27	0.53	0.80
25	Bifenthrine	0.27	0.53	0.80
26	IPBC	0.27	0.53	0.80
27	Hydro-acide	0.27	0.53	0.80
28	Cacao Extra 35 EC	0.27	0.53	0.80
29	Resin	0.27	0.27	0.54

Note. +The values represent percentage of respondents who identified an environmental hazard from treatment method; DAE: Danger to aquatic environment; & DOL: Danger to ozone layer

Reasons for toxicity of wood treatment methods

We have identified four reasons for toxicity of which the chemical nature of the products identified as the main reason.

Table 6. Reasons for treatment product toxicity

No	Reasons for toxicities	Localities (%)		Professional categories (%)				
		Douala	Yaoundé	WDA	SW	HSA	CA	Total (%)
1	Chemical nature	74.6+	89.1	100.0	75.0	77.1	85.4	83.5
2	Application technique	15.9	44.6	50.0	75.0	40.0	30.1	33.5
3	Traditional nature	1.6	2.0	0.0	0.0	2.9	1.6	1.8
4	Action mode	0.0	3.0	0.0	0.0	0.0	2.4	1.8

Note. +The values represent percentage of respondents who identified a reason for treatment method toxicity; WDA: Wood deposit agents; SW: Sawmill workers; HAS: Hardware store agents; & CA: Carpentry agents

The chemical nature is the one that confers more toxicity in the cities of Yaoundé and Douala, with a frequency of citation of 74.6% in Douala and 89.1% in Yaoundé. This reason is followed by the application technique with a frequency of 15.9% in Douala and 44.6% in Yaoundé.

The mode of action, which is another reason that was only recorded in Yaoundé with a frequency of 3.0%. However, there is a significant difference between the localities regarding the reasons for toxicity of the products (χ^2=16.355, $p<0.001$). Significantly higher percentage of toxicity reasons (89.1%) was reported in Yaoundé than Douala (74.6%) (**Table 6**).

The reasons for toxicity according to the professional categories show that, all of the wood storage agents considered that the reason for toxicity is mainly the chemical origin of the products, followed by the application technique (50.0%). The sawmill agents made the same observation for the chemical nature with a lower proportion (75.0%), on a par with the application technique.

The hardware store agents consider that the toxic origin of the preservatives is their chemical nature (77.1%) and the application technique used (40.0%), and very rarely the traditional nature (2.9%). The carpentry agents think that the chemical nature (85.4%) and the method of application (30.1%) are the main causes of toxicity of preservatives, followed by the method of action (2.4%) and the traditional nature are rarely recorded (1.6%).

However, there is a significant difference between the occupational categories regarding the reasons for product toxicity (χ^2=69.822, $p<0.027$). Wood depot agents and sawmill agents (50.0%) reported a significantly higher percentage of the reasons for toxicity than those of hardware store (8.6%) and joinery agents (5.7%) (**Table 6**).

Knowledge of cost-effective wood treatment methods

We have identified three cost-effective wood treatment methods. The physical method is identified through drying; the chemical method with 18 products and the traditional method with one product. The physical method is mostly identified as profitable in the two cities (Douala and Yaoundé) through the practice of drying (54.7%); the chemical method follows with Xylamon as a profitable chemical product (46.8%) and the traditional method is slightly identified as profitable through cocoa (0.5%) (**Table 7**).

Table 7. Cost-effective wood treatment methods

No	Product	Localities (%)		Total (%)
		Douala	Yaoundé	
1	DRYING	59.0+	50.5	54.75
2	XYLAMON	44.2	49.5	46.85
3	XYLOPHENE	31.1	26.8	28.95
4	PYRIFORCE	17.0	36.6	26.80
5	IMPREBOIS	0.0	28.7	14.35
6	WASTE OIL	23.0	2.0	12.50
7	ARSENIC SALT	18.1	0.0	9.05
8	RESISTOL	13.1	2.0	7.55
9	MAXYL	4.9	9.0	6.95
10	KOTSCIAGE	6.5	5.0	5.75
11	SARPAGRUM AF200T	4.9	0.0	2.45
12	XYLOMAX	4.9	0.0	2.45
13	CRESYL	3.2	1.0	2.10
14	SINOFORCE	0.0	2.0	1.00
15	MAXPRO	1.6	0.0	0.80
16	RESIN	1.6	0.0	0.80
17	CYPERCAL	0.0	1.0	0.50
18	COCOA Extra 35 EC	0.0	1.0	0.50
19	LAMIDACOT	0.0	1.0	0.50
20	REGENT	0.0	1.0	0.50
21	XYLOCLAIR	0.0	1.0	0.50

