STUDIES ON ARSENICAL CREOSOTE AS A WOOD PRESERVATIVE FOR MARINE STRUCTURES - PART II - OBSERVATION ON LEACHING, CORROSION AND RESISTANCE TO BORER ATTACK.

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A detailed study on arsenical creosote with reference to leaching, corrosion and antiborer properties was carried out. Results showed that aging had very little effect on the preservative which suggested better fixation of the preservative into the wood. Corrosion of mild steel, galvanised iron, aluminium-magnesium alloy (M57S) and copper panels in the preservative was found to be negligible, Normal creosote and low temperatuie creosote of Regional Research Laboratory, Hyderabad, both fortified with arsenic trioxide resisted borer damage on wooden panels for a period of over five months in the port of Cochin. The performance of low temperature creosote fortified with arsenic was found to be equally satisfactory when compared to normal creosote fortified in the same manner. A loading of 208.6 Kgs/m^3 for Haldu (*Adina cordifolia*) and 138 Kgs/m^3 for Mango (*Mangifera indica*) in the case of normal creosote and 177 Kgs/m^3 for Mango in the case of RRL creosote were found to be sufficient for treating the wood.

INTRODUCTION

wooden structures either continuously or intermittently exposed to sea - water are subject to marine borer attack which brings about considerable degradation of the material. The cost towards their repairs, replacements and maintenance are expensive and time consuming. Such of these structures have to be necessarily protected for prolonging their service life. wood, that is not naturally resistant to degradation, can be easily treated with suitable preservatives and timber structures treated and preserved with coal-tar and its derivatives have exhibited enhanced life. Studies (Bakshi et. al. 1961 and Pande and Jain 1967) have shown that low temperature creosote was very effective in preventing decay of wood both in land and water. The results of investigations on the fortification of creosote with arsenic at various temperatures as have been carried out by the authors at the Central Institute of Fisheries Technology was presented in an earlier pnblication (Nair et. al. 1972). The present paper is an attempt to bring out the essential features of the arsenical creosote with special reference to its leaching characteristics in sea water, its behaviour when in contact with metals and its resistance to marine borers in the tropical waters of India.

Material And Method

Arsenical creosote was prepared by dissolving a known quantity of arsenic trioxide in creosote and heating it up to 90°C to produce a concentration of 0.218% (w/w). Mango *(Mangifera indica)* and Haldu *(Adina cordifolia)* panels 10x 20x 4 cms. were treated by hot dip and brush applications after prior seasoning. In the hot dip method, the seasoned wooden panels were dipped into the preservative at 90°C and kept in that condition for about 2 hours while maintaining the temperature of the bath. After two hours, the panels together with the preservative were removed from the heater, and allowed to cool for about six hours. The treated panels were taken out and dried in the open air, until their weights became constant. The weights before and after treatment were noted and loading determined. (Tables I - IV). The treated panels were exposed to marine borer attack by suitably immersing them in seawater at different predetermined locations. The panels were examined periodically.

Table I: Assessment of boring on haldu test panels (10x20x4 cms) treated with arsenical creosote by brush application.

Panel No.	Initial wt. of panel before preservative treatment. gms.	Final wt. of panel after treatment. gms.	Loading Kg/m^3	Period of immersion in month.	No. of borer holes.	Internal damage %
H_1	354.0	366.0	22.874	5	10	Nil
H_2	335.0	345.0	19.062	5	2	Nil
H_5	318.0	331.0	24.780	5	8	0.8
H_7	327.0	340.0	24.780	5	7	Nil
H_8	313.0	323.0	19.062	5	47	0.8
		Average	22.09			

Tablf II: assessment of borinc on haldu test panels (10x20x4 cms.) treated with arsenical creosote by hot dip method.

Panel No.	Initial wt. of panel before treatment. gms.	Final wt. of panel after treatment. gms.	Loding Kg/m^3	Period of immersion in month.	No. of borer holes.	Internal damage. %
H_3	330.0	445.0	218.86	5	Nil	Nil
H_4	332.0	430.0	187.09	5	2	Nil
H_6	302.0	415.0	215.33	5	6	Nil
H_9	300.0	405.0	201.21	5	5	Nil
H_{10}	325.0	440.0	218.86	5	5	Nil
Haldu control				5	5	3.3
		Average	208.623			

TABLE III ASSESSMENT OF BORING ON MANGO TEST PANELS (10x20x4 cms.) TREATED WITH ARSENICAL CREOSOTE BY BRUSH APPLICATION.

