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Evaluation of the coastal processes induced in the arranged areas with hydrotechnical protection structures and beach sand nourishments

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***Abstract* – This study aims to assess the coastal processes induced by the geomorphological changes in the perimeter of the beach protection measures, which were implemented in 2015 for the Mamaia South coastal sector. Thereat, an evaluation of the beach changes was made in the context of structural protection measures (connected and parallel to the shore) and light type measures (the beach sand nourishments with sand transferred from sedimentation deposits located in the offshore area).**

Keywords* – *beach sand nourishments, hydrotechnical protection structures, Mamaia South sector.

1. INTRODUCTION

The development of the southern Romanian littoral, in a proportion of approx. 88% was requested by the general scheme of activities for the protection and conservation of the environment of the coastal area, in the conditions created by the extension of erosion phenomena, determined by the inland hydrotechnical works, but also by the navigation constructions materialized as a series of marine obstacles for the coastal drift.

The coastal surveillance and monitoring stages, following the implementation of the hydrotechnical protection structures followed by massive sand norishments of about 2 million cubic meters of material, are based on traditional topo-hydrographic methods, as well as on modern satellite or aerial imaging methods, consisting of the collection of data in situ and remotely, as well as their processing and storage in order to create a database

related to complex geographical/geodetic systems, as informational support for the development of coastal analyses and studies carried out for the purpose of optimization and sustainable maintenance of the coastal arrangements for the erosion control.

Although the coastal erosion on the Romanian coast is considered distant on a time horizon extended by over 50 years, due to the blockage of the main sedimentary source, in this case the Danube sedimentary drift, currently reduced and largely diverted by the longshore sediment transportation, the phenomena of natural hydromorphological processes of sedimentary transport currently determine a very intense redistribution process after seasonal storms, as well as at annual level erosion rates, relatively estimated in the sectoral planning phase and after, in the design phase.

At present, after 10 years since the reconfiguration and reimplementation of the protection system in the south of Mamaia resort, respectively the south of the coastal cordon with the same name, the most eroded sub-sector, of the sedimentation cell outlined as the "pocket beach" due to the extension of the Midia port jetties, there is a situation of relative equilibrium in Mamaia, quantified by in situ investigations in the present work, the options determined by calculation being in favor of compensating the solutions of the light type, sanding type with constant sources of sediment from areas of lower exposure at the level of the cold season, through a more elaborate sedimentary management, supporting both complementary solutions such as reed fences and weavers to stop the transport by the wind, respectively the process which cause real sandstorms in Mamaia, especially in the newly inhabited areas, with offshore sediments and with a high content of fine particle.

2. MATERIAL AND METHODS

In order to achieve the objective proposed in the study, geomorphological measurements of the emerged beach were made on the 4 landmarks in the Mamaia South sector of the coastal system located in 2014 by INCDM, for monitoring the coastal processes, in the area of protection measures planned in the short term, as well as measurements at the surface of the water. The particle size characteristics of the sediments on the sandy beaches were also analyzed.

To determine the geomorphological changes of the beach, the measurements (with the SOKKIA level on beach profiles) made in 2015, 2016 and 2017 were used, and to determine the beach surfaces, the measurements (with GPS at the water surface) made in 2015 and 2017 were used. The environmental conditions for those days indicate level differences from 22.2 cm to 35.9 cm, wave height from 0.3 cm to 0.9 cm, and wind speed was from 2.5 m/s to 10 m/s with variable wind directions, but more frequently from the northern sector (table 1).

