THE ECONOMIC-ENVIROMENTAL IMPACT ANALYSIS IN THE CHOICE OF THE MANAGEMENT OF THE DREDGING MATERIALS OF A PORT BASIN IN RELATION TO THEIR CLASSIFICATION AND QUALITY: THE EXPERIENCE OF THE PORT OF TERMOLI (2018)

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Abstract - The work to be illustrated shows the comparison of the economic and environmental impact analysis in a study case: "Dredging work on the seabed of the port of Termoli 2018". The entry into force of Ministerial Decree 173/2016 (ecotoxicological characterization of the sediments of the dredging area and of the diving area led). The new assessment required the search for solutions that summarized the economic aspects, linked to the financing available, and the adoption of a new technology that would allow a system process aimed at a better environmental protection.

Introduction

The Termoli's harbor, nowadays, has the typical structure formed by a basin with two breakwaters: the one "over-billow" has the function of repairing the stretch of water (outer harbor and the interior dock) from the differences conditions of the sea caused by the principals winds (mistral, north-east wind, north wind), the "over-billow" is oriented to east and it develops, orthogonally, at the end of the bedrocks of Termoli's promontory, it contains the sea conditions from secondary winds like east wind and south-east wind (which is protected by the Gargano's promontory).

The outers breakwaters, in using today, of Termoli's Harbor are not able to weaken "in an effective way" the waves. Therefore, in particular conditions of swell and/or strong east and north-east winds, the residual water can rough in the canal between the outer harbor and the docks which might cause strong oscillation of the boats. To avoid this problem, it's required a stronger keel clearance and problems to the seabed high -6 m AMSL.

The last dredging intervention of Termoli's harbor has been made in 2002 (reaching -6 m AMSL, then 120 000 m^3 of waste was spread on open sea).

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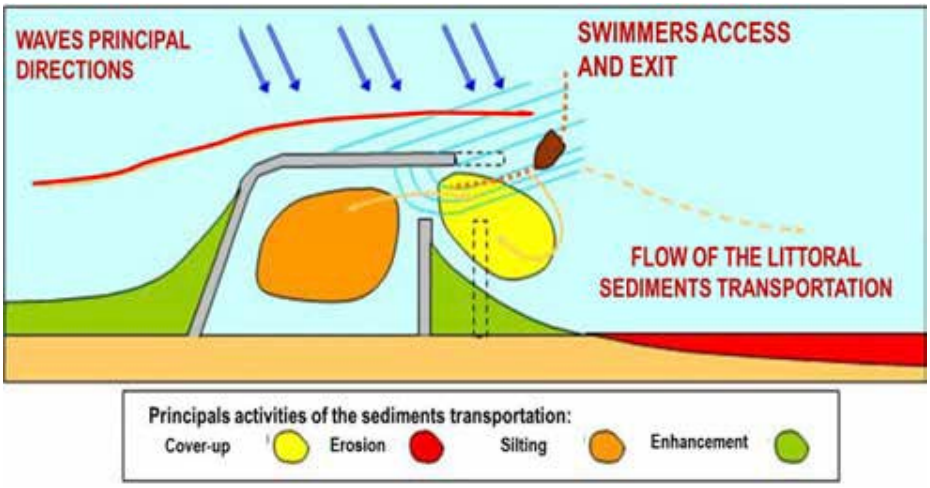
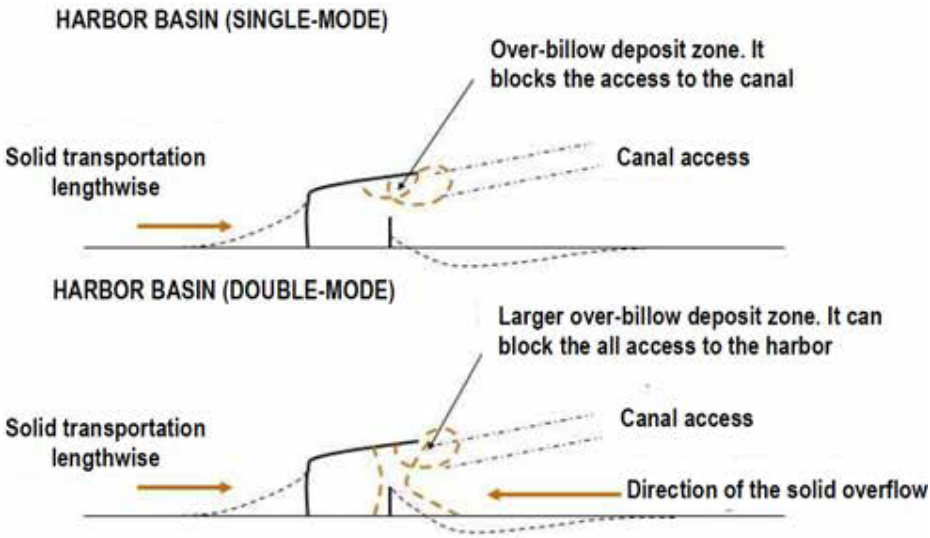
Photo 1 - Aerial shot of the port of Termoli.



