FOULING EFFECT ON CORRODING BEHAVIOURS OF BRASS IN PALK BAY WATERS OF MALLIPATTINAM COAST

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Abstract :

Fouling studies in the Mallipattinam seawater (10.2806₀ N, 79.3170₀E), south weastern Bay of Bengal, Thanjavur, India, were carried out for six months (January2016-June 2016) to understand the biofouling behaviours oforganisms. The fouling organisms of Palk bay waters of Mallipattinam coast (PBWMC) compress of algae(green and red), barnacles,molluscs, polychaetesand worms. The periodic attachment and aggregate of fouling organisms growth on brass over a period of six months have been inspected in the PBWMC. Assemblages of algae stimulate corrosion on brass.Barnacles and Mollusks cause pitting corrosion underneath their attachment site. Polychaetesexhibitedon last month coupons however, flatworms showed significant season-wise in settlement. Presence of oysters on coupons was enumerated in significant numbers during the present study. In general, the assemblages of biofoulingorganisms on brass surface over a period of exposure cause the corrosion rate. The extent of origin experienced by brass is highlighted in terms of change in mechanical properties and the surface characteristics of the material.

IndexTerms: **Fouling organisms, biofouling, assemblage, south western in palk bat waters of Mallipattinam coast .**

I. INTRODUCTION

The sedentary adult forms of marine organisms have the tendency to colonize on any hard substrate. This colonization, often causing undesirable consequences to man-made structures, such as offshore plat forms, ship hulls, ship machinery, coastal power plants, desalination plants etc., is termed as ‘biofouling’. Biofouling causes great operational hazard indifferent marine installations across the globe.The expenditure incurred on combating biofouling is a stounding. It is reported that shut down of a 235MW (e) power station due to fouling, costs 170 lakhs(at Rs. 3.00 per kw/h) per day. Because of this economic implication, biofouling has been a thrust area of study for the marine researchers. A plethora of work has been carried out on biofouling from different parts of the world including India[1]

Biofouling in tropical waters is a year-round phenomenon. Not withstanding this, seasonal influence has been known to affect fouling settlement variability, their breeding pattern,succession, species composition, distribution and density [(2)].The fouling organisms affect the working machinery parts in the sea and cause to a special characteristic of corrosion[(3)] .Whilst the effects of chemical and physical factors are thoroughly analysed and documented [4]. The role of fouling organisms[5] in respect of the growth of corrosion processes is not entirely in-depth and often contradictory. Aim of the present study is finding the role of fouling organisms on the corrosion behaviour of brass in Palk bay waters of Mallipattinam coast.

II. EXPERIMENT DETAILS

2.1 Material preparation

Brass metal sheets of 1.6mm thick were cut into pieces of size 110mm x 90mm, to the required numbers. The investigational metal coupons were pickled in the recommended cleaning solution[6], polished and holes were made on the centre of the top and bottom of each panel. The metal coupons were degreased with trichloroethylene and weighed to an accuracy of 10^{-4} g. Triplicate numbers of coupons in each experiments were fixed to wooden racks using brass bolts and nuts with proper insulation of PVC washers. The wooden racks fitted with metal coupons were tied to the stationary piles in the Palk bay waters of Mallipattinam coast [7]. They were immersed about 0.5 meter below the mean low wave level. The removals of exposed metal coupons were taken as monthly, quarterly and half yearly periods.

2.2 The Test Site

The experiment location is localized in Palk bay waters of Mallipattinam coast. The climate in Mallipattinam is motivated by the SW monsoon [8]. It occurs during March’16 to June’16, in a year respectively. NE monsoon is slowly changing from February’16. The existence of monsoon causes variations in the seawater characteristic [9]. The data such as wind direction, wind velocity, rainfall and wave action were acquired from Meteorological department, Adirampattinam. The recorded data are presented in table-**1**.

Table-**1**

Data on climate factors during the exposure period (jan'16–june'16) at mallipattinam seawater, india.

Climate factors/Period	Jan'16	Feb'16	Mar'16	Apr'16	May'16	June'16
WindSpeed (Km/h)*	7	7	7	8	9	8
Wind Direction	NE	NE	SW	SW	SW	SW
Rainfall (mm)	12.0	10.7	1.0	1.9	62.8	7.4
Wave Velocity# (m/s)	0.8	0.8	0.85	0.9	0.92	0.7

Key to table: * Weekly Average, # Daily Average, Km/h–Kilometer/hour, s– Second, mm-Millimeter, SW-South West , NE- North East

