CCA leachability of slow dried three major bamboo species of Bangladesh

A K LAHIRY

Office of the Timber Products Specialist, Wood Testing and Research Laboratory, Rural Electrification Board (REB), REB HQ Building, Joarsahara, Khilkhet, Dhaka 1229, Bangladesh

MS received 23 May 1997; revised 23 December 1997

Abstract. Chromated copper arsenate (CCA) leachability tests on full cell pressure impregnated (with 2–3% CCA solution) and slow dried (six months air-drying under cover) bamboo block of three major bamboo species of Bangladesh revealed initial insignificant leaching of CCA within first week and no leaching in next week. Use of low concentration of CCA, release of particle form of CCA due to exposure of bamboo blocks by cutting and presence of water soluble extractives in bamboo might be the causes for initial leaching of CCA.

Keywords. CCA leachability; slow dried bamboo; fixation.

1. Introduction

The bamboo is distributed world wide, especially in tropical areas. It is socioeconomically and environmentally important village and forest crop of Bangladesh (Lahiry 1995a). Besides ecological importance, bamboo is the main raw material for rural housing and also the principal source of withes for making basketry and matting (Banik 1998). From the environmental and economical point of views, the service life of bamboo and bamboo products have to be increased to control the present reserve. The untreated bamboo is perishable. The bamboo reserves can be increased two times (e.g. from 2–3 years to 5–6 years in ground contact) by any means (Lahiry 1995a). The CCA salt treated bamboo has been used in India as exterior claddings and as roofing support for over 33 years (Kumar and Dobriyal 1988). Such long service life has not been reported when used in ground and water (Lahiry 1995a). Effective CCA treatment of bamboo depends on penetrability, retainability, and leachability of CCA. Most of the research studies on preservation of bamboos have been conducted, in India by Purushotham (1963), Singh (1976), Singh and Tewari (1979, 1981), Liese (1980), Tewari (1981), Kumar and Dobriyal (1988), Choudhury (1993), and in Indonesia by Sultoni (1985, 1988). In Bangladesh the researches on preservative treatment of bamboos have been carried out by Salehuddin (1985), Latif *et al* (1987), Lahiry (1994, 1995a, b, c, 1996, 1997) and Lahiry *et al* (1996). The CCA treatability and grades of treatment by full cell pressure method at green, dry and round conditions of major bamboo species (*Bambusa balcooa*, *B. vulgaris*, *B. tulda* and *Melocanna baccifera*) of Bangladesh and their nonsplitting technique

during pressure treatment have been reported (Lahiry 1994, 1995a, b, 1996, 1997; Lahiry *et al* 1996). The CCA leachability of these bamboo species and others has not been reported earlier. The leachability of CCA treated green African mountain bamboo (*Arundinaria alpina*) have been reported (Slob *et al* 1989). The leaching tests carried out by them on CCA impregnated bamboo by Boucherie method, revealed that an average of 15% Cu, 17% Cr and 34% As could be removed by submerging 2 cm bamboo rings in water. A good fixation is possible when sufficiently high (5–10%) concentrations of CCA are used, fixation is mainly the result of formation of Cu–Cr–As complexes in the vascular bundles, in sawdust of bamboo the fixation takes place through the formation of CCA complexes with the bamboo constituents—cellulose and lignin, in this process, fixation of chromium onto cellulose and lignin is the key step (Slob *et al* 1989).

It is an attempt to study the leachability of CCA-C treated three major bamboo species of Bangladesh after slow air-drying the CCA-C treated bamboo for six months under cover for the environmental safety and effectiveness of CCA treated bamboo in ground and water contact use.

2. Materials and methods

The dry borak bamboo (*Bambusa balcooa* Roxb.), baija bamboo (*B. vulgaris* Schrad. ex Wendle.) and muli bamboo (*Melocanna baccifera* (Roxb.) Kurz.), full cell pressure treated with CCA-C (with 2–3% CCA-C solution) and air-dried in room temperature for six months were the materials for leachability test. Due to limited

facilities, the leachability test was carried out by the method developed by the author with partial modification of AWWA Standard (AWWA Standard E11 1987). About equal weight of treated bamboo blocks ($10 \text{ g} \pm 0.75$ at 14–15% MC, table 1) from internode was taken and dipped in 100 ml of ordinary tap water for leaching of CCA-C. The leachate was analyzed each after 24 h, continuously for 7 days, and at the end of 15th day (table 1). Before each analysis, the block of bamboo was agitated in water for 15 min with the help of magnetic stirrer. Every assay/analysis of leachate was compared with control blank water to find out the actual leaching in same continuous 100 ml of water used from the beginning to end of all tests. Before and after leaching, the level of internodal retention (w/w% = wt. to wt.% and w/v) of bamboo was found out by analysis (table 1). The preleaching retention was determined from different bamboo blocks of original bamboo.

