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Water pollution

COASTAL WORKS EXTENSIONS ON THE ROMANIAN TOURISTIC LITTORAL, ITS ECOLOGICAL IMPACTS ON THE NEARSHORE BATHING AREAS

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Abstract. Certain vulnerable bathing areas of the Southern Romanian littoral units are strongly influenced by the progress of the inland and coastal works in the context of sea level rise on a regional and local scale. The sand cells and new formed artificial sandy beaches include the sediment changes between submerged shore and adjacent; they are the major issues within the sediment budget of littoral areas. The paper provides an outline of the outcome of a series of studies carried out for the certain bathing areas of the southern Romanian littoral, especially of Mamaia Bay, with a view to providing an assessment of the ecological levels of impact induced by the coastal works and delineation of several coastal protection required solutions, extended in order to reduce the impact on the coastal hydrodynamics, its compliance with the ecologically accepted energetic parameters.

Keywords: coastal processes, coastal works, ecological impact, bathing areas, ICZM (Integrated Coastal Zone Management).

AIMS AND BACKGROUND

The interest zone analysed in this paper is the Romanian coastline stretching from Midia Cape – Navodari and Vama Veche at south (border with Bulgaria), with a length of approximate 82 km (Fig. 1). The area is of national importance concerning the economic, social, and tourism, being developed for port activities, housing, industry and tourism in particular, bathing and sunbathing.

The topography of this area is characterised by low altitude shores – beaches (80%) and relatively high shores – cliffs (20%).

The area is characterised by the presence of the hydraulic structures, natural and protected cliffs, cliffs, beaches located to the cliffs with steep underwater

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slopes. Some beaches have been artificially reconstructed, which introduced new sediment to the beach system[1].

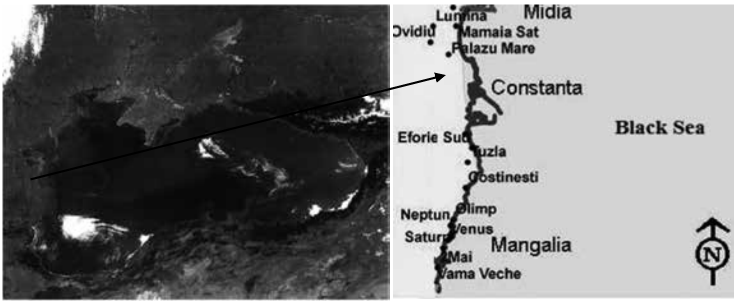

Fig. 1. The study area

EXPERIMENTAL

The coastal zones are ecologically fragile. This fragility is determined by the natural factors which are affected by the high impact activities on the environment. The ecologically fragile areas represent the areas whose dynamics in time and space is or may be adversely affected by a number of natural or anthropogenic factors[2]:

– The aquatic environment has a limited potential for self-purification, and from this its required a certain energetic level of the marine hydrodynamics;

– Biotic environment is very sensitive to energetic parameters of nearshore hydrodynamics;

– Presents a shore dynamics imposed a significant abrasion of the sea level rise and the shoreline features;

– Biotic environment is very sensitive;

– Especially Benthos shows very high vulnerability to changes.

– Climate risks, which constitute a risk factor for human activities (within the ports) with a high frequency.

Environmental issues identified in the Romanian coastal zone induced by the anthropogenic factor (dried-marine area) are: coastal erosion/sediment dynamics; unfinished flood protection solutions; sea water intrusion in coastal aquifers; water pollution/air, solid waste pollution from diffuse sources; population agglomeration in the coastal zone, in season; uncontrolled development of tourism construction and tourism and recreation activities over the carrying capacity of the environment; maritime and road transport in coastal areas: the execution of a technological road over coastal protection in the North Constanta; natural resources/sand beach extraction; exploitation of the fish stocks; habitat/endangered species loss – construction of coastal protection cliffs; urban expansion beyond littoral area carrying capacity[3–5].

