Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.2, No.2, 2012

Mitigating Climate Change Effects Using Eco-Friendly Wood Preservatives

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Abstract

Climate change, due to global warming has serious environmental phenomena, which result into loss of biodiversity. In view of the depleting effect of climate change on renewable forest resources, particularly woody species, it becomes necessary to consider strategies of preserving the limited wood resources using local preservatives. Consequently, a study was conducted to assess the effects of eco-friendly locally developed wood preservatives on the resistance of *Triplochiton scleroxylon* (Obeche) to termites attack. The research was carried out in 3 different locations, with 4 different treatments in Bassa L.G.A. of Plateau State. Thus, 3 termites' mounds were randomly isolated and labeled as locations A, B, and C. For each of the locations, 80 wood specimens were prepared for the field trail. Sixty (60) of the samples were treated with the various preservatives as follows: neem oil (20 pieces), mahogany oil (20 pieces), and shea butter oil (20 pieces). The remaining 20 pieces served as control. All the 240 wood specimens were spread on the sites where the presence of the termites was endemic for 24 weeks. Thereafter the degree of attack was estimated by measuring the length of furrow, and recording loss in weight of the wood samples. The data obtained were subjected to ANOVA to test for the level of significance between the locations and treatments. Results of the experiment showed that all the locally extracted wood preservatives significantly resisted the termites attack in treated wood samples. Neem-oil treated wood samples recorded the highest significant resistance, having the least (0.01cm) mean length of furrow and the least () mean weight loss. This is trailed alongside by mahogany oil (0.0017kg) and shea butter-oil () treated wood samples showing significant resistance against termites' invasion. Thus neem-oil extract is recommended as an eco-friendly protection against termite attack. Further studies can still be researched, on the most effective concentration(s) of neem-oil extract against termites' infestation and other biodegrading organisms.

Key words: Obeche wood, Termites, Neem-oil, Mahogany-oil, Shea butter-oil.

1. Introduction

Global warming refers to the accelerated warming of the earth's surface due to anthropogenic releases of greenhouse gasses as a result of industrial activity and deforestation. Bush burning releases excess carbon dioxide, which concentrates in the earth's atmosphere contributing to global warming. According to Cunningham (2002), globally, average temperatures are expected to increase between 1.5^{o}c to 6.1oc (2.7^{o}F to 11^{o}F) in the next hundred years. The effect of this temperature rise is depletion of the ozone layer due to the absorption of ultraviolet radiation on the earth's surface. This is a serious environmental phenomenon that cases climate change, as the ice caps.

Melt and sea levels rise due to the thermal expansion of the oceans. The end point of this is flood, which destroys farmlands, displaces people, causes famine and loss of biodiversity. Fresh water resources could be affected by saline intrusion as sea levels change. Existing dry land regions may become drier still resulting in a greater likelihood of desertification, which is a serious forest resources management problem as trees will be gradually depleted. In view of the depleting effect of climate change on renewable forest resources with particular reference to woody species, it becomes necessary to consider strategies of preserving the limited wood resources against deterioration. Preserving wood to enhance its durability makes wood to last longer, thereby decreasing the demand on the world depleting forest due to climate change. This of course enhances timber species conservation as well as utilization on sustain yield basis.

Termites are responsible for much of the degradation of wood and other cellulose materials in the Tropics and sub-Tropics (Peralta *et al*., 2004). While some wood are resistant to their attack, others are not (Nakayama *et al*., 2000). Degradation of wood by termites is a chronic problem in many tropical regions particularly in the Sub Sahara Africa, resulting in serious monetary and material losses with far reaching impact on the increasing demand for timber (Obi *et al*., 2008).

Wood can be effectively protected from decay organisms by impregnating the wood with pesticide effective chemicals. Impregnating wood by applying suitable chemicals is the most preferred preservation method. But some toxic synthetic chemicals used for wood preservation contain serious pollution risks to the environment (Bozkurt *et al*., 1993; Sen *et al*., 2002). Consumers have become concerned about pesticide residuals on food crops and governments have responded by legislating and restricting the usage of synthetic pesticides. The conventional wood preservatives although found to be very effective against wood destroying organisms, are said to cause environmental pollution and a few of them are hazardous to animals and human beings (Onuorah, 2000). Over the past few decades, there has been substantial global awareness to develop eco-friendly wood preservatives and those, which do not cause any ill effect on the health of mammals (Onuorah, 2000). Efficacious botanical derivatives can provide an alternative to synthetic pesticides and agrochemical companies have started to focus on these alternatives (Addor, 1995). Recently, herbal extracts that are not harmful to the environment, have been shown to be effective natural preservatives (Grafius & Hayden 1988; Sen, 2001).

