

## LOCAL WISDOM IN UTILIZING PEAT SWAMP SOIL AND WATER TO IMPROVE QUALITY OF GELAM WOOD

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### ABSTRAK

Local wisdom in utilizing swamp soil and water to improve the quality of gelam wood in Central Kalimantan becomes an interesting phenomenon. Improving the quality of wood can economize on the use of wood, which in turn preserves the forests in peat swamp lands. Gelam (*Melaleuca* sp.) woods that are mostly found in peat swamp forests can be used as piles/stakes in swamp soil, and they are durable for decades. The general objective of this study was to provide a scientific explanation of the effect of peat swamp soil and water on improving the quality of gelam wood either in barked and barkless conditions. This study was conducted by taking gelam trees that grew in Central Kalimantan. It was carried out for 18 months, and investigated the barked/barkless woods, media (swamp water, freshwater, peat swamp soil, and sandy soil) and 3 lengths of burying times. Wood properties analyzed were physical and mechanical properties. The standard of physical-mechanical property tests referred to British Standard 373.

The results showed that the interaction between bark factor (A) and media (B) affected specific gravity. Barked wood produced the highest specific gravity in swamp water medium. Water media (swamp and fresh water) improved the wood's specific gravity more than soil media (swamp and sandy soil). The highest values of hardness, stress on Proportional Limit, and Modulus of Elasticity were in the medium of swamp soil. The improvement of the quality of gelam woods, which were either buried or used as stakes/piles, was allegedly resulted from the swamp water infiltrating into gelam woods that thereby increased the specific gravity.

**Keywords:** burial, gelam, local wisdom, mechanical physical properties, peat swamp soil and water

### INTRODUCTION

Communities have local wisdom in utilizing natural resources in their surroundings. One of the communities is the community living in Central Kalimantan who uses the medium of peat swamp water to immerse the wood. The improvement of wood quality can economize on the use of wood, which in turn preserves the forests in peat swamp lands.

Gelam (*Melaleuca* sp.) is mostly found in peat swamp forests. People use gelam as stake/pile. Gelam's lifetime as the stake can reach several decades despite its durable class 3, according to the Indonesian durable class standard. This class means that gelam has only 3 years of lifetime when used in a direct contact with the ground.

Gelam tree is a species of Myrtaceae family which grows in swampy lowland areas (coastal swampy lowlands) in some countries such as Indonesia, Malaysia, Singapore, Thailand, and northern Australia. *Melaleuca* family which include over 200 species have a fairly wide distribution of growing place; most are endemic to Australia, and some species grow in Malaysia and New Caledonia (Quinn *et al.*, 1998). In Indonesia, gelam has a fairly spacious growing place distribution including the east coast of Sumatra and Kalimantan. Based on the Dotgrid calculation on the map of area direction and function which was conducted by Watershed Management Center (BPDAS) Kahayan (2007), it was estimated that gelam area in Central Kalimantan was more than 75,000 ha. In its natural growing place, gelam is found in open forests, shrub lands, especially along rivers and swamp edges. This type of plant is known for having morphological plasticity in the form of aquatic heterophylly so it can grow in wet and dry habitats (Quinn *et al.*, 1998). The ability to grow in open lands, waterlogged areas or in the lands with high acidity, makes this type often regarded as a pioneer species (Rachmanady *et al.*, 2004; Sayuto, 2004; Mulyanto *et al.*, 2000; Suyanto and

Khususiyah, 2004; Suyanto *et al.*, 2007; Chokkalingam, *et al.*, 2007) in accordance with the nature and ability to grow.

The purpose of this study was to provide a scientific explanation about the local wisdom in utilizing swamp soil and water that was to find out the effects of the burying media and the presence of bark in improving the quality of wood (mechanical physical properties).

The benefit of this study is to produce scientific information about the effects of peat swamp soil and water media in storing logs on the wood quality. The results would be used as guidelines for the utilization of peat swamp soil and water media for the efficiency of wood uses in the future.

The study of gelam properties is expected to be useful for the community and the government in Central Kalimantan to meet the wood supply for the piles/stakes. The results of this study can ecologically and

economically improve the development of gelam utilization.

