



Introduction to the TREASURE approach to monitoring environmental quality through Lines of Evidence – the Environmental quality assessment matrix

CRISTIAN MUGNAI -ISPRA

3° Transfer Webinar «Environmental Impact Assessment: the TREASURE experience», 7 May 2026



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How can ports solve environmental issues caused by human activities?



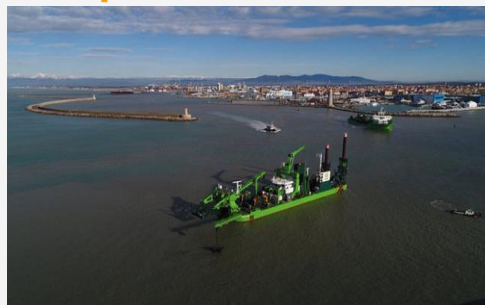
PORT OF BAR, MONTENEGRO:
dust pollution



PORT OF DURRES, ALBANIA:
Chemical pollution water



PORT OF VALENCIA, SPAIN:
Scrubber discharge



PORT OF LIVORNO, ITALY:
Sediment management



PORT OF VALLETTA, MALTA:
marine pollution risk



PORT OF PIREUS, GREECE:
sediment and water management



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C2

MONITORING ENVIRONMENTAL QUALITY [→ WP2]

New approaches to environmental assessment, through “**Lines of Evidence**”, for a qualitative evaluation of different compartments (sediments / water / biota) of the port environment

Activity 2.1

Knowledge transfer and Capture on Environmental Impact evaluation and Hazard management: capitalization of Interreg IT-FRA Maritime project GEREMIA, to calculate an integrated environmental index of port areas through the “Lines of Evidence(LOE)/Weight of Evidence(WOE)” approach. Partner develop a common language + transnational exchange

Activity 2.2

Defining Environmental Impact evaluation and Hazard Management matrix: Partners (with technical stakeholders) cooperate to develop a common Environmental Impact evaluation and Hazard Management matrix, based on WOE approach.



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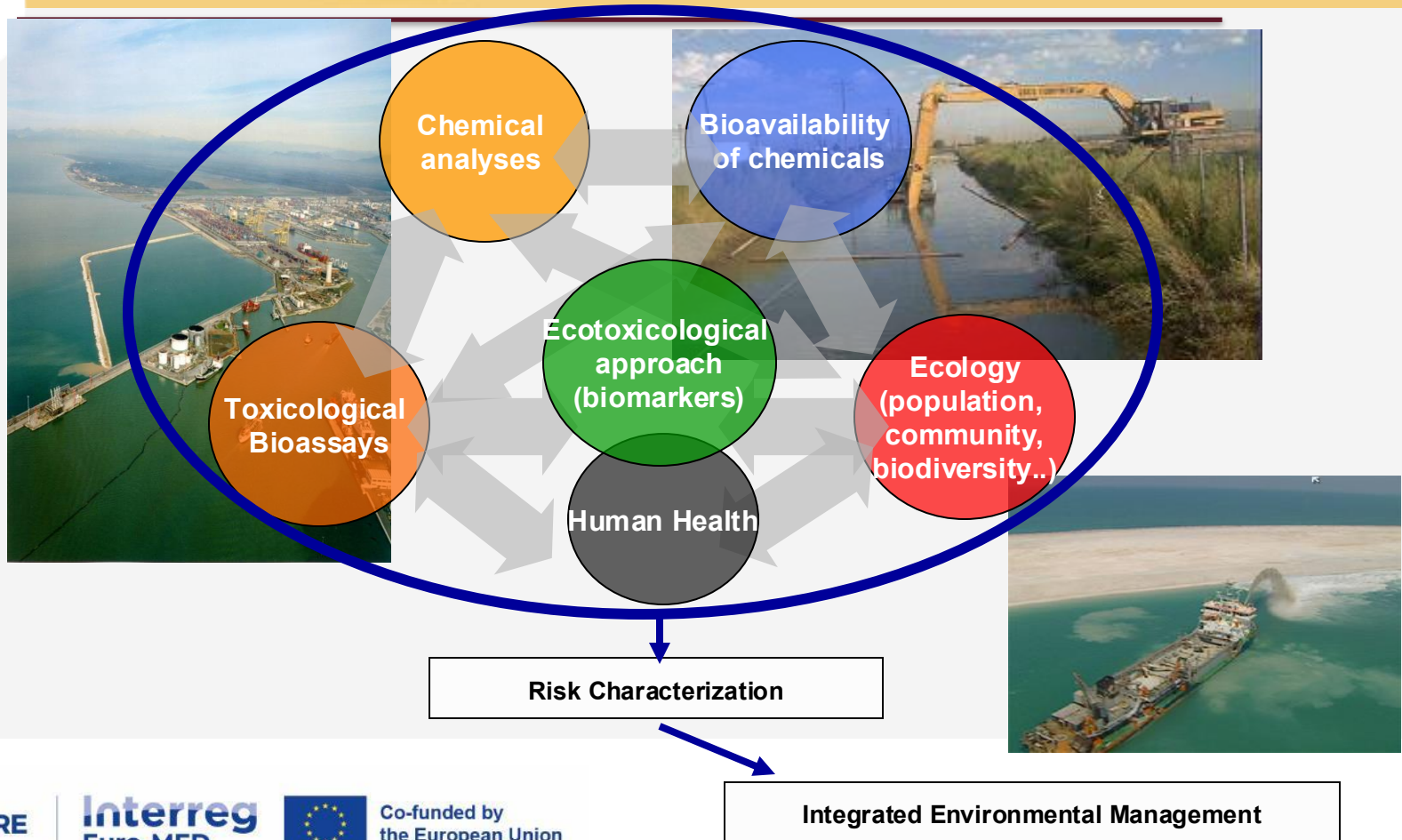