The country's dependence on imported wood preservatives attracts huge sum of foreign exchange, which could have been used in other sectors of the economy. The study would enable the country to save the much-needed foreign exchange, thereby improving the national economy. Finding of the research will in addition enable more wood to be preserved. This of course will reduce the demand of frequent felling. Thus, enhancing wood species conservation; more so that climate change tends to deplete the available wood resources. The study will also provide opportunity for the average Nigerian to locally preserve wood and wood based products at affordable prices. Considering the importance of wood preservation as a way of ameliorating the depleting effect of climate change on wood species, it becomes imperative that a research be carried out on less durable timber against attack by termites, using locally prepared compounds. The objective of this work was to study the termicidal effects of neem-oil extract, mahogany-oil extract, and shea butter-oil extract their decay resistance on treated wood samples.

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2. Materials and Methods

2.1. Study Area

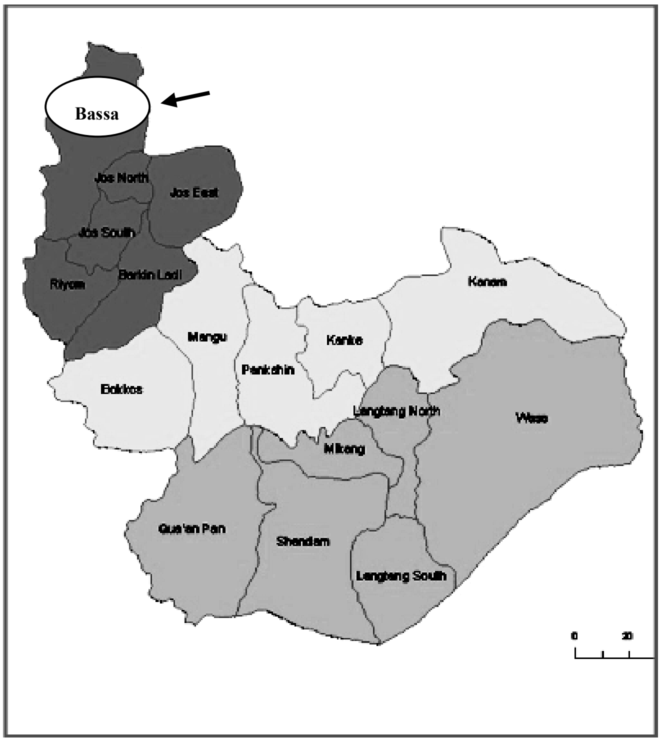

Figure 1: Map of Study Area (Bassa Local Government Area)
Source: http://speakersoffice.gov.ng/constituencies_plateau.htm

Bassa Local Government Area (L.G.A.) is one of the 17 LGAs of Plateau state, located on the Jos Plateau about 10km west of Jos, the Plateau State capital. The L.G.A. covers a landmass of 292 715sqm and has a projected population of over 160 000 people (based on local government targets). It lies between Longitude 90 58'West and Latitude 8o 45'North and bordered by Kaduna and Bauchi States. It is within the guinea Savannah of the northern Nigeria and characterized by a cool windy breeze like that of a temperate area due to its location on the higher altitude. The climate is typical of the rest of the Plateau, with a mean annual temperature of 20°C – 25°C. The mean annual rainfall is 146cm. April-October is generally warmer and this coincides with the rainy season. The harmattan period, December – February is much colder. (Plateau State Diary, 2012)

2.2 Preparation of Wood samples

Obeche (*Triplochiton scleroxylon*) was the considered wood species for the experiment, being one of the less durable timbers. The wood was cut to standard specifications of 100cm x 50cm x 20cm. All prepared wood samples were obtained from defects free areas of the planks. The test pieces were all labeled according to the applied preservatives. Neem-oil treated samples were labeled with the letter "N", while letters "S" and "M" were used for the sheabutter and mahogany oils treated wood samples respectively. Letter "C" was given to the rest 20 pieces that were used as control. Furthermore, all the wood species were seasoned to moisture contents of fiber saturation point of (28%), for adequate penetration of the preservatives into the wood. The moisture content of the wood samples was determined based on their oven dry weights with the formula.