### MATERIALS AND METHODS

This study was conducted in Central Kalimantan on gelam samples, barked and barkless, with diameter < 10 cm. They had been buried in 4 types of media for 0 month (control), 6 months, 12 months with 3 replications. The number of samples was 2 x 4 x 2 x 3 = 48 logs. The tests included the test for wood mechanical physical properties on the basis of the testing standards that had been determined.

The sample burial was conducted in soil and water media. Supporting data on the analysis of water medium were obtained from laboratory tests at the Center for Environmental Health Engineering (BBKTL), Yogyakarta.

Table 1. Average values of chemicals in water media

Sample of water	pH	Silica (mg/liter)	Sulfate	Zink	Nitrate	Nitrite
Swamp water	3.61	24.014	21	0.2049	1.236	0.0888
Fresh water	5.65	47.908	26	3.2153	6.228	0.0201

Table 2. Chemical and physical analyses of soil media

Code	Moisture Content		pH	EC	C	OM	N tot	Texture		
	0.5 mm	2.0 mm						H20	μS	%
11	5.81	7.28	4.46	12.25	9.24	15.94	0.50	48.90	37.16	13.94
12	10.31	10.10	4.05	8.25	8.60	14.83	0.39	48.27	39.55	12.18
13	19.85	22.61	3.69	12.50	11.97	20.63	0.54	47.84	30.31	21.85
14	6.58	6.35	3.56	18.50	8.98	15.48	0.26	53.22	35.03	11.75
21	0.35	0.18	7.70	18.15	0.19	0.34	0.06	2.04	2.73	95.23
22	0.37	0.22	7.87	16.10	0.16	0.27	0.04	2.14	1.46	96.39
23	0.50	0.06	7.57	14.00	0.13	0.23	0.03	1.56	2.74	95.69
24	0.41	0.20	7.61	15.24	0.11	0.19	0.05	1.72	1.8	96.47

Description: Code 11-14 = peat soil; 21-24 = sandy soil; EC = electrical conductivity; C = carbon; OM = organic matter; Ntot = total nitrogen; cl = clay; ds = dust; sd = sand.

The results of water analysis are presented in Table 1. Data of the soil chemical analysis (Table 2) were obtained from the study at the Laboratory of Soil Science, Gadjah Mada University.

**Test sample making.** There were 48 Gelam trees, 24 trees with bark and 24

barkless, buried in four different burying media, namely swamp water, non-swamp water, swamp soil, and non-swamp soil (sandy soil) for 0 month (control), 6 months and 12 months. In each treatment, 3 trees (replication) were taken randomly. The sampling is shown in Figure 1.

