International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Research Article

INFLUENCE OF COLOUR ON THE ATTACHMENT OF MARINE MICROFOULERS

E. Suresh[1], M. Jayavel[1], B. Kiruthiga[1] and P. Sureshkumar[2]*

[1]*Research Scholar, CAS in marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai-608502*

[2]*Assistant Professor in Environmental Sciences , CAS in marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai-608502*

ABSTRACT

Biofouling mainly micro-fouling is an incredibly intricate occurrence to understand. This present work is carried out to understand the influence of colour on the development of microfoulers. The panels were constructed by using commercially important wood such as *Tectona grandis, Pterocarpus Sp, Thespesia populnea and Mangifera indica* with and without colour. The panels were immersed and studied for the period of 21 days in velar estuary, Porto-Novo. The result shows that the red colour attracts more fouling bacteria while yellow prefers less fouling bacteria in all the wood. Thus, the selection of colour for the marine structures must be heedful to prevent the loss due to the fouling process.

Keywords: Biofouling, microfoulers, panels, wood, colour, etc.

INTRODUCTION

Marine fouling is an undesirable accumulation of biotic and abiotic depositions on a submerged engineered surface in sea water [1] [2]. Deposits of abiotic materials such as organic and inorganic substances called molecular fouling and deposits of biotic molecules such as micro and macro organisms known as biofouling [3].

Marine fouling phenomenon causes considerable economic losses in various industries throughout the world. These fouling organisms cause immense mechanical troubles through attaching on hulls of ship, power plants, cooling structures, aquaculture, fishing nets, pipelines and other marine infrastructures[4, 5, 6]. Once if the ship hull is fouled it increases drag and surface corrosion, followed to reduced velocity and thereby causing higher fuel utilization [7]. This in turn has economic and environmental issues, as increased fuel consumption leads to increased output of green house gases [8] and maintenance cost [9]. Parts of a ship other than the hull are also affected due to biofouling. The other structures with frequent contact in sea water such as heat exchangers, water cooling pipes, propellers etc. are also affected with biofouling [10]. Build up of matter inside cooling system pipes extends decreased performance due to biofouling [11]. A third important category of maritime industry plagued by biofouling problems are coastal power stations [12]. They draw vast quantities of seawater for cooling purposes [13, 14]. Sessile organisms colonizing in cooling system components can reduce water flow and block condenser tubes affecting power generation and under certain circumstances may even cause safety problems [15].

Aim:

This present study aims to observe the attachment of marine fouling bacteria on different colours such as red, green, blue and yellow. To select the colour for antifouling paints, which will helps to prevent the fouling effectively, reduce the cost of maintenance and increase the life of marine structures.

.

MATERIALS AND METHODS

Study area:

A study on the rate of biofilm formation of different types of wooden panels was carried out at Vellar estuary during January/February, 2015. The study area of Vellar estuary is located along Lat. 11°29'N and Long. 79°46'E near Parangipettai, Cuddalore District, Tamil Nadu. It has permanent connections with Bay of Bengal and near its mouth it gets connected with a complex system of backwaters extending southwards to Coleroon estuary, about 15 km away.

Assembly and Deployment of different test panels:

Test panels consisting of different colour:

The *T. grandis, Pterocarpus Sp, T. populnea and M. indica* wooden panels were coloured using yellow, red, blue and green oil immersion paints on one side and other side used as a control.

Deployment of panels:

Before using, panels consists of different woods were sterilized with 10% HC1, washed with water and dried in an oven and kept in a dry place until being used. The primed panels were immersed about 1 meter depth in surface waters (~l m) of the Vellar Estuary at low tide mark. **Collection and estimation of**

fouling bacteria:

The samples were periodically (three days once) scraped randomly 1cm^2 area and cultured [16, 17]. The samples were serially diluted and cultured using Zobell marine agar medium by pour plate method [18]. The plates were incubated at (28°C ± 2°C) for 24 hours in the incubator. After 24 hrs the CFU were counted.

Statistical methods:

Duncan's Multiple Range Test was performed using spss16 packages for all the data to know the significance.