$$\text{M. C. (\%)} = \frac{Ww - Wo}{Wo} \times 100$$

Where M.C. = Moisture Content (%)
Wo = Oven-dry Weight (Kg)
Ww = Initial/Wet Weight (Kg)

At the end of the field work, the weight loss of the wood samples was evaluated using the formula below:

$$\text{Weight Loss} = \frac{Wob - Woa}{Wob}$$

Where: Wob = Oven dried weight of samples before attack
Woa = Oven dried weight of samples after attack

2.3 Preparation of preservatives

Seeds of the selected trees (Mahogany, Neems, and Sheabutter) were collected and their respective oils were extracted. Extremely shrink and unhealthy seeds were rejected. The oils were extracted by weighing 5.0kg into flat container. The container was placed in the sun for open air drying for 2 weeks to ease the grinding process and oil extraction. The seeds were then ground into paste, after removing the seed coats which does not contain much oil. 4 litres of warm water of $55^{o}c$ were mixed with 2.5kg of the seed paste in a plastic bucket. The mixture was left for a period of 3 hours. This enabled the paste to settle at the bottom of the container, and the oil to float on top of the water. The floated oil was carefully scooped out into another container, where it was boiled to eliminate any traces of water through evaporation.

2.4 Experimental design (procedure) and layout.

Within the study areas, sites that are inhabited by subterranean termites (*Macrotermes subhyalinus*) were isolated for the laying out of both the treated and untreated wood samples. Preliminary field survey was carried out in Mista Ali Ward, Bassa Local Government Area of Plateau State, where nine (9) termites' mounds, of almost the same sizes were identified. For ease and effective monitoring of the field trails, 3 (three) termites mounds were randomly selected and labeled as follows: location A, B, and C for the study. The method of treatment of the wood samples with the various preservatives was by complete immersion for a period of 24 hours, to provide for effective chemical penetration into the wood pores. Thereafter the treated wood samples were air dried for one week to ensure chemical retention in them. The samples were randomly exposed in a circle around the base of the mounds in such a way that all the specimens had equal or almost equal chances of being attacked by the termites. All the wood samples were at the same distance of 0.5m from the peak of the mounds.

For the experimental layout, the trial was replicated in these locations, with a total of 240 wood samples. For one location, eighty test pieces were prepared for the field trial. Sixty (60) of the wood samples were treated with the various compounds as follows: neem-oil (20 samples), sheabutter-oil (20 samples) and mahogany-oil (20 samples). The remaining twenty (20) wood samples that were not treated, served as control. The period of the field trail experiments was for 24 weeks (6 months). After 6 months, all the samples were removed from the termite's mounds, and cleaned with a mop to remove traces of sand/mud from them. The purpose is to obtain accurate weights of the wood samples. In order to remove possible moisture absorbed by the samples, they were oven dried at a temperature of $103^{o}C \pm 2^{o}c$ for 24 hours. After the wood samples have dried, they were regrouped according to the various preservative treatments for the purpose of verifying the extent of attack by the termites. Two parameters were used to determine the extent of attack viz: the measurement of the length of furrow caused by the termites, and the loss in weight of the wood specimens. To verify the extent of attack through length of furrow a 30cm ruler and thread were used to measure the length of furrow in the test pieces. In order to obtain a weight loss, the final weights of the wood samples after being attacked by the termites were subtracted from the original oven dry weights of the samples. The data obtained were subjected to analysis of variance (ANOVA) in order to test the level of significant difference and Duncan's New Range Multiple test was used to analyze the established variation. Bar chart was also used for clearer presentation of the data.

3. Results And Discussion

3.1 Degree of attack by length of furrow

The result indicated neem-oil treated wood samples having the least mean length (0.01cm) of furrow, followed by mahogany-oil treated wood samples with mean length of furrow of (0.82cm) and sheabutter-oil treated wood samples with mean length of furrow of (1.50cm), while the control i.e. untreated wood samples had the highest mean length (4.24) of furrow (Table 1 and Fig. 1).

The analysis of variance revealed that the locations showed no significant effect on the degree of attack by the length of furrow, whereas the preservative extracts showed significant effect (Table 2). Further analysis by Duncan's New Range Multiple Test presented all the preservative extracts (neem-oil, mahogany-oil, and sheabutter-oil) as having significant effect on the degree of attack by the length of furrow (Table 3).

