BIOFOULING EFFECT ON CORRODING BEHAVIOURS OF COPPER IN THE PRESENCE AND ABSENCE OF FOULING IN PALK BAY WATERS OF MALLIPATTINAM COAST

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Abstract : Corrosion behavior of copper metal coupon in palk bay waters of mallipattinam coast influenced the presence and absence of fouling organisms study for six months have been studied from january16 to june16.The parameters such as open circuit potential (OCP) ,settlement of organisms ,rate of corrosion , pitting corrosion ,change in mechanical properties and surface analysis have been studied for copper corrosion behavior in sea water In presence and absence of fouling . Digital multi meter ,polarization technique ,XRD method ,SEM ,tenso meter instruments have been used for investigating period .

Key words : Open circuit potential ,biofouling organisms , pitting corrosion , scanning electronic microscope , tensometer ,palk bay waters of mallipattinam coast (PBWMC) ,corrosion rate .

I. INTRODUCTION

Corrosion is a natural phenomenon ,reversion for metallic compound state . so it becomes evident that corrosion can not be fully prevented instead it can be controlled to a great extent .It is a reaction of a solid with its environment[1], In other words ,corrosion is a destruction of a metal due to its environmental[2] attack I.e chemically or electrochemically[3].The rate of the metal to stable condition of the metal dissolution is governed by material characteristics and the environment[4] .

II. EXPERIMENTAL DETAILS

1. Material preparation

Copper metal sheets of 2mm thick sheet were cut into pieces of size 3 x 1 inch, 7.5 cm x 20.5cm were cut into required numbers . The investigational metal coupons were cleaned in the recommended pickling solution (10% sulphuric acid)of ASTM standard[5,6] and holes were made on the center of the top and bottom of each panel. Degreased with trichloroethylene and weighed to accuracy of 10^{-5} grams. The test material were fixed to PVC strips, inside the boxes with insulated brass bolts and nuts , total set fixed to a specially fabricated wooden frame and tied to the piles .The total set emerged in a sea up to a 0.5 meter below the mean low tide level during study period[7] .Inside the box covered with plankton net was monitored regularly .

2.The test site

The experiment location is localized in the palk bay waters of mallipattinam coast (PBWMC) . The mallipattinam coast climate is monitored by the SW to NW monsoon . It occurs during January 16 to June16 in a year respectively . NE is slowly changing from February16,Causes variation in sea water characteristics[8,9,10] such as wind direction ,wind velocity ,rain fall were acquired from metrological department ,adirmapattinam .

III. PROCEDURE

The potential values of the presence of fouling and absence of fouling have been monitored using universal multimeter ,the exposed metals coupons were pickled in 10% sulphuric solution for two minutes , rinsed with water and dried in an air oven at 60º Celsius for an hour ,after that the coupons were cooled and weighed . From the weight loss of coupons , the gravimetric corrosion rate were determined . After that rate of corrosion were evaluated as the rate of corrosion[11,12,13] in presence of fouling is higher than absence of fouling . The fouling on metal surface was evaluated in terms of biomass , pattern of fouling community and seasonal seasonal recruitment organisms , after evolution of rate .After evolution of corrosion rate[14,15] values , pitting corrosion[16] behaviour were analyzed in terms of probability of pitting , pit density , with ,depth using high resolution microscope .The surface characteristics[17,18] of each metal coupons were analyzed using ASTM standard Scanning electronic microscope. The change in mechanical properties[19] copper were distinguished using an INSTRON 1195 universal testing machine .

1. open circuit potential of copper metal in presence and absence of fouling in palk bay waters of mallipattinam coast

Fig (1,2) shows the OCP values of copper metal in the presence and absence of fouling. The potential value of presence of fouling is (1.04) times higher than in the absence of fouling for the January month exposure. In the month April'16 potential value of presence of fouling (1.01)times higher than the absence of fouling.

1.Monthly Exposed metal

Fig.(1) shows, the OCP values of monthly exposed copper metal falls in the range from (-376mV to -314mV) for the presence of fouling and (-386mV to -294mV) for the absence of fouling. The OCP values substantiate the corrosion values of copper metal in the both condition. The highest corrosion rates of copper in the presence of fouling and absence of fouling prevails in the month of April'16. It infers that low rain fall and high wave velocity prevailed the month of April'16.