RESULTS

Rate of bacterial fouling on different colours:

Two woods such as *M. indica* and *Pterocarpus Sp* ((highly fouled and least fouled in the previous observations) are coated four different colours such as red, yellow, blue and green and tested.

The rate of bacteria fouled on red colour of *Pterocarpus Sp* and mango during 3, 6, 9,12,15,18 and 21 days is 11, 13, 25, 32, 39, 48, and 64 X 10^{-5} CFU/cm^2 , mango wood is 18, 21, 36, 40, 51, 60, and 80 X 10-5

CFU/cm^2 (Table 3 and 4). The CFU on green colour of *Pterocarpus Sp* is 10, 12, 22, 25, 32, 39 and 49 X 10^{-5} CFU/cm^2 and mango was 16, 18, 29, 34, 45, 51 and 63 X 10^{-5} CFU/cm^2 (Table 3 and 4) . The CFU on blue colour on *Pterocarpus Sp* is 4, 6, 10, 12, 18, 25 and 28 X 10^{-5} CFU/cm^2 and in mango is 8, 10, 13, 19, 24, 33 and 39 X 10^{-5} CFU/cm^2 (Table 3 and 4).The CFU on yellow colour on *Pterocarpus Sp* is 4, 5, 7, 11, 14, 21 and 25 X 10^{-5} CFU/cm^2 and in mango is 6, 8, 9, 18, 22, 29 and 31 X 10^{-5} CFU/cm^2 (Table 3 and 4).The observation showed that the bacteria fouled on red colour (*Pterocarpus Sp* and mango) are higher than all the other colours tested. And the bacteria fouled on yellow colour are lesser than the other colours. These variations are statistically significant (Tables 4, 4.B).

COLOUR OF THE WOOD	*PTEROCARPUS SP*						
	EXPOSURE DAYS						
	D3	D6	D9	D12	D15	D18	D21
RED	11.00±0.72	13.00±0.36	25.00±0.56	32.00±0.19	39.00±0.49	48.00±0.46	64.00±0.26
GREEN	10.00±0.60	12.00±0.18	22.00±0.32	25.00±027	32.00±0.55	39.00±0.68	49.00±0.84
BLUE	4.00±0.34	6.00±0.57	10.00±0.82	12.00±0.52	18.00±0.16	25.00±0.16	28.00±0.48
YELLOW	4.00±0.44	5.00±0.66	7.00±0.43	11.00±0.36	14.00±0.38	21.00±0.29	25.00±0.27
UNCOATED	19.00±0.56	22.00±0.43	29.00±0.15	35.00±0.60	49.00±0.61	58.00±0.56	80.00±0.53

Table 3: Bacterial densities on the *Pterocarpus Sp* wooden panel with different colours exposed to estuary of study area during different time intervals in different woods.

S.NO	ANOVA		
	Period	F	Sig.
1.	RED	4.342E3	.000
2.	GREEN	2.392E3	.000
3.	BLUE	1.027E3	.000
4.	YELLOW	783.429	.000

Table 3.B: Statistical result for bacterial densities on the *P.indicus* wooden panel with different colour exposed to estuary of study area during different time intervals in different woods.

COLOUR OF THE WOOD	*M. indica*						
	EXPOSURE DAYS						
	D3	D6	D9	D12	D15	D18	D21
RED	18.00±0.56	21.00±0.70	36.00±0.47	40.00±0.46	51.00±0.45	60.00±0.47	80.00±0.58
GREEN	16.00±0.94	18.00±0.45	29.00±0.34	34.00±0.58	45.00±0.56	51.00±0.53	63.00±0.46
BLUE	8.00±0.78	10.00±0.50	13.00±0.59	19.00±0.62	24.00±0.51	33.00±0.59	39.00±0.50
YELLOW	6.00±0.70	8.00±0.76	9.00±0.23	18.00±0.70	22.00±0.60	29.00±0.51	31.00±0.52

Table 4: Bacterial densities on the Mango wooden panel with different colours exposed to estuary of study area during different time intervals in different woods.