In addition, neem-oil treated wood showed a significant resistance with the least mean length of furrow. This is in confirmation with the findings of Akwasi *et al*., (2001) that neem extract treated alstonia wood recorded less attack. According to ICRAF (1992) and Haygreen *et al*., (1982), Neem wood is tough and resistant to decay and termites, while the heartwood is generally resistant to decay fungi and insects. Venmalar and Nagaveni (2005) also opined that neem possesses a number of toxic constituents exhibiting high toxicity against wood destroying microbes. The control having the highest mean length of furrow thus confirms Obeche wood as a less durable wood species as classified by Scheffer & Morrell, (1998) and FAO 1986 cited by Belie *et al*., (1999)

Table 1: Degree of Attack by Mean Length of Furrow (cm) in the Study Locations

	Preservative Extracts			
Locations	**Neem-oil (N)**	**Mahogany oil (M)**	**Sheabutter oil (S)**	**Control (C)**
Location A	0.01	0.77	1.49	4.20
Location B	0.01	0.86	1.54	4.40
Location C	0.01	0.84	1.48	4.11
Mean	**0.01**	**0.82**	**1.50**	**4.24**

Table 2: ANOVA of Degree of Attack by Mean Length of Furrow (cm)

Variables	**df**	**Sig.**	**Decision**
Locations	2	0.198	NS
Preservatives	3	0.000	S

Table 3: Follow-up Analysis of the Effect of the Preservative Extracts on the Degree of Attack by Mean Length of Furrow (cm) - (DUNCAN)

Preservative Extracts	**Mean**
Neem oil	$0.01{\pm}0.00^{d}$
Mahogany oil	$0.82{\pm}0.05^{c}$
Sheabutter oil	$1.50{\pm}0.03^{b}$
Control	$4.24{\pm}0.15^{a}$

***Means along each column bearing different superscripts are significantly different ($P < 0.05$) at 5% level by Duncan's New Multiple Range Test.

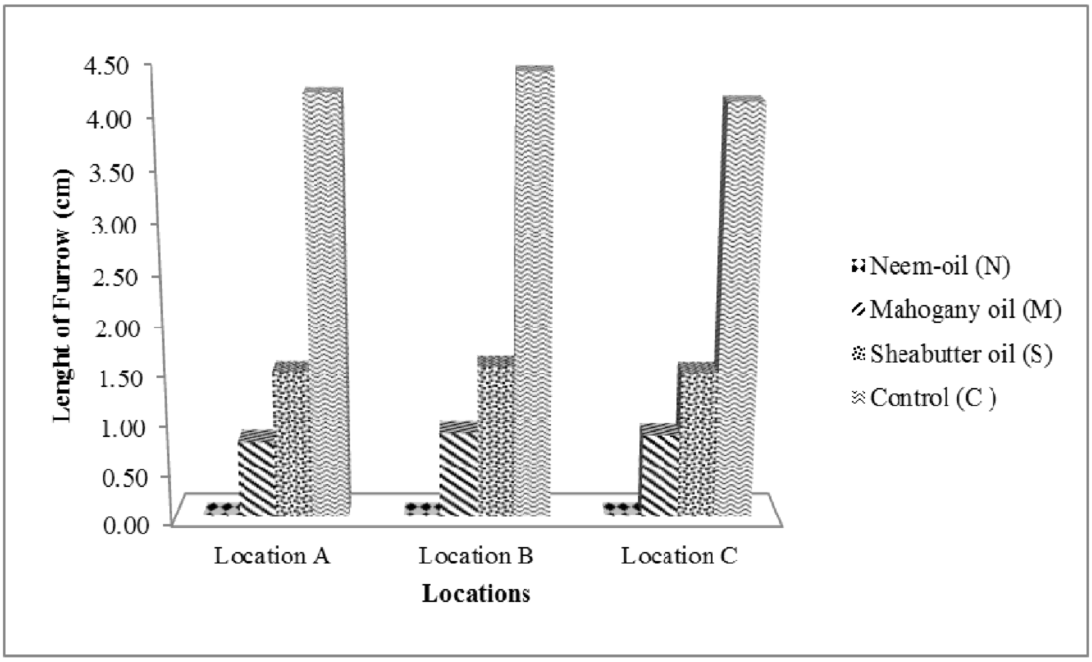

Figure 1: Bar chart showing length of Furrow by Termite attack

3.2 Degree of attack by loss in weight

The degree of attack on the wood samples as a result of termite infestation was also measured in terms of the weight loss. Table 4 and Figure 2 showed the mean weight loss of the treated wood samples due to termites' invasion. The result revealed that neem-oil treated wood samples had the lowest mean weight loss of 0.0017kg, trailed by mahogany-oil and sheabutter-oil treated wood samples with mean weight loss of 0.0155kg and 0.0243kg respectively, while the untreated wood samples (control) had the highest mean weight loss of 0.0451kg. The implication of this is that wood of *Triplochiton scleroxylon* is susceptible to termite attack.

