CHECKING, SPLITTING AND PRESENCE OF MOULDS IN NEEM (AZADIRACHTA INDICA) WOOD AND CARVED PRODUCTS: CAUSES AND POSSIBLE SOLUTIONS

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Abstract

Neem (*Azadirachta indica*) is one of the main good woods for carving being promoted, in Kenya, to replace the over-exploited indigenous species like Muhugu (*Brachylaena huillensis*) and Mutamaiyo (*Olea africana*) among others. However, Neem wood and carvings easily crack and mould. There was need therefore to determine the reasons for these and to suggest solutions on how to arrest or control these two major problems. A three day study was carried out at Akamba Carving Co-operative in Mombasa in Coast Province in order assess the existing conditions and appropriateness of current methods used to dry Neem, establish (state) appropriate drying techniques to ensure recommended moisture levels are achieved and recommend proper handling and storage methods for Neem logs to reduce checking. The moisture content of randomly chosen logs and carved products was determined using a moisture meter, the heartwood proportion of these logs and some carved items measured, an audit of the drying kilns carried out and causes of moulds assessed.

The study reveals that the checking could be due to growth and drying stresses. All the cracking in the logs is noted to be originating from the pith, which is the weakest point in a log. The cracking appears to be accelerated by the exposure of the logs to direct sunrays and wind in an open yard and the likely uneven distribution rate of moisture loss at the pith, heartwood and sapwood. The proportion of heartwood in logs is found to be about 51% and that in carved stool tops as about 60 %.

It is concluded that there is need for more controlled drying of the carved Neem products; presence of moulds in the carved items is due to high moisture content in the sapwood and warm and damp conditions in the show rooms; cracking is more pronounced in large carved items; lack of a shed at the log yard promotes the end checking and finally it is necessary to understand the factors that influence the checking of the Neem before concrete guidelines to curb the problem can be developed. In the short term, improvements in some of the practices at the society to ensure that better quality products are produced have been recommended. A study on drying behaviour and properties of Neem has also been recommended.

1.0 Introduction

The wood carvers in Kenya, have for a very long time had preference for a limited number of indigenous hardwood species for carving. A current campaign to have certified forest products sold on the international market has resulted in the loss of three quarters of the Kenya's export market for woodcarvings in the last three years. The business that used to earn $20 million every year for the country is now making less than $ 5 million and the value is still dropping. The effect is felt country wide as wood carvings make up to 25 % of the timber business, employing 80,000 directly and half a million others indirectly.

The People and Plants Initiative of the United Nations Education and Scientific Organisation (UNESCO) and the World Wildlife Fund (WWF) is working in collaboration with WWF (UK) and WWF East Africa to get Kenyan carvings certified. Carving certification is being carried out on pilot bases in Malindi and Mombasa Co-operative Societies. Neem (*Azadirachta indica*) is one of the main good woods being promoted to replace the over-exploited indigenous species like Muhugu (*Brachylaena huillensis*) and Mutamaiyo (*Olea africana*) among others.

In order to facilitate the process of wood carving certification in Kenya a project on capacity building in the sustainable use of plant resources for woodcarving was formulated and is being funded by UNDP-GEF and coordinated by Coastal Forest Conservation Unit (CFCU). CFCU contracted Kenya Gatsby Trust (KGT), a business development NGO, to implement, through a participatory approach the findings of the business assessment that had been carried out by Oxfam UK on Akamba Handicraft Co-operative Society in Mombasa. Kenya Gatsby Trust in the first stage of their assignment realized that Neem wood and carvings easily crack and mould. There was need therefore to determine the reasons for these and to suggest solutions on how to arrest or control these two major problems.

The objectives of the study were to:

(i) Assess the existing conditions and appropriateness of current methods used to dry Neem at the Akamba co-operative society.

(ii) Establish (state) appropriate drying techniques to ensure recommended moisture levels are achieved.

(iii) Recommend proper handling and storage methods for Neem logs to reduce checking.