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Integrated models for ecological risk assessment





Quantitative risk assessment model on Weight of Evidence (WOE) approach: Sediqualssoft® tool

Full online user-friendly interface
Import data from excel files

Sample code
Point 1 ☒

Sampling code
La Spezia

Area

Site
La Spezia

Latitude
9.888055

Longitude
44.067735

Core code

Level code
0.46

Date
09/04/2019

Note

Trophic index
TRIX units: 2.96

Trophic state: **Stenotrophic**

Conditions: Oligotrophic

Water quality conditions

- Scarcely productive waters
- Good water transparency
- Absence of anomalous water colors
- Absence of oxygen undersaturation in the bottom waters

Chla: 0.69 µg/L

DO: 97.9%

N: 31.57 µg/L

P: 2.47 µg/L

SQA CMA (D.Lgs. 172/2015)

Level of chemical hazard
NEGLIGIBLE

Chemical HQ: 1.11

Max % contr. to HQ: 100% - Crtot

N. exceeding param: 1

N. param with refer: 1

N. analysed param: 18

SQA (freswater; D.Lgs. 172/2015)

Level of chemical hazard
ABSENT

Chemical HQ: 0.34

Max % contr. to HQ: 0% -

N. exceeding param: 0

N. param with refer: 2

N. analysed param: 18

SQA (marine; D.Lgs. 172/2015)

Level of chemical hazard
ABSENT

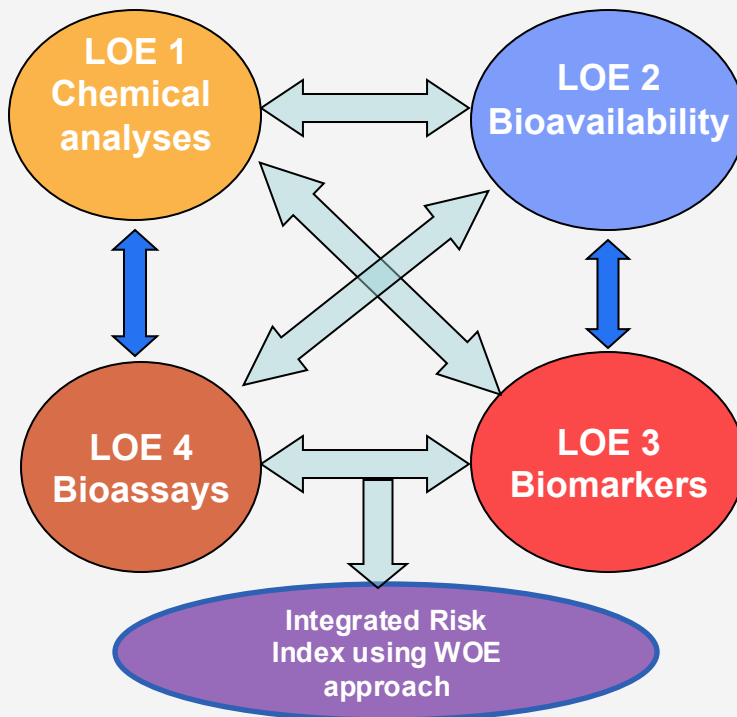
Chemical HQ: 0.44

Max % contr. to HQ: 0% -

N. exceeding param: 0

N. param with refer: 3

N. analysed param: 18





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MARITTIMO-IT FR-MARITIME

Fondo Europeo di Sviluppo Regionale

GEREMIA

Gestione dei REflui per il Mlgioramento delle Acque portuali

Governance tools for the prevention and control of pollution and for the improvement of water quality in ports