Analysis of variance (ANOVA) indicated significant difference in the effect of the locations and preservative extracts on the degree of attack by mean weight loss (Table 5). In the same vein, Duncan's Range New Multiple Test further revealed that only location B in all the locations had significant effect on the degree of attack by mean weight loss, while all the preservative extracts (neem-oil, mahogany-oil and sheabutter) also showed significant effects (Tables 6 & 7). This confirmed effectiveness of extract solutions in enhancing decay resistance of wood (Goktas *et al.*, 2007).

Moreover, neem-oil extract treated wood also recorded a significant least mean weight loss as a result of the termites' invasion. This finding confirmed the effectiveness of neem extracts reported by Moyin-Jesu (2010).

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Table 4: Degree of Attack by Mean Weight Loss (kg) in the Study Locations

Locations	Preservative Extracts			
	Neem-oil (N)	Mahogany oil (M)	Sheabutter oil (S)	Control (C)
Location A	0.002	0.0121	0.0221	0.0452
Location B	0.002	0.0223	0.0287	0.0483
Location C	0.001	0.0122	0.0220	0.0418
Mean	**0.0017**	**0.0155**	**0.0243**	**0.0451**

Table 5: ANOVA of Degree of Attack by Mean Weight Loss (kg)

Variables	df	Sig.	Decision
Locations	2	0.027	S
Preservatives	3	0.000	S

Table 6: Follow-up Analysis of the Effect of Locations on the Degree of Attack by Mean Weight Loss (kg) - (DUNCAN)

Locations	Mean
Location A	0.020 ± 0.019^{b}
Location B	0.025 ± 0.017^{a}
Location C	0.019 ± 0.018^{b}

***Means along each column bearing different superscripts are significantly different ($P < 0.05$) at 5% level by Duncan's New Multiple Range Test.

Table 7: Follow-up Analysis of Effect of the Preservative Extracts on the Degree of Attack by Mean Weight Loss (kg) - (DUNCAN)

Preservative Extracts	Mean
Neem-oil	0.0017 ± 0.001^{d}
Mahogany-oil	0.0155 ± 0.006^{c}
Sheabutter-oil	0.0243 ± 0.004^{b}
Control	0.0451 ± 0.003^{a}

***Means along each column bearing different superscripts are significantly different ($P < 0.05$) at 5% level by Duncan's New Multiple Range Test.