2. 0. Study Area
Akamba Co-operative Society

The Akamba Carving Co-operative is located at Changamwe, Mombasa West in Coast Province. It is probably the world's largest open-air studio. It has more than 1500 highly skilled craftsmen working on an eight-acre estate and producing approximately half a million carvings a month. The craftsmen model each form using simple hand tools. All carvings meet rigid standards of quality for the export market. Simplicity of form and exquisite craftsmanship are the hallmark of the Akamba master works.

The carved items range from ornamental/decorative, ornamental/functional, functional/utilization, fetish/sculpture, families of animals etc.
The finished carved products have 3 colours: black, natural and colortone and are exported to Europe (France, Germany, Denmark, Hungary, Czechoslovakia Republic, Austria, UK, Poland, Spain), USA, Canada, Australia and New Zealand.

3.0. Study Methods/Activities.

1. Familiarization with the operations at the co-operative and attempting to understand the actual problem through informal discussions with carvers and the management.
2. Determination of the moisture content of randomly chosen logs at the yard, freshly carved products and dried and un-dried carved products using a moisture meter in order to have a general idea on the moisture distribution from pith to bark (Pith[1], Heartwood[2] and Sapwood[3]).
3. Observation of the log yard and the logs at the yard and noting presence of checks and hypothesising on possible causes of the checks.
4. Determination of heartwood[4] proportion (HW %) by measuring the mean heartwood diameter (HWd) and mean diameter under bark (D) of selected logs and carved items in 2 above and computing the value using the following equation: $HW\ \% = (HWd)^2 \times 100 / D^2$.
5. Carrying out an audit of the drying kilns in use to establish that all the basic and necessary equipment are installed and operating well, assessing kiln charge practices, kiln control, kiln operation, air circulation and final moisture content attained after the prescribed period of drying.
6. Measurement of moisture content of sapwood of a random sample of carved items displayed in the showroom that have moulds using a moisture meter.

[1] Pith is the small, soft core occurring near the centre of a tree trunk, twig or log.
[2] Heartwood is the wood extending from the pith to the sapwood, the cells of which no longer participate in the life process of the tree
[3]Sapwood is the wood of pale colour near the outside of the log.

4.0. Results and Observations.

4.1. Log handling and storage

The Neem logs are felled by brokers/sellers and transported almost the same day to the Co-operative Society. Sometimes if the demand for the logs by carvers is low, the felled and cut logs may not be transported to the yard the same day. The logs are off loaded into an open yard as shown in Figure 1.

The carvers buy the logs from the brokers once these are brought to the yard. The carvers choose the logs or part of the log they require and the brokers cut and sell to them. A discussion with the brokers indicated that there is usually a high demand for the logs due to the scarcity of the raw material (Neem wood) and the demand for its products for the export market. This coupled with the fact that a carver's choice of a log depends on the size of the item to be carved, may make it difficult for them to wait for the logs to dry in the yard. It was further noted that a carver's choice of a log depends on the size of the item to be carved.

4.2 End Checking and splitting (Cracking) of the logs

This is one of the most common degrades which occurs during seasoning of logs or timber. The checking and splitting normally become extensive when green wood is piled in warm, dry and sunny situations.

It was observed that the checking of the logs start immediately they have been cut. This is probably due to the fact that upon felling of the trees and cutting into logs, the wet surfaces are exposed to the air and evaporation begins. Accompanying this drying is shrinkage or change in size and shape of the wood. Neem has fibres with thinner walls and wood rays (2-5 cells wide) larger than Muhugu (1-2 cells wide) and Mutamaiyo (1-3 cells wide) (Muga *et al.* 1998), and is therefore expected to have a higher rate of moisture loss during the drying and consequently a higher degree of uneven shrinkage. The cracking could be as a result of exposure of the wood to direct sunrays and wind in an open yard and the likely uneven distribution rate of moisture loss at the pith, heartwood and sapwood. Assessment of a few logs at the yard indicated that the mean amount of heartwood for any given diameter of the Neem wood was about 51 % (Table 1). It was also evident that the moisture at the exposed surfaces of the logs varied from a mean of 13.5 % to more than 28 %, Table 1. The amount of moisture varied from pith to sapwood, generally increasing from the pith to sapwood, as shown in Table 1. In almost all cases, the moisture content at the heartwood was lower than at the sapwood. This confirms an established scientific fact (Henderson, 1925, Simpson, 1999). Because chemical extractives in heartwood plug up passageways, moisture generally moves more freely in sapwood than in heartwood; thus sapwood generally dries faster than heartwood.