2nd Call of the Italian-France Maritime Cross-Border Cooperation Program 2014-2020



ISPRA participated to the project in collaboration with ARPAL e Polytechnic University of Marche (Department of Life sciences and Environment)



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Sediqualssoft: GEREMIA

Chemical analyses

Sediments

LOE 1

Water column

LOE 2

Bioaccumulation of chemicals

LOE 3

Biomarkers analyses

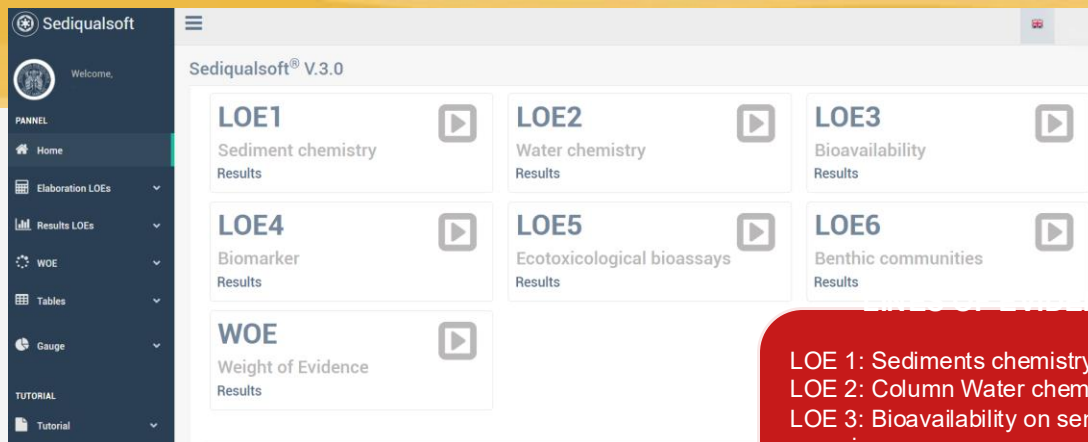
LOE 4

Ecotoxicological tests

LOE 5

Analyses of benthic communities

LOE 6



LOE 1: Sediments chemistry
LOE 2: Column Water chemistry
LOE 3: Bioavailability on sentinel organisms
LOE 4: Biomarkers on sentinel organisms
LOE 5: Bioassays
LOE 6: Analyses of benthic

Environmental Integrated Quality index for ports



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Sediment

Conservative compartment

In port areas, sediments are often contaminated by chemicals linked to anthropic activities

Lines of Evidence

Chemical analyses (LOE 1)

- Grain size
- Trace elements
- PAHs
- PCBs
- Organotin compounds
- Organochlorine pesticides

Bioassays (LOE 5)

- *Bioluminescence inhibition bioassay with Aliivibrio fischeri*
- Inhibition of algal growth *Phaeodactylum tricornutum*
- Embriotoxicity with sea urchin *Paracentrotus lividus*

Benthic communities (LOE 6)

AMBI index



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Water column

Dynamic and highly variable compartment

LOEs

Chemical analyses (LOE 2)

- Trace metals in dissolved fraction
- Passive accumulator DGT
- Complementary parameters (nutrients, conductivity, turbidity, suspended solids, TOC, etc.)



<https://pastor>

<https://www.directindustry.it/fabbricante-industrie/onda-multiparametrica-104310.html>

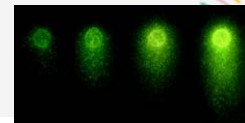
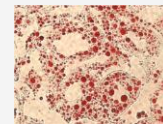
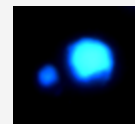


<http://interreg-maritime.eu/web/guest/geremia-presentazione-partner-ias>



Bioaccumulation mussels and fishes (LOE 3)

