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THE USE OF EPIBIOSIS PRODUCING FACILITIES FOR A SUSTAINABLE MANAGEMENT OF THE MARINE ENVIRONMENT QUALITY

Cornel URSACHE, Tania ZAHARIA, Victor NIȚĂ

NIRDEP - National Institute for Marine Research and Development "Grigore Antipa", 300 Mamaia Blvd. 900581, Constanța, Romania

ABSTRACT

The epibiosis that develops spontaneously in the Black Sea is composed of a cluster of organisms (mono/multicellular algae, protozoa, coelenterates, bryozoans, mollusks, crustaceans etc.), which, during juvenile stages, attach themselves on existing rigid surfaces in the water mass (natural or artificial), where they run their entire life cycle. The qualitative and quantitative structure of this epibiosis varies depending on the existing environmental conditions, but generally bivalve mollusks prevail, with over 80% of the total biomass.

A modern and efficient technology for obtaining marine epibiosis in the Romanian Black Sea coastal area is the arrangement in seawater between the 10 to 15 m isobaths of marine equipment - **floating facilities** - able to maintain suspended in the water column suitable artificial supports, for the fixing and growth of epibiotic bodies.

Under the specific environmental conditions of the Romanian Black Sea coast, the marine organisms comprised in the epibiosis have an explosive growth, reaching mean biomasses of approx. 6 to 8 kg living biological material per m^2 on support and ensure a biomass of approx. 3 t/facility/growth cycle.

Due to the biodiversity of bodies in the structure of marine epibiosis (approx. 30 species), it has, as a whole, a complex biochemical composition comparable to animal products and a higher bioactive compound content - essential amino acids, vitamins, enzymes and hormones - that can be capitalized in animal husbandry, both fresh and processed.

The production technology of marine epibiosis enables obtaining substantial profits by using unexploited marine areas and is a completely ecological method, aiming at improving marine water quality of the tourist zone littoral areas, by the quantitative increase of epibiotic biofiltrators.

KEY-WORDS: *marine epibiosis, mono/multicellular algae, protozoans, coelenterates, bryozoans, mollusks, crustaceans, floating facilities*

BACKGROUD

Marine water quality in shallow areas is of major importance for coastal zones of tourist and leisure interest; it must be transparent, without impurities and the biological load must be minimized, whether or not composed of bodies with or without direct effects on humans.

Municipal waste waters discharged in shallow areas close to urban clusters contain additional significant amounts of organic suspensions, various organic and inorganic compounds dissolved in water, high fungi and bacteria load.

The additional nutrient and organic matter input exceeding the real food consumption requirements led to the increase of primary planktonic productivity, the frequency and extent of blooming phenomena, followed by the negative effect generated by it - hypoxia and anoxia -, benthic fauna fatalities, sharp reduction of biodiversity and depopulation of areas bordering the pipe discharge outflows.

The severe imbalance of the marine ecosystem, caused by the increase of eutrophication, equally affects biological resources and significantly reduces the bathing qualities of marine waters, entailing significant risks for public health.

The above mentioned negative issues point out the urgent need of initiating concrete actions for the improvement of the marine environment quality in the shallow sectors, areas extremely important for tourism and leisure activities.

For the improvement of the marine environment in tourist coastal areas, it is imperative to improve, first of all, the quality of the discharge wastewaters and the simultaneous use of an ecological method.

As the Romanian shallow marine area hosts acknowledged natural bio-filters, which can efficiently cleanse marine waters - epibiotic bivalves -, the use of such bodies is envisaged for the improvement of the marine environment in tourism and leisure coastal areas.

Photo 1. Mussels attached to the natural substrate

As such, an ecological method for improving the qualities of marine waters in areas affected by wastewater discharges was tested, consisting in constructing a barrier of local epibiotic bio-filtering bodies, using the proper technical means.

MATERIAL AND METHOD

Marine epibiosis, developing spontaneously on the rocky facies of the littoral zone, is an important component of the Black Sea ecosystem, with a major ecological role in the sustainable development of the marine environment quality/natural biofilter of the coastal zones.

