“IN SITU STUDY ON THE SETTLEMENT PATTERN OF BIOFOULERS ON TEST PANELS”

Project Work By

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CERTIFICATE

This to certify that the project work entitled **"IN SITU STUDY ON THE SETTLEMENT PATTERN OF BIOFOULERS ON TEST PANELS"** submitted by Ms.ARSHIYA SHAJAN is a bonafide work done under my guidance and super vision and to the best of my knowledge, this is her original effort.

Dr.Meera Jan Abraham	Dr.Soja Louis
Supervising teacher,	Head of the Department,
Department of Zoology,	Department of Zoology,
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EXAMINERS:

1)

2)

DECLARATION

I MS.ARSHIYA SHAJAN, and hereby declare that the project report entitled **“IN SITU STUDY ON THE SETTLEMENT PATTERN OF BIOFOULERS ON TEST PANELS”** is a bonafide record of work done by me during the academic year 2017-2018 in partial fulfillment of the requirements of Bachelor of Science degree of Mahatma Gandhi University, Kottayam.

This work has not been undertaken or submitted elsewhere in connection with any other academic course and the opinions furnished in this report is entirely my own.

ARSHIYA SHAJAN

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Every small or big project is successful only because of the efforts that have been put by many dedicated people. I sincerely appreciate the inspiration, support and guidance of all those who have been instrumental in making this project a success.

I respect and thank Dr Soja Louis, Head of the department of Zoology and owe ourprofound gratitude to our project guide Meera Jan Abraham who took keen interestin our project work and guided as all along till the completion of our project work by providing all the necessary information.

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SYNOPSIS

Biofouling or biological fouling is the accumulation of microorganisms, plants, algae, or animals on wetted surfaces. The fouling of ships results in a reduction of speed, and increased cost in fuel,and losses in time and money.

Biofouling prevention systems employ protective coatings that prevent barnacles, oysters, tubeworms, and other marine organisms from attaching to the ship's hull. Overtime, the accumulation of biofoulers on hulls increases both the hydrodynamic volume of vessel and the frictional effects leading to increased drag of up to 60%.Continous uses of toxic paints on ship causes severe heavy metal toxicity in marine environment.

The aim of this project "IN SITU STUDY ON THE SETTLEMENT PATTERN OF TEST PANELS" is to analyze the antifouling properties of different timbers and thus to identify the woodwhich shows the maximum antifouling activities. The chemical components present in these woods are responsible for those antifouling properties which can be extracted and can be used in the manufacture of natural antifouling paints. This helps in saving the marine environment from the effects of heavy metal antifouling paints.

Wood species used in this study were:

1. *Tectona grandis* (Teak)
2. *Bombax ceiba* (cotton tree)
3. *Artocarpus hirsutus* (Aanjili),
4. *Mimosops elanji* (Bullet wood),
5. *Albizia lebbeck* (Frywood),
6. *Syzigium cumini* (Njaaval),
7. *Artocarpus heterophyllus* (Jack wood)

The wood panels were exposed by the period of 2 weeks.Terracota used as a control panel for experiment. The identification of fouling organisms obtained from wooden panels revealed the presence of 6 species belonging to (barnacles),tube worms,*Bugula neritina*(bryozoans),*Hydroides elegans*(hydroids) and *Crassostrea madrasensis.*

INTRODUCTION

Marine fouling is an undesirable accumulation of biotic and abiotic depositions on a submerged surface in sea water. Deposits of abiotic materials such as organic and inorganic substances are called molecular fouling. Deposits of biotic molecules such as micro and macro organisms is known as bio fouling. The fouling process occurred by three phases i.e. Molecular, Micro foulingand Macro fouling. The first phase-molecular fouling or abiotic fouling is the accumulation of organic and inorganic molecules from solution onto immersed structures. The establishment of microbial colonization rise as the surface irregularity develops. Adhesion of abiotic materials alters the property of any substratum making all surface becomes wet. Molecular fouling is hasty, reversible and is synchronized by the laws of mass action and the chemistry of molecular bonding relations. The second stage- micro fouling is the establishment of microorganisms such as bacteria,fungi, algae, etc. on the immersed structures. Substrate appears to influence micro fouling at all stages of development. In any aquatic environment, microbial cells attached to the submerged substratum, including metals, immobilized cells grow, reproduce and produce extracellular polymers forming a biofilm. Microbial colonization of a solid-liquid interface may occur in sequence. First in transport of cells to a surface by three different modes i.e., by diffusive transport, connective transport of cells and by active movement. The next occurrence is initial adhesion. After the bacterium deposited special structures fibrils form strong link between cell and solid surface. After attachment, microorganisms initiate production of slimy adhesive substances termed extracellular polymeric substances (EPs) which assist in the formation of micro colonies and microbial films. Last in the sequence is surface colonization. Followed by micro fouling the macro organisms such as plants and animals started colonizing on the immersed surfaces. This is highly irreversible process. These macro fouling secretes a proteinaceous adhesive. Macro fouling is further divided into soft fouling (algae, ascidians, bryozoans etc.) and hard fouling such as calcium carbonate secretors of barnacle and oysters. These macrofoulers react to physical and chemical natures of the substratum.