III. PROCEDURE

The following ions such as chloride, carbonate, bicarbonate, sulphate, calcium and magnesium were estimated using respective methods and the dissolved oxygen by iodimetric method. The pH of seawater and temperature were perceived periodically, using a digital pH meter and Celsius thermometer respectively.Fouling on metal surface was evaluated in terms of biomass, pattern of fouling community and seasonal recruitment organisms. The exposed metal coupons were pickled in 10% sulphuric acid for two minutes, rinsed with water and dried in an air oven at 60^0 C for an hour after that the coupons were cooled and weighed. From the weight loss of coupons, gravimetric corrosion rates were determined. The metals after evaluation of corrosion rate were analyzed for their pitting corrosion behaviour in terms of probability of pitting[10], pit density, width and depth of pit(maximum, minimum and average) using a high resolution microscope[11].The surface characteristics of each exposed metals were analyzed as per ASTM standard[12]using scanning electron microscope (SEM).The change in mechanical properties of brass were distinguished using an INSTRON 1195 universal testing machine.[13]

IV.RESULTS AND DISCUSSION

4.1. **Environmental factors of MSW.**

Table-**1** shows the climatic factors which were recorded during the study period (Jan'16 to Jun'16) at Palk bay waters of Mallipattinam coast. The North East monsoon is characterized by considerably lower wind velocity than the South West monsoon. During the period (Mar'16 to Jun'16) the Sea Water are in great unrest and get the higher values of wave velocity[14]. The SW monsoon is characterized by higher wind and wave velocity and resulting MSW get low rain fall.MSW becomes more concentration which favours the settlement of fouling organisms on the metal surface.

Table-**2** reveals the characteristics of Palk bay waters of Mallipattinam coast. The monsoons cause variations in the sea water characteristics such as surface temperature, dissolved oxygen (DO) level and calcium, magnesium and sulphate ions[15,16]

table-2

Characteristics of bay of bengal of msw. period (jan'16 to june'16)

Characteristics	Maximum (SW)	Minimum (NE)	Average
SurfaceTemperature(°C)	33.3	26.8	30
Chloride (ppt)	35.2	30.6	33
DO (mg/L)	6.0	5.4	5.7
Calcium (mg/L)	484	430	457
Magnesium (mg/L)	1232	1190	1211
Carbonate (mg/L)	0.0168	0,0144	0.0156
Bicarbonate (mg/L)	0.1864	0.1802	0.1833
Sulphate (mg/L)	230.8	196.4	213.6
pH	8.4	8.0	8.2

Key to table: mg/L – milligram/Liter, ppt – parts per thousand, C-Celsius

4.**2. Seasonal attachment of organisms on brass at** Palk **bay waters of Mallipattinam coast.**

The seasonal attachment of organisms of all exposures of Palk bay waters of Mallipattinam coast are presented in table-3 & 4.Fouling of Algae is identified on all the exposed metal coupons. Algae or fungal[17,18] is one of the initiator to corrosion . Barnacles and Molluscs are recorded on II quarterly and half yearly exposed metals. Oysters are settled with significant intensity on half yearly exposed metals. Red rust is observed beneath the barnacle shells on the half yearly exposed surface of brass where in the organisms are dead. But it has no considerable protective effect towards the overall corrosion rates. The species namely *Enteromorpha* and Coscinodiscuscentralis are settled in January and February months and Chetomrpha(G) and Naviculaspare identified on March and April months of exposed metals. May month's exposure comprises chaetomorpa(G) and Cladophorasp (G). Rhizosoleniaalata and Cladophorasp (G) are settled on June month of metal coupons.

table – 3

Seasonal attachment of organisms on brassmetal in palk bay waters of mallipattinam coast. (jan'16- june'16)

organisms /period	jan'16	feb'16	march'16	april'16	may'16	june'16
algae (macro)						
chaetomorpha(g)	-	-	+	+	+	-
chara sp(g)	-	-	-	-	-	-
cladophora sp(g)	-	-	-	-	+	+
Enteromorpha	+	+	-	-	-	-
diatoms						
coscinodiscus centrails	+	-	+	-	-	-
naviculasp.	-	-	+	+	-	-
rhizosolenia alata	-	-	-	-	-	+

Key to table :(+) Presence, (-)Absence, G : Green, Sp : Species

table – 4

Seasonal attachment of organismson brass cumulative metal in palk bay waters of mallipattinam coast. (jan'16-june'16)

ORGANISMS /PERIOD	I Quarterly (Jan16-Mar16)	II Quarterly Ap16-Jn16)	Half yearly (Jan16-Jn16)
ALGAE (MACRO)			
chaetomorpha annennina (g)	+	+	+
cladophora, sp	-	-	-
enteromorpha compressa(g) (r)	+	+	+
gracilaria edulis (r)	-	+	+
padina gymnospora(b)	-	-	+
DIATOMS			
biddul phia, sp	+	-	+
navicula, sp	+	-	-
rhigosolenia alata	-	+	+
ANIMALS			
Bryozoa	+	+	+
Barnacles	-	-	+
Mollusks	+	-	-

key to table : (+) presence, (-) absence, (b) brown, (bg) blue green, (g) green, (r)red

4.3 Corrosion behaviours of brass in Palk bay waters of Mallipattinam coast

The corrosion rate by weight loss method[19,20,21]of brass in bay of Bengal of MSW for an exposure period of six months are depicted in table-5. The corrosion rate values of brass in sea water ranges from $0.1156x10^{-5}$mmpy to $0.1071x10^{-5}$mmpy. Of all the monthly exposures the May month of brass coupon is met higher corrosion. The non aggressive rain fall and wind speed dilute the concentration of seawater. The climatic factor favours the settlement of fouling organisms on the surface of exposures. The lowest corrosion rate occurs in the month of June.Corrosion rate value of the June month exposure is a direct indication of the characteristics of seawater, formation of oxygen film and settlement of organisms.

table-5.