2. Cumulative exposed metal

Fig.(2) shows, the OCP values of cumulative exposed copper metal falls in the range from (-388mV to -370mV) for presence of fouling and (-380mV to -329mV) for the absence of studies. The OCP values of the copper metal in the both conditions. The highest corrosion rate of copper in presence of fouling and absence of fouling in I-quarterly asserts that high wind velocity and alkalinity of the two quarterly exposures, the I-quarterly exposure experienced higher corrosion rate is due to the period of low rain fall, which influence the more alkalinity and the sea water characteristics.

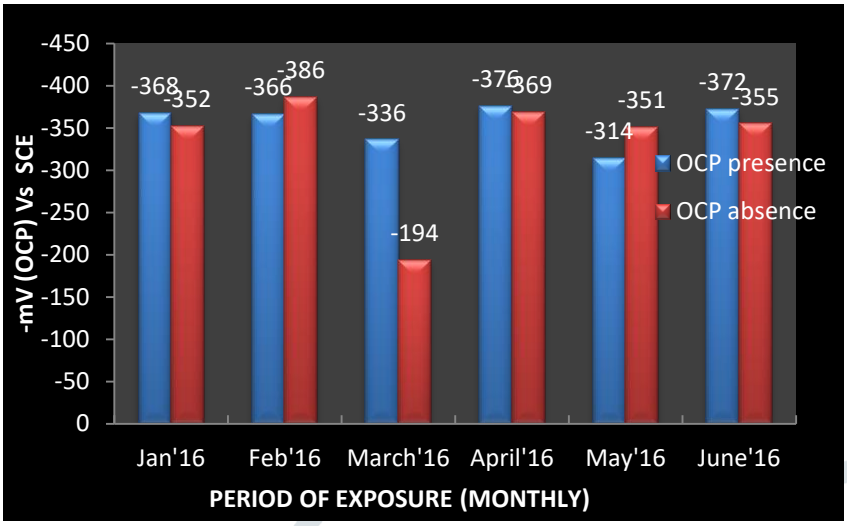

fig-1: open circuit potential of copper metainpresence and absence of fouling in palk bay waters of mallipattinam coast (january'16 – june'16)

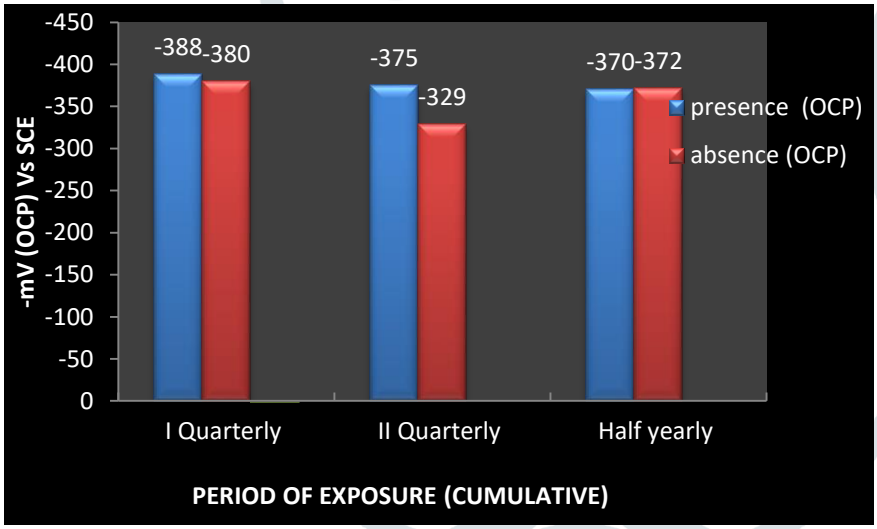

fig-2 : open circuit potential of copper cumulative metal inpresence and absence of fouling in palk bay waters of mallipattinam coast

2. corrosion parameters of copper metal in the presence and absence of fouling in palk bay waters of mallipattinam coast.