Biological clogging or biofouling is the aggregation of biological components such as in microorganisms, plants algae or animals on wetted surface (Thompson et al, 2004 Barnes; 2005). Artificial substrate in the aquatic environment is subjected to biofouling i.e., accumulation of micro and macro organisms with in time (Railkin, 2004; Durr and Thomaso, 2010). Majority of the fouling species are small sized sedentary, burrow dwelling or clinging species (Galil & Zenetos, 2002) include mobile species such as crabs, brittle stars and small fish.

Marine fouling phenomenon causes considerable economic losses in various industries throughout the world. These fouling organisms because immense mechanical troubles through attaching on hullsof ship increases drag and surface corrosion, followed to reduced velocity and thereby causing higher fuel utilization. This in turn has economic and environmental issues, as increased fuel consumption leads to increased output of greenhouse gases and maintenance cost. 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.

REVIEW OF LITERATURE

Wood is a renewable, cheap, and biodegradable bioresource with interesting mechanical properties which make it a competitive material in construction applications. In marine environments, wood is used as a raw material for the construction of waterfront structures, e.g., groynes, jetties, dolphins and classic boats (Crossman and Simm, 2002). Besides, wood is highly hydrophilic and very sensitive to the attack of biological organisms. These characteristics are a major challenge in marine environments, due to the regular wet conditions and the great number of living organisms in seawater. Under these conditions, all the immersed surfaces are rapidly colonized by different microorganisms leading to the formation of a biofilm, but also larger organisms could colonize the substrata after the biofilm formation. This phenomenon is commonly known as marine biofouling (Jain and Bostle, 2009).

The biofilm formation starts with the adsorption of free organic material onto the surface of the substrata. Such biofilm may change the physicochemical properties of the substrata, influencing the future adhesion of larger fouling organisms (e.g., barnacles, molluscs).Colonization is the process of biofouling organisms collecting and growing on a surface. In the marine environment, this usually starts with the formation of a biofilm that attracts larger macrofoulers .For instance, tubeworms prefer settling on biofilms, but bryozoans and barnacles do not require a biofilm. Rougher surfaces, which have more turbulent boundary layer flows, are preferred by some hydroids, barnacles. Conversely, many other species, including ascidians, bryozoans and polychaetes and barnacles preferentially settle on smooth surfaces. (Wright and Boxshall, 1999)

The five-stage colonization process includes initial attachment, irreversible attachment, initial growth, final growth and dispersion. Initial attachment starts the colonization process, which begins within days to a few weeks. The biofilm covered surface then attracts other organisms that may have been previously deterred. Initial attachment of micro-organisms is reversible, but once they secrete the EPS, the bond becomes irreversible. This permanent attachment allows initial growth, final growth and dispersion (Bixler&Bhushan, 2012). An important challenge for the functioning and durability of marine infrastructure is biofouling and bioerosion – the growth of barnacles, algae, sponges, and other sessile organisms on or within submerged or partially submerged structures (Callow and Callow, 2002). For instance, biofouling can corrode and degrade metal structures including offshore oil rigs and obstruct the optical window of submerged sensors. Because this pervasive and widespread problem affects a variety of marine structures and instruments, significant investment continues to be made to combat biofouling.

Wooden ships can be adversely affected by the settlement and growth of oysters, barnacles and other sessile invertebrates, and by the infestation of boring bivalve molluscs of the genera *Teredo*, *Bankia*, and *Lyrodus*, collectively known as shipworms. Barnacles, for instance, increase drag on wooden ships, resulting in increased fuel consumption (Schultz et al., 2011). In contrast, shipworms destroy wooden structures with the aid of symbiotic gut bacteria and for centuries have posed a problem for humans. In the 1730s, shipworms caused extensive damage to wooden 'wave breakers', which left Dutch dikes and the cities that they protected vulnerable to storm surgeand damage. The costs of rebuilding and treating structures against future boring and biofouling in

