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The influence of the erosion process in the coastal zone of Olimp-Vama Veche

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Abstract

One of the most important natural processes that affects the coasts around the world is coastal erosion. In the Black Sea, coastal erosion is a result of the action of several factors, such as waves, wind, storms, rains and human activities. The research carried out in the coastal area of the Black Sea highlighted the phenomenon of beach and cliff erosion, which led to collapses and landslides that endanger human lives and the stability of buildings located on the upper part of the cliffs. In this work, the erosion process in the area between Olimp and Vama Veche and some works proposed for the rehabilitation of the beaches and the consolidation of the cliffs are presented.

Keywords: Erosion; Coastal protection; Hydrotechnical constructions; Strengthen the cliffs.

1. Introduction

The coastal zone in Romania faces significant problems regarding the destruction of habitats, coastal erosion, water pollution and the impoverishment of natural resources. The rapid growth of the population and tourism, the large-scale exploitation of natural resources and the rapid development of the infrastructure have led to the severe degradation and decline of the quality of the Romanian coastal area. Among these, coastal erosion represents one of the major environmental problems of the coastal zone in Romania (Anton *et al*., 2017).

The objective of the work is the presentation of the influence of the erosion process on the beaches and cliffs in the Olimp-Vama Veche coastal area, of the existing and proposed works for the protection of the beaches and the consolidation the cliffs.

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The coastal area between Olimp and Vama Veche is characterized by high cliffs with different heights, between 3 and 35 meters, short stretches of sandy beaches and steeper submarine slopes than in the northern area. Along this area the cliffs are steep and unstable, susceptible to collapse due to landslides, especially in areas with pronounced beach erosion. In these areas, the waves, reaching the base of the cliff, frequently produce cliff collapses. The cliffs along the southern area are formed by layers of loess that allow water to infiltrate, and at the base a layer of impermeable clay, which leads to the production of sliding planes. Following the collapse of the cliffs, the sediments, which are generally too fine to accumulate on the beach, are carried by the waves out to sea. The erosion of the cliffs in this area does not present a significant contribution to the neighboring beaches. The loess is too fine and is carried offshore, while the harder limestone, at the base, is very resistant to wave action and generates very small amounts of sediment (mainly boulders and stones, less often sand) and over long periods of time.

2. Coastal erosion in the Olimp, Vama-Veche region

One of the most important processes, with a negative impact on the infrastructure of the Black Sea coastal area, as well as on the environment, is erosion. In the last decades, this phenomenon has spread especially in the southern part of the Romanian coast, which has contributed to the loss of important areas of beaches.

For these reasons, it was necessary to develop an integrated management plan for the coastal zone. The integrated management of the coastal zone aims at the sustainable development of the coastal zone, reducing its vulnerability and its inhabitants to natural risks and preserving the main economic processes and biological diversity (Anton *et al*., 2017). An effective strategy of the integrated management of the coastal zone can be established after the correct assessment of the erosion risk of the coastal zone, the hazard factors and the impact factors (vulnerability) of the zone.

The main causes that led, emphasized and extended this phenomenon are:

- The massive reduction of the sediment flow transported by the Danube (up to approximately 40%) mainly due to the construction of the dams at Portile de Fier I and II;
- The tendency to raise the sea level by an average of 1.5 - 2 mm/year, which causes the shoreline to recede;
- The construction and expansion of port protection dikes, which block or divert the transport of sediments by the longitudinal current on the Romanian Black Sea coast (for example: The Mangalia dike that led to a phenomenon of severe beach and cliff erosion on 2Mai);
- The expansion and modernization works of the port of Mangalia generated the deviation towards the sea of the paths of the coastal currents that ensured the supply of sand to the beaches in the south of the coast;

- Climatic changes with increasingly frequent storms, of high duration and intensity;
- Changing the configuration of the shore effects on the configuration and nature of the seabed.

Sunai and Ichinur (2013) the state of the Romanian coast and its coastal areas from the point of view of coastal erosion processes was presented. In the study area, the following subjects were recorded:

- In the Neptun sector, slightly lower rates (below 2m/year);
- In the Mangalia sector the highest erosion rates, with rates of over 4m/year;
- In the sector 2Mai - Vama Veche, as a result of the effect created by the southern dike of Mangalia port, the erosion rates are approximately 3 - 4m/year.

3. Existing and proposed works

In the study area there are coastal protection systems that have produced changes in currents and sediments. Next, for each sector, the existing hydrotechnical constructions in the study area, the state of the beaches and cliffs, as well as the proposed beach and cliff rehabilitation works will be presented.