S.NO	ANOVA		
	Period	F	Sig.
1.	RED	5.771E3	.000
2.	GREEN	3.619E3	.000
3.	BLUE	1.670E3	.000
4.	YELLOW	1.259E3	.000

Table 4.B: Statistical result for bacterial densities on the mango wooden panel with different colour exposed to estuary of study area during different time intervals in different woods.

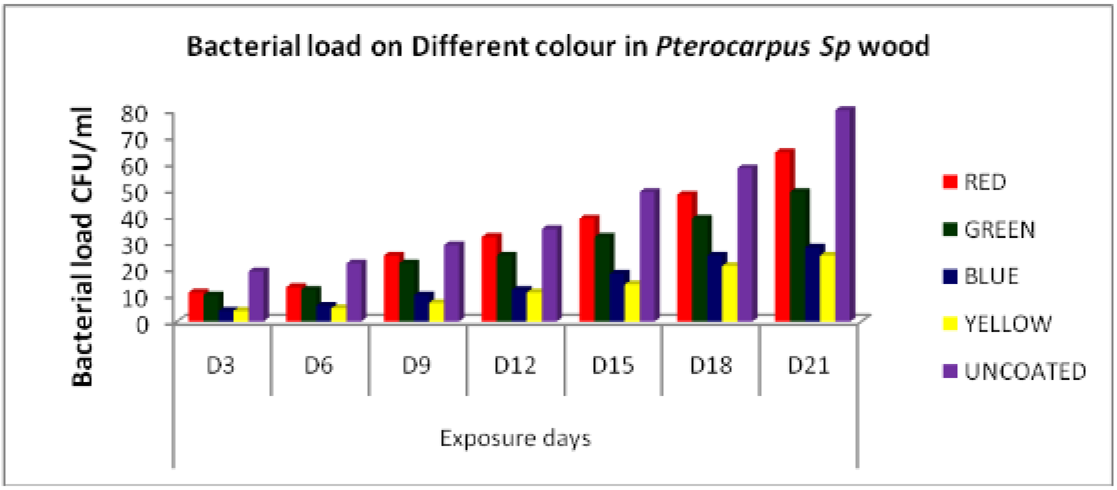

Figure 10: Bacterial densities on the *P.indicus* wooden panel with different colours exposed to estuary of study area during different time intervals in different woods.

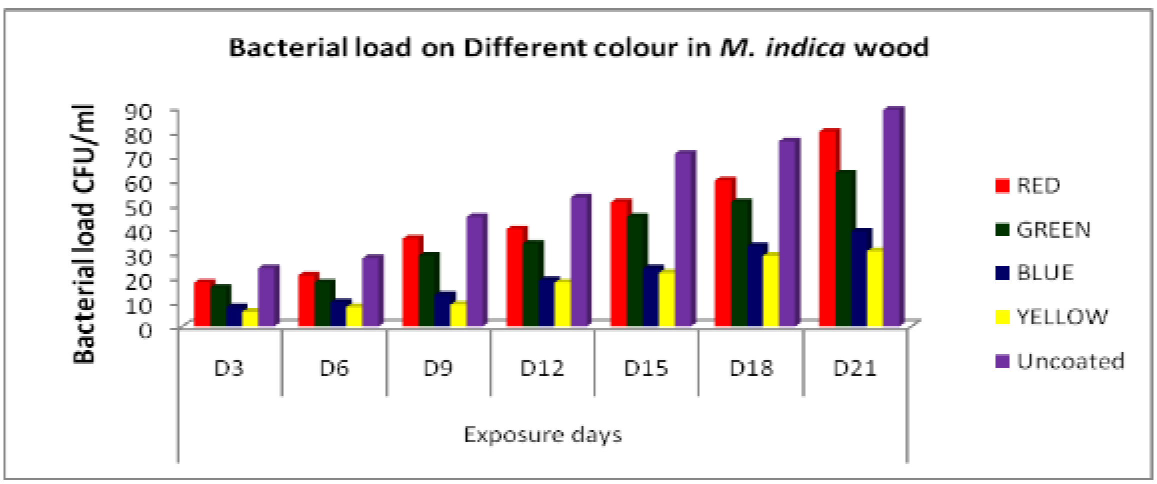

Figure 11: Bacterial densities on the Mango wooden panel with different colours exposed to estuary of study area during different time intervals in different woods.