San Francisco Bay after this epidemic, along with the economic losses due to lost business from damaged infrastructure, totaled approximately half a billion US dollars (Nelson, 2015). Althoughshipworms and biofouling species are prevalent pests in marine systems, they are especially problematic in coastal and estuarine environments that harbor many wooden structures (e.g. wharves, piers, docks) and significant wooden debris (e.g. fallen trees)). Shipworms have the potential to disperse hundreds of kilometers in currents and ballast water. Barnacles and oysters, the biofouling taxa observed in this study, exhibit similar life history traits and tolerances to salinity and temperature fluctuations, although they are encrusting, sessile filter feeders rather than wood- consumers). Collectively, these life history traits make shipworms, barnacles and oysters well- equipped to survive, persist and damage wooden structures in tropical and temperate estuaries worldwide(Scheltema, 1971).

To prolong the lifespan of wooden structures in estuarine environments, humans have employed different methods. Historic accounts show that ancient Egyptians and Chinese protected wooden structures with resin, pitch, and paint. Other cultures placed copper or lead plates on wooden ships, as well as used paraffin, tar, and asphalt on piers, wharves, and other structures, to protect against biofouling. Creosote – a material derived from the carbonization of coal and one of the most effective protective measures against marine wood borers – has also been applied commonly to marine timber but has been banned or highly regulated in many countries due to its carcinogenic properties More modern approaches include treating wood with chromate copper arsenate (CCA), which is relatively effective at deterring biofouling CCA is widely used to protectwood but remains a controversial approach due to its negative environmental effects. Although shipworms, barnacles, and other biofouling organisms have posed a problem for centuries, no method has been developed that is one hundred percent effective at preventing their settlement and growth on wooden structures. The lack of treatment against shipworms and biofouling, and limited understanding of their ecological impacts on various wood types is problematic because wood continues to be a commonly used construction material in estuaries (Borges et al., 2003).

To better understand the environmental and substrate characteristics that modulate shipworm infestation and biofouling of intertidal break wall branches and posts, we conducted a 6-month field experiment to test how distance from the sediment surface, tree species identity, branch diameter, and site interact to mediate shipworm burrow density and percentage of wood volume lost to burrowing in two northeast Florida estuaries. We then tested how tree species identity and distance from sediment mediate patterns in shipworm infestation and barnacle and oyster settlement across southeastern US estuaries by replicating this experiment for three months in the same two sites and at four additional sites. Finally, we compared barnacle and oyster colonizationas well as shipworm infestation of two non-chemical (tape and silicone wraps) and two chemical techniques (pressuretreated wood and copper-based antifouling paint) meant to protect wooden posts against biofouling and enhance their longevity to unprotected, control posts .

The findings of various studies and others suggest that artificial substrates likely do not intrinsicallyfavor non-native species. It is likely that other factors, including substrate orientation, predation exposure and distance to the water surface, may play a more important role than substrate material itself in explaining the abundance of introduced species on manmade structures. Nevertheless, substrate can influence fouling community composition, and certain materials (e.g. concrete) mayprovide favorable habitats for particular species (e.g. C. intestinalis, B. schlosseri). Extensive usage of certain construction materials might therefore change local-scale composition of fouling assemblages. As these effects seem to be material specific, targeted studies of the effects of material (including different brands of concrete) on fouling organisms in different geographic locations might inform material usage in marine construction.(Vaz-Pinto et al. 2014)

Tectona grandis is a tropical hardwood tree species in the family Lamiaceae. It is a large, deciduous tree that occurs in mixed hardwood forests. . Teak wood has a leather-like smell when it is freshly milled and is particularly valued for its durability and water resistance. The wood is used for boat building, exterior construction, veneer, furniture, carving, turnings, and other small wood projects. Teak has been used as a boat-building material for over 2000. In addition to relatively high strength, teak is also highly resistant to rot, fungi and mildew. The wood has a relatively low shrinkage ratio, which makes it excellent for applications where it undergoes periodic changes in moisture. Teak has the unusual property of being both an excellent structural timber for framing or planking, while at the same time being easily worked and finished, unlike some otherwise similar woods such as purpleheart. For this reason, it is also prized for the trim work on boat interiors. Due to the oily nature of the wood, care must be taken to properly preparethe wood before gluing.