3.1. Olimp

The beach of the Olimp resort is small, being made up of bays protected by three dikes from the anchorages. The embankments are deteriorating, requiring repairs and strengthening. The protective dikes have proven effective, protecting the beach against erosion. Works are proposed to remove some of the existing structures to widen the bays, rehabilitate, improve and build new protective structures and sand the beach (Sunai and Ichinur, 2013; Omer *et al*., 2015; Văidianu *et al*., 2020). Works were carried out to protect and strengthen the cliff in the northern area of the Olimp resort by building a retaining wall with a length of 630 m and a height of 5 m (Figure 1).

Figure 1. Works to strengthen the Olimp cliffs

3.2. Neptune

The coastal protection system is made up of breakwaters, breakwaters, offshore dikes. The general direction of littoral alluvial transport is the southern one. The exceptions are local

and are induced by the existence of breakwaters and other coastal development works. The beaches are narrow and underfed with sediments. The main sources of beach sediments are shells and fragments of limestone eroded from the seabed. The dynamics of beaches is almost entirely controlled by human intervention, but, in general, beaches are narrow and erode due to the lack of new sediment inputs and structures about to fail (Sunai and Ichinur, 2013; Omer *et al*., 2015; Văidianu *et al*., 2020). Along this area, between Pescarie Tatlageac and Hotel Silvia, there is a succession of controlled and artificially maintained beaches. These beaches are protected by modified breakwater structures and artificial headlands, with occasional offshore reefs. On the Olimp-Neptun shore area, there are six detached sea dikes and one submerged sea dike, parallel to the shore. The dikes show signs of degradation (Figure 2).

Figure 2. Neptune Bridge

The following works are proposed:

- rehabilitation and improvement of some dikes;
- removal of some of the existing structures to widen the bays;
- building new protection structures and sanding the beach.

3.3. Jupiter-Cap Aurora-Venus

At Jupiter, Cape Aurora and Venus, there are a number of enclosed bays, protected by modified breakwaters and artificial headland structures with occasional offshore reefs (Figure 3 and Figure 4).

From place to place there are stone outcrops and seawalls behind the beaches, generally narrow. The piers are made of anchors and protected with stabilopos. The shore of Cape Aurora (between Jupiter and Venus) includes a succession of breakwaters and a large submerged breakwater. This resulted in the creation of a series of small artificial bays. In general, the beaches are less narrow in the southern area of Venus resort where there is a wide beach. The beaches suffer a slight erosion, and the protective structures show degradation.

Works are proposed to rehabilitate and improve some dikes, to remove some of the existing structures to widen the bays, with the exception of the two breakwater dikes in front of the Carmen Hotel, to rehabilitate, improve and build new protective structures, sanding of the

beach, repairs and improvements to the two breakwaters in front of the Carmen Hotel (Sunai and Ichinur, 2013).

3.4. Saturn

The beach consists of four bays protected by five T breakwaters from anchorages protected by stabilopods. This coastal area, between Hotel Cerna and Mangalia, is characterized by a series of well-dammed intervals, supported by modified breakwaters and artificial headland structures. The beaches are narrow and have been protected by dikes against erosion.

Figure 3. Pier from anchorages in Cape Aurora

Figure 4. Dike from anchorages with stabilopods. in Venus

A slight degradation of the dikes is observed. The general coastal alluvial transport system is maintained in the south direction and continues in this direction until the northern breakwater of Mangalia port, where it is blocked, therefore resulting in a local alluvial accumulation. It is expected that the inputs from the area opposite the direction of coastal alluvial transport will be reduced, due to the structures and the lack of sediments; therefore, the main sources of beach sediments are shells and limestone fragments eroded from the seabed. An erosion phenomenon is manifested in the center of the bays created by the protection structures.

Moreover, an accretion phenomenon is manifested in the area opposite the direction of coastal alluvial transport near the Mangalia dike, which forms the southern border of this area. In general, the cliffs do not show instability, and in areas with erosion, works to

strengthen and protect the cliffs are foreseen (Figure 5). Rehabilitation and improvement works of the existing protections are proposed.