For weight measurement, an analytical optical balance (Mettler H35AR) was used. Moisture content (MC) of bamboos was measured with a calibrated resistance type digital moisture meter (Delmhorst). All the analyses (retention and concentration of leachate) were carried out spectroscopically with an X-ray ASOMA analyzer (model 8620) following standard method (AWWA Standard A9 1990). The chemical balance of individual component of CCA-C was determined from all analyses.

3. Results and discussion

The results of leaching of CCA-C from three bamboo species have been presented in table 1 and discussed as follows.

3.1 Leaching time and causes

The present method of leachability tests reveals that leaching of CCA-C only occurs in first week in all three bamboo species and shows no leaching in next week. It was observed that after completion of initial leaching of CCA-C from all types of bamboos, leachates (100 ml tap water with bamboo block) were straw in colour and gelatinous in nature. The same gelatinous nature was also observed in water dipped with untreated bamboo blocks which indicates that the initial leaching only occurs due to presence of nonfixative type of substances e.g. water soluble starches, extractives etc in bamboo, as reported possible in timber by Pizzi *et al* (1986). Use of low concentration of CCA-C and release of particle form of CCA-C due to exposure of bamboo blocks by cutting might be the secondary causes of leaching. Due to slow drying of full cell pressure treated bamboo, the components of CCA-C fixes with the cellulose and lignin of bamboo. This initial leaching would

not be significant if CCA-C treated intact bamboo is used in ground or water, because in such conditions the most leaching areas of bamboo piece will not be exposed compared to the test sample. Several years will be required for the completion of initial leaching.

3.2 Leaching amount and characteristics

The leachability test from bamboo block permits leaching of CCA-C components preferably from surfaces rather than inner most or central portion where leaching may not occur at all. Moreover different anatomical structure of different bamboo species responsible to release differential amount of CCA-C e.g. the texture of *M. baccifera* is rather fine. Due to these phenomena of leaching, the different results reflected in leachate and post leaching retention. As such the leaching characteristics of individual component of CCA-C have been analyzed (discussed) separately as follows.

3.2a From retention: The chemical balances of CCA-C before and after leaching was found within the limit of CCA type (AWWA Standard P5 1991) in all bamboo species with the marginal insignificant exception in As_2O_5 in *B. balcooa* and *M. baccifera*, where the corresponding balances were found as 27.91% and 29.66% after leaching (30% is minimum normal). But the leachate showed different results.

3.2b From leachate: The obtained average chemical balance of leachate in three bamboo species were 64.95% CrO_3 , 16.73% CuO and 18.32% As_2O_5 (equivalent to CCA type A) against expected normal CCA-C type of 44.5–50.5% CrO_3 , 17–21% CuO and 30–38% As_2O_5 (AWWA Standard P5 1991). This imbalance in leachate is the indication of higher initial leaching of CrO_3 rather than CuO and As_2O_5 . Since the leaching of CCA-C was stopped in second week, the necessary key step for fixation of chromium onto cellulose and lignin is not significant here as reported earlier in *A. alpina* by Slob *et al* (1989). Slob *et al* (1989) reported that good fixation is possible when sufficiently high (5–10%) concentration of CCA are used. In the present study, good fixation was obtained with low (2–3%) concentration of CCA, because the treated bamboo was dried slowly for six months.

3.3 Fixation time

Slow fixation of CCA treated bamboo was found effective but too long to follow. Accelerated fixation process of CCA treated bamboo by higher temperature, as reported for timbers (Cooper and Ung 1992; Artymko and Cooper 1994; Boone *et al* 1994), would be developed if time is a factor for implementation.

Table 1. Leaching of CCA from three major bamboo species of Bangladesh.