Bombax ceiba, like other trees of the genus *Bombax*, is commonly known as cotton tree. More specifically, it is sometimes known as Malabar silk-cotton tree; red silk-cotton; red cotton tree; or ambiguously as silk cotton or kapok both of which may also refer to *Ceibapentandra*.This Asian tropical tree has a straight tall trunk and its leaves are deciduous in winter. Its trunk bears spikes to deter attacks by animals. Although it’s stout trunk suggests that it is useful for timber, its woodis too soft to be very useful

Artocarpus hirsutus, commonly known as wild jack, is a tropical evergreen tree species that is native to India, primarily in Kerala, but also in Karnataka, Maharashtra and Tamil Nadu, where itprefers moist, deciduous to partially evergreen woodlands. The tree is prized for its durable timberwhich is comparable in quality with teak. The timber was used extensively in the construction of ceilings, door frames and furniture in older buildings, especially in Kerala. The famous snake boats of Kerala are often hewn out of the Aini's wood.140 tons of A.hirsutus wood from Kerala was used for Tim Severin's ship Sohar, in which he traveled from Muscat to Canton in 1980-81.

Mimusops elengi(Elanji) is a medium-sized evergreen tree found in tropical forests in South Asia, Southeast Asia and northern Australia. English common names include Spanish cherry, medlar and bullet wood. Its timber is valuable, the fruit is edible, and it is used in traditional medicine. As the trees give thick shade and flowers emit fragrance, it is a prized collection of gardens. Bullet wood is an evergreen tree reaching a height of about 16 m (52 ft.). It flowers in April, and fruiting occurs between June and October. The leaves are glossy, dark green, oval-shaped, 5–14 cm (2.0–5.5 in) long, and 2.5–6 cm (0.98–2.36 in) wide. The flowers are cream, hairy, and scented. The fruits are fleshy, range in color between yellow and brown, and contain a large brown seed. The pulp has a yellow color and it is edible. The bark of the tree is thick and appears dark brownish black or grayish black in colour, with striations and a few cracks on the surface. The tree may reach up to a height of 9–18 m (30–59 ft.) with about 1 m (3 ft. 3 in) in circumference.

Albizia lebbeck (vaaga) is a species of Albizia, native to Indomalaya, New Guinea and Northern Australia and widely cultivated and naturalized in other tropical and subtropical regions. English names for it include Sirisa, Siris, lebbeck, lebbek tree, flea tree, frywood, koko and woman's tongue tree. The latter name is a play on the sound the seeds make as they rattle inside the pods. Being one of the most widespread and common species of Albizia worldwide, it is often simply called siris or Sirisa though this name may refer to any locally common member of the genus. It is a tree growing to a height of 18–30 m tall with a trunk 50 cm to 1 m in diameter.

Syzygium cumini, commonly known as Malabar plum, Java plum, black plum, jamun, jaman, jambul, or jambolan, is an evergreen tropical tree in the flowering plant family Myrtaceae, and favored for its fruit, timber, and ornamental value. It is native to the Indian subcontinent, adjoining regions of Southeast Asia, including Myanmar, Sri Lanka, and the Andaman Islands. It can reach heights of up to 30 meters (98 ft.) and can live more than 100 years. A rapidly growing plant, it is considered an invasive species in many world regions. As a rapidly growing species, it can reach heights of up to 30 m (100 ft.) and can live more than 100 years. Its dense foliage provides shade and is grown just for its ornamental value. At the base of the tree, the bark is rough and dark grey, becoming lighter grey and smoother higher up. The wood is water resistant after being kiln-dried. Because of this, it is used in railway sleepers and to install motors in wells. It is sometimes used to make cheap furniture and village dwellings, though it is relatively hard for carpentry.

Artocarpus heterophyllus, also known as the jack tree, is a species of tree in the fig, mulberry, and breadfruit family (Moraceae). Its origin is in the region between the Western Ghats of southern India, all of Bangladesh, Sri Lanka, and the rainforests of the Philippines, Indonesia, and Malaysia. The golden yellow timber with good grain is used for building furniture and house construction in India. It is termite-resistant and is superior to teak for building furniture. The wood of the jackfruit tree is important in Sri Lanka and is exported to Europe. Jackfruit wood is widely used in the manufacture of furniture, doors and windows, in roof construction, and fish sauce barrels. The wood of the tree is used for the production of musical instruments. In Indonesia, hardwood from the trunk is carved out to form the barrels of drums used in the *gamelan*, and in the Philippines, its soft wood is made into the body of the *kutiyapi*, a type of boat lute. It is also used to make the body of the Indian string instrument *veena* and the drums *mridangam*, *thimila*, and *kanjira*.

METHODOLOGY

STUDY AREA

The trials were carried on the shores of marine ferry foreshore road near CUSAT School of marinescience from 17 to 31 January 2023.

RESEARCH DESIGN

7 different wooden panels of external dimensions 26x30x4 were taken and suspended from a 5mlong rope.Terracota were used as control panel for this experiment. Each of the panels immersedin the water completely at the same level for uniform germination of biofouling organisms. The study aims to investigate the natural antifouling properties of 7 different timbers.