DISCUSSIONS

Deposition of molecules and microorganisms then macro organisms is the general phenomenon of marine fouling [19]. Biofilms occur spontaneously on both inert and living systems, being of concern to a wide range of scientific disciplines [20]. In industry, biofilms can have a detrimental impact on account of the undesirable effect of biocorrosion promoted by microbial cell accumulation at interfaces [21]. Competition for living space is more intense in marine environment; hence all submerged surfaces in the marine environment are rapidly colonized by bacteria and they form the important component in the development of a fouling community [22]. Biofilms are formed by microbial cells embedded in an exopolymeric matrix. The extracellular matrix is mainly composed of polysaccharides and proteins, although other compounds such as DNA and humic substances [23, 24].

In the present study, four different coloured wooden substratums (substrata) were exposed to seawater in order to determine their influence on the rate of fouling of bacteria along velar estuary, Southeast coast of India. During the experimental period, CFU is gradually increased according to the increase of exposure time. Thus the developments of colonies are directly proportional to the time of exposures in all the study panels. [25]. the increase in the microfouling biomass was due to enhanced settlement and growth of already colonized microbes on the panel surface also observed similarly [26].

Surfaces in contact with seawater medium are rapidly colonized by bacteria due to ease access to nutrients, protection against antibiotics, maintenance of extracellular enzyme activities and shelter for predation [27]. The materials which possess high wetability also attract more foulant [28]. If the substratum has such properties the rate of fouling will be increased. In the present study, out of four substrata tested, mango show that the highest bacterial load; whereas, the lowest bacterial population is observed on the *Pterocarpus Sp*. The highest population on the mango may be due to its surface nature and wetability, etc... It has been widely reported that rough surfaces are more favorable for settlement than the smooth surfaces [29].

The result of the test of colour on the rate of fouling shows that the higher bacterial accumulation on the dark colours such as blue, red and green. In the present result red colour has the maximum accumulation followed by green, blue and yellow and also made similar observation by the researcher [30].

In agreement with the present result, [31] stated that the pattern of colonization of the submerged surfaces by bacteria is influenced by the physical and chemical characteristics of the surface. Also reported that absorbed molecules alter the property of the substratum making all surface wettable and influence the rate of attachment of bacteria to a variety of substrates [28]. [32] have reported that the rate of initial bacterial colonization is substratum dependent, i.e., not all surfaces are colonized at the same rate or to the same extent and hence the observed differences in total viable count with different substratum is obvious.

The present study, the variations of colour found in the recruitment of the fouling organisms between different coloured panels indicated that surface colour has some influence on rate of fouling.

Colonisation of fouling community on blue and red coloured panels is significantly varying from green, white or yellow coloured ones. However, no significant effect is observed between red, green, blue and yellow coloured panels. Here the yellow colour recruits the low CFU value of the bacterial load then the red colour. The higher loading of red colour is 80 $X10^{-5}$ CFU/ml at 21st day in the *M. indica* wooden panel but incase of the yellow panel shows the 31X 10^{-5} CFU/ml at 21st day in the *M. indica* wooden panel. These findings were identical to Daniel, 1963. The higher recruitment of invertebrates on red and black surfaces may be due to the preference of larvae for darker, deep colour and less reflective substratum[33] (Su et al., 2007). For example, the barnacle, *Amphibalanus amphitrite* preferentially recruited on red or blue coloured panels. It is possible that they may prefer to settle on surfaces that do not reflect much light (e.g. dark colours).

Marine invertebrate larvae contacting a substratum during exploration of potential habitats for settling are exposed to chemical and physical cues derived from surface-associated microorganisms [34]. It should also be noted that the link between the colour of the surface and viable cell numbers (biofilm community) in a surface has been established [35]. These findings are identical to present investigation.