Bamboo information		CCA-C component		Analyses of leachate and bamboo									
w/w%	kg/m ³		→	Analyses of leachate, dipped in 100 ml of water (containers) concentration (%)									
Bamboo species	BMC of CCA-C treated bamboo in July	Wt of bamboo block (CCA-C treated) at EMC (g)		24 h	48 h	72 h	96 h	120 h	144 h	168 h (7 d)	360 h (15 d)	Pretreating intermodal retention w/w% kg/m ³ (balance %)	After leaching intermodal retention w/w% kg/m ³ (balance %)
Black bamboo (<i>Bambusa baluana</i> Roxb.)	15% ± 0.2%	10 ± 0.75	CrO ₃ =	0.000%	0.000%	0.030%	0.030%	0.030%	0.030%	0.030%	0.030%	1.33 (30.00%)	1.27 (32.93%)
			CuO =	0.000%	0.002%	0.002%	0.004%	0.004%	0.005%	0.008%	0.008%	7.66 (65.22%)	7.32 (59.16%)
			As ₂ O ₅ =	0.000%	0.000%	0.000%	0.000%	0.001%	0.003%	0.008%	0.008%	0.50 (11.79%)	0.46 (19.16%)
			Total =	0.000%	0.002%	0.032%	0.034%	0.035%	0.038%	0.046%	0.046%	8.83 (31.20%)	8.67 (27.91%)
												4.78 (17.39%)	3.86 (100%)
Baja bamboo (<i>Bambusa vulgaris</i> Schrad. ex. Wendl.)	15% ± 0.2%	10 ± 0.75	CrO ₃ =	0.010%	0.007%	0.021%	0.021%	0.027%	0.028%	0.028%	0.028%	1.21 (30.22%)	1.08 (31.40%)
			CuO =	0.000%	0.002%	0.004%	0.004%	0.005%	0.005%	0.006%	0.006%	6.97 (66.67%)	6.22 (51.40%)
			As ₂ O ₅ =	0.000%	0.002%	0.002%	0.002%	0.002%	0.003%	0.008%	0.008%	0.42 (17.44%)	0.38 (18.10%)
			Total =	0.010%	0.011%	0.027%	0.027%	0.034%	0.036%	0.042%	0.042%	8.60 (32.34%)	8.64 (30.50%)
												4.49 (19.04%)	3.69 (30.50%)
Muli bamboo (<i>Meibomia baccifera</i> (Roxb.) Kazz)	14% ± 0.5%	10 ± 0.75	CrO ₃ =	0.000%	0.000%	0.013%	0.015%	0.017%	0.017%	0.017%	0.017%	2.41 (100%)	2.10 (100%)
			CuO =	0.000%	0.001%	0.001%	0.004%	0.004%	0.004%	0.005%	0.005%	13.88 (52.91%)	12.10 (51.33%)
			As ₂ O ₅ =	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.005%	0.005%	1.09 (62.46%)	0.97 (51.33%)
			Total =	0.000%	0.001%	0.014%	0.019%	0.021%	0.021%	0.027%	0.027%	6.28 (18.52%)	5.59 (19.01%)
												0.35 (17.02%)	0.36 (19.01%)

3.4 Removal of extractives

During post treatment weathering or immersion in water, the extractives may be removed enough as reported possible in sundri wood (*Heritiera fomes*) by Lahiry (1994). Leachability of CCA treated bamboo-treated at green vs at kiln-dried vs at weathered and air-dried conditions require to be found out, because presence of water soluble extractives in timber may enhance leaching as reported by Pizzi *et al* (1986).

4. Conclusion

The slow fixation of CCA-C treated three major bamboo species of Bangladesh at low concentration was found significantly effective for ground and water contact use compared to higher concentrations reported earlier for other species. CCA treated bamboo shall have to be dried slowly for proper fixation before outdoor use.

Acknowledgement

I thank two of my Laboratory Technicians, Farid Uddin Ahmed and Md. Khorshed Alam for their help during tests.