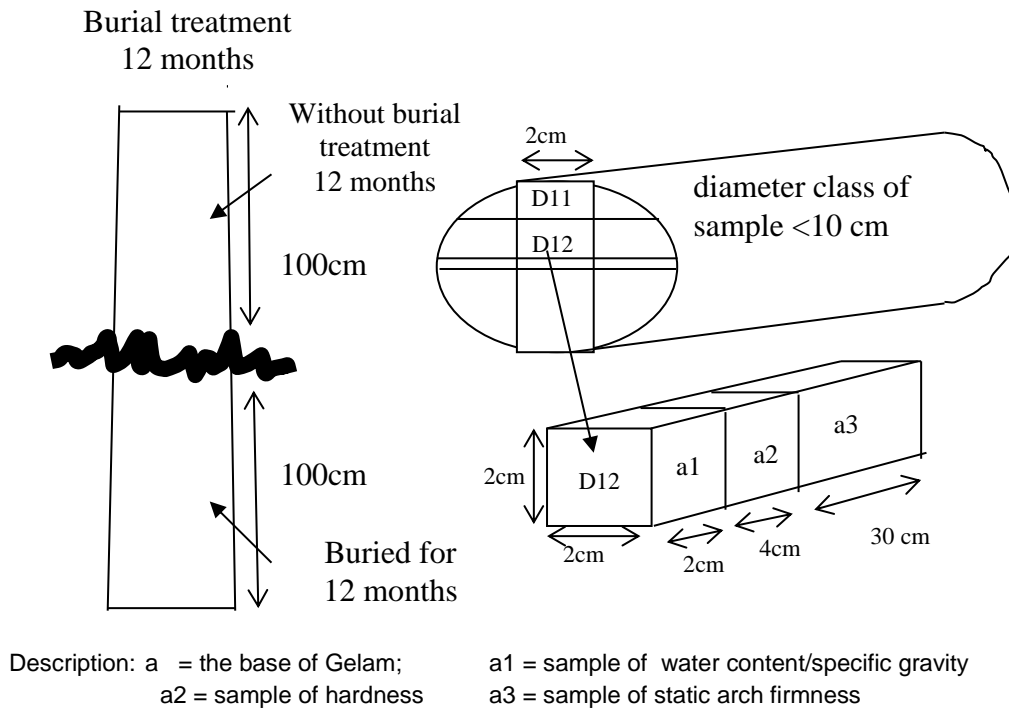


Figure 1. Wood Physical and Mechanical Sampling

Tree was cut as low as possible (50 cm above the ground surface), and the branch-free trunk was taken, cut into the respective length of 2 m, and then buried upright; a half part (1 m) was buried in the four media for 1 year and the other half (1 m) was not buried (control). The other trees were buried for 6 months. The burying media are presented in Figure 1.

The model of statistical design used in the study was equation (3). The results obtained through the F test had not been able to provide the information on which treatment was more significant than other treatments.

Therefore, it was necessary to make the comparison using SAS. Data analysis was performed to determine the significance of the factors A, B, C and factor interaction ABC.

The design used in the study was a completely randomized design with  $2 \times 4 \times 3$  factorial experiments (Sudjana, 2002).

## RESULTS AND DISCUSSION

This study was conducted on a sample diameter class  $< 10\text{ cm}$  of barked and barkless trees. Samples were buried in 4 types of media and for 3 different lengths of time.