The rate at which moisture moves in wood depends on the relative humidity of the surrounding air, the steepness of the moisture gradient, and the temperature of the wood

(Simpson, 1999). The lower the relative humidity, the greater the capillary flow. Low relative humidity also stimulates diffusion by lowering the moisture content at the surface, thereby steepening the moisture gradient and increasing the diffusion rate. The relative humidity in Mombasa is generally high, recording more than 92 % at the time of the study. This explains the generally higher amount of moisture in the sapwood than heartwood for logs that have been in the yard for sometime. As it was also evident that all the cracking in the logs originated from the pith as shown in Figure 2, it may be inferred that the internal stresses resulting from the drying of the wood causes the wood to start cracking at the pith, which is the weakest point. The pith and heartwood for all the logs sampled had moisture content lower than the fibre saturation point (about 28 %), their cells must be shrinking while losing water to the atmosphere and swelling while absorbing water by diffusion from the sapwood, this swelling and shrinkage results in the checking and splitting (USDA, 1974). The possible solution to the above problem would be to control the drying process or use end-sealing compounds to control the rate of moisture loss from the logs.

Controlled air-drying.

Controlled drying would be achieved through accelerated air- drying. Accelerated air-drying involves the use of fans to force air through lumber piles in a shed. It reduces drying time and introduces some control in the drying from green to 20 % or to 25 % (Simpson, 1999). Small amounts of heat may be used to lower the relative humidity and to slightly increase the temperature.

End sealing of the logs

Application of end sealing compounds to the logs would greatly retard the loss in moisture and consequently reduce end checking/splitting of the logs (Anon, 1968). Polythene sheeting and cleats[1] may also be used to restrain the development of the checks and splits in logs (Anon, 1968). A heavy grade of polythene should be used to reduce tearing and splitting. The main types of end sealing compounds in use are: Bituminous paints and emulsions, waxes and wax emulsions and paints. An effective end-sealing compound should be cheap and easy to apply in order to realise the full advantages. It must also form an efficient moisture barrier when applied to green timber.

The other possible cause of the checking could be due to growth stresses. It is a general perception that fast-grown trees are more prone to end splitting. Neem takes a shorter time to mature as compared to the indigenous hardwoods previously preferred by wood carvers and would therefore be expected to be more prone to end-splitting. Studies done by South African scientists Maree and Malani (2000) on Eucalypts confirmed this perception. They found that log end splits (both lengthwise and width wise) increase with diameter growth.

The fast growth rate and the resultant relative short rotation ages, the large proportion of juvenile wood and the possible differences in density and other wood properties within the

[1] Cleats –these are either wood or iron or plastic materials nailed to the end of the logs or boards so that they are unaffected by any distortions that may take place.

wood may also contribute significantly to difficulties in drying. Extension of the rotation age can obviously make a significant contribution to reduce the juvenile wood proportion while tree improvement can address the non-uniformity in density and growth stresses.