Monthly exposure

The corrosion rates obtained by Weight loss method are compared in the table(1). The I_{corr} values are maximum during April'16 month exposures. Hence the corrosion rate is maximum during April'16 months. It is (1.97) times higher than absence of studies due to higher ionic concentrations of sea water and more attachments of organisms on the exposure. This is also in agreement with the corrosion rate determined by weight loss method. The Tafel slopes for April'16 month exposure is portrayed in fig(3)

Cumulative exposures

Table (2) summarizes the results of Electrochemical polarization studies on the corrosion behavior of cumulative exposures of natural seawater. The corrosion rates of cumulative exposures are provided in the table for comparison. The exponential decrease in I_{corr} values over the period of time, implies the protective nature of corrosion products and bio assemblage on copper metal. The corrosion rates obtained by Polarization method are also in agreement with that of the weight loss method. Figs (4,5) portray the Tafel slopes for I-quarterly (Jan'16 - Mar'16), I-half yearly (Jan'15-June'16).

3. corrosion behaviour and biofouling characteristics of copper in presence and absence of fouling in palk bay waters of mallipattinam coast

Monthly exposed metals

April month exposure infers that in the presence of fouling copper metal corrodes (1.97) times higher than in the absence of fouling. April'16 month exposure of copper indicates that in the absence of fouling, the exposed metal corrodes (1.51) times faster than in the absence of fouling of Jan'16 month.

Cumulative exposures

The corrosion rate of I-quarterly exposure is (1.59) times faster than the absence of fouling. Of the two quarterly exposures, the highest corrosion rates (0.0324mmpy) for presence of fouling and (0.0188mmpy) for the absence of fouling are observed on I-quarterly exposure.

table – 1

corrosion parameters of copper metal in the presence and absence of fouling in palk bay waters of mallipattinam coast (jan'16 – june'16)

	presence of fouling					absene of fouling			
s. no	period of exposure	weight loss (mmpy)	polarization (mmpy)	e_{corr} - mv	i_{corr} (ma)	weight loss (mmpy)	polarization (mmpy)	e_{corr} - mv	i_{corr} (ma)
	january	0. 0756	0. 0808	-281	7. 120	0. 0432	0. 0580	-264	5. 1109
	february	0. 0812	0. 0857	-338	7. 551	0. 0485	0. 0532	-258	4. 687
	march	0. 0916	0. 1020	-315	8. 988	0. 0496	0. 0548	-282	4. 828
	april	0. 0968	0. 1370	-296	12. 072	0. 0531	0. 0693	-290	6. 106
	may	0. 0942	0. 1063	-280	9. 367	0. 0517	0. 0652	-286	5. 745
	june	0. 0818	0. 0864	-291	7. 613	0. 0492	0. 0541	-273	4. 767

table-2

corrosion parameters of copper cumulative metal in the presence and absence of fouling in palk bay waters of mallipattinam coast

	presence of fouling					absence of fouling			
s. no	period of exposure	weight loss(mmpy)	polarization (mmpy)	e_{corr} - mv	i_{corr} (ma)	weight loss(mmpy)	polarization (mmpy)	e_{corr} - mv	i_{corr} (ma)
	monthly(april)	0. 0756	0. 0808	-281	7. 120	0. 0432	0. 0580	-264	5. 110
	i quarterly (jan'16-mar'16)	0. 0324	0. 0465	-409	4. 097	0. 0188	0. 0292	-248	2. 5730
	ii quarterly (apr'16-june'16)	0. 0310	0. 0453	-428	3. 991	0. 0152	0. 0246	-236	2. 1677
	half yearly (jan'16-june'16)	0. 0196	0. 036	-402	3. 172	0. 0108	0. 0214	-230	2. 1236

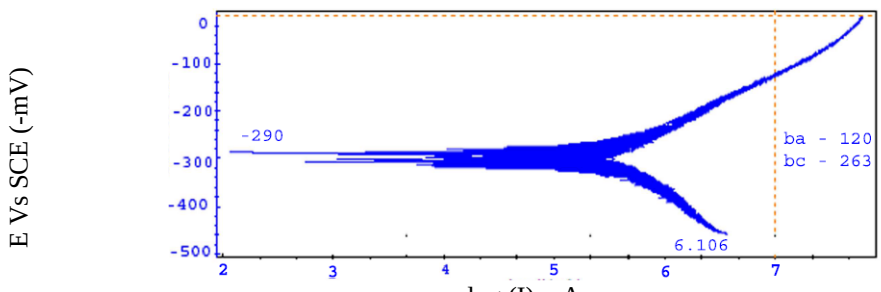

Fig-3 : Polarization curve for the monthly exposure of copper metal in Palk Bay water's of Mallipattinam coast for the period (April'16)