Monthly corrosion rates of brass in palk bay waters of mallipattinam coast

Month- 2016	Corrosion Rate $x10^{-5}$ (mmpy)
January	0.1128
February	0.1136
March	0.1071
April	0.1112
May	0.1156
June	0.1134

table-6.

Cumulative exposures of corrosion rates in bay palk bay waters of mallipattinam coast

Period - 2016	**Corrosion Rate x10^{-5}(mmpy)**
Monthly (May)	0.1156
I Qly (Jan – Mar)	0.0482
II Qly (Apr – Jun)	0.0442
Hfly (Jan – Jun)	0.0412

Key to table :Qly – Quarterly, Hfly – Half yearly

Table-6 reveals that the corrosion rate values become to decline from monthly to half yearly exposures. II-Quarterly(Apr’16-Jun’16) and half yearly (Jan’16-Jun’16) exposures proficient of lower values of corrosion rates (0.0442 x10^{-5}mmpy & 0.0412x10^{-5}mmpy). Rain fall level is low in the period. Hence, seawater acquires little bit more concentration which favourable for settlement of organisms on the exposed metals.The attachment of Barnacles and Molluscs are found out on second and half yearly exposed metal surfaces. Pits formation may be shaped underneath of the supplement of animals.
The pitting behaviour, pitting probability and width of pit (maximum, minimum and average)of cumulative exposures of brass are presented in table-**7.**

table - 7

Pitting corrosion behaviour of cumulative exposuresof brass in bay of bengal of msw

Period	Properties of Pits		
	Probability (%)	Density of pits Nos/Sq.dm	Width of Pits(mm)
Monthly	50	01 - 10	0.4
I Quarterly	100	03 - 15	0.8
II Quarterly	100	04 - 20	1.0
Half Yearly	100	05 - 20	1.2

The maximum pit density (05-20 Nos. / sq.dm) and width of pits (0.2mm) perceived on half yearly exposed metal surface, implies that more settlement of hard foulers such as barnacles, Oysters and Molluscs during the study period. The monthly exposure(May’16) is characterized by the lowest value of pit density (01 -10 Nos./ sq.dm) and width of pit (0.4mm). The II-Quarterly exposures characterized by moderate values of pit density (04-20 Nos./ sq.dm) and width of pit (1.0mm). Crevices are faintly noted beneath the settlement of molluscs and barnacles.

4.4. **Change in mechanical properties and surface characteristics of brass due to exposure in Palk bay waters of Mallipattinam coast**

The change in mechanical properties such as yield load and % elongation of brassmetal coupons are presented in table-8.

month	yield load(mpa)	yield strength (psi)`	ultimate tensile strength	percentage of elongation
reference	376	256.56	308	52.8
monthly(may16)	365	241.08	292	48.3
i quarterly	332	222.40	281	44.2
ii quarterly	329	209.12	285	40.1
half yearly	193	127.37	273	39.63

The metal surfaces of experimentation[22]from immersion in Palk bay waters of Mallipattinam coast for monthly, quarterly and half yearly are depicted in figures-1,2,3 The surface of polished brass shows α-grains. Quarterly exposures are characterized by bundled of grains and half yearly exposure is characterized by glazed grains.Explanations of the exposed metal coupons have a pattern of dissimilarity over the period of exposure. The percentage of elongation takes a falling trend over the period. The half yearly exposure gets the lowest yield load. The change in mechanical properties of the cumulative exposed metal coupons could be ascribed to the pitting, seasonal attachment of organisms, ionic species and climatic factors.

[Half Yearly]

[II Quarterly]

[**Monthly**]

V.CONCLUSION

In the present exploration, identified fouling organisms on all cumulative surfaces of brass are algae, barnacles, molluscs, oysters and worms. The decrease in corrosion rate values of cumulative exposed brass coupons in Mallipattinam seawater over the period indicates the productive nature of algae, sessional attachment of animalsand formation of oxygen film. Pitting /crevice corrosion on brass is enhanced by the hard fouler such as barnacles, molluscs, oysters and chloride ions. The change in mechanical properties of brass over the period of exposed metals are in same alignment with degree of pitting corrosion and weight loss of materials.

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