Table 1. Environmental conditions in the period 2015 – 2017

Data	Level (cm)	Wave-height (cm)	Wind (Speed/direction)
Beach Profiles			
2015.04.12	24.8	0.4	6.7m/s-NNE
2015.04.13	23.6	0.3	3m/s-NV
2015.04.14	22.2	0.4	7.3m/s-N
2016.05.11	34.2	0.3	2.8m/s-NE
2016.05.12	32.4	0.5	2.5m/s-NE
2016.05.25	35.9	0.4	5.5m/s-SV

2017.05.17	22.4	0.4	6.3m/s-E
2017.05.23	28.9	0.5	4.6m/s-E
2017.05.25	25.2	0.7	6.6m/s-SV
Shoreline			
2015.03.16	28.6	0.8	10m/s-NE
2016.06.26	25.1	0.7	6.4m/s-SE
2017.07.14	27.3	0.9	7.3m/s-N

The profiles were made with the SOKKIA level, and the results were processed and interpreted with the CEDAS program, the BMAP subprogram, the width of the beach, the seasonal rhythm and the sedimentary stock being determined (the cold seasons 2015-2016 and 2016-2017, for the Mamaia South sector). Based on the data recorded with the GPS, the position of the sea-dry contact line was determined, for which the surface of the beach after sand nourishments was calculated. The data was processed and interpreted with the MapSys topographic engineering program.

For sediment analysis, samples were taken on 9 profiles, between 18-20 July 2017, from points located on the upper beach, the middle beach, the water face and from a depth of 1m.

The sediment characteristics were determined based on particle size analyses, by the dry sieving method, with 23 sieves (6.3 mm, 5.0 mm, 4.0 mm, 3.15 mm, 2.5 mm, 2.0 mm, 1.6 mm, 1.25 mm, 1.0 mm, 0.8 mm, 0.63 mm, 0.5 mm, 0.4 mm, 0.31 5mm, 0.25 mm, 0.2 mm, 0.16 mm, 0.125 mm, 0.1 mm, 0.08 mm, 0.063 mm, 0.05 mm, 0.04 mm) for the range of dimensional classes corresponding to the particle size classes: buckets - gravel - sand - coarse silt.

The processing and interpretation of the data was carried out with the GRADISTAT v.8 program. As a result of the analyses, statistical parameters were determined [6] which refer to the parameters of the central values (average diameter Dm), the standard deviation (degree of sorting So) and the indices of the shape of the distribution (asymmetry - Sk and sharpness - Kg) [1]. The sedimentary classes [1, 6, 7] are as follows: gravel (P) with a grain > 2.0 mm, very coarse sand (NFG) with a grain between 2.0 – 1.0 mm, coarse sand (NG) with a grain of 1.0 – 0.50 mm, medium sand (NM) with a grain of 0.5 – 0.25 mm, fine sand (NF) with a grain size between 0.25 - 0.125 mm and very fine sand (NFF) with a grain size of 0.125 - 0.0625 mm.

3. RESULTS AND DISCUSSIONS

The Mamaia South sector has a length of 1.2 km and represents the southern part of the Mamaia tourist beach, which has a total length of approx. 7 km. The measures for the protection and rehabilitation of the beach carried out in 2015 were: the rehabilitation of two longitudinal "wavebreaker", the maiSouthn pier connected to the shore (for sand retention, connecting structure between the offshore pier and the herringbone in front of Parc Hotel), spurs (6 geo–synthetic tubes filled with sand and buried in the sandy beach, as a conservation measure, sand retention and beach stability) and beach sand nourishments (Fig. 1.)

Fig. 1. Coastal protection measures – in the short term, Mamaia South (Photo. INCDM, 2015)

Fig.2. Monitoring cross-sections in the Sothern sector of Mamaia

Before the sand sand nourishments (2015, May) the average width of the beach was 70 m, with variations from 50 m (R2) to 100 m (R5). Immediately after sand nourishments, the average width of the beach doubled to 146.9 m (2016, May), with variations from 125.6 m (R4) to 162.7 m (R5). Two years after sand nourishments (2017, May) the width of the beach shows a state of equilibrium, the average width being 150.8 m, with variations from 121 m (R4) to 162.4 m (R5) (Table 2).

Table 2. Mamaia South - beach width (m) between 2015 and 2017

Profile/data	R2	R3	R4	R5	Average
2015.05	50	70.6	59.2	100	70.0
2016.05	157.0	153.0	125.6	162.7	149.6
2017.05	162.2	157.6	121	162.4	150.8

The average seasonal pace, 2015 - 2016 was 80.9 m with variations from 66.6 m (R4) to 107 m (R2). The sedimentary stock averaged 93.79 m/sqm, with variations between 67.15 m/sqm (R4) and 113.02 m/sqm (R2) (Fig. 3.)