Table 1: Moisture distribution in logs at the log yard

No. of days after felling of logs	Diameter (cm)	HW %	SW Width (cm)	Moisture content (%)				Remarks
2	19.2	53.0	5.3	Pith	HW	SW	Mean	
2	34.0	51.2	9.3	14.3	12.6	13.7	13.5	Cracked from pith
2	17.7	39.4	6.5	26.0	24.8	26.1	25.6	Cracked from pith
2	18.5	39.8	7.1	>28	>28	>28	>28	Small crack. Freshly cut surface
5	8.5	51.7	5.4	13.2	22.6	>28	>21.3	-
21	56.0	69.3	9.3	21.5	20.2	>28	>23.2	Surface cut 1 wk ago and cracked from the pith.
Mean 6	**25.7**	**50.7**	**7.2**	**>20.6**	**>21.6**	**>24.8**	**>22.3**	

Key: SW – Sapwood; HW - Heartwood

4.3 Moisture distribution in carved items

Moisture in air-dried carved items

Six stools that had been carved and air-dried in the carver's shed for varying number of days were chosen and the distribution of the moisture from pith to sapwood determined using a moisture meter. The results are as indicated in Table 2. It is evident that it is possible to achieve a moisture content of about 13 % by air drying carved items under a shed, for about 3 weeks. It also appears that when the heartwood proportion in the carved stool is higher than 70 % and sapwood width is less than 4 cm then there may be no crack during air-drying of the item.

Table 2: Heartwood proportion and sapwood width and moisture content for air-dried carved stools

No. of days after carving of stool	Diameter (cm)	HW %	SW Width (cm)	Moisture content (%)				Remarks
				Pith	HW	SW	Mean	
7	23.5	65.6	4.9	18.8	19.3	19.2	19.1	Cracked from SW
7	22.4	63.2	5.1	14.0	14.5	14.4	14.3	Cracked from Pith
14	23.4	46.1	8.2	18.0	17.3	21.3	18.9	Cracked from SW
14	25.0	71.8	3.8	18.5	14.7	19.4	17.5	No crack
21	22.8	75.3	3.3	14.5	12.8	12.8	13.4	No crack
21	23.5	36.4	10.2	12.2	12.1	12.6	12.3	Cracked from SW
Mean	**23.4**	**59.7**	**5.9**	**16.0**	**15.1**	**16.6**	**15.9**	

Key: SW - Sapwood; HW - Heartwood

Moisture in large items being carved

Two large giraffes being carved were chosen and the moisture distribution measured and the results are as indicated in Table 3.

Table 3: Moisture distribution in large giraffe items being carved

Date carving started	Last day carved	Date moisture measured	Moisture content (%)				Remarks
			Pith	HW	SW	Mean	
11-11-02	18-11-02	20-11-02	>28	16.2	>28	>24.1	Cracked from pith
19-11-02	20-11-02	20-11-02	24.0	>28	>28	>26.7	Cracked from pith

The results, though only from 2 samples, indicate that large items may have high moisture content with very steep moisture gradients.

4.4 Presence of moulds in air dried carved items

Moulds are confined largely to sapwood and are of various colours. Under favourable moisture and temperature conditions, moulding fungi may become established and develop rapidly in sapwood of logs shortly after they are cut. In addition, timber and such other wood products may become infected at any stage of manufacture or use if they become sufficiently moist. Freshly cut or unseasoned items in warm, humid weather may be noticeably discoloured within 5 or 6 days (USDA, 1974). Moulding does not practically impair the wood or wood product but is not acceptable in appearance products like woodcarvings.

To assess the situation at the society in terms of moulding of carved items, six giraffe items 16 inches and above were chosen at random from among the finished items displayed at the show room for sale to the tourist's. The moisture content at the surface was determined and presence of moulds observed. Also 5 small items of various animals, which had moulds, were chosen at random and the moisture at the sapwood where moulds were present determined and recorded. The results are shown in Table 4.

The results show that the presence of moulds was observed in small and large items with in sapwood moisture content as low as 18.6 %.

Moulds as compared to stains do not penetrate deep into sapwood and can be removed by surfacing. It was observed that items at the showroom that were regularly surfaced by carvers using a cloth had a lower incidence of moulds.