Panel No.	Initial wt. of panel before treatment. gms.	Final wt. of panel after treatment. gms.	Loding Kg/m³	Period of immersion in month.	No. of before holes.	Inter-nal damage %
M_1	230.0	245.0	28.24	5	30	0.9
M_2	250.0	265.0	28.24	5	30	0.8
M_5	260.0	270.0	17.65	5	17	0.9
M_6	240.0	255.0	28.24	5	18	0.8
M_8	235.0	250.0	28.24	5	30	0.8
		Average	26.122			

TABLE IV ASSESSMENT OF BORING IN MANGO TEST PANELS (10x20x4 cms.) TREATED WITH ARSENICAL CREOSOTE BY HOT DIP METHOD.

Panel No.	Initial wt. of panel before treatment. gms.	Final wt. of panel after treatment. gms.	Loading Kg/m³	Period of immersion in month.	No. of borer holes.	Internal damage %
M^3	262.0	330.0	130.61	5	11	Nil
M^4	262.0	322.0	112.96	5	13	Nil
M^7	248.0	317.0	130.61	5	4	Nil
M^9	252.0	326.0	141.20	5	10	Nil
M^{10}	262.0	355.0	176.50	5	12	Nil
Mango control				5	30	4.9
		Average	137.67			

For laboratory leaching studies, round panels of mango and haldu (10 cm. diameter) were cut, provided with a central hole, and treated with the preservative by hot dip and brush application. These treated panels were aged for different periods in slow ruuning sea water in the laboratory. The apparatus designed and used for determining leaching is as shown in Figure I. The treated wooden

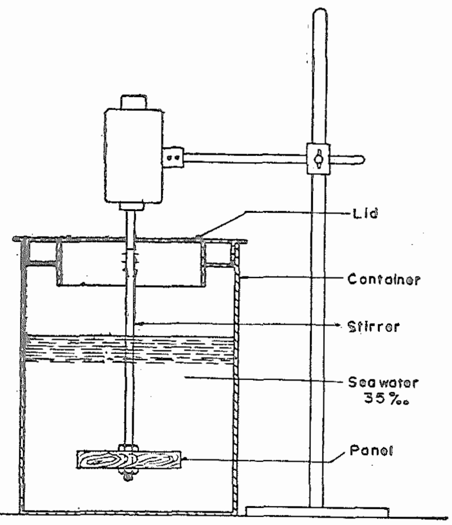

Fig. I. THE ARRANGEMENT OF LEACHING EXPERIMENT

Fig 1

panels were fixed to the stirrer and kept immersed in one litre sea water of 35% salinity and rotated for 50 hours at a peripheral velocity of 4 meters/sec. The preservative that leached into the water was extracted in solvent ether and the weight determined. The results obtained are presented in Table—V.

For quantitative estimation of corrosion, metallic panels of copper, aluminium magnesium alloy (M57S), galvanised iron and mild steel of size 5 x 8 cms. were cut, polished and initial weight determined. These panels were numbered for proper identification and kept immersed in the preservative saturated with sodium chloride and treated with saw dust. Duplicate panels were examined at an interval of 60 days. The procedure for corrosion

TABLE V LABORATORY LEACHING RATE STUDIES (CIRCULAR PANELS)

Panel No.	Type of treatment.	Wt. before treatment. gms.	Wt. after treatment. gms.	Aged for days.	Running time. Hrs.	Preservative leached in gms.
H_9		132.5	139.8	36	50	0.0492
H_1	Brush	120.3	130.3	132	50	0.0330
H_5	application.	121.8	132.0	173	50	0.0712
H_8		132.2	182.9	83	50	0.2530
H_2	Hot dip	124.0	168.1	213	50	0.2100
H_3		125.6	176.9	226	50	0.2720
H_{10}		119.6	168.6	256	50	0.1368
H_4		131.5	180.6	281	50	0.1670
M_{10}		114.5	123.6	43	50	0.0504
M_5	Brush application.	113.2	121.7	137	50	0.0212
M_4		112.9	120.1	171	50	0.0520
M_6		102.7	109.5	194	50	0.0276
M_9		116.5	160.5	81	50	0.0610
M_2	Hot dip	108.4	149.2	221	50	0.0470
M_1		113.3	145.0	248	50	0.0539
M_3		104.7	143.1	283	50	0.0450
M_8		116.0	124.8	287	50	0.0400

H—Haldu M—Mango

determination was as followed by Champion (1952). The results of the observation on quantitative corrosion are summarised in tables VI to IX.