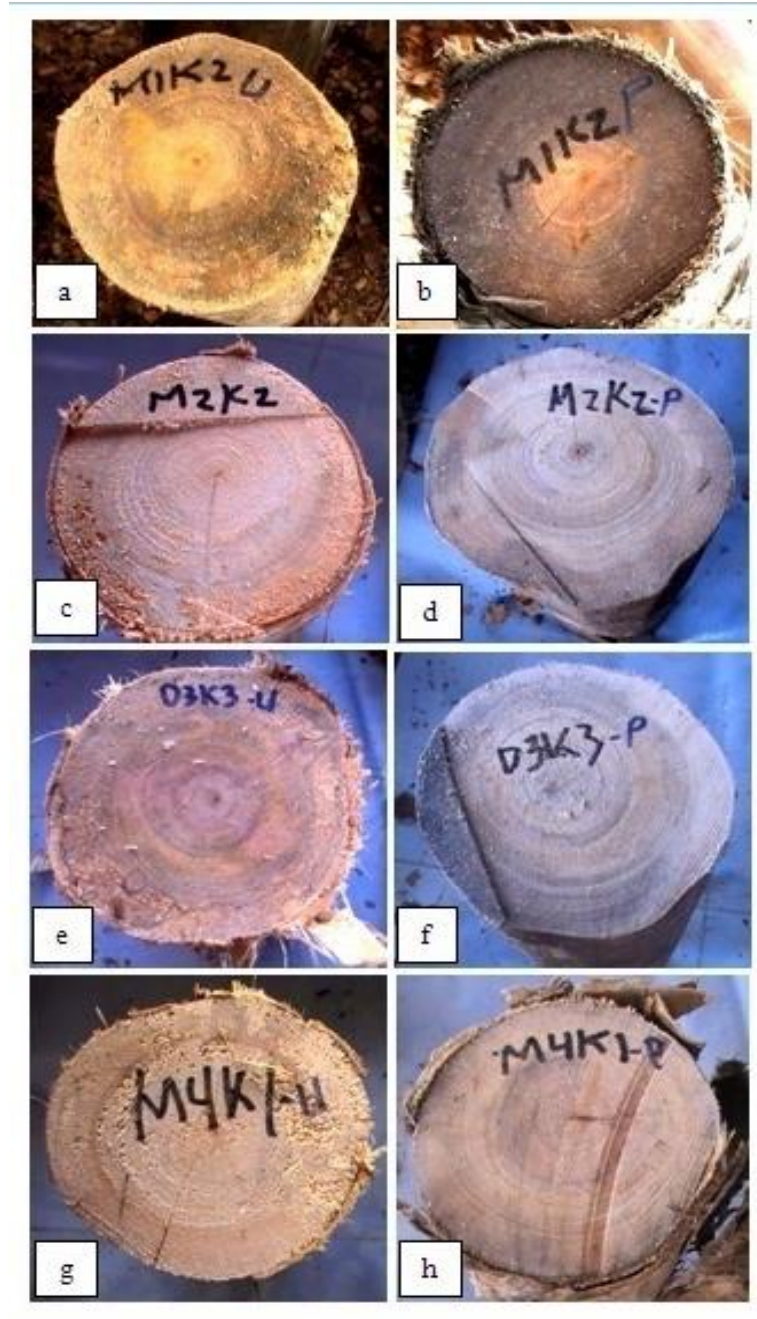


Figure 2. Appearance of barked stakes/piles a) swamp water media, without burial, b) swamp water media, buried for 12 months; c) freshwater media, without burial; d) freshwater media, buried for 12 months; e) peat soil media, without burial; f) peat soil media, buried for 12 months g) sandy soil media, without burial; h) sandy soil media, buried for 12 months.

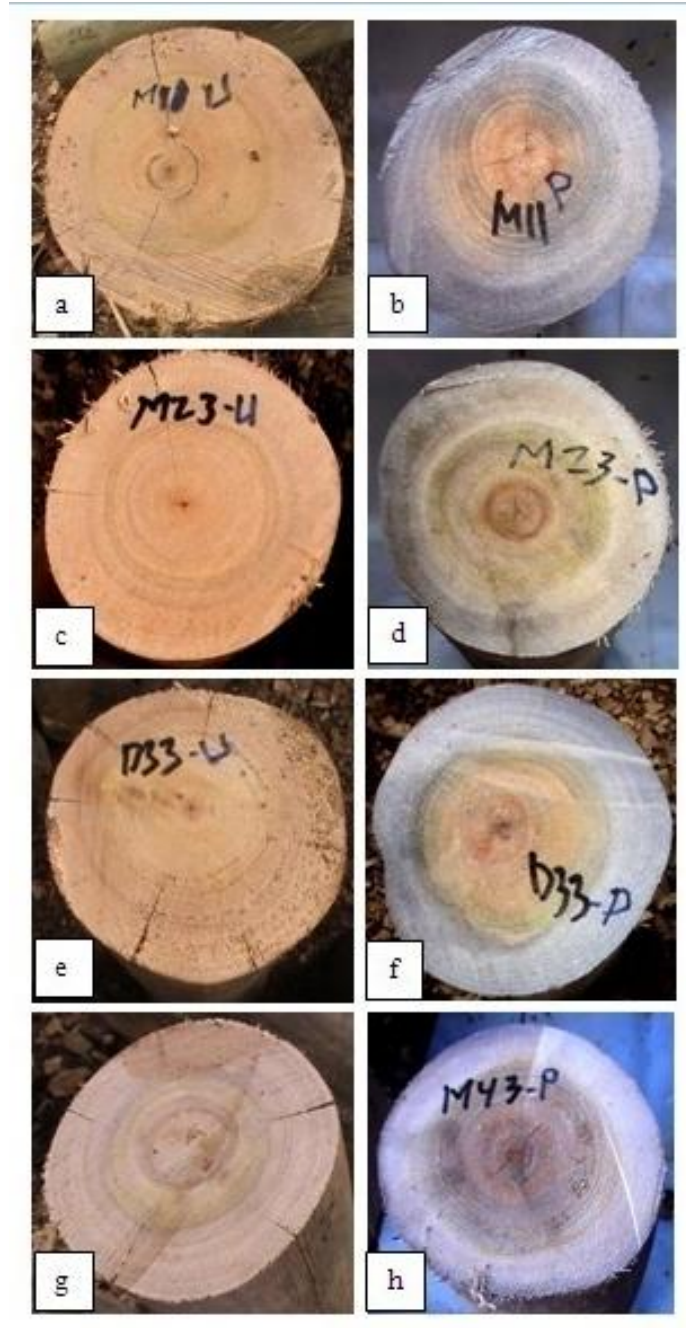


Figure 3. Appearance of barkless stakes/piles a) swamp water media, without burial; b) swamp water media, buried for 12 months; c) fresh water media, without burial; d) freshwater media, buried for 12 months; e) swamp soil media, without burial; f) swamp soil media, buried for 12 months; g) sandy soil media, without burial; h) sandy soil media, buried for 12 months

The average values of physical characteristics observed in the study are presented in Table 3. Physical properties

include specific gravity (SG) and moisture content (MC).