The coastal protection works affect the local sediment transport and helps to maintain a beach along the front. The hydraulic structures existing in the study area are: dams, breakwaters, jetties, sea walls, touristic ports, etc.

The many dams built since 1980 had led to fluctuations in the shoreline position, as these structures were determined by forming the accumulation of localised deposits, unnoticed in previous periods. The development of the three ports (Constanta, Midia and Mangalia) resulted also in a major change sediment drift along the coast. Since 1980 there has been an increase of the erosion rates compared with previous periods. The only sector, characterised by accumulation, is Midia, although even here the rates were slightly lower since 1980 (about 2 m/year). The erosion was more pronounced in the northern and central barrier of Mamaia after 1980 (values over 2 m/year) (Fig. 2). The Eforie barrier was characterised by rates of erosion of 2 m/year, with higher values along the southern extremity. Slightly lower erosion rates (less than 2 m/year) were recorded at Neptun seaside. The highest rates of erosion are recorded in the Mangalia, at the south breakwater, with rates of over 4 m/year (Ref. 1).

Fig. 2. Photo of coastal hydraulic structures – Mamaia breakwater

The Vama Veche – 2 Mai coastal zone was a line of accumulation, however, in the period 1960–1980, due to the effect of the southern breakwater of the port of Mangalia on sedimentary contribution, this section of coast has become one of erosion, with the erosion rate of approximately 3–4 m/year (Ref. 1).

The current defenses structure is in poor condition and is expected to yield within a few years. The proposed coastal works are[1]:

– rehabilitation of the existing defense systems or building of new defense structures;

– sanding of artificial beach to provide protection against coastal erosion;

– since the beach has a great socio-economical value, for creating and retaining the beach are recommended the lightweight protection, possibly in combination with the heavy defense systems.

The ‘*soft*’ protection are the beaches sanding process whereby the sediment beaches are artificially restored us, with or without protection of beach structures, the method of 'by-pass' or recycling sandy beach, and the '*hard*' protection solutions are represented by the breakwaters and artificial reefs, the protection of rocks and groins.

The breakwaters have the advantage of providing a stable environment for shellfish growth, a source of sediment to the beach.

The heavy protections include the linear structures such as vertical walls and protection of concrete structures built along the shoreline. This type of protection is usually built at the foot of cliffs in order to achieve the promenade by the sea.

The coastal zone is running a permanent program of the Black Sea Integrated Monitoring, supported by PHARE and TACIS Programs. For this monitoring are use the spatial data and NIMRD monitoring and surveillance coastal erosion and water quality data[6].

Also the support of the marine integrated monitoring (sub) systems, developed gradually towards an integrated surveillance system by using the in situ automatic equipment and remote sensing data, includes marine pollution and accidental oil pollution, shellfish water, dangerous substances in dredged sediments within ports and maritime shipping routes; monitoring of ballast waters; monitoring of coastal erosion, biological diversity, with special attention on marine mammals populations including accidental catches and stranding, as well on marine habitats, bathing waters and beaches quality, extreme marine phenomena (with meteo-hydrologic and tectonic causes)[6].

For the purposes of the marine waters monitoring a representative and precise network of stations was design to sustain the continuity of the assessment of the marine and coastal environment status.

The studies based on the physical hydraulic models, dimensioned at different dimensional and the studies based on the numerical models for the simulation of the response shoreline in the vicinity of natural cliffs and/or of the cross dams, prepared in connection with the formation and expansion of the protected beaches from the Romanian seaside, have been performed using a operative methods, graphics, adjustment of the two-dimensional numerical model with results less realistic forecasting the diffraction and refraction processes of the wave[4,7].

Thus, the size optimisation in plan of the concave beaches from the South Mamaia, requires beyond the achieved of the coastal protection Master-plan, should be considerate the main graphical methods to improve the prediction of the shoreline shape and the stability of the morphological formations obtained after the execution of the artificial sanding protected by the groins and extended longitudinal breakwaters.