Wood species used in the study are:

1. *Tectona grandis* (Teak)
2. *Bombax ceiba* (Tree cotton)
3. *Artocarpus hirsutus* (Wild jack)
4. *Mimusops elanji* (Spanish cherry)
5. *Albizia lebbeck* (Bullet wood)
6. *Syzigium cumini* (Java plum)
7. *Artocarpus heterophyllus* (Jack fruit tree)

The wooden panels and terracotta were evaluated on two to four occasions for two weeks. The panels are then exposed to sunlight and completely dried for further examination. The sedentaryorganisms are counted on each of the panels. The results are then compared to check its resistivity to the various amounts of biofouling organisms within a limited time duration.

OBSERVATION AND RESULT

Results are given in table 1-5 and figures 1-9

TABLE 1:**Settlement of barnacles on different panels**

SL.No	Name Of timbers	No.of barnacles attached
1	*Tectona grandis* (Teak)	46
2	Bombax ceiba (Cotton tree)	49
3	Artocarpus hirsutus (Aanjili)	532
4	Mimusops elanji (Bullet wood)	137
5	Albizia lebbeck (Fry wood)	52
6	Syzigium cumini (Java plum)	241
7	Artocarpus heterophyllus (Jack wood)	88
8	Terracotta	17

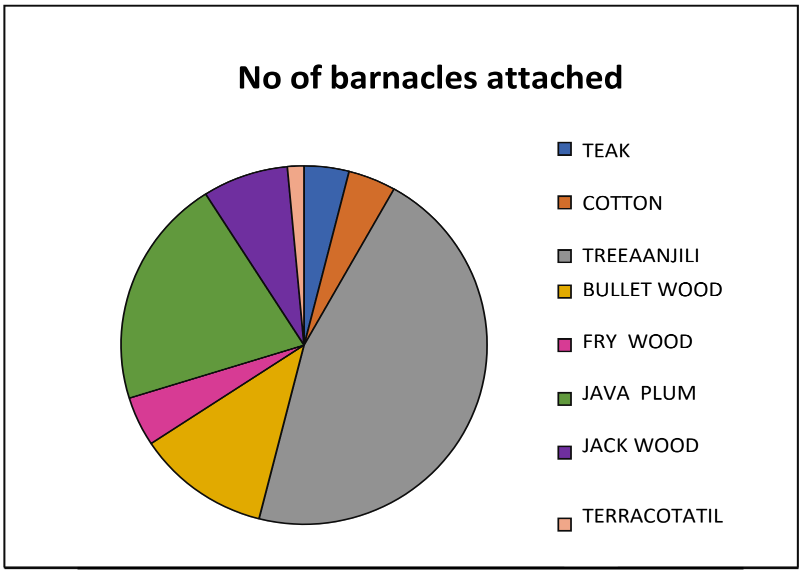

Figure 1: <u>Settlement of barnacles on different panels</u>

TABLE 2: <u>Settlement of tubeworms on different panels</u>

SL.No	Name Of timbers	No.of tubeworms attached
1	*Tectona grandis* (Teak)	15
2	Bombax ceiba (Cotton tree)	17
3	Artocarpus hirsutus (Aanjili)	39
4	Mimusops elanji (Bullet wood)	46
5	Albizia lebbeck (Fry wood)	55
6	Syzigium cumini (Java plum)	24
7	Artocarpus heterophyllus (Jack wood)	13
8	Terracotta	3