The arrangement of an autochtonous epibiotic biofilter barrier can be made by using marine equipment adapted to the hydro-meteorological conditions typical for the Romanian Black Sea area (Ursache, 1993).

The application of the bivalve culture technology ensures stable marine epibiosis biomasses, with relatively small expenses, by capitalizing an important marine resource - phytoplankton - in coastal areas not suitable or not profitable for other activities.

The biotechnology for producing marine epibiosis on floating facilities is a fully ecological method, dedicated to improving the marine water quality in the tourist interest coastal areas, by means of autochtonous epibiotic biofilters.

Producing marine epibiosis requires the construction and arrangement in the water mass of marine facilities specific for the major stages of the technological process, tightly connected with the biological status of the natural populations of bodies in the natural environment and the evolution of hydro-climatic conditions in the area.

An efficient technology for obtaining marine epibiosis in the Romanian Black Sea coastal area is the arrangement in seawater between the 10 to 15 m isobaths of marine equipment - **floating facilities** - able to maintain suspended in the water column suitable artificial supports, for the fixing and growth of epibiotic bodies.

The population of the artificial facilities set out at sea with filtering epibiotic bodies is made naturally, by larvae resulting as a follow-up of mussels breeding in the area. The high density of epibiotic bodies attaching themselves to the arranged artificial surfaces and their explosive growth ensures the production of a biomass of approx. 3 t/facility/growth cycle.

Applying this method shall lead to the production of large amounts of marine epibiosis, which shall contribute to the improvement of the marine water quality in the area, by the quantitative increase of epibiotic bio-filters and by the consequent enhancement of their bio-cleansing efficiency.

RESULTS ANS DISCUSSION

Technical Means for Producing Marine Epibiosis

The absence of naturally sheltered areas reducing the destructive force of waves and the low amplitude of tides in the Black Sea (approx. 11 cm, with an average period of 12 hours and 25 minutes) do not allow arranging directly on the substrate artificial collectors to entrap the juveniles, due to the fact that during violent storms, generating waves and marine currents, the rearing platforms can be destroyed or covered by sand and algae fragments.

The only accessible option for rearing epibiotic bivalves in the Romanian coastal area of the Black Sea is suspended rearing in the water mass, on floating facilities (Ursache, 1993).

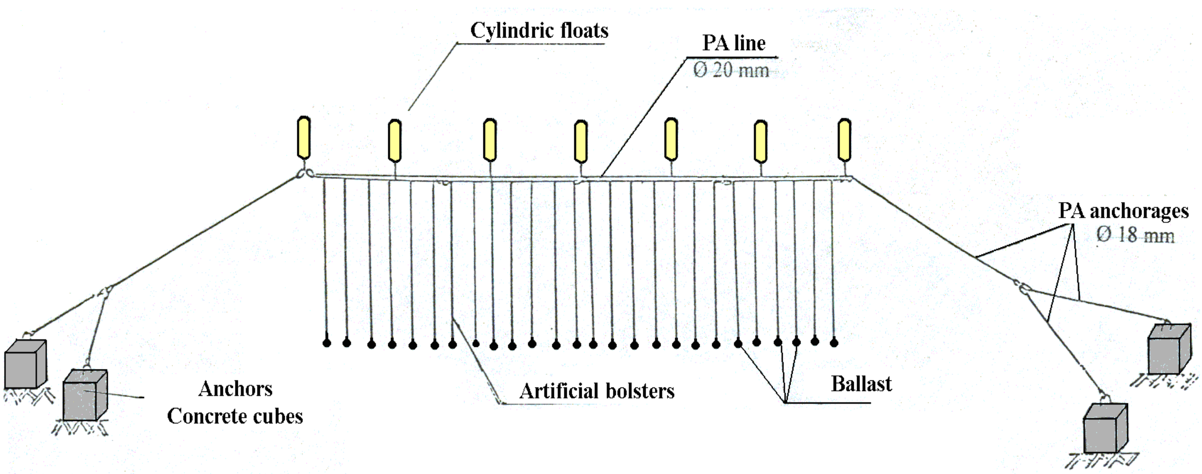

Fig. 1. Floating faclity equipped with artificial collectors

Rearing bivalves suspended in the water mass, where phytoplanktonic food is more abundant, requires the construction of floating marine equipment, able to support the populating material submerged 1 to 5 m deep.