For the simulation of a concave beach shoreline it is used a graphical method of the logarithmic spiral, according to which the angle between the radius vector

R and the tangential to the intersection point with the radius vector is constant. This spiral satisfies another condition:

$$R_2/R_1 = \exp(\alpha \text{ ctg } u),$$

where R_1 and R_2 are the lengths of two radius-vectors and α – the angle between the two radius vectors, u – the angle between the radius vector R and the tangential to the intersection point with the radius vector.

In essence, the trace method the development trend of the shoreline in bays admits a stake centre of the spiral in the dominants movement direction, relative to the fixed point in the downstream of beach or groins. Both mentioned conditions have subjectivity elements in the formulation; the successful application of the method depends on the synergistic combination of a main system components and interactions of the marine and the coastal environment. In time, confronted to the terrain studies, the method was processed by the partial simulation of the shoreline by spiral segments, in the international community; application software of the parabolic model MEPBAY was realised, towards the stability of the sandy coastal beaches.

The software of the protection hydraulic systems implementation from the South Mamaia zone on the situation plan, is different from that achieved by the designer and it is necessary a manual tracing of the results on the execution plan of these protection solutions.

Thus, for the implementation of the artificial sanding, in the parabolic graphical application, the topographic maps were used and the used procedure has considered[8]:

(1) choosing of a line command Ro, an upstream point of the wave diffraction and the one/in the dominant sense of the drift littoral like the position limiting of the development shoreline which can be influenced by the incidence waves by the diffraction process;

(2) establishment of the dominate waves – by the incidence angle β;

(3) calculation of the wave lengths R_n by the θ angle which radiating outside of the upstream diffraction point, for constant intervals of 10 degree, calculated using the following equation (Fig. 3):

$$R_n/R_\beta = C_0 + C_1(\beta/\theta_n) + C_2(\beta/\theta_n)^2 \qquad (1)$$

where R_n is the distance from the point of diffraction to the beach at an angle θ between the wave crest line and the said radius; R_β – the control line length; β – the angle between the incident wave crest at the diffraction point and the control line; C_0, C_1, C_2 – constants which vary uniformly with β and are generated by regression analysis.

(4) outline of the shore line interface in static equilibrium: joining the points (R_n, θ) can be calculated in the final of the interface/platform in static equilibrium;

(5) graphics automatic drawing of the sandy beach forecast form.

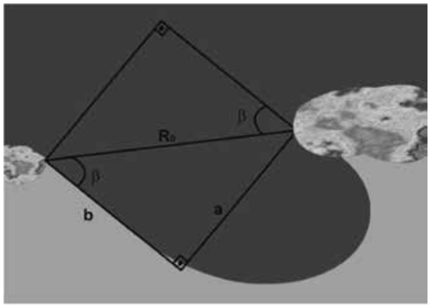

Fig. 3. Outline of defining the parabolic model by Hsu and Evans (1989), defining the reference wave angle β

The implementation of the self-acting calculation – MEPBAY was done by the following steps:

(1) Defining the control line, R_0. The distance between the control points from upstream and downstream is done by the following equation:

$$d^2 = (X_1 - X_0)^2 + (Y_1 - Y_0)^2, \tag{2}$$

where d is the length (in units of screen/pixels) of the control line R_0; X_0 and Y_0 are the coordinates of the upstream control point, where R_0 starts; coordinates X_1 and Y_1 are downstream control point, where R_0 ends.

(2) Calculation of the reference angle of the incidence wave, β. The dominant direction is noted perpendicular to the tangent towards downstream.