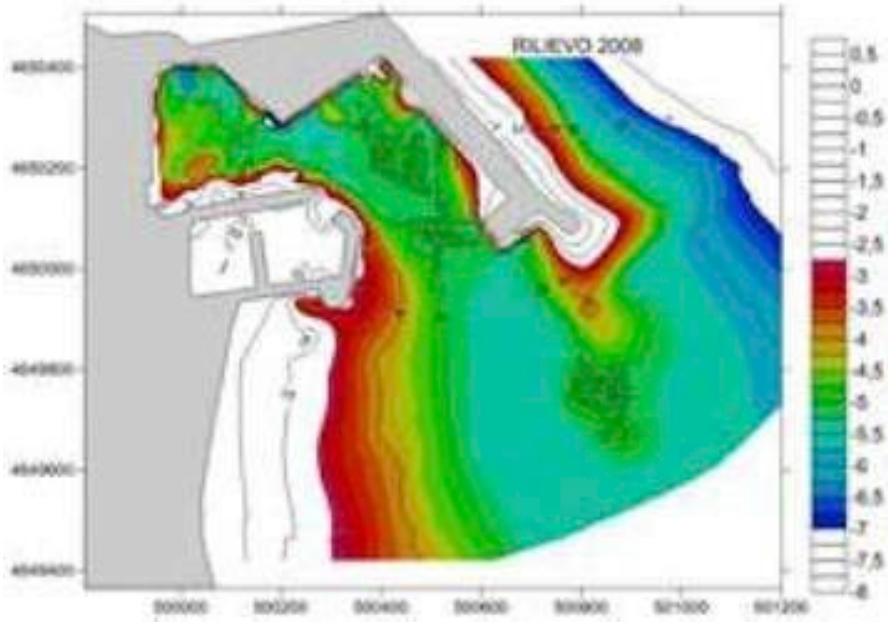
Picture 1 - Principals activities of the sediments transportation.



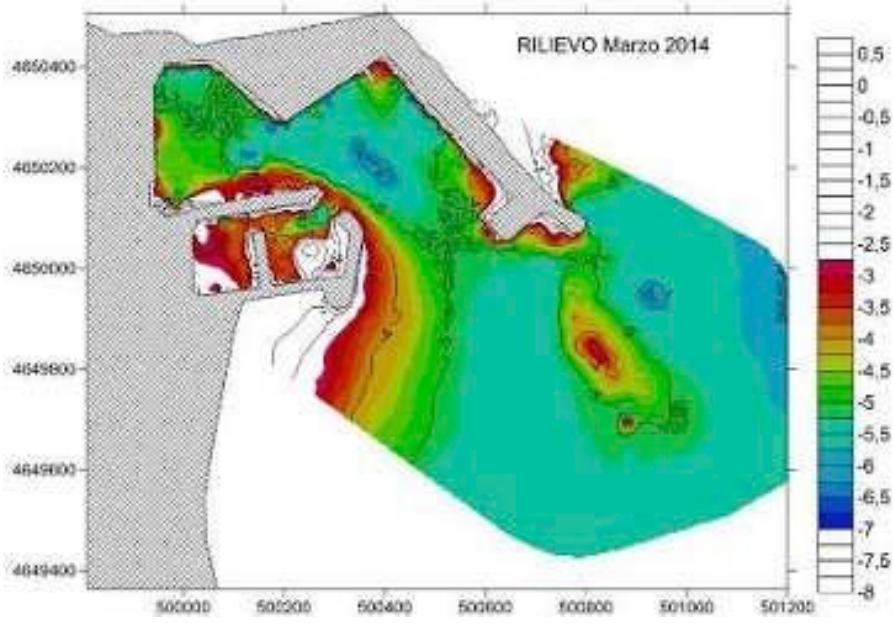
Picture 2 - Hypothesis for the transport of sediment harbor basin.

