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MODULAR SYSTEM MEANT FOR EPIBIONTIC BIOFILTER DEVELOPMENT IN THE BLACK SEA

MIHAI Carmen[1], GROSU Catalin[2], SCARLAT Razvan[3], VLADU Alina[4], ENE Alexandra[5], JOMIR Mihaela[6]

[1, 2, 3, 4, 5, 6] The National Research & Development Institute for Textiles and Leather, 16th Lucrețiu Pătrășcanu Street, 030508, Bucharest, Romania, E-mail: office@incdtp.ro

Corresponding author: Scarlat Razvan, razvan.scarlat@incdtp.ro

Abstract: *EU policy in the field of marine biodiversity, including protected areas, is developing in the context of global, regional, and European Union commitments. In this context, the ecosystem-based approach focuses on a management system that maintains the health of the ecosystem along with the proper use of the marine environment by humans, to the benefit of present and future generations. The natural marine epibiontic filter includes all living invertebrates attached to the stiff submersible substrate. Epibiontic organisms comprise all marine invertebrates that, during the juvenile stages, are fixed on hard natural supports (rock, submerged rocky platforms) and carry out their entire life cycle. The slow and insignificant recovery process of the natural biofilter in the coastal area of the Romanian Black Sea coast requires the elaboration of ecological methods meant to increase the populations of epibiontic organisms that constitute filters, able to accelerate the restoration of the marine environment in tourist areas on the coast. In order to improve the quality of the marine environment in coastal areas affected by anthropogenic impact, it is recommended to build epibiontic biofiltration barriers throughout the water column, including the affected sedimentary substrate. In this respect, a modular system was designed, created and experimented, which has the role of allowing the development of the epibiontic material.*

Key words: *ecosystem-based approach, epibiontic organisms, modular system, experiment, composite, floating system*

1. INTRODUCTION

Knowing the major ecological role of the epibiontic biofilter in seawater cleaning and the fact that, in recent decades, its natural restoration in coastal areas of major social and economic interest has been insignificant, it is necessary to find feasible and appropriate measures to ensure a quick inspection and the efficient rehabilitation of epibiontic organisms that feed the filters, strongly affected by anthropogenic impact [1,2].

Epibiosis that develops spontaneously in the Black Sea is composed of a group of organisms (mono/ multicellular algae, protozoa, coelenterates, mollusks, crustaceans, etc.) which, during the juvenile stages, attach to the rigid surfaces in the water (natural or artificial), where it carries out its entire life cycle [1,2]. The negative effect of reducing the bio-cleaning capacity of the natural epibiontic biofilter is visible every year, especially during the summer season, due to the poor quality of marine coastal waters outside urban areas and resorts (high turbidity and high biological load) [3,4,5]. In the Black Sea coastal area, epibiontic organisms grow in varying proportions almost throughout the year. This is supported by the constant presence in the water of a variable amount of larvae [4,6]. However, at certain times, the periodic increase of reproduction leads to the occurrence in the water of extremely numerous generations of larvae [7].

2. MATERIALS AND METHOD

The operating conditions in the open sea imposed the design and manufacture of some floating elements, with a special shape that could diminish the specific mechanical shocks [1,5]. Depending on the location area, the wave force, and the current intensity (agitation of the sea), the floating elements were designed taking into account a value for the hydrodynamic resistance coefficient in the range of (0.6 - 0.7).

In order to obtain a minimum resistance to the sea current and action of the waves, the cylinder and the double cone were chosen as geometric shapes, efficient in the operating conditions of the system: buoyancy, placement of the fastening and anchoring eyelets, stability in vertical plane [1,2,3].

Furthermore, to establish the values of the geometric parameters, it was taken into account that the resistant surface of the modular system increases by growing the attached biological material. Also, the action of external forces on the anchors increases proportionally [5,6,7].

The component elements of the designed modular system, manufactured and subjected to shore experiments and in open sea conditions are represented by:

1. ***the floating superstructure;***
    - 1 floating element located offshore - ME1;
    - 1 floating element located in the shore area - ME2;
    - 1 central floating element for system support and for growth and development of biofiltrating material (mussels and oysters) - ME4;
    - 4 floating elements for the controlled growth of mussels - ME5;
    - 2 floating elements for the controlled growth of mussels and the development of oysters - ME6.
2. ***submerged enclosure for oyster larval development - ME7;***
3. ***artificial collectors for the controlled growth of mussels and the development of oysters;***
4. ***subassemblies for fixing and supporting the modular system:***
    - 1 submerged cylinder for fixing the floating elements for growth and development of biofiltrating material (mussels and oysters) - ME3;
    - 2 main anchors, mooring type;
    - 1 secondary anchor, mooring type.

The physical-mechanical parameters of the composite textile structures used in the construction of the seven experimental models are presented in table 1.

Table 1: *The physical-mechanical parameters of the composite textile structures*

Parameter	ME1	ME2	ME3	ME4	ME5	ME6	ME7	Reference document
Raw material	100% PES	50/50 PA/ PES	55/45 PA6.6/ PES	100% PES	100% PES	100% PES	100% Cotton	-
Mass, g/m^2	237	436	437	1123	301	303	312	SR EN 2127:2003

Tensile strength, daN warp/weft	232/ 225	365/ 375	412/ 410	530/ 550	210/ 220	204/ 217	287/ 172	SR EN ISO 13934-1/2013
Tear strength, daN warp/weft	65/62	25/22	38/42	55/65	20/33	25/29	12/13	SR EN ISO 13937-2/2001

The testing of the experimental model of the modular system for the development of the biofiltrating material was performed in collaboration with the researchers and the diving team from The National Institute for Marine Research and Development “Grigore Antipa“ Constanta. The test location chosen was The National Institute for Marine Research and Development “Grigore Antipa“ Constanta - *Pescarie* area, Mamaia (coordinates: 44°12’54.80” N; 28°38’55.94” E) (Fig. 1).