Knowledge of Reasons for Choosing or Not Choosing Wood Treatment Products

Reasons for choosing treatment methods

We have identified three reasons why agents in the timber sector choose a timber treatment method. The city of Douala has two reasons, the most common of which is to improve the durability of wood (50.8%) and the least common is to be less toxic to health and the environment. The city of Yaoundé also has two reasons for choice, the most important of which is the improvement of the durability of the wood and the least important is the less costly nature of the methods used (1.0%) (**Table 8**).

The reasons for choice for the professional categories show that three reasons are listed. Wood storage and sawmill agents

Table 8. Reasons for choice of wood treatment methods

Reasons for choice of wood treatment methods	Localities (%)		Professional categories (%)			
	Douala	Yaoundé	WDA	SW	HSA	CA
Improves the durability of wood	50.8+	87.1	0.0	0.0	78.0	73.2
Less toxic for health & environment	4.8	0.0	50.0	25.0	0.8	1.8
Less expensive	0.0	1.0	0.0	0.0	0.6	0.6

Note. +The values represent percentage of respondents who identified a reason for choosing a wood treatment method; WDA: Wood deposit agents; SW: Sawmill workers; HAS: Hardware store agents; & CA: Carpentry agents

Table 9. Reasons for not selecting wood treatment methods

No	Reasons for not selecting treatment methods	Localities (%)		Professional categories (%)				
		Douala	Yaoundé	WDA	SW	HSA	CA	Total (%)
1	Chemical nature	28.6⁺	5.0	50.0	25.0	5.7	15.6	14.2
2	Application technique	1.6	3.0	0.0	25.0	0.0	2.5	2.4

Note. ⁺The values represent percentage of respondents who identified a reason for not choosing a wood treatment method; WDA: Wood deposit agents; SW: Sawmill workers; HAS: Hardware store agents; & CA: Carpentry agents

only identified the less toxic nature of the treatment methods with frequencies of (50.0% and 25.0%), respectively for each category. As for the carpentry agents, the majority of them identify the improvement of the durability of the wood (78.0%), followed by the less toxic character of the methods on human health and the environment (0.8%) and the less expensive character of the treatment methods (0.6%) (**Table 8**).

Reasons for not choosing treatment methods and opinion on the need for ecological wood treatment methods

We have identified two reasons for not choosing the methods, the majority of which are that they are expensive (14.2%) and that they are polluting (2.4%). The city of Douala recorded the costly character in majority with a frequency of (28.6%) and the polluting character at (1.6%). The city of Yaoundé also records the same reasons with lower proportions of 5.0% for the costly nature and 3.0% for the polluting nature (**Table 9**).

The majority of professional categories identify the costly nature of wood treatment methods at 14.2% and the pollutant at 2.4%. Wood depot agents identified the only reason for non-choice at 01, with a proportion of (50.0%) for the costly nature. The sawmill agents identified the costly and polluting aspects in equal proportions (25.0%). Agents in hardware stores only identified costliness with a low frequency of 5.7%, and agents in carpentry stores identified two reasons with a high frequency for costliness (15.6%) and pollution (2.5%) (**Table 9**).

The agents of the timber sector in Douala and Yaoundé have a favourable opinion on the need for ecological timber treatment methods with respective frequencies of (98.4%) and (96.0%). The majority of the professional categories have a favourable opinion, with timber depot agents considering it necessary with a frequency of (100.0%), followed by joinery agents (97.6%), hardware store agents (97.1%) and sawmill agents (75.0%).

DISCUSSION

Knowledge of Wood Treatment Methods Against Termites and Implications

Knowledge of wood treatment methods against termite attack is relatively low in the two localities in this study. It is likely that these results be influenced by the diversity and occurrence of biodeterioration agents in the study environment. In fact, Hamon and Roullat (2016) linked knowledge of wood treatment to the types of bio-pest the treated wood will face.