Under the typical hydrological conditions of the Romanian Black Sea coast, the floating facilities meant for suspending the epibiotic bivalve rearing artificial floaters in the waters mass were designed to be made of polyamide textile fabric (PA relon ropes), comprising two distinct sub-assemblies:

- the floating suprastructure, anchored on location;
- artificial bolsters suspended in the water mass.

When designing the marine facilities, we aimed at annihilating the destructive force of the hydro-meteorological factors - wind, marine currents, wave height and extent, surge, nature of the substrate - by means of marine engineering elements: material strength in the marine environment; flotability requirements and anchorage system, helping create a floating facility model able to withstand the environmental conditions of the location they shall be set in (Adam et al., 1981; Anton et al., 1989; Voinicanis, 1954).

Work Methodologies

The technical-functional and biotechnical researches were carried out on the biofiltering barrier arranged in the outflow area of the Constanța North Wastewater Treatment Plant, between May and November.

In order to maintain the normal integrity and operability of the facility, monthly check-ups were carried out by means of autonomous divers and, in case of damages occurring as a follow-up of bad weather (collectors entangleing, float breakage etc.), quick interventions for repairs were ensured.

Througout the immersion, quantitative samples were collected, consisting in epibiotic bodies from the collectors attached to the floating facility. The collected samples were analyzed both quantitatively and qualitatively in the laboratory, pursuant to the classic methodology for investigating benthos samples, in order to identify the structure and quality of the bio-filters present during the above mentioned months, as well as their evolution in time.

In order to size more accurately the amounts of bio-filters attached to the artificial collectors, qualitative-quantitative analyses were performed on epobiosis samples collected from the - 1m, - 3 m, - 5 m depths.

Photo 2. Mussels attached to the artificial bolster

In order to assess the water bio-filtering capacity of filtering epibiotic bodies attached to artificial collectors, we proceeded to collecting simultaneously 12 water samples from the area close to the site of the floating facility and performing qualitative-quantitative laboratory analyses of the chemical composition and microbiological load of marine waters.

The samples were collected at 0.5 m, 5 m and 10 m, to the shore and open sea in relation to the suprastructure of the facility. Water samples from the 1 m, 3 m and 5 m isobaths were collected from each distance.

In order to compare the results obtained in the polygon with a witness sample, three water samples were collected from a 100 m distance from the facility, on the above mentioned isobaths. These analyses aimed at assessing directly into the sea the biofiltering efficiency of the epibiotic bodies present on the artificial collectors.

Results Obtained

Bioproductivity of the Floating Facilities

The artificial bolsters for the natural attachment of epibiotic bodies on the floating facilities are represented by artificial collectors immersed in the water mass, yet significant attachments of epibiosis are also encountered on the floating suprastructure and the anchorages of the facility, made of relon lines.

The marine epibiosis attached naturally and developed both on artificial bolsters specially designed for the attachment of epibiotic bodies - artificial collectors in the water mass - and on the floating suprastructrure of the facility, made of relon lines.

One artificial collector, 5 m long, made of relon line and provided with knots every 30 cm, is an artificial bolster with an initial area of 0.3768 m^2.

Considering the annual biological cycle both for epibiotic invertebrates and epibiotic micro and macroalgae, it is recommended to launch the facilities at sea during April-May, when most of the mentioned bodies have a very high metabolic activity and breed massively.

The first to attach themselves on the artificial collectors launched into the sea are epibiotic micro-organisms (microalgae, micro-fungi, protozoans etc.), forming the first bioderm layer. On this bioderm layer, depending on environmental conditions, seasonal macrolagae embryos, bivalve mollusk post-larvae, bryozoans and cirripeds attach themselves naturally and successively, and subsequently grow and reach maturity.