Table 3. Average values of SG and MC of gelam wood based on condition, media and length of burying time.

C	M	L	r	Wet SG	ADSG	ODSG	Wet MC (%)	ADMC (%)
C1	M1	L1	12	0.51	0.54	0.62	69.56	13.40
		L2	12	0.58	0.63	0.66	89.72	13.38
		L3	12	0.55	0.60	0.65	82.54	13.68
		Average		0.55	0.59	0.65	80.61	13.49
C1	M2	L1	12	0.53	0.57	0.62	86.75	13.55
		L2	12	0.54	0.62	0.67	85.18	13.05
		L3	12	0.53	0.56	0.60	91.30	13.72
		Average		0.53	0.58	0.63	87.74	13.44
C1	M3	L1	12	0.53	0.57	0.61	78.84	13.46
		L2	12	0.58	0.63	0.69	81.10	13.58
		L3	12	0.56	0.62	0.67	82.82	13.27
		Average		0.56	0.61	0.66	80.92	13.44
C1	M4	L1	12	0.50	0.53	0.57	75.25	14.04
		L2	12	0.57	0.61	0.65	87.59	13.36
		L3	12	0.54	0.57	0.60	76.36	13.50
		Average		0.54	0.57	0.61	79.73	13.63
C2	M1	L1	12	0.58	0.61	0.67	57.68	13.63
		L2	12	0.59	0.64	0.68	86.06	13.51
		L3	12	0.59	0.65	0.71	70.16	13.42
		Average		0.59	0.63	0.68	71.30	13.72
C2	M2	L1	12	0.56	0.61	0.67	51.36	13.72
		L2	12	0.58	0.63	0.67	89.88	13.23
		L3	12	0.59	0.64	0.69	70.05	13.65
		Average		0.58	0.63	0.67	70.43	13.52
C2	M3	L1	12	0.55	0.59	0.63	85.08	13.47
		L2	12	0.60	0.63	0.67	84.28	13.52
		L3	12	0.55	0.59	0.63	69.64	13.72
		Average		0.57	0.60	0.64	79.67	13.57
C2	M4	L1	12	0.54	0.57	0.60	73.37	13.81
		L2	12	0.56	0.58	0.61	96.00	13.39
		L3	12	0.54	0.57	0.61	83.23	13.55
		Average		0.55	0.57	0.61	84.20	13.58
Total n			288					
SD				0.05	0.06	0.06	14.33	0.49

Notes: C = condition with/without bark; M = media; L = length of burying time; r = replication; C1 = with bark, C2 = without bark; M1 = swamp water; M2 = fresh water; M3 = swamp soil; M4 = sandy soil; L1 = 0 month (control); L2 = 6 months, and L3 = 12 months; n = number of samples; SD = standard deviation.

The highest average of ODSG in barkless condition was in swamp water media. The results of statistical analysis of wood physical properties can be seen in Table 4. The results showed that there was no significant difference in the interaction between these three factors towards specific gravity.

The average value of wet MC in the barked wood was higher than in the barkless wood. The increasing of wet MC in barked wood (82.05%) was higher than in barkless wood (76.38%) about 7.42%. This was due to the properties of the barked gelam which was relatively watertight so that it held out the water.

The average values of water content based on the burying media successively from the largest one were M4 (sandy soil), M3 (swamp soil), M2 (freshwater) and M1 (swamp water). The pattern of changes in the lowest wet MC was found in the woods that were not buried. This was allegedly due to the unburied woods were left to dry exposed to wind so the wet MC decreased. The buried woods were more capable of holding moisture content of barked gelam woods. Moreover, the barked gelams were relatively able to hold reduced moisture.