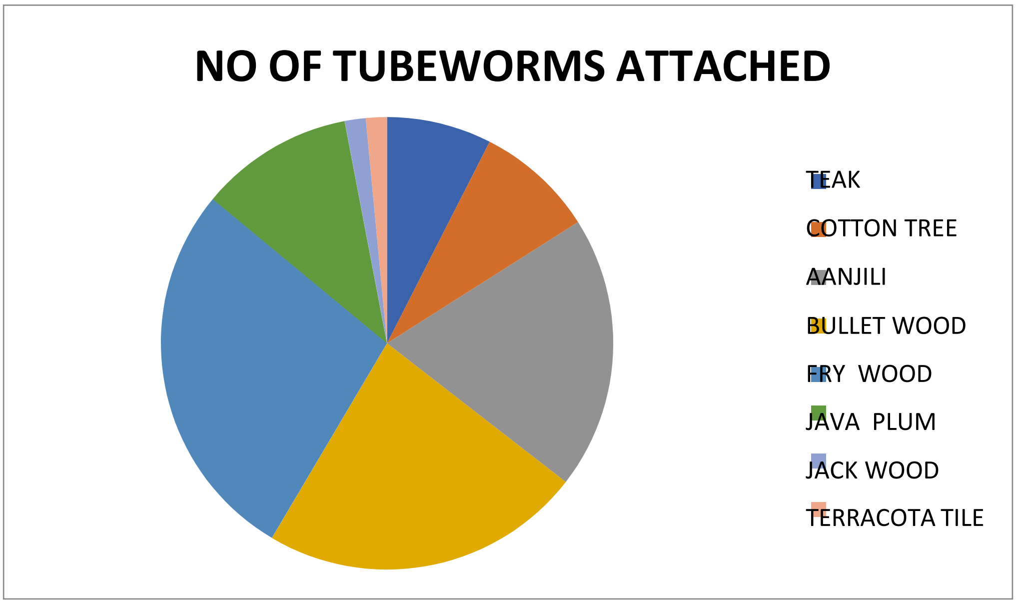

Figure 2: <u>Settlement of tubeworms on different panels</u>

TABLE 3 : Settlement of bryozoans on different panels

SL No	Name of timbers	No of bryozoans attached
1	Teak (*Tectonia grandis*)	28
2	Cotton tree (*Bombax ceiba)*	20
3	Aanjili *(Artocarpus hirsutus*)	35
4	*Bullet wood* *(Mimusops elengi)*	31
5	*Fry wood* *(Albizia lebbeck)*	19
6	*Java pulm* *(Syzygium cumini)*	4
7	*Jack wood* *(Artocarpus heterophyllus*)	1
8	Terracotta	44

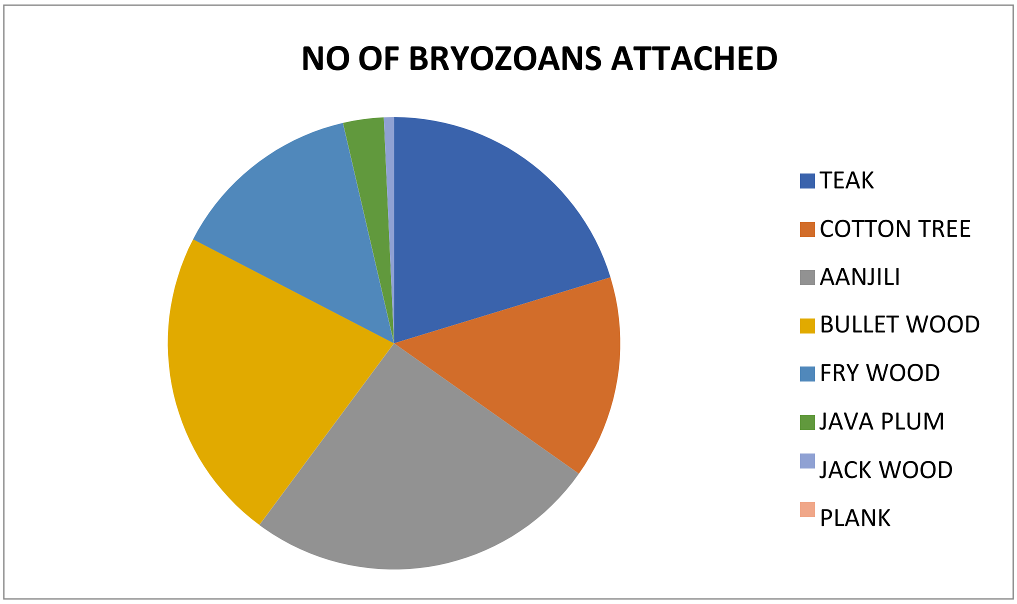

Figure 3: <u>Settlement of bryozoans on different panels</u>

TABLE 4: Settlement of Crassostrea madrasensis on different panels

SL No	Name of timbers	No of bryozoans attached
1	Teak (*Tectonia grandis*)	11
2	Cotton tree (*Bombax ceiba)*	7
3	Aanjili *(Artocarpus hirsutus*)	12
4	*Bullet wood (Mimusops elengi)*	27
5	*Fry wood (Albizia lebbeck)*	3
6	*Java pulm (Syzygium cumini)*	3
7	*Jack wood (Artocarpus heterophyllus*)	5
8	Terracotta	4