STAZIONE	LATITUDINE	LONGITUDINE
D1	42° 0'10.47" N	15° 0'19.03" E
D2	42° 0'80.39" N	15° 0'22.14" E
D3	42° 0'80.50" N	15° 0'25.42" E
D4	42° 0'30.50" N	15° 0'29.50" E
D5	41° 59'59.91" N	15° 0'36.39" E
D6	41° 59'56.54" N	15° 0'43.37" E

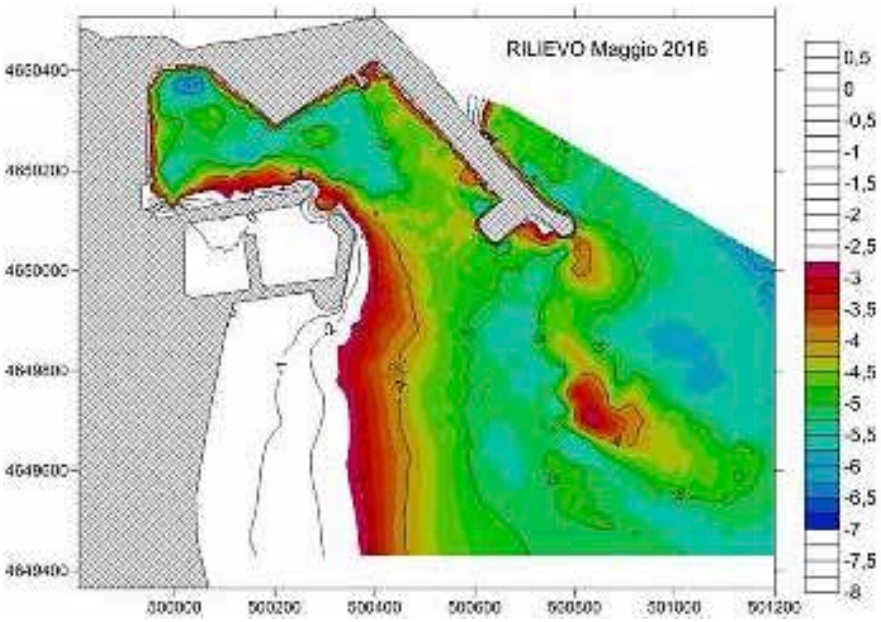
Picture 3 - Layout of areas identified for the characterization of dredged deposits



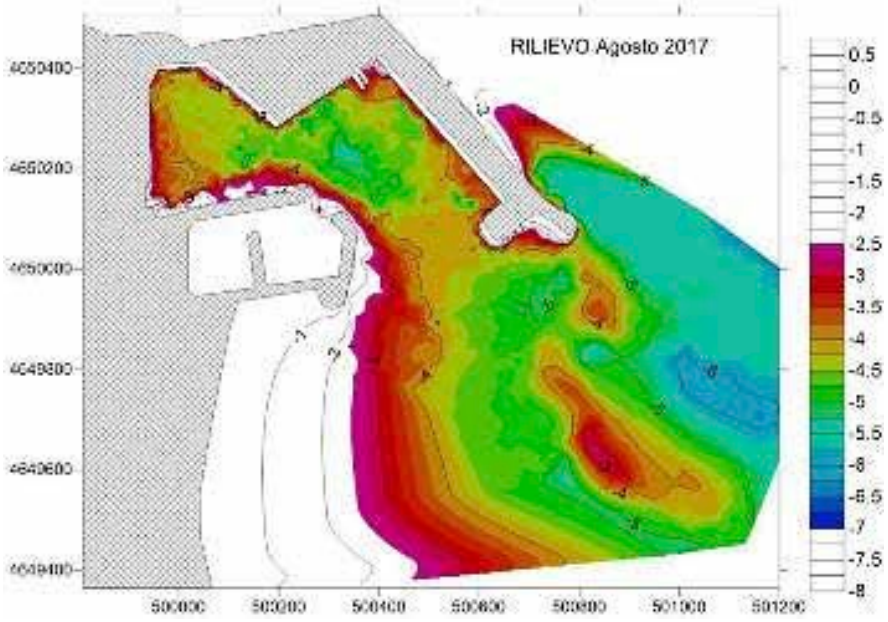
Picture 4 - Bathymetric topographic survey; Port of Termoli 2008.