Table 4. Varian analysis of factors of bark, media and length of burying time towards parameters of physical properties

Factor	Df	Wet BJ	ADSG	ODSG	Wet MC	ADMC
A	1	**	**	**	**	ns
B	3	**	**	**	**	ns
C	2	**	**	**	**	**
AB	3	*	**	**	**	ns
AC	2	Ns	**	**	**	ns
BC	6	Ns	Ns	ns	**	**
ABC	6	Ns	Ns	ns	**	ns

Notes: A = condition with/without bark, B = media; C = length of burying time;

\* / \*\* = significantly different/very significant, ns = not significant.

The effect of bark was assumed to occur because the barked gelam was watertight thereby blocking the infiltration/effects of other substances into the wood. The outside effects to the wood can affect the wood specific gravity, Akahane *et al.* (2004).

Akahane *et al.* (2004) proved that the hot spring water filled the pores of the wood and saved silica into the cell wall. It showed the changes in the wood which reached 40% of its weight in the period of 7 years. In their study, they did not include barked woods so that the infiltration of substances into the wood was easier. The highest specific gravity (SG) was found in swamp water media (M1), that was successively followed by swamp soil (M3), freshwater (M2) and sandy soil (M4). Further HSD/Tukey test showed the difference between the M1 and M3 M4. The wood specific gravity (SG) in sandy soil media (M4) differed significantly from the other media. The increase in wood SG in water swamp (0.66) compared to sandy soil (0.61) was 8.20%.

Interaction between bark factor (A) and media (B) affected the value ODSG. The ODSG average value tended to be higher in the wood without bark (0.651) than in barked wood (0.63). The change in increasing ODSG value in buried barkless woods compared to barked woods was 2.36%. Barked woods producing the highest ODSG value was buried in swamp water media (21), the lowest value was in sandy soil media. This was presumably due to the sandy soil condition that allowed

microorganisms to live, resulting in decreasing ODSG value.

The interaction between bark and length of burying time affected ODSG. The highest interaction was in barked woods buried for 6 months. Statistically, the specific gravity of buried woods (L2 and L3) differed significantly from the wood that was not buried (L1). Length of burying time affected SG, with the lowest one in L1. Further test for ODSG showed no difference between L2 (buried for 6 months) and L3 (12 months). Barked condition without burial allowed microorganisms to live so ODSG became small.

The buried woods had higher SG than the woods which were not buried. The increased SG value of woods with 12 month burial (0.65) toward woods without burial (0.62) was 3.64%. Christienin *et al.* (2009) stated that carbonization or petrification depend on the condition of immersion in an anaerobic environment. Different conditions of media were suspected to cause the different carbonization or petrification processes.

Bark significantly influenced wet MC, SG and hardness. The highest values of wet MC, SG, hardness and MOR were in barkless woods. This indicated that bark actually reduced the infiltration process of substance from media to wood which encouraged the increasing of the wood SG. It can then be concluded from such a phenomenon that the use of gelam wood as the stake/pile is more advisable in barkless condition when bark is not required as the stabilizer in soft soil (peat swamp).

Environmental effects (burying media) found in the increased value of wood ODSG burried in swamp water (M1) rather than in sandy soil (M4) was 8.67%. The difference in level of silica in freshwater media (M2) toward the M4 (sandy soil) was 9.00% (higher in M2). It was connected with the silica level of wood buried in fresh water which was relatively higher than that of wood buried in swamp water. Despite this difference, the wood silica levels found were not significant. Sulthoni (1988) found out that the starch content of bamboo buried in mud did not change significantly. Changes in starch on bamboo buried in river water was caused by bacteria that lived in the water (*Bacillus* sp.). These bacteria had the most prominent role in the

process of dissolving the starch content of bamboo buried in river water. On the other hand, the pH of soil and water in the study area (Central Kalimantan) that was relatively low had reduced the number of microorganisms in it (Noor (2001).

In general, the water media (swamp water and freshwater) improved the wood specific gravity more than soil media (swamp soil and sandy soil). The increased quality of gelam as the pile was allegedly caused by the swamp water infiltrating into the wood, that thereby increased its specific gravity.

Tables 5 and 6 show the average wood mechanical properties and ANOVA. The values of hardness seem higher in barkless woods burried in swamp soil.