Table 4: Moisture Content and Presence of moulds in carved items at the showroom

Size (height) of item (inches)	Type of carving	Moisture content (%)				Remarks
		Pith	HW	SW	Mean	
4	Elephant	-	15.5	18.8	17.1	Moulds present
7	Giraffe	-	-	21.6	21.6	Moulds present
8.5		-	-	19.2	19.2	Moulds present
9.0	Rhino	-	-	21.3	21.3	Moulds present
9.5	Elephant	-	-	21.4	21.4	-
16	Giraffe	-	-	19.4	19.4	Moulds present
18	Giraffe	-	22.0	22.5	22.3	Recently brought in the show room
24	Giraffe	16.5	17.0	18.6	17.3	Recently brought in the show room
36	Giraffe	20.8	15.5	25.5	20.6	Recently brought in the show

						room
48	Giraffe	21.5	19.5	25.8	22.2	Recently brought in the show room
72	Giraffe	16.3	15.0	20.5	17.2	Moulds present. Been in the show room for > 6 months
120	Giraffe	17.5	19.0	23.0	20.2	Moulds present. Been in the show room for> 6 months

4.5 Drying of carved items

Drying of wood in general

Drying of wood reduces the weight of wood, with a resulting decrease in shipping costs; reduces or eliminates shrinkage, checking, and warping in service; increases strength; decreases susceptibility to infection by fungi; reduces chances of attack by insects; and improves the capacity of wood to take preservatives and hold paint (USDA, 1974).

Ideally wood should be dried to moisture content it will reach in service. However, this optimum may only be possible with timber that is less than 76 mm (3 in.) thick (Simpson, 1999). It is seldom practical to obtain fully dried timbers when thicker sizes are used. However, the recommended moisture content of wood should be matched as closely as practical to the equilibrium moisture content (EMC) in service. The need to dry timber from air dry to EMC is a major reason for the use of kiln drying. It has been observed that the shrinkage in timber that takes place between 17 % and 12 % moisture content is enough to ruin accurately made wood products (Plumptre and Jayanetti, 1996). It is therefore important to dry timber as nearly as possible to the EMC prevailing where it will be used.

Current drying method at the Co-operative.

This is carried out in cylindrical drums of 57.5 cm diameter and 87.5 cm in length as shown in Figure 3. There are a total of 6 drums. Each drum contains approximately 226 carved items (giraffe of 8 inches height). Each drum is heated from below, using wood wastes from the carvings. The distance from the source of the heat to the base of the cylinder is 75 cm.

Each charge is dried for 48 hours. The intensity of the fire varies from time to time and goes off about mid-night, as there is nobody to continue adding the wood wastes. There is therefore a large variation in temperature within the dryer. The following were also noted:

- The arrangement of the carved articles is done in a haphazard manner.
- Due to lack of fans in the dryer the air circulation is poor. This may result in parts of the items being over dried causing an imbalance in moisture distribution. This leads to cracking especially of the large giraffe items 18 inches and above in height and other animals 8 inches in height and above.

- ❖ The items are also dried after finishing and coloration occurs. These items should therefore be dried before finishing to enhance faster and better drying as the chemicals used for finishing block the wood rays and pores and prevent moisture loss.
- ❖ The initial moisture content of the items to be dried is not measured and there is a likelihood of the items in the drier having significantly high differences in moisture levels and this can result in non-uniformity in the final moisture content in the items.

Moisture content in finished carved items before drying in the drum kiln

The moisture content of 6 randomly picked small carved and finished giraffe items were measured and recorded. The results are as shown in Table 5.

Table 5. Moisture distribution in small carved and finished giraffe items (8 inches high) from Neem before drying

Item	Moisture content (%)			
	Pith	HW	SW	Mean
1	13.0	-	16.7	14.9
2	13.2	-	24.1	18.7
3	-	-	12.7	12.7
4	-	12.3	12.6	12.5
5	-	-	12.7	12.7
6		12.4	-	12.4
Mean	**13.1**	**12.4**	**15.8**	**14.0**

The results show that small items can attain reasonably low moisture content (14 %) without being subjected to artificial drying and with no cracks. A number of the small-carved items measured were made up of sapwood only and would therefore be expected to mould if not properly dried.