TABLE VI PERCANTAGE WEIGHT LOSS OF G. I. PANELS IN THE PRESERVATIVE

Panel No.	Period of immersion days.	Percentage wt. loss of metal.
GI_1	60	0.0563
GI_2	120	0.1462
GI_3	180	0.2153
GI_4	210	0.4309
GI_5	330	0.4455

TABLE VII PRECENTAGE WEIGHT LOOSS OF COPPER PANELS IN THE PRESERVATIVE.

Panel No.	Period of immersion in days.	Perceutage wt. loss of metal
C_1	60	0.0965
C_2	120	0.1389
C_3	180	0.1875
C_4	240	0.2575
C_5	360	0.4738

TABLE VIII PERCENTAGE WEIGHT LOSS OF MILD STEEL PANELS IN THE PRESERVATIVE

Panel No.	Period of immersion in days.	Percentage wt. loss of metal.
Ms_1	60	0.0211
Ms_2	120	0.0593
Ms_3	180	0.0598
Ms_4	240	0.0650
Ms_5	360	0.0781

TABLE IX PERCENTAGE WT. LOSS OF *ALUMINIUM MAGNESIUM PANELS IN THE PRESERVATIVE

Panel No.	Period of immersion in days	Percentage wt. loss of metal
Al_1	60	0.1649
Al_2	120	0.0438
Al_3	180	0.0326
Al_4	240	0.0314
Al_5	308	0.0876

*Indal M57S with 2% Mg.

Results And Discussion

Studies on the fixation mechanism of arsenical creosote into wood is of special interest. Johanson (1972) found that extraction of arsenical creosote with water indicated the presence of hydrophilic and water resistant arsenic compounds. He also noted that after removal of leachable arsenic the remaining arsenicals resisted water and at the end of 360 days 40 to 50% of the initial arsenic remained. In a further test Johnson (1969) subjected creosoted wood to exhaustive leaching with water to remove hydrolysable and leachable arsenic, and then extracted with toluene, which showed retention of 30% of the original arsenic in the sapwood of two Eucalyptus Spp. The present study on the leaching rate of panels treated with arsenical creosote by hot dip and brush application and aged for different periods (Table-V) showed no significant variation in the quantity of the presevative leached out. It is thus evident that aging had very little effect on the preservative, as the preservative was better

TABLE X ASSESSMENT OF BORING IN MANGO AND HALDU WOODEN PANELS TREATED WITH NORMAL CREOSOTE AND LOW TEMPERATURE CREOSOTE OF RRL BY HOT DIP AND BRUSH APPLICATION. IMMERSED ON 27-11-69 AND HAULED UP ON 23-4-70 (150 DAYS APPROX).

Panel No.	Type of treatment.	Preservative used.	Wt. before treatment. gms.	Wt. after treatment. gms.	Loading gms.	Surface borer holdes	Internal damage %
M_6	Brush application 2 coats.	Straight creosote	318.0	350.0	32.0	2	Nil
M_7	—do—	—do—	310.0	330.0	20.0	1	1.4
M_8	—do—	—do—	306.0	330.0	24.0	25	Nil
M_9	—do—	—do—	297.0	315.0	18.0	Nil	Nil
M_{10}	—do—	—do—	338.0	362.0	24.0	Nil	NIl
M_1	Hot dip at 90°c	—do—	302.0	485.0	183.0	Nil	Nil
M_2	—do—	—do—	325.0	485.0	160.0	Nil	Nii
M_3	—do—	—do—	323.0	480.0	157.0	Nil	Nil
M_4	—do—	—do—	310.0	502.0	192.0	Nil	Nil
M_5	—do—	—do—	345.0	472.0	127.0	Nil	Nil
M_{11}	Hot dip	Low temperature creosote of RRL	306.0	387.0	81.0	Nli	Nil
M_{12}	—do—	—do—	299.0	358.0	59.0	Nil	Nil
M_{13}	—do—	—do—	299.0	370.0	71.0	Nil	Nil
H_1	—do—	—do—	350.0	464.0	114.0	1	Nil
H_2	—do—	—do—	355.0	482.0	127.0	Nil	Nil
H_3	—do—	—do—	370.0	480.0	110.0	Nil	Nil
				Average	94.0 (177 Kg/m³)		
Mango control						9	6
Haldu control						10	5

fixed into the wood. As observed by Johanson (1969) fixation may be due to the "water resistant arsenical fractions which remain dispersed in the creosote medium and some which interact with wood substance and fix directly on the wood matrix".