Table 5. The average values of hardness and static arch firmness of gelam wood based on condition (barked/barkless), media and length of burying time

C	M	L	r	Hardness	Stress on PL (Kg/cm <sup>2</sup> )	MOR (Kg/cm <sup>2</sup> )	MOE (Kg/cm <sup>2</sup> )
C1	M1	L1	6	353.8	546.1	1143.2	120,428
		L2	6	411.3	672.7	1141.9	110,198
		L3	6	464.3	618.2	1055.0	126,420
	Average C1M1			409.8	612.4	1113.4	119,015
C1	M2	L1	6	272.7	646.1	1047.3	112,263
		L2	6	437.5	652.0	1030.2	86,051
		L3	6	328.8	690.8	1185.2	140,768
	Average C1M2			346.3	663.0	1087.5	113,027
C1	M3	L1	6	400.6	550.8	735.7	73,840
		L2	6	465.4	689.4	1091.1	110,655
		L3	6	526.9	594.6	1084.1	137,379
	Average C1M3			464.3	611.6	970.3	107,291
C1	M4	L1	6	337.7	483.0	827.1	97,007
		L2	6	528.4	550.6	902.6	105,868
		L3	6	503.3	537.2	885.1	125,045
	Average C1M4			456.5	523.6	871.6	109307
C2	M1	L1	6	476.0	521.2	926.6	103,409
		L2	6	493.8	596.5	1115.5	103,640
		L3	6	563.8	556.5	1177.4	125,906
	Average C2M1			511.2	558.1	1073.3	110,985
C2	M2	L1	6	389.9	590.6	1054.4	107,868
		L2	6	461.3	542.3	916.3	94,364
		L3	6	472.7	631.2	1103.8	140,423
	Average C2M2			441.3	588.0	1024.8	114,218
C2	M3	L1	6	433.6	602.1	924.8	120,299
		L2	6	572.1	657.3	1171.4	116,406
		L3	6	537.7	648.0	1156.2	132,536
	Average C2M3			514.4	635.8	1084.1	123,080
C2	M4	L1	6	261.0	515.0	806.0	77,043
		L2	6	371.3	595.2	979.2	86,721
		L3	6	325.7	433.8	647.3	95,319
	Average C2M4			319.3	514.7	810.8	86,361
Total n				288	144	144	144
SD				102.5	100.6	195.9	24,470



Notes: C = barked/barkless condition; M = media; L = length of burying time; r = replication; C1 = with bark, C2 = barkless; M1 = swamp water; M2 = fresh water; M3 = swamp soil; M4 = sandy soil; L1 = 0 month (control); L2 = 6 months, and L3 = 12 months; n = number of samples; SD = standard deviation; PL = Proportional Limit.

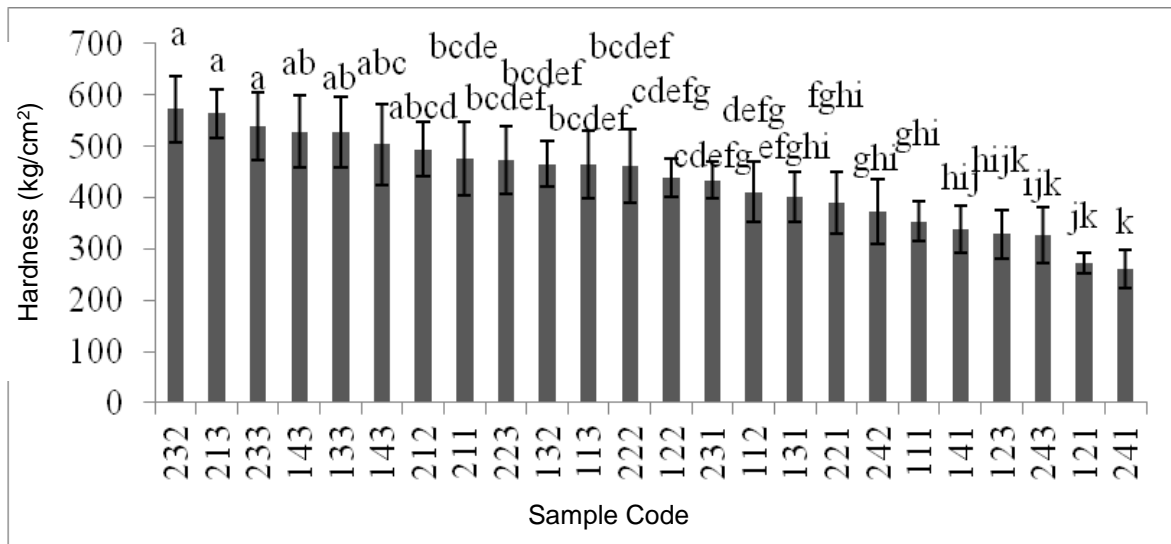
Table 7 Burial toward Parameters of Mechanical Properties