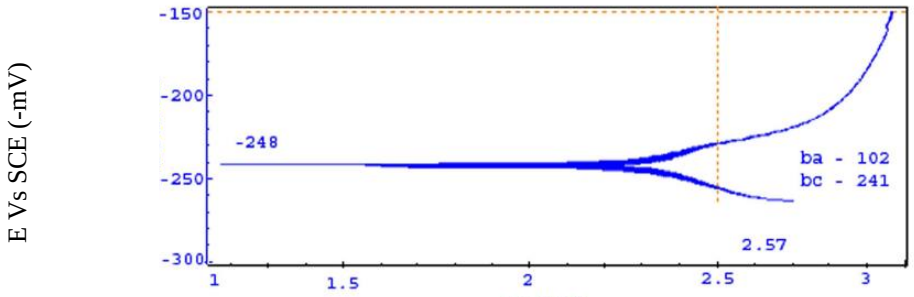

Fig-4 : Polarization curve for the I-Quarterly exposure of copper metal in Palk Bay water's of mallipattinam coast for the period (Jan'16 to March'16)

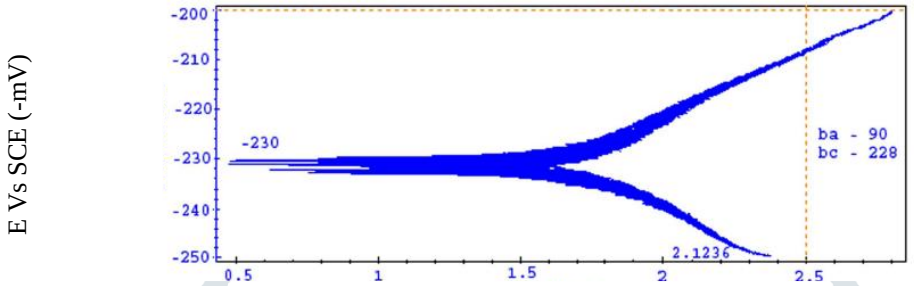

Fig-5 : Polarization curve for the Half Yearly exposure of copper metal in Palk Bay water's of mallipattinam coast for the period (Jan'16 to June'16)

4. pitting /crevice corrosion behaviour of copper in the presence and absence of fooling in palk bay waters of mallipattinam coast.

The monthly exposed metals of copper are examined for susceptibility to Pitting / Crevice corrosion in terms of probability of pits or crevices, density, width of Pits/ crevices. It is noted that none of the copper metals (presence and absence) in monthly experiments find Pitting /Crevice corrosion. The cumulative experiments such as I-quarterly, II-quarterly exposed metals of copper experienced no pitting corrosion except on half yearly exposure observed the pits beneath the shell dwelling organisms such as Barnacles and Mollusks. The pit density range is 1 No/sq. dm exposed metal

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5. change in mechanical properties of copper in the presenceand absence of metal fouling exposed in palk bay waters of mallipattinam coast.

The change in mechanical properties such as, yield load, yield stress, ultimate tensile strength and % of elongation of exposed copper metal due to immersion in PBWMC are presented in fig (6). The tensile strength of exposed copper metal coupons such as monthly(April'16),I-quarterly (Jan'16 to March'16), half yearly (Jan'16 to July'16) and fresh sample (reference material) (Jan'16 to July'16) where tested using universal testing machine. It is observed that the ultimate tensile strength and % of elongation have a pattern of declining trend over the period ofexposure.