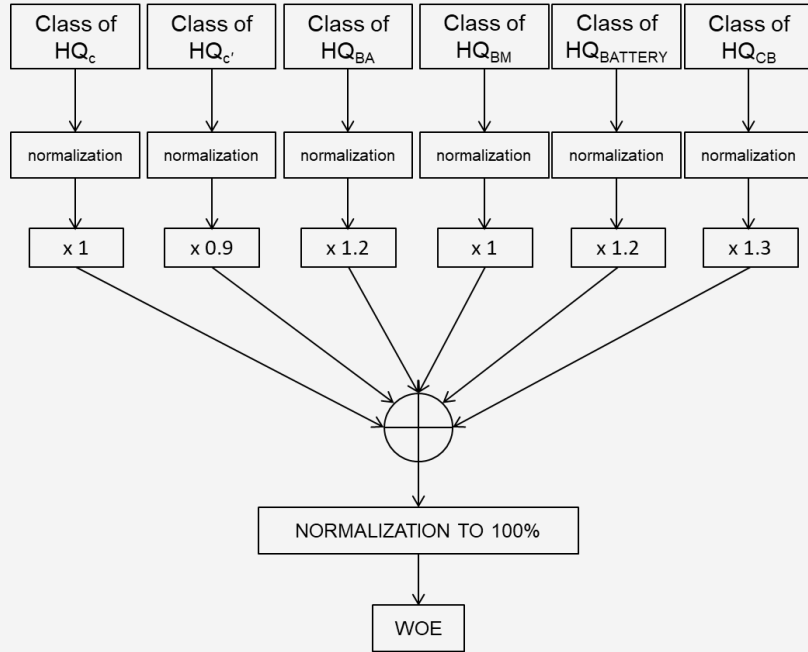
Biomarker mussels and fishes (LOE 4)



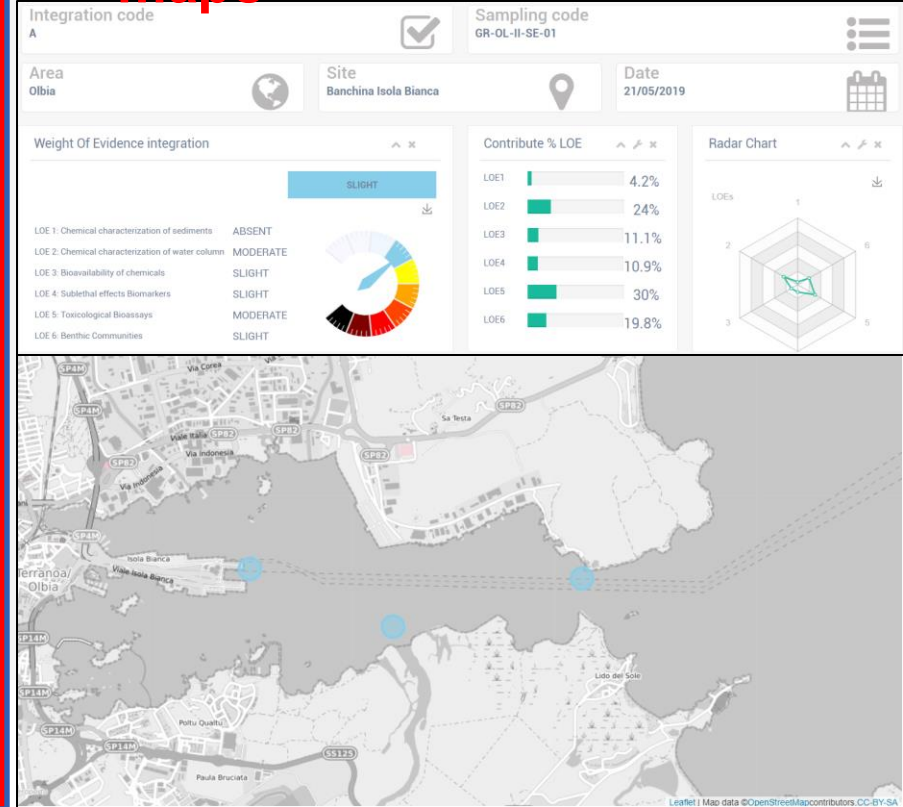


Integration of various LOEs into WOE and integrated index

environmental 'hazard'
maps



integrated environmental quality index (colour score)





Requested information

Partner name

Test area : *Please insert the name of the port, location of sampling stations, adding the map and coordinates*

Lines of evidence and specific parameters applied in the matrix tool. *Please indicate also the analytical methods and thresholds (add as many lines as necessary)*