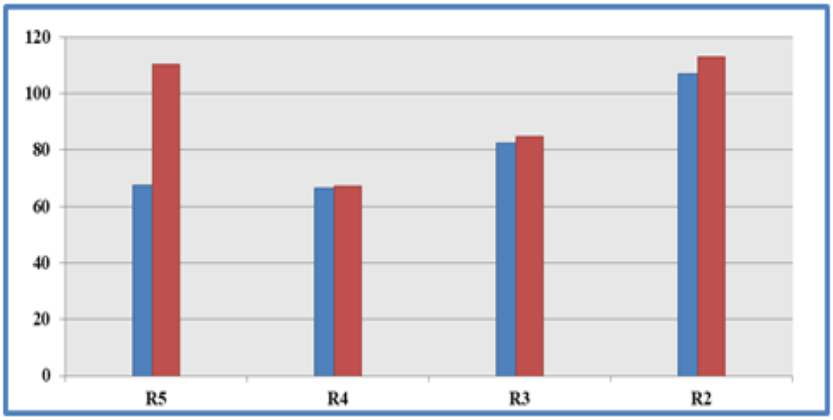

Fig. 3. Seasonal beach changes, 2015 - 2016 – Mamaia South
Red: Sedimentary stock (m/mp); Blue: Seasonal rhythm (m)

After sand nourishments, the average seasonal rate 2016 - 2017 was 1.2 m with variations from - 4.6 m (R4) to 5.2 m (R2). The sedimentary stock was on average -0.47 m/sqm, with variations between -3.48 m/sqm (R5) and 3.6 m /sqm (R3) (Fig. 4.)

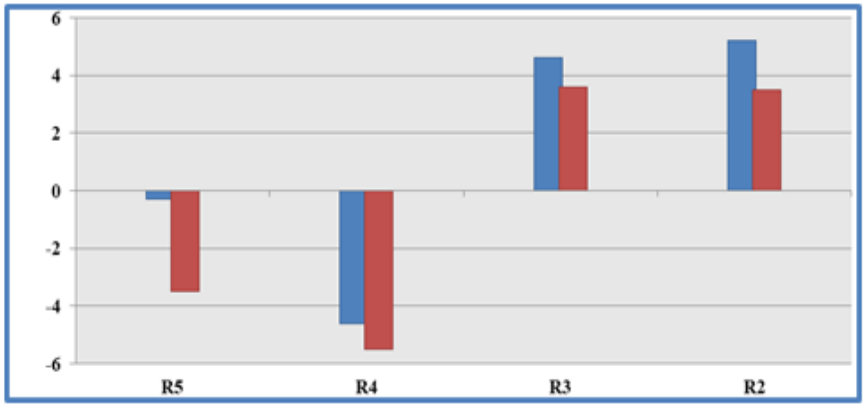

Fig. 4. Seasonal beach changes, 2016-2017 – Mamaia South
Red: Sedimentary stock (m/mp); Blue: Seasonal rhythm (m)

In the northern part of the sandy beach (R5 and R4 finds) negative rhythms and stocks have been determined, probably as an effect of the transfer of sediments to the open sea or to the neighboring beaches.

Based on GPS measurements, carried out at the water's surface in 2015 and 2017 (before and 2 years after sand nourishments), the area between the two positions of the shoreline of 10.6 ha was determined (Fig. 5), which means an extension of the tourist beach area, as well as an increased comfort of tourists, who come to the beach in the summer season.

Fig. 5. Mamaia Souther Sector - changes to the large interface

The sediment analysis was performed on sedimentary samples collected from two geomorphological sections of the beach (R5 and R3). The average diameter (Dm) of the grains is generally 0.34 mm and 0.35 mm. Sorting (So) is poor (S) except for samples from the face of water with good and relatively good sorting (B, RB).