table - 3

change in mechanical properties of copper metal exposed in palk bay waters of mallipattinam coast

months	studies	yield load	yield strength	ultimate tensile strength	%of elongation
reference	presence	210	145. 06	218. 28	44. 6
	absence				
monthly	presence	243	192. 5	213. 3	38. 6
	absence	245	196. 4	216. 28	42. 4
i quarterly (jan'16-mar'16)	presence	284	190. 43	206. 6	34. 5
	absence	253	191. 56	208. 7	37. 4
ii quarterly (apr'16-june'16)	presence	245	187. 4	207. 1	35. 3
	absence	257	188. 3	208. 92	38. 2
half yearly (jan'16-june'16)	presence	256	174. 8	194. 78	32. 7
	absence	216	179. 3	200. 15	30. 4

6. surface characteristics of copper in the presence and absence of fouling exposed in palk bay waters of mallipattinam coast

Surface characteristics of exposed metal of, such as received, polished, monthly, quarterly and half yearly are highlighted, Through Scanning electron micrograp(SEM)figures (6,7,8) respectively. The monthly exposure surface is characterized by stains and voids. The quarterly surface is characterized by the fine crystalline grains. The half yearly exposed surface of exposed metals is characterized by uniformly distributed fine grains in plying the extent of pits.

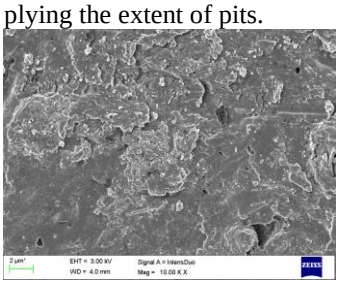

Fig-6 :SEM of Monthly(April'16) exposure in the presence and absence of Copper in PBWMC

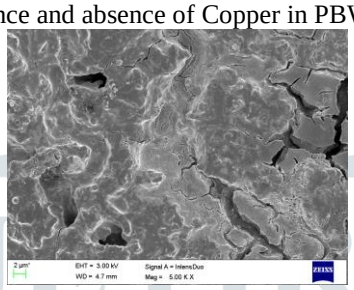

Fig-7 :SEM of I Quarterly (Jan'16 to March'16) exposure in the presence and absence of Copper in PBWMC

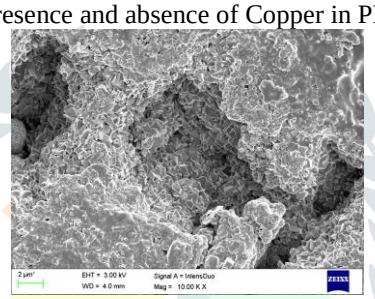

Fig-8 :SEM of Half yearly (Jan'16 to June'16) exposure in the presence and absence of Copper in PBWMC

IV. RESULTS AND DISCUSSION

In the present investigation ,identified open circuit potential(OCP) values on all present and absent metal coupons , the highest OCP values in presence of studies due to low rain fall causes high alkalinity and sea water characteristics influence the high rate of corrosion in the month April16.The corrosion rates obtained by Weight loss method are compared in the table(1). The I_{corr} values are maximum during April'16 month exposures. Hence the corrosion rate is maximum during April'16 months. higher than absence of studies due to higher ionic concentrations of sea water and more attachments of organisms on the exposure . The exponential decrease in I_{corr} values over the period of time, implies the protective nature of corrosion products and bio assemblage on copper metal. The rate of corrosion is less in february16 indicates the productive nature of algae ,seasonal attachment of animals and formation of oxygen film . Fouling organisms on all presence of metal coupons of monthly and cumulative algae ,barnacles ,mollusks, oysters and warms . Pitting corrosion , it is noted that none of the copper metals (presence and absence) in monthly and cumulative experiments find Pitting /Crevice corrosion. The change in mechanical properties of metals, it is observed that the ultimate tensile strength and % of elongation have a pattern of declining trend over the period of exposure. The monthly exposure surface is characterized by stains and voids. The quarterly surface is characterized by the fine crystalline grains. The half yearly exposed surface of exposed metals is characterized by uniformly distributed fine grains in plying the extent of pits.

IV. ACKNOWLEDGMENT

We are very thankful to Dr.P.Mahammed Sirajudeen , PG & Research deportment of chemistry , Adirampattianam ,Tanjour ,Tamilnadu, for providing necessary facilities to carry out the research work .

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