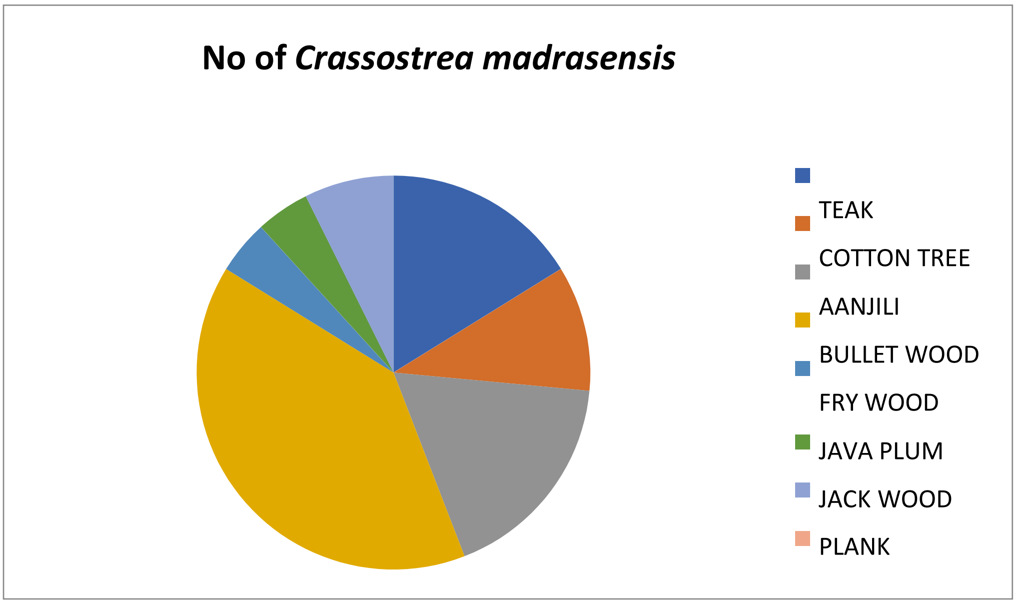

Figure 4: Settlement of *Crassostrea madrasensis* on different panels

TABLE5: Settlement of Hydroids on different panels

SL No	Name of timbers	Percent of Hydroids attached
1	Teak (*Tectonia grandis*)	O
2	Cotton tree (*Bombax ceiba)*	0
3	Aanjili *(Artocarpus hirsutus*)	50%
4	*Bullet wood (Mimusops elanji)*	75%
5	*Fry wood (Albizia lebbeck)*	0
6	*Java plum (Syzigium cumini)*	25%
7	*Jack wood (Artocarpus heterophyllus*)	0
8	Terracotta	0

TEAK

TREE COTTON

AANJILI

ELANJI

Fig 5: Settlement of barnacles on different panels

FRY WOOD

NJAAVAL

TERRACOTA

Fig 6: Settlement of tubeworms on different panels

TEAK

TREE COTTON

AANJILI

ELANJI

Fig 7: Settlement of *Crassostrea madrasensis* on different panels

TEAK

TREE COTTON

AANJILI

ELANJI

Fig 8: <u>Settlement of bryozoans on different panels</u>

AANJILI

ELANJI

NJAAVAL

Fig 9: Settlement of hydroids on different panels

Discussion

The outcomes of this research have provided insight into the differences between the resistances of various wooden panels to the biofouling organisms. A total of five marine biofoulers were predominantly identified which included *Balanus amphitrite* (barnacles) ,*Riftia pachyptila* (tubeworms),*Crassostrea madrasensis*(Indian oyster)and *Bugula neritina*(bryozoans),*Hydroides elegans(*hydroids). Amongst them Barnacles were the most dominant followed by tubeworms, bryozoans and larvae of Indian oyster.In addition, we found that trees with lower wood and tannin densities were more vulnerable to biofoulingthan higher wood density tree species. Together, these results indicate that biofouling and bioerosion of wooden marine infrastructure can be reduced through the strategic use of certain tree species and that interfere with the settlement and growth of these biota.

Wood consists mainly of two groups of organic compounds: carbohydrates(hemicelluloses and cellulose) and phenols (lignin), that correspond to (65-75%) and (20-30%), respectively. The wood is also constituted of minor amounts of organic extractives (usually 4–10%) and inorganic minerals (ash); mainly calcium, potassium, and magnesium, besides manganese and silica. Wood species with high wood extractive content have more protection against marine biofouling compared with those with less wood extractive content. However, not all extractives are toxic to marine biofoulers. In addition, wood hardnessalso influences durability against marine biofoulers. A combination of wood extractives and wood hardness will improve the durability of wood against marine bio fouler.