Parameter

Units

Method

Starting date and periodicity of WP2 testing activities: as *partners apply the matrixes in selected port areas as a pre-test, before applying novel techniques in WP3, and collect data throughout the WP3 testing phase and come to a final evaluation, please consider starting no later than 01/06/2025 and to finish no later than April 2026.*

Start date

End date

Periodicity

Parameter	Units	Method
Phosphates	mg/L	Colorimetry
Anthracene	µg/L	Gas Chromatography/Masses
Benzene	µg/L	Gas Chromatography/Masses
Cadmium	µg/L	ICP Spectroscopy/Masses
Aldrin	µg/L	Gas Chromatography/Masses
Dieldrin	µg/L	Gas Chromatography/Masses
Endrin	µg/L	Gas Chromatography/Masses
Sum of DDT, DDD & DDE	µg/L	Gas Chromatography/Masses
α-HCH, β-HCH, δ-HCH, Lindane.	µg/L	Gas Chromatography/Masses
Lead	µg/L	ICP Spectroscopy
Mercury	µg/L	Atomic Fluorescence
Naphthalene	µg/L	Gas Chromatography/Masses
Niquel	µg/L	ICP Spectroscopy/Masses
Benzo(a)pyrene	µg/L	Gas Chromatography/Masses
Benzo(b)fluoranthene	µg/L	Gas Chromatography/Masses
Benzo(k)fluoranthene	µg/L	Gas Chromatography/Masses
Benzo(g,h,i)perylene	µg/L	Gas Chromatography/Masses
Indene(1,2,3-cd)pyrene	µg/L	Gas Chromatography/Masses
Heptachlor epoxide	µg/L	Gas Chromatography/Masses



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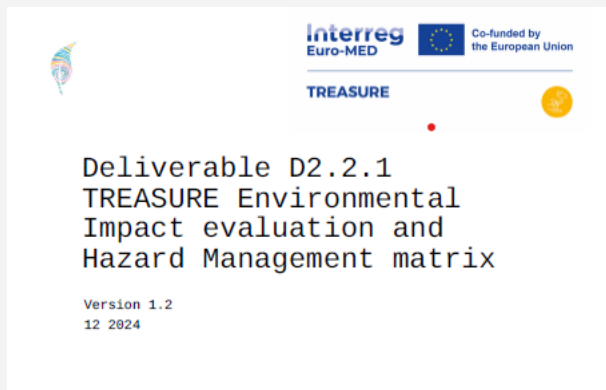
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All TREASURE partners with allocated budget (PP2, PP3, PP4, PP5, PP7 and PP8) were asked to select a minimum of 2 LOEs to be tested in their port areas during the project lifetime, collecting data from at least 2 sampling stations. The stations are suggested to be located one inside and one outside the port area, to reflect different gradients of contamination (e.g. sediments, dredging, river estuary, etc.). The minimum periodicity for sampling within TREASURE activities is at least once in Spring 2025 (Period 3), and once after testing the treatment solutions selected within WP3. Periodical sampling, twice per year, is suggested as optimal.



Sediqualsoft® TREASURE

Online tool-accessible via all platforms (e.g. Linux, Mac OS X, Windows) using any web browser, from both "Mobile" and "Desktop" devices, at the following link

<https://woe-model.univpm.it/treasure>

4 LOEs

Sediqualsoft
a quantitative Weight Of Evidence (WOE) model to integrate huge amounts of heterogeneous data and to validate this approach in complex monitoring scenarios.

Different data are elaborated within specific modules through logical flowcharts and mathematical algorithms, which provide synthetic hazard indices for each line of evidence, before their final integration in a quantitative risk evaluation. The model has been applied to different multidisciplinary studies for the characterization and classification of sediment quality, the assessment of environmental hazards in coastal areas and brackish environments and within ecological risk assessment procedures.