The high frequency of chemical treatment methods in this study is in line with previous observations by Damai (2014). However, these products are known to be toxic. Similar work showed that some products are monitored in several countries around the world before they are made available on the market (Chèvre & Burkhardt, 2008; MINADER, 2019). Chemical methods are increasingly being replaced by methods that are less polluting for human health and the environment in most industrialised countries; some work is turning to physical methods that are recognised as less polluting (Candelier et al., 2016; Salman et al., 2017). However, although physical methods like drying is known to be an eco-friendly practice, authors have reported stress in wood during drying that may affect its physical and thermodynamic properties (Sehlstedt-Persson, 2005; Yin & Liu, 2021). Monitoring drying process parameters, as well as drying conditions, is a challenge for the success of the drying operation.

Although use of plant-based materials for wood preservation was not very frequent in our survey, evidence from previous literature have reported efficacy of botanicals for the control of wood-degrading agents like fungi and termites (Bessala et al., 2023; Georges et al., 2022; Lyon, 2007; Lyon et al., 2007; Verma et al., 2009)These new ecological solutions currently represent a strong potential for treating wood in a less polluting way compared to other methods.

Hazard Assessment of Products

The use of wood preservatives containing certain substances was restricted to strictly professional use by (Directive, 2001), which propelled research into new and less toxic methods. The hazard classes showed that chemical and traditional methods are the only methods that present hazards to both human health and/or the environmental. Physical methods and plant extracts were found to be safe for human health and environmental. These data are in line with the results of some studies (Chèvre & Burkhardt, 2008; Damai, 2014; Neuenschwander et al., 2023) that after the restrictions and ban on the use of some wood treatment chemicals; the wood treatment sector is turning to less polluting or not polluting methods, which should be appropriated, and the polluting methods abandoned.

Some of the chemicals products identified in this study are registered as propiconazole, carbendazim, cypermethrin, bifenthrin, and IPBC as active ingredients and xylamon, xylophene, pyriforce, resiltol, imprébois, maxpro, maxyl, koatsciage, crésyl, sarpaagrum AF200T, maxyl TSE+, preventol HS12, sinoforce, cypercal, lamidacot, regent, and cocoa extra 35EC as their trade names, but their composition in combination with the registered active ingredients. Unregistered products, but whose study showed a significant census such as arsenic intervenes on the human organism by modifying numerous enzymatic systems and by disturbing the synthesis of certain proteins or nucleoproteins. The intensity of the disorders varies according to the compound involved, its nature and the dose (Spinosi et al., 2009) and lead, which is the active ingredient in impregnated wood, which also features prominently in this study, is recognised as a product that causes illnesses such as encephalopathy, kidney damage and anaemia (Dehon et al., 2001). This variation in the use of chemicals that are intended to be toxic to human health and the environment is consistent with the work of Chèvre and Burkhardt (2008), which raises the importance of monitoring pesticides used in insecticide control.

CONCLUSIONS AND RECOMMENDATIONS

There is currently a real challenge of biodeterioration of wood products by termites, decay fungus, and other organisms that must be avoided. This study investigated on the variety of wood treatment methods used in the city of Douala and Yaoundé in Cameroon.

The chemical method was the main means of preserving wood against termite attack among the respondents (40.4%). Woodworkers used it at 91.1%, sawmills at 12.5%, and wood depots at 1.4%. The use of chemical methods is more important in Douala (20 products) than in Yaoundé (16 products).

Considering the environmental and health protection as well as disposal concerns and governmental regulations discouraging the use of these of these products, this study is expected to hasten the introduction of cutting-edge, green wood treatments onto the Cameroonian market and encourage the efficient and sustainable use of wood in the building and construction sector.

As implication, there is a need to better supervise the wood treatment sector. It would be advisable to ban all hazardous/toxic chemical preservatives and to turn to new methods of wood treatment, to train more and more people who will be able to practise wood treatment so that this sector complies best with the requirements for the preservation of the environment, the safety of workers and users of the wood material treated.

The treatment of wood against termite attack with plant extracts should be explored, as some research showed that this method is environmentally and, above all, human health friendly.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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