(3) Application of the graphical parabolic model. According to the three constants C, which were generated by the regression analysis on the 27 representative prototypes of the bay-shape beaches, and differ function of the reference angle β (Hsu and Evans, 1989), and were formulated in the forth order of the polynomials form as follows:

$$\begin{aligned} C_0 &= 0.0707 - 0.0047\beta + 0.000349\beta^2 - 0.00000875\,\beta^3 + 0.00000004765\beta^4 \\ C_1 &= 0.9536 + 0.0078\,\beta - 0.00004879\,\beta^2 + 0.0000182\,\beta^3 - 0.000001281\,\beta^4 \\ C_2 &= 0.0214 - 0.0078\,\beta + 0.0003004\,\beta^2 - 0.00001183\,\beta^3 + 0.00000009343\,\beta^4 \end{aligned} \tag{3}$$

Thus, in the application of the parabolic model for the determination of the designed coastline stability of the southern sector Mamaia beach, was followed the identification of the shoreline development adjusting effect, designed for transverse and longitudinal protection solutions and the results confirm a significant difference to the shore line stable, especially in the protected areas, the alignment H. Park – H. Dacia.

It can be concluded that by applying MEPBAY model can be seen that the current platform of the South Mamaia beach (bold line in Fig. 4) is almost identical, as guidance, to the beach parabolic equation form in the static equilibrium.

This indicates that the beach is overall in static equilibrium, their existing a imbalance/withdrawal tendency in the southern area (protected) for the situation of the designed shoreline.

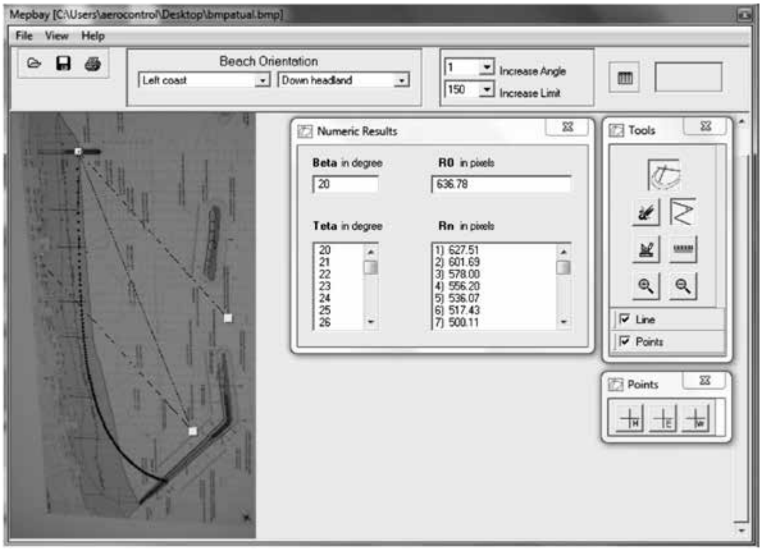

Fig. 4. Application of the parabolic model at Mamaia beach

It is thus revealed that the coastal morpho-dynamics represents a very complex problem, whose solution cannot be done only partly, because of the many factors that lead to the emergence and evolution in space and time of various coastal processes and the graphical calculation methods should be considered properly, being given their contribution to the process models adjustments in the description of the coastal response.

The anthropogenic influence, amplified at the Romanian seaside, has resulted in a number of changes in the marine biotope, in the biosphere populating this biotope and in the associations of plant and animal organisms, both in the water table (plankton), but especially those related to the substrate (benthic organisms)[9]. This influence has resulted in a persistent tendency, more or less pronounced, fund impoverishment of marine flora and fauna (Fig. 5).

As background information provided by Romanian Waters Authority about algae development in Mamaia Bay (Fig. 6), it can be mentioned that the total quantity of algae is at high level and represents an important issue in touristic development.