Moisture content in finished carved items after drying in the kiln

The moisture contents at the pith, heartwood and sapwood of 14 randomly chosen finished carved items (giraffes), 10 (8 inches in height) and 4 (14 inches in height) were measured using a moisture meter and recorded. The results are as indicated in Table 6.

Table 6. Moisture distribution in small carved and finished giraffe items from Neem after being dried for '48 hours' in a dryer and ready for shipment.

Size of item (inches)	Moisture content (%)			
	Pith	HW	SW	Mean
8	11.5	-	12.2	12.2

8	-	12.8	13.3	12.8
8	-	11.5	12.5	12.0
8	12.5	-	12.5	12.5
8	-	11.5	12.2	11.9
8	-	-	12.4	12.4
8	12.8	-	12.5	12.7
8	-	-	12.5	12.5
8	-	11.5	12.1	11.8
8	11.5	11.6	12.3	11.8
Mean	**12.0**	**11.8**	**12.4**	**12.2**
14	11.1		11.6	11.4
14	11.0	11.5	11.5	11.3
14	11.4	11.0	11.5	11.3
14	12.5	10.8	11.5	11.6
Mean	**11.5**	**11.1**	**11.5**	**11.3**
Overall mean	**11.8**	**12.9**	**12.0**	**11.9**

The results indicate that a mean moisture content of 12 % can be achieved by the current drying method. The moisture distribution seems to be uniform after drying to about 12 %. However, it appears that the drying of the carved items as practiced currently at the society does not seem to be effective as a reduction in moisture of 2 % only (14.0 % to 12.0 %) is achieved.

Electric dryer

It was also noted that there is an electric dryer that is currently not being used due to overloading of the power line at the Society and cost implications. The dryer was assessed. It has internal dimensions of: Width 165 cm, Length 227 cm and Depth of 50 cm and can dry a large quantity of carved items in one charge. The power rating could not be immediately established, as the manual was not readily available. It has one fan, one thermometer, no vents and no mechanisms for controlling humidity. The door is quite heavy and needs at least two people to open the same.

This electric dryer could be used for more uniform and controlled drying. However, there is need to develop drying schedules for the various sizes of the carved items. There is also need for the Society to sort out the power supply issue with Kenya Power and Lighting Company as soon as possible.

Use of Solar Kiln

Because of the higher costs involved in operating an electric dryer, a solar kiln may be more desirable. There may be need for design of an appropriate solar kiln to help in controlling the drying of the carved products. Solar kiln has a number of advantages over air drying, these include: higher temperatures give faster drying, EMC is reached is much lower and therefore it is possible to dry up to 6 % moisture content or below and due to the control of humidity the quality of drying is therefore good (Plumptre and Jayanetti,

1996). As compared to the conventional kilns they provide nightly 'reconditioning' which tends to give good quality drying with more difficult timbers, they require less attention, much less expensive to purchase initially and almost always cheaper and easier to operate and are relatively easy to manufacture

Limitations of the study

Detailed technical evaluation of the problem using several wood samples and more accurate methods for moisture determination could not be done due to the short duration of the study (3 days) and lack of the necessary equipment at the society. The moisture meter used could only measure the surface moisture content to a maximum depth of 1 cm and is limited for measurement of moisture below fibre saturation point i.e. 28 %.

5.0 Conclusions and Recommendations

The above limitations notwithstanding, the following conclusions and recommendations can be made.

Conclusions

1. The current drying of carved items at the society is not properly supervised or controlled. Even with better control and supervision dryers may only effectively dry the small-carved items (16 inches high and 3 in thick and below).