Hence, more studies related to the formation of biofilms on different coloured surfaces may improve our understanding on this field. The present study showed that the colour of the substrata should be taken into consideration along with other factors when interpreting results from short-term biofouling studies (ecological studies to test various hypotheses or antifouling trials). For practical reasons, the colour of the substratum used for biofouling studies should be kept as similar as possible. The results also suggested that light coloured surfaces would be preferable for marine applications. Further studies on the development of micro- and macro fouling communities on different coloured surfaces from other regions are also necessary to ascertain the influence of surface colour on biofouling.

CONCLUSIONS

Despite the relationship between the fouling of bacteria on the substratum is highly complex, the following conclusion can be drawn from the present study executed to comprehend the influence of different wood and colour on the rate of fouling of marine bacteria. The mango fascinated higher bacterial foulant than the other woods. The *Pterocarpus Sp* attracted less bacterial colonies. Rate of settling and the exposure time of the substratum are directly proportional. The colour also showed significant variation on the rate of fouling. The red colour attracts more fouling bacteria and yellow colour prefers less fouling bacteria. Thus, the selection of materials and colour for the marine structures must be heedful and well established to prevent the loss due to the fouling process.

REFERENCES

1. Clare, A. S. (**1996);** Marine natural product antifoulants: status and potential. *Biofouling, 9*: 211- 229.
2. Callow ME (1996); Ship-fouling: the problem and methods of control. Biodeter Abstr 10:411–421
3. Amy, G. (**2008);** Fundamental understanding of organic matter fouling of membranes. *Desalination 231*, 44–51.
4. Malik A U, Prakash T L, Andijani I (1996); Failure evaluation in desalination plants - Some case studies. *Desalination* **105**: 283-295
5. Melo LF and Bott TR (1997); Biofouling in water systems. *Exp. Thermal. Fluid Sci*., 14: 375-381
6. Wood T S, Marsh T G (1999); Biofouling of wastewater treatment plants by the freshwater bryozoan, Plumatella vaihiriae (Hastings, 1929). *Water Res* **33**: 609-614.
7. Younglood, J. P., L. Anderuzzi, W. Senaratine, C.K. Ober, J. A. Callow, J. A. Finlay and M. E. Callow. (2003); New materials for marine biofouling resistance and release. Semi fluorinated and pegylated block copolymer bilayer coatings. *Polymeric Mater. Scien Eng.,* 88: 21 – 24.
8. Anderson D. T. (1994); Barnacles: structure, function, development and evolution. *Springer*,
9. Hattori, T. and Shizuri, Y. (1996); A screening method for antifouling substances using spores of the fouling microalgae *Ulva conglobata kjellmann. Ash. Sci.*, 62 : 955 – 958.
10. Brizzolara, R. A., (2002); Adsorption of algenic acid to titanium investigated using x-ray photoelectron spectroscopy and atomic force microscope. *Sur. Inter. Anal.,* 3(4): 351 - 360.
11. Lee, H. J., Han, D., Lee, S. H., Yoo, J. W., Baek, S. H., & Lee, E. K. (1998); On-line monitoring and quantitative analysis of biofouling in low-velocity cooling water system. *Korean J. Chem. Eng., 15*(1), 71-77.
12. Thyagarajan, V., Venugopalan, V.P., Subramoniam, T. and Nair, V.K., (1997); Macrofouling in the cooling water conduits of a coastal power station, *Indian J. Mar. Sci.*, **26**(3), 305-308.
13. Nair, K. V. K. (1987); Biofouling porblems in cooling conduits of power stations. In: *Advances in aquatic biology & fisheries: Symposium to facilitate Dr. N.B. Nair,* 257- 262, Kerala University, Trivandrum
14. Masilamani, J.G., Nandakumar, K., Satpathy, K.K., Jesudoss, K.S., Nair K.V.K.& Azariah. J. (2002); Lethal and sublethal responses of chlorination on green mussel *Perna viridis* in the context of biofouling control in power plant cooling system. Marine Environmental Research, 53(1), p65-76.
15. Sasikumar, N., (1991); Ecology and control of biofouling in a coastal power station with special reference to Mega *Balanus titunabulam* (c) Ph. D. Thesis, University of Madras Chennai, India.
16. Bhosle, N.B, K. Nandakumar and A.B. Wagh, (1990);S Influence of particulate matter on microfouling biomass in the Arabian Sea*. Biofouling,* 2: 65-74.
17. Bragadeeswaran,S., and U. Kanagarajan (2007). Composition of microfouling on different panels exposed in Vellar estuary*. Proceedings in 94th Indian Science congress*.
18. Wahl, M., (1995); Bacterial epibiosis on Bhamian and Pacific ascidians. *J. Exp. Mar. Biol. Ecol.*, 191: 239 - 255.