Syers et. al (1966) and Johanson et. al (1968) tested various metals like iron, aluminium, brass and copper in arsenical creosote and found that arsenical creosote inhibited corrosion to some extentd. Table VI to IX summarises the percentage weight loss of metals like galvanised iron, copper and mild steel and aluminium magnesium alloy in the preservative fortified with Sodium chloride and treated with saw dust. When the panels were examined after 60, 120, 180, 210 and 330 days of immersion in the preservative corrosion was found to be negligible. In the case of aluminium magnesium alloy (M57S) though the initial corrosion after 60 days (0.1649%) was found to be high, it was found to be within negligible limits under prolonged immersion. Another interesting observation was that corrosion was least in mild steel when compared to other metals.

Results of raft trials conducted to determine the antiborer properties of the preservative are presented in Table I-IV. The panels were immersed in the backwaters for a period of 5 months. (For a detailed description of the test site attention is drawn to the publication of Balasubramanyan et. al. 1963). Haldu panels treated by brush application recorded 0.8% internal damage (Table-I), while Mango and Haldu panels treated by hot dip method recorded no internal damage at all (Table II and IV). Maximum damage was noted in Mango panels treated by brush application being 0.9% (Table-III). Untreated Haldu and Mango controls recorded 3.3% and 4.9% internal damages respectively. In both the woods, hot dip method of treatment gave the maximum loading and thereby established maximum resistance to marine borers.

Results of comparative performance of arsenic treated normal creosote (Heavy creosote oil) and low temperature creosote of RRL are presented in table-X. The panels were exposed in the back waters for a period of 5 months. Mango and Haldu panels, treated both by hot dip and brush application performed satisfactorily. No internal damage due to borer infestation could be observed in any of the treated pane s. Panels treated by brush application also resisted borer damage very effectively. Superficial borer holes were observed in panels M6, M7, M8, and H1, but on closer examination no internal damage could be observed. Borers attacked the superficial layers of treated wood but they never went deep into the wood, may be due to the unpalatable nature of creosote treated wood as suggested by Johanson (1969). Nair et. al (1972) found greater affinity for arsenic in RRL creosote. Added to this, the antiborer properties of this preservative was also found to be equally satisfactory during the present study when compared to normal creosote. An average loading of 203.6 Kg/m^3 for haldu and 138 Kg/m^3 for mango (hot dip) in the case of normal creosote and 177 Kg/m^3 for mango (hot dip) in the case of RRL creosote were found to be sufficient for treating the wood. Arsenic concentration needed are 0.2180 w/w for low temperature creosote and 0.03840% w/w for normal creosote both at 90°C (Nair et. al. 1972).

ACKNOWLEDGEMENT

The authors are thankful to Dr. V. K. Pillai, Director and Shri G. K. Kuriyan, Head of Division (Craft & Gear) of the Central Institute of Fisheries Technology, Cochin, for their keen interest and encouragement.

REFERENCES

Balasubramanyan, R & Menon, T. R. 1963 *J. Mar· Biol. Assn.* (India), **5** *(2)*: 294-310.

Bakshi, B. K. et. al. 1961 *J. Sci. Indust. Res.* **20** D *(7)*: 273-276.

Champion, F. A. 1952 *Corrosion testing Procedures.* John Wiley and Sons Inc., New York 1952.

Johanson, R. 1967 *J. Inst. Wood Sci.* (4919): 15-26

*Johanson, R & Syers, T. 1968 *CSIRO Division of Forest products, project p. 9-17. Laboratory Report No 2 November 1968.*

Johanson, R. 1969 *Holsforschung*, **23***(6)*: 181-184.

Johanson, R. 1969 (a) *Australian power Engineering*, 9*(5)*, Sep. 1969

Pande, J. N. & Jain, J. K. 1967 *J. Timber. Dev. Assn. (India)* **13***(3)*:9-15.

*Syers, T, Siggs Margaret & Johanson, R. 1966 *CSIRO Division of Forest Product P. 9-17. Laboratory* Report No. 1 November 1966.

Unnikrishnan Nair, N, Gopalakrishna Pillai, A. G. & Balasubramanyan, R. 1972. *Fish. Technol.* **9***(1)*:76-80.

*Not referred to in original.