Given the fact that seasonal macroalgae and epibiotic invertebrates breed 2-3 times a year (during March - November), on the first layers of bodies already attached to the bolsters, new generations shall attach themselves, leading to a significant increase in time of their biomass.

The qualitative structure and especially the amount of epibiotic bio-filters on the artificial bolsters in the sea depends on the characteristics of the abiotic and biotic environmental factors, such evolution being specific for each year and reference season.

After having analysed the samples on age classes, about 56% of the annual biomass of these filters is a follow-up of the intense spring breeding of the bodies it comprises. The remaining biomass accumulates subsequently, after the summer-autumn breeding of the epibiotic bodies.

The total amount and the amount divided on groups of epibiotic bodies per 1 m of artificial collector suspended in the water mass at the end of July (three months after the launch) is given in Fig. 2.

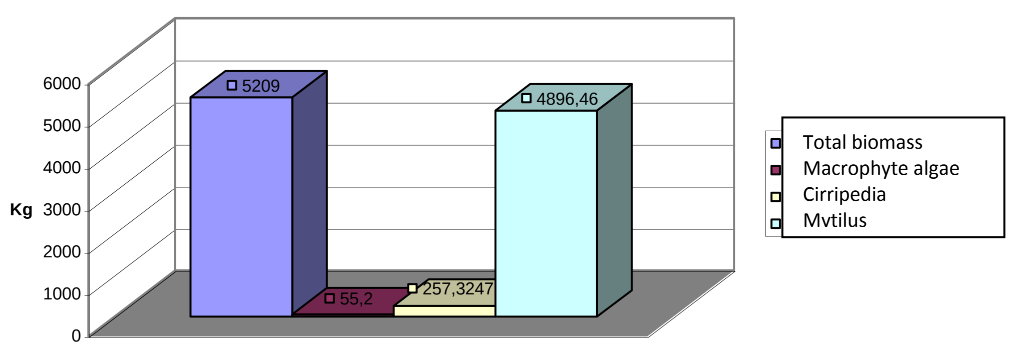

Fig. 2. Total and living body group attachments (biomasses) on the artificial collectors set on the floating facilities, three months after launch

The total biomass of the bodies present on the collectors three months after the launch into the sea is, on average, about 5.209 kg/m collector.

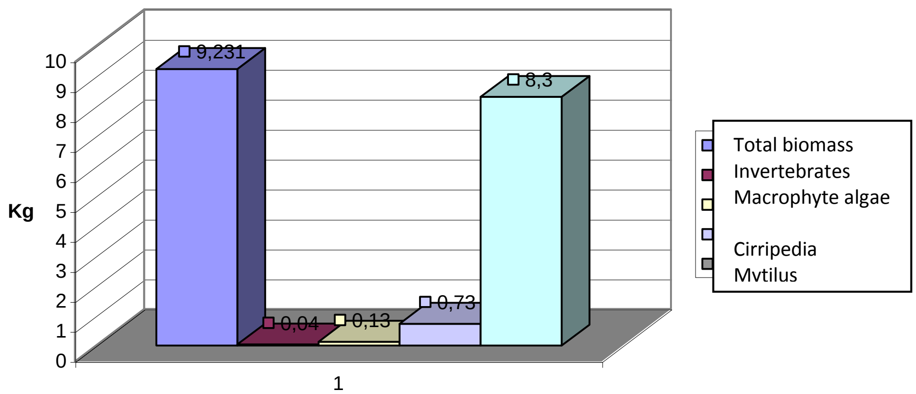

Fig. 3. Total and living body group attachments (biomasses) on the artificial collectors set on the floating facilities, seven months after launch

Among the bodies populating the collector, mussels are clearly predominant, reaching about 94% of the biomass, followed by cirripeds (balanus), with about 4.94% of the total. The remaining existing biomass, of about 1%, is covered by seasonal macrophyte algae, which, as it is known, have a very short life cycle.