Figure 5. The jetty on the southern side of Saturn beach

3.5. Mangalia

There are dikes made of anchorages protected with stabilopods that delimit the semicircular beach. On the northern side, the dike is T-shaped, and on the southern side it is Y-shaped. In the northern part, the beach narrows and is protected by anchorages. The shelter piers of the port of Mangalia and the tourist port are made with a core and protective mantles made of anchors, and in the offshore area they are protected with stabilopod shells. At the top of the shelter piers there is a concrete crown slab along the entire length of the pier. The sheltering dikes of the port of Mangalia have in turn affected the transport along the shore and the general circulation of the sediments, some of them being transported out to sea. The port of Mangalia influences the erosion of the cliffs and beaches between the villages of 2Mai and Vama Veche. Like other ports located on this section of the coast, Port Mangalia constitutes an impermeable boundary for the transport of sediments. Immediately south of the breakwater there is a small strip of stable or slightly growing beach, several tens of meters long. This represents a small sedimentary basin as an effect of sheltering and produces an impact on the offshore waves generated by the Mangalia port breakwater. There is erosion in the northern part of the beach and deposits in the southern part as an effect of the delimiting dikes beach. For this reason, a stone protection was created in the northern area of the beach (Figure 6). Repair works and improvement of the existing protections are proposed. Artificial beach sandbanks, 20m wide between the piers in front of the President Hotel (Văidianu *et al*., 2020).

Figure 6. Dikes in Mangalia

3.6. 2Mai

There is a breakwater made of stone and reinforced concrete elements in an advanced state of decay. Otherwise, there is no coastal protection. Next to the second golf beach from 2Mai, direction the alluvial transport changes suddenly, the influence of the breakwater dikes is reduced, and the longitudinal alluvial transport resumes its general southern course. Compared to the 1960 and 1979 maps, there are major changes in the appearance of the shoreline in this area. Due to the breakwater sheltering the port of Mangalia, there is a strong erosion of the beaches, and the waves reaching the base of the cliff cause collapses, endangering the nearby constructions (Figure 7).

Figure 7. Erosion of the beach and the cliff on 2Mai

At the northern end, the beach is relatively stable due to the influence of the Mangalia breakwater. The other portions are affected by a net erosion trend, accompanied by the loss of beach sediments. The cliffs are susceptible to erosion and collapse through landslides. On 2Mai and in the central part, where narrow gulf beaches narrower than 10 meters are present, during the summer/calm season, the retreat of the shore during storms is close to the base of the cliff. The exception is the northernmost section of the 2Mai beach, which is protected by the southern dike at Mangalia.

Works are proposed to rehabilitate the existing dike and protect the base of the cliff, where appropriate, together with measures to reduce the impact on habitats (Sunai and Ichinur, 2013; Văidianu *et al*., 2020).

3.7. Vama-Veche

There are no hydrotechnical constructions or coastal protection elements. This area stretches to the Romanian border with Bulgaria. The area includes cliffs and a sandy beach. The beach is subject to erosion and the cliff is susceptible to landslides (Figure 8).

Figure 8. Erosion of the cliff at Vama Veche

Conclusions

In the coastal area of the Black Sea on the territory of Romania, coastal erosion represents a real risk for the environment, the phenomenon manifesting itself in different degrees of intensity along the approximately 245 km of coastline, measured from North to South, from the arm Chilia (Musura bay) and up to Vama Veche (border with the Republic of Bulgaria). There are a number of human activities that have influenced the way the Romanian coast is presented at the moment, such as: coastal protection measures, protection dikes in ports, the development of industrial capacities in the coastal area, the introduction of alien species into the ecosystem, the construction of reservoirs and dams in river basins, coastal interventions that affected sediment deposition.

Based on the research carried out by the Dobrogea Litoral Water Basin Administration (Halcrow reports), GEOECOMAR, INCDMN "Grigore Antipa", Royal Haskoning, JICA, USAID regarding the evolution of the coastal zone, it was concluded that coastal erosion in some areas reaches a rate of about 3- 4 m/year. Following the realization of the Master Plan "Protection and rehabilitation of the coastal zone" of the A.N.R. Romanian Waters, developed by Halcrow Romania S.R.L. in December 2011 and the presentation of the "Coastal protection plan for the Southern Romanian Black Sea shore" report developed by the Japan International Cooperation Agency Ecohcorporation in March 2006, the areas of Mamaia Sud and Eforie Nord are considered priority regarding the rehabilitation and improvement of the existing coastal protections (Kuroki *et al.*, 2007; Filip *et al.*, 2016; Pătrașcu, 2022) .

The dikes of the port of Mangalia affect the transport along the shore and the general circulation of sediments, some of them being transported out to sea. For this reason, Mangalia port significantly influences the erosion of the cliffs and beaches of 2 Mai and Vama Veche. Following the study, it can be observed that apart from the areas mentioned as priority, the 2Mai - Vama Veche areas are also seriously affected. For this reason, these

areas should also be considered a priority and rehabilitation and improvement works should be provided for the existing coastal protections.

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