Fig. 5. Water and jelly-algae accumulation and stagnation in south of Mamaia beach (Summer season 2010)

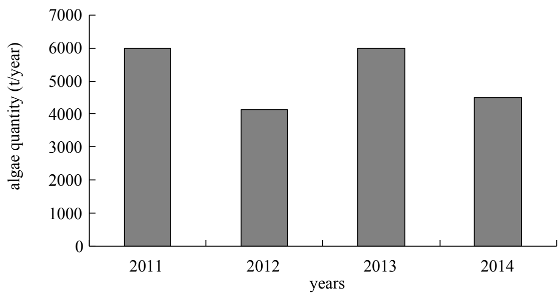

Fig. 6. Algae quantities in the summer season (Mamaia)

One of the disturbing factors, acting at the Romanian seaside, along with other negative influences, while causing a decrease of the biodiversity, are the erosion and the coastal construction works and many designed to prevent erosion.

Although the coastal buildings have generally positive biological effects on the specific components, the coastal consequences of their location were the changes in the morphology shoreline and underwater slope changes in the structure of the substrate, flow regime change or turbidity increase, increasing the concentration of the organic matter in water and sediment – a default change of the optical regime.

All these led to the installation of the conditions less favourable for life, and consequently the coastal change (reorganisation) and marine habitats; particularly the algal macrophytes have recorded a significant decline.

In addition, the changes in the mid-coastal sediment texture, the advanced silting of certain protected coastal hydraulic systems, and negatively influenced on the organisms life (such as the diversity of species, as well as the density) from the interstitial. The ecological degradation trend of the two biotopes, mid-coastal sand and interstitial super littoral – regime change, was determined by the hydro-dynamic flow and the circulation of increasing organic matter amounts through the micro porous, up to silting and reduction of the permeability sediment, they often causing the anaerobic conditions installation. All these have a reverse impact on certain sectors of the tourism attractiveness shore, which include the protected sector Mamaia[9].

There are also a number of problems that can affect the Mamaia beach, including aesthetic, health and environment problems. Thus, the eutrophication can lead to the beaches and bathing areas degradation related both in terms of aesthetic view and by the accumulation of micro algae and/or macrophytes due to the shore protection extension and configuration, as well due to the polluted sweet water inflow form Tabacarie lake and Constanta-North waste-water plant overflow pipe; this can lead to significant losses in the number of tourists in summer inconsequence to deprivation of the environmental attractiveness[10].

In conclusion, although the selection and implementation process of the numerical models used for the South Mamaia sector aimed the beach surface stability desired by the customer for a period of 50 years, it is necessary to extend the boundary conditions of the field work, considering the fact that in its vicinity (300 m) the dam is inside the fishing port and two sources of freshwater discharge from a lacks complex Sutghiol–Tabacarie and the overflow pipe of the wastewater treatment North Constanta, that can change major the problem data, both in terms of waves propagation and coastal currents, including the pollution, as well as the sedimentation.

CONCLUSIONS

To maintain the natural coastal processes will, unfortunately, the major changes in the current landscape. If the trend is maintained or increases, the loss of the beach sediment erosion can affect the attraction of tourist facilities, the health and safety risk with the structure degradation and loss of protection.

The maintenance of the erosion may lead to potential loss of tourism goods and recreational as well as local infrastructure and services. There is a risk extended to the many cultural and historical places. The main aspects of the environment, the marine and coastal quality reflects directly on tourism activities especially in relation to its attractiveness for both mass and ecological tourism.

The marine traffic characteristics related to the Mamaia beach sector are currently different from natural shoreline, unprotected coastal construction. The waves diffraction and refraction in Mamaia Bay (caused by the presence of longitudinal dikes system and the isobaths asymmetry on the north – south direction) may cause an increase of the jellyfish, shells of clams transport (*Mya arenaria* mainly, *Mytillus galloprovincialis*, *Rapana thomasiana*) on the beach space and the algae and macrophytes/or microphytes concentration in the southern, after and during summer storms and thus an discomfort increase, resulting from their decomposition in the sun.

The recent protection works design/modeling-validation optimisation should be consider main ecological state of the coastal ecosystem. The ecosystem based management should be extended and assimilated by the national authorities dealing with ICZM (Integrated Coastal Zone Management).

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