Picture 5 - Bathymetric topographic survey; Port of Termoli 03/2014.



Picture 6 - Bathymetric topographic survey; Port of Termoli 05/2016.



Picture 7 - Bathymetric topographic survey; Port of Termoli 08/2017.

Materials and Methods

In August 2015, on behalf of the Molise Region, the Arpa Molise closed the investigation campaign aimed at sampling and characterizing the port sediments, the access channel and the outpost, in line with the provisions:

1) by the Decree of the Ministry of the Environment of 24 January 1996, concerning the preliminary activities for the release of the authorizations referred to the article 11 of the law 10 May 1976, n. 319 and subsequent amendments and integrations related to the discharge into the waters of the sea or in adjacent environments of the materials coming from excavation of sea or brackish seabed or of emerged coastal soils, as well as from any high movement of sediments in marine environments;
2) About what reported in the tables 2.3A, 2.3B and 2.3C of book ICRAM-APAT 2007 "*Manual for the handling of marine sediments";*
3) About what provisioned by Legislative Decree 152/2006 in article 109;

34 samplings in the dredging area and 6 samplings in the spill area identified offshore have been made.

The following physical characteristics have been found: description of macroscopic appearance (color, smell, possible presence of coarse materials), the grain size according to the Wentworth scale, the specific weight and humidity.

The chemical characterization concerned the following elements: Total Organic Carbon (TOC), Total Nitrogen in N, Total Phosphorus in P, Aluminum, Arsenic, Cadmium, Total Chromium, Iron, Mercury, Nickel, Lead, Copper, Total Hydrocarbons, total PCBs and Organochlorine pesticides.

The microbiological characterization concerned the following elements: Total coliforms, Faecal coliforms, Salmonella, Mycetes, Sulphite clostridia – reducers.

Based on the results of the chemical - physical and microbiological analysis, it is concluded: *"(..) is compatible the unloading of the materials and the excavation of the seabed coming from the port and the outpost of Termoli, limited to the areas characterized by the marine area indicated by the Molise Region and corresponding to the quadrilateral identified offshore Termoli and by the vertices corresponding to .coordinates"* [5].

Table 1 - Limits of the offshore storage area.

Quadrilateral vertices	Coordinates N	Coordinates E
A	42° 06' 30''	15° 06' 30''
B	42° 06' 30''	15° 08' 00''
C	42° 07' 30''	15° 06' 30''
D	42° 07' 30''	15° 08' 00''

With the entry into force of Ministerial Decree 173/2016, according to what is reported in Chapter 2 of the Technical Annex for the quality assessment of the sediments to be dredged and immersed in a special spill site, before the start of the works it was necessary to follow a specific investigation path (Path I), since it is an internal area of a port even partially industrial, commercial, passenger service, fishing boats.

Results

For the Eco toxicological and chemical classification of sediments, the weighted integration criteria were applied, set out in Appendices 2B and 2C of the Decree of the Ministry of the Environment and Protection of the Territory and the Sea of 21 September 2016 n.173. After it was proceeded with their integration, in order to determine the quality class of the sediments, always using of the applicative tool named Sediqualsoft.