References

- Artymko J and Cooper P A 1994 *Effects of fixation temperature and humidity on CCA leaching and effectiveness against brown rot fungi and eastern subterranean termites*, MSc thesis, Toronto University, Toronto
- AWPA Standard A9 1990 *Standard method for analysis of treated wood and treating solutions by X-ray spectroscopy* (Book of Standards Amer. Wood Preserver's Association) p. 4
- AWPA Standard P5 1991 *Standards for waterborne preservatives* (Book of Standards Amer. Wood Preserver's Association) p. 4
- AWPA Standard E11 1987 *Standard method for determining the leachability of wood preservatives* (Book of Standards Amer. Wood Preserver's Association) p. 2
- Banik R L 1998 *Bono Biggyan Patrica* 18 65
- Boone R S, Winandy J E and Fuller J J 1994 *Enhanced preservative fixation by redrying CCA treated lumber* (USA: USDA For Ser. For Prod Lab)
- Choudhury M Y 1993 *Physical and chemical treatments of bamboo for strength and durability*, Chinese Acad. Forestry Int. Trop. Timb. Organiz., Yokohama, Japan, in *Bamboo and its use, Int. symp. on industrial use of Bamboo, Beijing, China*, pp 155-157
- Cooper P A and Ung Y T 1992 *Accelerated fixation of CCA treated poles* (Canada: Toronto University)
- Kumar S and Dobriyal P B 1988 *Preservative treatment of bamboo for structural uses*, in *Bamboo Current Research, Proc. Int. Bamboo Workshop, Cochín, India* (KFRI, India) and (IDRC, Canada) pp 199-206
- Lahiry A K 1994 *J. Timb. Dev. Assoc. (India)* 40 20
- Lahiry A K 1995a *J. Timb. Dev. Assoc. (India)* 41 10
- Lahiry A K 1995b *Wood preservation science (Bangali)* (Dhaka: Bangla Academy) 1 ed. vol. 1, p. 184
- Lahiry A K 1995c *Wood preservation science (Bangali)* (Dhaka: Bangla Academy) 1 ed. vol. 2, p. 211
- Lahiry A K 1996 *CCA treatability of 100 timbers of Bangladesh*; Internat. Res. Group on Wood Preserv. Document No. IRG/WP/40069, p. 17
- Lahiry A K 1997 *J. Sci. & Ind. Res. (India)* 56 39
- Lahiry A K, Begum S, Ilias G N M, Matin Sheikh M A, Fakir M A B and Hossain M I 1996 *An effective preservative treatment of borak bamboo (Bambusa balcooa Roxb.)* Internat. Res. Group on Wood Preserv. Document No. IRG/WP/40070 p. 17
- Latif M A, Dasgupta S R, De B C and Zaman Y U 1987 *Preservative treatment of bamboo and low cost housing, Bulletin 3 Wood Preservation Series* (Bangladesh: BFRI) p. 5
- Liese W 1980 *Preservation bamboos*, in *Bamboo Research in Asia* (Canada: IDRC) pp. 165-172
- Purushotham A 1963 *Timber Dryers' Preser. Assoc. (India)* 9 pp. 1-2
- Pizzi A, Contradie W E and Bariska M 1986 *Polyflavonoid tannins from a cause of soft rot failure to the 'missing link' between lignin and micro-distribution theories*; Int. Res. Group on Wood Preserv. Document No. IRG Doc. No. IRG/WP/3359
- Singh B 1976 *Studies on the diffusion of water soluble wood preserving chemicals in bamboo*, Ph D Thesis, Punjabi University, Patiala, India
- Singh B and Tewari M C 1979 *J. Indian Acad. Wood Sci.* 10 68
- Singh B and Tewari M C 1981 *J. Timb. Dev. Assoc. (India)* 27 68
- Sultoni Achmad 1985 *Traditional preservation of bamboo in Java*, in *Recent Research on Bamboos* (Canada: IDRC) pp. 349-357
- Sultoni Achmad 1988 *A simple and cheap method of bamboo preservation*, in *Bamboos Current Research, Proc. Int. Bamboo Workshop, Cochín (India)* (India: KFRI) and (Canada: IDRC) pp. 209-211
- Salehuddin A B M 1985 *REB manual for preservative treatment of bamboo culms—improved sap displacement method* (Dhaka: REB) p. 4
- Slob J W, Nangawé P F, de Leer E and Donker J 1989 *CCA impregnation of bamboo-leaching and fixation characteristics* (Netherlands: Delft University of Technology, Water Chemistry Group) pp. 321-335
- Tewari M C 1981 *Recent studies on the protection of bamboo against deterioration*, in *Proc. Group 5 03 XVII TUFRO World Cong. Japan*