Making a ratio between the average biomass achieved on the area and the total surface covered by the artificial collectors, we estimate that the total biomass for one facility in June is 1,719 kg.

At the end of October, seven months after launching, the average amount of epibiotic bodies covering 1 meter of collector is 9.231 kg.

The biomass covering the artificial collectors of the floating facility, seven months after launch, is clearly dominated by mussel juveniles (about 90%), followed by cirripeds, about 8% of the total biomass.

Seasonal algae reach about 1.5%, while the 0.5% difference is represented by invertebrates.

By multiplying the average existing biomass per collecting unit by the total length of the collectors attached to the facility suprastructure (L_{total} = 330 m), it results that the total biomass of epibiotic bodies on the collectors reaches about 3,000 kg, only seven months after their launching.

We mention that, for technical reasons, the significant attachments of about 500 kg of epibiotic bodies present on the floating suprastructure of the facility and the anchorage lines were not assessed quantitatively.

Marine Water Bio-cleansing Capacity of Filtering Epibiotic Bodies

In order to answer their main vital requirements, the filtering epibiotic invertebrates apprehend from marine water “actively inhaling“ the oxygen used for breathing, as well as various trophic bio-components: phytoplanktonic micro-organisms (bacteria, micro-algae, fungi and macroalgae sporules), organic detritus, of sizes and shapes appropriate for ingestion, all used as food. By means of the own organs and filtering mechanisms of each invertebrate group, they also apprehend from the water mass various inorganic particles in suspension, which, after embedding in mucus, they eliminate on the hard substrate.

By filtering the water, invertebrates contribute to its bio-filtering (by micro-organism consumption), as well as to reducing turbidity, by apprehending from the water mass the suspended inorganic particulates, thus favoring the penetration of sunlight into the water.

Among local bio-filters, the most efficient filtering bodies are mussels: 1 kg of mussels can filter simultaneously, up to 65 ÷ 80%, a volume of 5 ÷ 6 m^3 in 24 hours. Out of the total biomass of bodies attached to the artificial collectors, mussel juveniles often reach 80 ÷ 95%.

In order to assess the water cleansing capabilities of the epibiotic bio-filters attached to the artificial collectors, water samples collected simultaneously close to the location site of the floating facility were collected.

The highest amounts of phytoplankton were reported in samples collected 10 m to the shore off the suprastructure position, at the three isobaths analyzed.

5 m off the facility, the phytoplankton densities recorded at the three reference isobaths are on average about 23% smaller than those for 10 m.

The lowest phytoplankton densities were recorded in samples collected from the minimum distance of solely 0.5 m from the facility axle.

At approx. 5 m off the facility location site, an increase of the phytoplankton density compared to the areas close to the bio-filtering barrier was reported.

Based on the results obtained after analyzing the 5 m and 0.5 m samples, we can conclude that the epibiotic biofilters attached to the collectors suspended in the water mass actually contribute to reducing the phytoplankton amounts in marine water.

The epibiotic bio-filters on the collectors apprehend and preferably absorb the microalgae belonging to the groups *Bacillariophyta* and *Chrrisophyta* (Fig. 4).

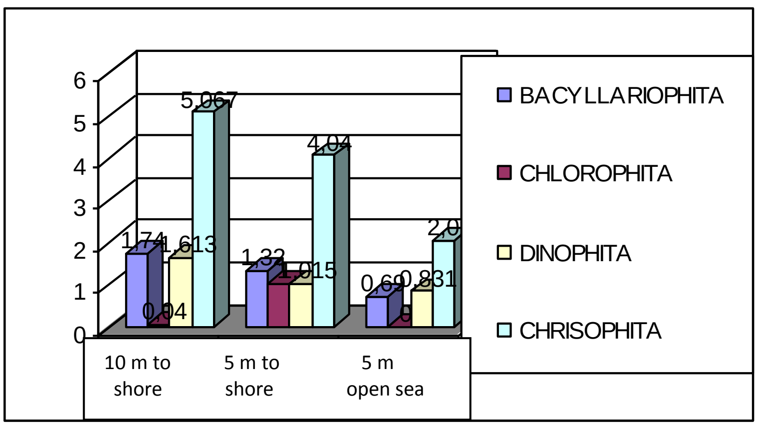

Fig. 4. Amount of marine phytoplankton (density) on systematic groups in the location area of the floating facility, in relation to the sample collection distance

The epibiotic bodies are highly selective in the consumption of the microalgae species comprised in marine phytoplankton as well (Fig. 4).