19. Callow ME. (1986); Fouling algae from in-service ships. *Bot Mar* 29:351 - 357.
20. Walker, I., (1998); Non-toxic fouling control systems. *Pitture Vemici. Eur*., 13: 17-22.
21. Characklis WG and Cooksey KE (1983); Biofilms and microbial fouling. Adv. Appl. Microbiol., 29: 93–138.
22. Mitchell, R. and D. Kirchman, (1984); The microbial ecology of marine surfaces. In: *Marine Biodeterioration an interdisciplinary study.* Annapolis, Maryland, *Naval Institute press*. 49-56.
23. Nielsen, P. H., A. Jahn and R. Palmgren (1997); Conceptual model for production and composition of exopolymers in biofilms. *Water Sci. Technol.,* 36: 11-19.
24. Jahn, A., T. Giebe and P. H. Nielsen, (1999); Composition of *Pseudomonas putida* biofilms: accumulation of protein in the biofilm matrix. *Biofouling,* 14: 49-57.
25. Wiencek, K. M., and M. Fletcher, (1995); Bacterial adhesion to hydroxyl- and methylterminated alkanethiol self-assembled monolayers. *J. Bacteriol*, 177: 1959-1966.
26. Immanuel, G., P. Iyapparaj, R. Ramasubburayan, A. Palavesam and M. Peter Marian, (2005); Screening of medicinal plant extracts for eco-friendly antimicrofouling compounds. *J. Biol. Res.,* 4: 181-188.
27. Dang, H. and C. R. Lovell, (2000) Bacterial primary colonization and early succession on surfaces in marine waters as determined by amplified 16s rRNA genes. *Appl. Environ. Microbiol.*, 66: 467 – 475.
28. Dexter SC, Sullivan JD, Williams D and Watson J (1975); Influence of substrate wet ability on the attachment of marine bacteria to various surfaces, *Appl. Microbiol.,* 30: 298 - 308.
29. Anderson, A. J and M. J. Underwood, (1994); Effects of substratum on the recruitment and development of an intertidal estuarine fouling assemblage. *J. Exp. Mar. Biol. Ecol.,* 184: 217 – 236.
30. Guenther, J., C. Christina and L. Magne Sunde, (2009); The effects of colour and copper on the settlement of the hydroid Ectopleura larynx on aquaculture nets in Norway. *Aquaculture*, 292: 252–255
31. Fletcher, M., and K. C. Marshall, (1982); Are solid surfaces of ecological significance to aquatic bacteria. *Adv. Microb. Ecol.,* 6: 199-236.
32. Little, B. J. and P. A. Wagner, (1997); Succession in microfouling. In: Nagabhusanam, R. Thompson, F. eds. Fouling organisms organisms of the Indian ocean, Biology and Control technology, *Oxford and IBH Publishing*, New Delhi, 105-134.
33. Su, Z., L. Huang, Y. Yan and H. Li, (2007); The effect of different substrates on pearl oyster *Pinctada martensii* (Dunker) larvae settlement. *Aquaculture*, 271: 377-383.
34. O'Connor N.J. and Richardson D.L. (1996); Effects of bacterial films on attachment of barnacle (Balanus improvisus Darwin) larvae: laboratory and field studies. Journal of Experimental Marine Biology and Ecology, 206: 69-81.
35. Pitts, B., M.A., Hamilton, G.A. McFeters, P.S. Stewart, A. Willse and N.Zelver, (1998); Colour measurement as a means of quantifying surface biofouling. *Journal of Microbial Methods*, 34: 143-149.