Table 3 Particle size parameters of sediments – section R 5

Proof	Dm (mm)	So	Sk	Kg	PF	PFF	NFG	NG	NM	NF	NFF
Upper beach	0.37	S	FN	FL	4.3	6.8	7.2	4.9	17.1	56.3	3.3
Middle beach	0.49	S	FN	P	9.3	9.4	8.4	7	19.7	44.4	1.6
Water face	0.20	B	S	L	0.4	0.1	0.5	1.6	14.9	77	5.4
Depth of 1m	0.31	S	FN	FL	4.2	4.0	5.2	6.3	20.8	54.4	5
Average	0.34				4.6	5.1	5.3	5	18.1	58	3.8

The asymmetry is very negative, apart from the face of the water, where the distribution is symmetrical. The sharpness ranges from very leptocurtic (L) to platicurtic (P).

Table 4. Particle size parameters of sediments – section R 3

Proof	Dm	So	Sk	Kg	PF	PFF	NFG	NG	NM	NF	NFF
Upper beach	0.44	S	FN	M	9.6	6.4	7.3	6.5	18.8	49	2.3
Middle beach	0.49	S	FN	P	9.3	11.4	8.6	6.7	16.9	44.5	2.3
Water face	0.19	RB	S	L	0.3	0.9	1	2	13.5	72.4	9.9
Depth of 1m	0.27	M	FN	FL	0.8	1.7	4.3	7.5	33.1	48.2	4.4
Average	0.35				5	5.1	5.3	5.7	20.6	53.5	4.7

Fractions of medium sand and fine sand (NM, NF) are predominant, 74% and 76%.

For the Mamaia South sector, it is noted that the sediments on the surface of the water have the smallest granule diameter, 0.19, 0.20 mm, good and relatively good sorting, symmetrical sharpness and platicurtic arching. These particle size parameters mean that at the surface of the water, within the swash zone (advance and retreat of the wave on the beach) fine sediments are deposited with an advanced degree of sorting with a symmetrical distribution curve (Sk=0) and good central sorting (leptocurtic graphic sharpness).

4. CONCLUSIONS

The coastal processes induced by the recent geomorphological changes in the perimeter of the beach protection measures were evaluated, which were implemented in 2015 for the coastal sector Mamaia South.

In the Mamaia South sector, before the sand nourishments, in 2015 the beach had a width of 70 m and in 2017 it reached 150.8m. The beach area determined by the position of the shoreline in 2015 and 2017 indicates an extension of 10.6 ha. Medium and fine sand fractions, 74% - 76% are predominant for the surface sediments of the beach.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] Anastasiu N., Jipa D. (1983), *Texturi şi structuri sedimentare*. Ed. Tehnică, Bucureşti, pp. 320

[2] Bomboe P. (1979). *Geologie matematică – vol. 1 Analiza statistică a datelor geologice*, Universitatea Bucuresti, p. 599

[3] Blott S.J., Pye K. (2001), *GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments,* Earth Surface Processes and Landforms 26, pag 1237-1248

[4] Coșarcă C. (2003), *Topografie Inginerească*, Ed. Matrixrom, ISBN: 9736855600

[5] Dally W.R. (1993), *An overview of coastal surveying technology documenting beach - interaction*, Journal of Coastal Research, Special Issue No. 18,291-300

[6] Folk RL, Ward WC. (1957), *Brazos River bar: a study in the significance of grain size parameters*, Journal of Sedimentary Petrology 27, pag 3–26.

[7] Jipa D, C. (1987), *Analiza granulometrica a sedimentelor*, Ed. Academiei, Bucureşti

[8] JICA (2007). *The Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore in Romania*, www.mmediu.ro

[9] Master Plan (2012), *Protecția și Reabilitarea Zonei Costiere*, https://dobrogea-litoral.rowater.ro/wp-content/uploads/2022/03/Master-Plan.pdf
[10] INCDM, *PUNCT DE VEDERE pentru soluţia tehnică modificată la soluţia aprobată iniţial în proiectul "Protecţia şi reabilitarea zonei sudice a litoralului românesc al Mării Negre în zona Municipiului Constanţa – Mamaia Sud (lot 1)*", 2014