The Eco toxicological classification was based on an Eco toxicological hazard judgment (Absent ÷ Very High) elaborated by the weighted integration of the results of all the components of the whole battery of biological tests (3 for each sediment sample).

The chemical classification, instead, was based on the elaboration of a chemical Hazard Quotient index (HQc), that considers the type and the number of parameters not compliant, as well as the extent of these exceedances and on its subsequent attribution in a hazard class (absent ÷ very high).

Based on the integration of data, coming from the chemical and Eco toxicological classification of each sample, it was possible to determine the quality class of the material, as indicated in the table 2.7 of annex A.

Table 2 - Quality class of the material (cfr. Annex A Table 2.7).

Ecotoxicological hazard class developed for the whole battery (HQ batteria)	Chemical classification	Quality class of the material
Absent	HQc (L2) ≤ Negligible	A
	Low < HQc (L2) < Medium	B
	HQc (L2) = High	C
	HQc (L2) > High	D
Low	HQc (L1) ≤ Low	A
	HQc (L1) < Medium and HQc (L2) ≤ Low	B
	Medium ≤ HQc (L2) ≤ High	C
	HQc (L2) > High	D
Medium	HQc (L2) ≤ Low	C
	HQc (L2) ≥ Medium	D
≥ High	HQc (L2) ≤ Low	D
	HQc (L2) ≥ Medium	E

The area subject of the dredging works was divided into 6 sub-areas unit so distinct (Picture 3):

- n ° 1 unitary sub-area D3 on the external mouth of 50 m x 50 m side adjacent to the quay (type 1);
- n° 2 unitary sub-areas D1 and D2 in the access step to the port, side 100 m x100 m (type 2);
- n° 3 unitary sub-areas D4, D5 and D6 external to the mouth of the port with side 200 m x 200 m (type 3).

Table 3 - Quality class of the material port Termoli.

Sample code	Sample Code sub-area Sample depth from the fund	Eco toxicological hazard class	Chemical classification	% Pelite	Quality class of the material
17-AM19344	D1 F/50	HIGH	HQc (L2) ≤ Low	56.8	D
17-AM19345	D1 50/100	HIGH	HQc (L2) ≤ Low	59.3	D
17-AM19346	D1>100	HIGH	HQc (L2) ≤ Low	58.4	D
17-AM19347	D2 F/50	HIGH	HQc (L2) ≤ Low	60.1	D
17-AM19348	D2 50/100	HIGH	HQc (L2) ≤ Low	61.4	D
17-AM19349	D2>100	HIGH	HQc (L2) ≤ Low	61	D
17-AM19350	D3 F/50	HIGH	HQc (L2) ≤ Low	62.8	D
17-AM19351	D3 50/100	HIGH	HQc (L2) ≤ Low	63.1	D
17-AM19352	D3>100	HIGH	HQc (L2) ≤ Low	42.1	C
17-AM19353	D4 F/50	ABSENT	HQc (L2) ≤ Negl	7.2	A
17-AM19354	D4 50/100	MEDIUM	HQc (L2) ≤ Low	5.2	C
17-AM19355	D5/50	ABSENT	HQc (L2) < Negl	25.1	A
17-AM19356	D5 50/100	ABSENT	HQc (L2) < Negl	6.9	A
17-AM19357	D6 F/50	ABSENT	HQc (L2) < Negl	5.4	A
17-AM19358	D6 50/100	MEDIUM	HQc (L2) < Low	2.7	C

Discussion

According to the monitoring studies led by Arpa Molise and the into force regulations of November 2015, the totality of materials coming from the Termoli's harbor dredging could be immerged in a compatible area chosen in open sea.

With the drafting of the final project (August 2017), according to the new normative, the results of the environmental analyses, led from October 2017 and January 2018, have showed the impossibility to dissipate, in open sea, wastes "as such" as they were in the harbor's canal, but it is important to divide the dredging activity in two different areas:

- Zone A of the external canal of the harbor's entrance, where the waste materials coming from the dredging can be:
  1. dissipate in open sea, with the limit of 160 000 m³ of volume; 50 cm of superficial thickness from the maximum depth (i.e. between -5.4 m e 5.6 m ASLM). At this level deposits have to be of Class A, they have to plainly respect the environmental conditions in order to be deliberately dissolved in see areas far from the cost (more than three miles).
  2. made of deposits of inferior thickness (so up to a depth of dredging of -6.0 m ASLM) which are included to the class C of the environmental quality, but they have to respect the standards values (physical, chemical end eco-toxicological) with a better environmental quality than deposits located on the seabed of the chosen area

(as indicated by Molise region in Det. Dir. n.5976/2015, the initial project which still in progress), but they aren't an arm for the environmental quality of the sea.