2. There is need for more controlled drying of the carved Neem products.

3. Moulding of the carved items result due to high moisture content in the sapwood and warm and damp conditions in the show rooms.

4. Most cracking was observed to originate from the pith in the case of the logs. However, cracking was more pronounced in large carved items with a large volume of wood hence lower degree of moisture loss/drying.

5. Logs are exposed to harsh environmental conditions due to lack of a shed and this promotes the end checking and cracking.

6. There seems to be a number of factors that influence the cracking of the Neem that need to be understood before concrete guidelines can be put in place to curb the problem. However, there are improvements in some of the operations/ practices at the society that can be carried out in the short term to ensure that better quality products are produced.

Recommendations

1. Need to develop a proper drying schedule for the drying of the carved items in a more controlled situation. There is need to evaluate the suitability of the electric kiln or a solar kiln for this purpose and to trial various sizes in the kiln to establish the optimal conditions for drying of each size.

2. As even years of drying outdoors would not be sufficient to prevent checking and shrinkage when thick solid wood carvings are to be made, it is recommended that carvers work on these pieces periodically so as to allow the newly exposed surfaces to dry out. The carvers should be encouraged to let the partly carved items to lose some additional moisture as they carve other items.
3. Discussions with carvers on recommendation 2 indicated that this might only be possible if there is capital set aside for the carvers, as they wait for the pre-scribed period of time, as the carvers depend on the income from the carvings for their livelihood and cannot afford to wait. There is therefore need for change in practice of the co-operative management; money needs to be invested up front in establishment of log yards and storing of logs before carving.
4. To avoid the exposure of the logs at the yard to harsh weather/climatic conditions, it is recommended that a shed be put up by the co-operative to shield the logs and help reduce the uneven drying of the wood and the consequent checks and splits.
5. There is need to identify cheap and easy to apply end-sealing compounds and evaluate their effectiveness in reducing or minimising the splitting and checking of the logs while at the yard.
6. Suitable sheeting materials should also be identified and evaluated for use in restraining the development of the checks and splits on large wood surfaces like stool tops while being worked on by carvers or while being air dried before finishing. The air-drying of such finished items should be under the carving shed.
7. The society should assign somebody to ensure that the fire used for drying the small-carved items does not go off to ensure uniform drying and achievement of moisture content below 12 %. Possibilities of introducing fans to circulate air in the dryers should be explored to ensure uniform distribution of the warm air. Further, there is need to introduce a few more drying compartments using wire meshes and to reduce on the number of carvings being dried per charge. Meanwhile the items to be dried should be natural and unfinished at the time of drying. There is also need to have ten randomly selected samples in each charge to be used for monitoring the progress of the drying by measuring moisture content at 5 hours interval. The items to be dried in a particular kiln should be of the same species, size and moisture content.
8. To reduce on the effect of the drying or growth stresses on the weaker pith, it may be necessary to avoid the pith by bisecting the logs to be used in carving small items and to refine the carver's technology of drilling out the pith in logs for carving large items and filling the gaps with timber and glue. In the case of the former accuracy must be emphasized.
9. There is need for a well-planned study to help in understanding the drying behaviour and properties of Neem in order to develop concrete guidelines on its drying, utilisation and tree improvement. There is need to survey log quality, form (shape) and dimensions, determine pith eccentricity, green moisture content and moisture content of wood during processing and storage, shrinkage and swelling properties, moisture movement, percentage of sapwood and if sapwood should be used, determine and record existing practices. It may also be necessary to correlate

degrade with log form. It will also be essential to establish the most viable method of drying the wood to achieve a satisfactory product.

10. There is need for the carvers, log sellers, the Society management and members to be made aware of these findings and other relevant information on wood utilisation. A workshop should also be held to seek their views and the most appropriate way forward and address some of the problems identified, especially the non technical ones. Sending a copy of the report to the Society by itself may not have any significant impact given its set up and the level of knowledge of the members and carvers.

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