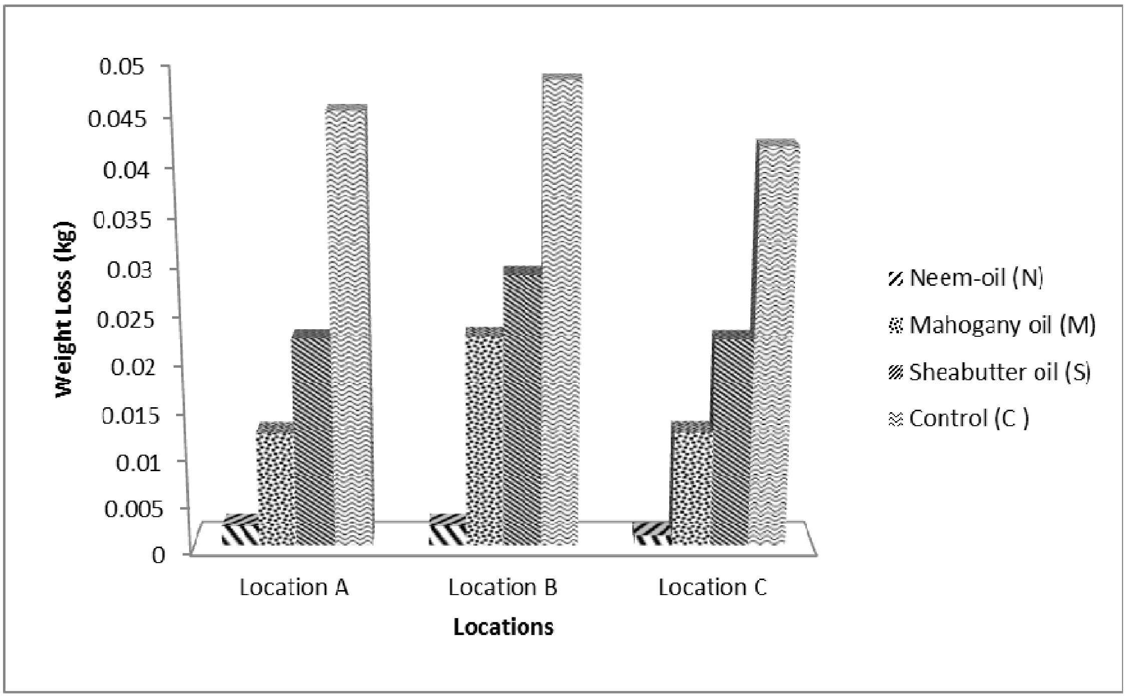

Figure 1: Bar chart showing Weight Loss due to Termite attack

4. Conclusion and Recommendation

The three locally developed preservatives (neem-oil, mahogany-oil and shea butter-oil) effectively resisted the termites attack, thus confirming the effectiveness of extract solutions in enhancing decay resistance of wood. These eco-friendly wood preservatives are less toxic, harmless to the environment and can be produced at low cost. Moreover, they are biodegradable and renewable resources. For instance, Neem compounds do not persist or accumulate in the environment after being applied as pesticides. They break down quickly when exposed to sunlight, usually within one week. Neem's principal active compound has been identified as Azadirachtin. It acts on insects by repelling them, by inhibiting feeding, and by disrupting their growth, metamorphosis and reproduction. Neem-based formulations do not usually kill insects directly, but they can alter their behaviour in significant ways to reduce pest damage to crops, and reduce their reproductive potential. Azadirachtin affects insect physiology by mimicking a natural hormone. It has been shown to affect egg production and hatching rates.

These plant extracts could be exploited to develop new wood preservatives to protect wooden structures, agricultural crops, plants and as well as trees. The development of their production technology will reduce the nation's dependence on foreign wood preservatives; thereby saving the country's much needed foreign exchange and also reduce the demand of frequent felling, thus, enhancing wood species conservation; more so that climate change tends to deplete the available wood resources.

In the manufacturing sector today, human capital is still essential for most factories to carry out a variety of manual operations, in spite of the rapid advancement of automation technology and robotics. Futuristic vision of "unmanned manufacturing" (Deen 1993) is forbiddingly expensive, because all its hardware components need to be computer controlled so as to freely communicate with each other; and yet, most of the outcomes are not promising (Sun & Venuvinod 2001). By and large, factories equipped with relatively simple machinery controls will require continuous attendance of human operators; for examples, textile mills, leather products, and medical appliances. With limited capital investments in production equipment, the main budget of their fixed costs lies on the workforce size (Techawiboonwong *et al.* 2006).

With regard to cost-effectiveness, labour planning always opts for the minimum amount of workers needed to deal with the daily operations, as well as the probable rate of disturbance (Lim *et al.* 2008). The workforce disturbance is often ascribed to absenteeism and turnover, which may result in considerable loss of productivity for any labour-intensive division (Easton & Goodale 2002). Buffering with redundant skilled workers (Molleman & Slomp 1999) or relief workers (Redding 2004) might be a direct solution to absenteeism; however, the rising labour cost must be justifiable due to the fact that underutilisation of labour during low demand seasons is considered a waste of resources. Absenteeism is the measure of unplanned absences from workplace due to some reasons like personal emergency, accident, illness, etc. Turnover occurs when an active worker resigns from the company of his own accord, thus leaving a vacant post until a replacement is found. If such disturbance has caused a large number of tasks become unattended and overdue, the company is then vulnerable to overtime cost, shrunk capacity and productivity, extra queuing time, lost business income, etc. In order to prevent these deteriorative effects, optimising the number of workers can be helpful. As a fundamental branch of knowledge in manufacturing business, workforce management will never fall behind the times. Therefore, it is worth an attempt to incorporate a novel methodology, such as HMS, into the state of the art of workforce sizing.

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