Fig. 1*: The experimental activities location of the experimental modular system model for the development of the biofiltrating material: Pescarie area, Mamaia*

The hydrometeorological test conditions were:
- clear sky, light wind from the SE direction (speed 10-35 km/h);
- air temperature: 20-24°C;
- seawater temperature: 18-25°C, salinity: 13‰, surge: 20-100 cm;
- seawater depth at the location: 3m.

3. RESULTS AND DISCUSSIONS

The results obtained after testing and verifying the modular system for the development of the epibiontic biofilter (Fig. 2) show that:

- The textile materials have matched the imposed requirements and the composite structures comply with the technical quality conditions stipulated by the norms in force for these types of materials [3,4].

- The characteristics for each subassembly of the system correspond to those stipulated in the norms imposed by design from the geometric, dimensions, and colors point of view.

a. b. c. d.

Fig. 2. *Dimensional and gravimetric checks of the experimental model:*
a. ME4 - Central floating element to support the system; b. ME1 - Floating element located offshore; c. ME6 - Floating element for controlled growth of mussels and oyster development; d. ME2 - Floating element located in the shore area; ME5 - Floating elements for the directed growth of mussels.

- The main and secondary anchors were fixed on the marine substrate, allowing the extension of the connecting elements of the floating elements, the entire modular system being stable and positioned appropriately for the following tests. All floating elements from the modular system, respectively: the floating element located offshore - ME1; the floating element located in the shore area - ME2; central floating element for system support and for growth and development of biofiltrating material (mussels and/ or oysters) - ME4; the floating element for the controlled growth of mussels - ME5; the floating element for the controlled growth of mussels and the development of oysters - ME6 have kept their shape and implicitly the dimensions imposed by the specifications. In addition, the loads produced in the installation under the action of external dynamic forces are evenly distributed on anchorages and anchors (Fig. 3).

a. b. c.

Fig. 3. *The floating elements transport and launch:*
a. the ME2 and ME4 transport to the waterfront; b. the ME2 and ME 4 launch into the water;
c. the ME6 transport in the test area with the help of the diving team from The National Institute for Marine Research and Development "Grigore Antipa" Constanta

- After 10 days of exposure in open sea conditions, floating elements located offshore - ME1 and on the shore area - ME2, the central floating element for support the system and for growth and development of biofiltrating material (mussels and/ or oysters) - ME4 and the floating element for the controlled growth of mussels - ME5 remained in position, showing no damage due to open sea conditions. In addition, the loads appearing in the installation under the action of external hydrodynamic forces are evenly distributed on anchorages and anchors. Deposits of epibiontic material were not found for these floating elements either (Fig. 4).

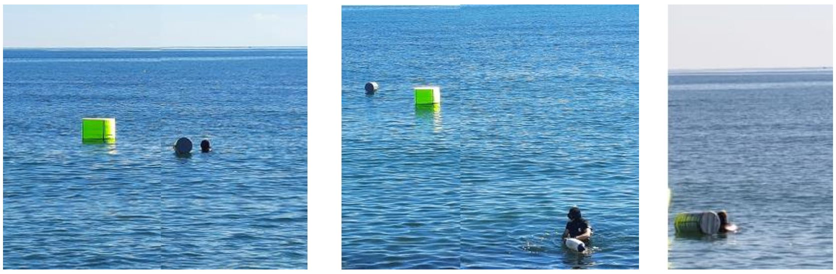

Fig. 4. *Qualitative inspections of modular system for the development of biofiltrating material (ME1, ME2, ME4) performed by the diving team of The National Institute for Marine Research and Development "Grigore Antipa" Constanta*

- Following the inspections, traces of deposits of living organisms were found on the floating elements (Fig. 5).

a b

Fig. 5*. Inspection of the floating element ME1:*
a. located offshore; b. inspected at the shore

- The immersed part of the floating elements is covered with a thin, slippery, brown film with a mucilaginous texture, represented by cyanophyte colonies (Cyanobacteria branch) (Fig. 6). No fixations of epibiontic macro-organisms (*Balanus spp.* or *Mytilus galloprovincialis*) were found.

Fig. 6*. Deposition of epibiosis on ME1 - floating element located offshore*

5. CONCLUSIONS

The experimental model of the modular system for the development of biofilter material designed made by specialists from The National Research and Development Institute for Textiles and Leather Bucharest was tested on shore and in open sea conditions in collaboration with researchers and the diving team from The National Institute for Marine Research and Development "Grigore Antipa" Constanta. The chosen test location was The National Institute for Marine

Research and Development “Grigore Antipa“ Constanta - *Pescarie* area, Mamaia (coordinates 44° 12'54.80 "N; 28° 38'55.94" E).

After 20 days of immersion in the conditions of the Romanian coast, on the floating bodies was found the formation of a thin film of micro-epibiosis, represented by the cyanophyte colonies (Cyanobacteria Branch). During the monitoring period, no fixations of epibiontic macro-organisms (*Balanus spp*. or *Mytilus galloprovincialis*) were observed.

The tests continue, according to the experimental program, depending on the biological development cycle of the epibiontic biofilter, in order to establish the technical resource of the composite materials from the system and to determine the productivity of epibiontic material on its collectors.

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