Factor	Df	Hardness	Stress on PL	MOR	MOE
A	1	**	Ns	ns	ns
B	3	**	**	**	**
C	2	**	**	**	**
AB	3	**	*	ns	**
AC	2	ns	Ns	ns	ns
BC	6	**	Ns	**	**
ABC	6	**	Ns	**	*

Notes: A = barked/barkless condition, B = media; C = length of burying time;  
 \* / \*\* = significantly different/very significant, ns = not significant.

The interaction among the three factors affected the hardness of wood. The highest value of hardness was found in the barkless wood buried in the swamp soil media. The lowest value of hardness was found in unbursed woods. This was in line with the research by Supriyati *et al.* (2013) on gelam woods buried in different diameter classes. The condition of the soil also reduced the ability of optimum life wood destroying organism (Scheffer, 1987). It was consistent

with the pattern of change in SG. Bowyer *et al.* (2003), Panshin and de Zeeuw (1980) and Wangaard (1950) which stated that the specific gravity affected some wood strength. Further test of the burial effect showed the 6 and 12 month burials did not differ significantly. This was allegedly due to the length of burying time that did not last long between the two treatments, in line with the results of the research by Lionettoa *et al.* (2013) that found only a little change in burial.



Notes: the first scores are for conditions = 1 (barked), 2 (barkless); the second scores are for media = 1 (swamp water); 2 (freshwater); 3 (swamp soil); 4 (sandy soil); the third are for lengths of burying time = 1 (without burial); 2 (buried for 6 months); 3 (buried for 12 months). Value of HSD = 85.117

Figure 3. Interaction of condition (barked/barkless), media and length of burying time toward hardness

The change in burial was in accordance with the study by Akahane *et al.* (2004). They soaked wood samples in water and the samples experienced more strong physical changes due to the increase of the silica value. They proved that the hot spring water filled the pores of the wood and saved silica into the cell wall. Akahane showed that the changes of the wood reached 40% of its weight in the period of 7 years.

The highest average value of MOR was in barkless woods buried in swamp soil media. The burial in medium 4 (sandy soil) produced the lowest value of MOR and differed significantly from the other media. It had the same pattern with SG and in line with the opinion of Zhang (1996) that described the relationship between SG and mechanical properties. Specific gravity was a measure of wood content; the increase in SG tended to increase the wood strength.

MOE was influenced by the interaction between the three factors. The highest MOE was in the barked woods, medium 2 (fresh water) and buried for 12 months. The MOE in M4 did not differ significantly from that in M1 and M2.

The smallest average value of MOE was in M4, M1, M2, and M3. MOE was significantly influenced by the burying media. Further tests showed that M3 (peat swamp soil) was significantly different from the other media. MOE was also influenced by the length of burying time. It was associated with the wood condition that allowed the destroying organisms to lower their mechanical strength. Along with that, the fibre stress dropped to more than 15 percent of the fibre, which was caused by fungus, Nicholas (1987).

The average value of the stress on PL was higher in barkless wood than in barked wood. The highest values of hardness, stress on PL and MOE were found in swamp soil media.

## CONCLUSION

The results showed that the interaction between bark factor (A) and media (B) affected the value of specific gravity (SG).

Barked wood produced the highest specific gravity in the medium of swamp water. Water media (swamp water and freshwater) improved the specific gravity of wood when compared with soil media (swamp soil and sandy soil). The highest values of hardness and stress on Proportional Limit and Modulus of Elasticity were found in the woods buried in swamp soil media. The increase in the quality of immersed gelam woods as the stakes/piles was allegedly resulted from swamp water infiltrating into gelam that thereby increased the specific gravity.

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