The wood species used in this study are 1.*Tectona grandis* (teak), 2.Bombax *ceiba* (cotton tree), 3.Artocarpus *hirsutus* (Aanjili), 4.*Mimosops elanji* (Elanji), 5. *Albizia lebbeck* (Fry wood), 6.*Syzigium cumini* (Njaaval), 7.Artocarpus *heterophyllus* (Jack). Panels (26cmx20cm) of these timber species were immersed in the waters of Cochin estuaries from 1701-2-2023 to 31-01-2023, the period during which maximum fouling occurs at this station.The faunal composition exhibited remarkable variation among different species of wood.

Based on the results(Fig1;table1) obtained by visual observation, it was found that the number of barnacles on *Artocarpus hirsutus* followed by *Mimusops elanji* was the greatest .This is because several
studies have shown a percentage of phenolic compounds lower in comparison . These phenolic compounds include flavonoid, phenolic acids, and tocopherols. Flavonoids are hydroxylated phenolic substances known to be synthesized by plants in response to microbial infection and they have been foundto be antimicrobial substances against a wide array of microorganisms in vitro. Tannins were known to possess general antimicrobial and antioxidant activities. Minimum fouling was recorded on terracotta tiles.

The patterns of settlement of tubeworms(table 2 and figure 2)was maximum tubeworm coverage was seen on *Albizia lebbeck* because it contains lesser phytochemicals related to alkaloids, anthroquinones,

Essential oils, Flavonoids , glycosides , phenolic , saponins, steroids and triterpenoids in comparison and minimum seen in terracotta due to its higher resistance of antifouling properties.

Settlement pattern of bryozoan (table 3 and fig 3), showed greatest presence on terracotta this could be because the clay mineral structures contain hydroxyls that are lost in water at elevated temperatures. The least settlement of bryozoans was shown by *Artocarpus heterophyllus* might be due to the presence of tetracyclic triterpenoids, a new prenylated flavonoid like 3-prenyl luteolin and phenolic compounds.

It was observed that the settlement of *Crassostrea madrasensis* (table 4 and fig 4) was maximum in *Mimusops elanji* and least in *Albizia lebbeck, Syzigium cumini* due to compounds rich in alkaloids, anthocyanin and glycosides.

As per table 5 and fig 5 the attachment of hydroids was low in almost all panels only a few wood showed attachment the maximum settlement of hydroids was noticed on *Mimusops elanji* followed by terracotta and *Syzigium cumini* which might be due to the presence of phytochemicals like flavonoids, alkaloids, saponins, phenolic chemical’s, steroids, lignin, cellulose, silic,ash and pentosane and also due to certain secondary metabolites like rhmanose,arabinose and galactose

The varying chemical composition and content of wood is responsible for their varying properties. At the same time the very presence of barnacles, tubeworms, bryozoans and *Crassostrea madrasensis* on all timber species probably points to the lack of adequate concentration of effective chemicals for complete prevention of bio fouling. Factors like availability of larvae, exposure depth of panels, interspecific competition, and surface chemistry of substratum which influence the intensity of fouling.

CONCLUSION

Seven wood species were screened for their antifouling properties against five fouling species. In situ Study on settlement of biofoulers employing wooden test panels shows that *Artocarpus heterophyllus*,*Syzigium cumini* and *Albizia lebbeck* among the wood panels along with terracotta used as a control panel shows maximum fouling resistance .The results shows that the wood species involved are effective against almost all fouling organisms like tubeworms, hydroids ,bryozoans, barnacles and bivalves.

According to the above result maximum resistance towards fouling organisms was shown by Jackwood (*Artocarpus heterophyllus)* and minimum by Bullet wood (*Mimusops elanji)*.the fouling organisms that we studied included Barnacles,Tubeworms,Bryzoans,Hydroids and Crassostrea madrasensis. Among them hydroids and Crassostrea madrasensis showed less settlement pattern on almost all wooden panels.

Barnacles had maximum number on *Artocarpus hirsutus* and minimum on *Tectona grandis* .The maximum *number of tubeworms* were recorded on Frywood (*Albizia lebbeck*) and the minimum number recorded on Jackwood (*Artocarpus heterophyllus*).Relatively lesser number of bryozoans settled on Jackwood (*Artocarpus heterophyllus*).On comparison Crassostrea madrasensis showed a lesser settlement throughout all the panels. Observation of hydroids showed greater growth coverage in Bullet wood (*Mimusops elanji*) and lesser growth in Java plum(*Syzigium cumini*).

Through the further detailed studies, biochemical assays, the chemical composition of these wood species can be found .Thus the chemical compounds responsible for the antifouling effects of *Artocarpus heterophyllus* ,*Syzigium cumini* and *Albizia lebbeck can* be identified. These compounds can be extracted and used in the manufacture of natural antifouling paints which will not cause threat to the environment.

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