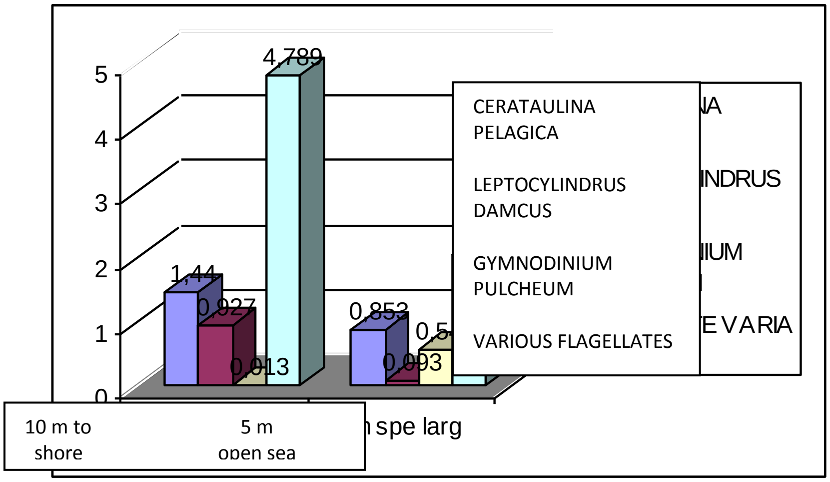

Fig. 5. Selective algae consumption by the epibiotic filters attached to artificial collectors

Given the fact that qualitative-quantitative analyses of the phytoplankton, performed on the samples collected in the area of the bio-filtering barrier only provide indicative information on the micro-algae consumption of epibiotic bio-filters, due to the continuous water movement and, consequently, the modification of the phytoplankton in marine water quantity and quality, a test was performed in an exterior stale water tank, in order to measure accurately the amount of phytoplankton consumed.

Based on the initial phytoplankton in the tank compared to the density recorded 24 hours after introducing the 15.62 kg of living epibiotic bodies, with the above mentioned quality/quantity composition, it was measured that one kg of epibiotic bio-filter can consume up to 73,517 million micro-algae/24 hours.

Making a ratio between the cleansing capacity and the average amount (approx. 3,000 kg/year) of bio-filters attached to the collectors of one facility, it results that these bodies could purify of algae to an extent up to 95% a total volume of 126,346 m^3 marine water in 24 hours.

CONCLUSIONS

An ecological solution for improving the marine environment quality in areas affected by human impact is the construction of an epibiotic barrier, which, by means of the natural filtration process, can contribute to the biocleansing of water in the area.

The population with epibiotic bodies of the artificial collectors is made exclusively by natural attachments.

Seven months after launching the mariculture facilities, the average value of the epibiotic bodies' biomass per 1 meter of collector device is 9.23 kg/m, while the mean bioproductivity is approx. 2.5 - 3 tons, depending on the hydroclimatic conditions during each season.

Mussels are by far dominant on the mariculture facility collectors, reaching 90% of the biomass, followed by cirripeds, with about 8% of the total. Seasonal algae represent approx. 1.5%, while the remaining 0.5% of the total biomass comprises epibiotic invertebrates.

Depending on the mean bio-cleansing capacity of marine water, established through tests out at sea and laboratory analyses, it results that the epibiotic invertebrate biomass attached to the artificial collectors can filter and purify biologically, to an extent up to 80-90%, a total volume of 126,346 m^3 during a 24 hour cycle.

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