- Zone B of the internal canal of the harbor's entrance, materials coming from the dredging have to have a maximum volume of 51 000 m³, but it must be treated in order to select and divide:
  1. the sandy fraction (about 43 000 m³ dissipate far from the coast)
  2. the thinner fraction (maximum 8 000 m³) which should be spread on the internal seabed of the harbor, in areas which were previously selected and agreed by the city hall and the coast guard. Therefore the analyses conducted on samples selected in the zone B show that deposits are class D and so, according to the norms, the materials come from the dredging have to be treated to select the smallest fractions in order to reduce the amount of toxic substances of the sandy fraction before it can be dissipated in open sea in the same amount as the zone A.

Conclusion

The coming into force of the new "Regulation concerning the modality and criteria for the authorization to dissipate, in the sea, materials coming from the digging of the seabed" (DM 15 July 2016 n.173) states the priority of the management strategies to be adopted.

In the management strategy of the Termoli's harbor it's been fundamental to find solutions, in order to respect the budget of a prior contract.

Therefore, in order to limit operational costs and to complete the operations of dissipation in open sea of the dredging deposits (less management costs), which was included and counted in the preliminary draft, confirmed in final draft and presented to the contractor during the tender, it was necessary to execute the operations of dredging of the zone b, provide two extra interventions:

- The first consist in the 'cleaning" of the granulometric fraction, the thinnest, of the material which was dredged at the interior of the harbor, with a maximum quantity of 51 000 m³, following the technique called 'Sedimentological washing".
- The second, the sedimentological washing; is a process of granulometric separation of deposits, firstly remove the thinnest granulometric component (pelite) by using pumps and water jets which are presents in the hopper of the dredger.

By activating the pumps, the materials, present in the hopper waterproofed, has been diluted and transformed in a mix of water and sand at the interior of the hopper. Little by little that the water injected by the pumps fill, the hopper the thinner components are pulled through the top and the water jets, which are located on the side of the hopper, help the components to be ejected by the "overflow system". This technique consists of the two gates, located on the top of the hopper, which help to regulate the amount of water by sliding the excess of water and keeping inside the thicker granulometric component. During the overflow, in order to limit the dispersion of thin deposits in the harbor's basin; purlins PVC are been used to favorite the deposit of these "keels" in the area where the dredger is stopped. Once the operations of the Sedimentological washing are finished, the thinnest components remain in the harbor limited area thank to the purlins; on the other hand, bigger components are ready to be ejected in the sea. From this moment it's possible to start a

second dredge and spread the deposits all along the seabed of the port in area selected and agreed with the cost guards. Different analysis were led to find out the costs of all operations, taking in consideration the machinery needed and, in function of the length and the productivity of a work cycle, obtain the unitary cost which were used to the final draft of the budget.

To follow it will be reported the analyses of the costs of the two extra operations.

NP1: A higher price is applied for the dredging because the extra treatments o the materials dredged at the interior of the Termoli's harbor which are class D of the environmental quality scale. The analysis of the production cycle led to estimate a unitary cost for a meter cube of deposit equal to 3.36 €.

NP2: A higher price is applied for the dredging because the transportation of the materials (class D of the environmental quality scale) dredged in Termoli's harbor. The analysis of the production cycle led to estimate a unitary cost for a meter cube of deposit equal to 1.98 €.

At the end of new enquiries of the environmental characteristics of deposits (according to the DM 173/2016), it has been necessary to add to the executive project two extra operations in order to treat the sediments dredged in the port. For those operations, an analysis has been led in order to define the costs which have increased of 7 % the total cost.

Aknowledgement

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