LOEs Line of Evidence

- LOE1** **Sediment chemistry**
Module 1 - Sediqualsoft®
For each analyzed parameter, the Ratio To Reference (RTT) is calculated toward several normative limits or international guidelines, and further corrected (RTTcor) according to the typology of pollutants (i.e. hazardous or priority). By differently weighting parameters with RTTcor from those with RTTcor=1, the cumulative hazard (CQ) is calculated even moderately polluted sites (close to reference values). It increases according to number and magnitude of exceeding parameters, and it is not covered by measurement of severe "not exceeding" parameters. The cumulative HQ is assigned to 1 of 5 classes of hazard identified with different colours and the model output provides, for each of considered guidelines, the HQ value, and additional information on parameters.
- LOE2** **Water chemistry**
Module 2 - Sediqualsoft®
For each analyzed parameter, the Ratio To Reference (RTT) is calculated toward several normative limits or international guidelines, and further corrected (RTTcor) according to the typology of pollutants (i.e. hazardous or priority). By differently weighting parameters with RTTcor from those with RTTcor=1, the cumulative hazard (CQ) is calculated even moderately polluted sites (close to reference values). It increases according to number and magnitude of exceeding parameters, and it is not covered by measurement of severe "not exceeding" parameters. The cumulative HQ is assigned to 1 of 5 classes of hazard identified with different colours and the model output provides, for each of considered guidelines, the HQ value, and additional information on parameters. The model also elaborates the TTC index which is not integrated in the final elaboration, but can still provide useful indication on water quality assessment.
- LOE3** **Ecotoxicological bioassays**
Module 3 - Sediqualsoft®
Integrated invertebrate bioassays as the results from batteries of ecotoxicological assays. Specific methods and weights are assigned to each bioassay (depending on the biological endpoint, tested matrix, time of exposure, and the probability of harmful responses). A cumulative HQ for the battery is calculated from the variation of each bioassay compared to its threshold, normalized for the statistical significance and the score of the assay, and then assigned to 1 of 5 classes of hazard. The model output gives information on the responses of each bioassay and for the integrated battery, including the cumulative HQ and the class of ecotoxicological hazard.
- LOE4** **Benthic communities**
Module 4 - Sediqualsoft®
The analysis of benthic communities represents a fundamental and ecologically relevant LOE within a weight of evidence approach. The module has been developed to elaborate already available univariate and multivariate indices of benthic communities, providing the relative classification of ecological quality in different classes of hazard (from absent to severe). Below indices used for the analysis of benthic communities are: Benthic Opportunistic Polychaetes (BOP), Benthic Opportunistic Crustaceans (BOC), Benthic Opportunistic Invertebrates (BOI), Benthic Opportunistic Nematodes (BON), Benthic Opportunistic Polychaetes (BOP), Benthic Opportunistic Crustaceans (BOC), Benthic Opportunistic Invertebrates (BOI), Benthic Opportunistic Nematodes (BON), Benthic Opportunistic Polychaetes (BOP), Benthic Opportunistic Crustaceans (BOC), Benthic Opportunistic Invertebrates (BOI), Benthic Opportunistic Nematodes (BON).
- WOE** **Weight of Evidence**
Module 5 - Sediqualsoft®
The HQs obtained for individual LOEs are finally elaborated through a visual Weight Of Evidence integration. After normalization of indices to a common scale, a different weighting is given to LOEs based on their ecological relevance, and the capability of indicators to directly assess negative effects. An overall WOE level of risk is then calculated and assigned to 1 of 5 classes from absent to severe.

- **Sediment Chemical analyses (LOE 1)**
- **Water Chemical analyses (LOE 2)**
- **Bioassays (LOE 5)**
- **Benthic communities (LOE 6)**

WOE



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LOE 1 Sediment chemistry

LOE1 Import CSV file

CSV Data Imported into the Database

Choose C.S.V File

Scegli file

Nessun file selezionato

Import

Chemical Characterization of Sediments LOE1

Unit measures to be used: Grain size: % - Heavy metals and trace elements - AH C>12: mg/Kg (d wt.) - Organic compounds: µg/Kg (d wt.)

Show 10 entries

Latitude	Longitude	Area	Site	Date	Sampling code	Core code	Level code	Sample code	Integration code	Note	Gravel	Sand	Pelite	Silt	Clay	TOC	OM	N tot	P tot	A
42.890267	19.877878	Luka 1		14/05/25	149/05/25	149/05/25	1	1	807	1 sampling							16.7	1190	515	<
42.894583	19.878783	Luka 1		14/05/25	147/05/25	147/05/25	1	1	805	1 sampling										
42.896339	19.885580	Luka 1		14/05/25	148/05/25	148/05/25	1	1	806	1 sampling										
42.897094	19.877303	Luka 1		14/05/25	145/05/25	145/05/25	1	1	803	1 sampling										
42.898394	19.882511	Luka 1		14/05/25	146/05/25	146/05/25	1	1	804	1 sampling										

Showing 1 to 5 of 5 entries

Chemical Characterization of Water LOE1

Data Entry Specifications:
Nutrients, Metals, Organic compounds: Enter all concentrations
Dissolved Oxygen (DO): Enter the % saturation (e.g. 5%)
Physico-Chemical: Use standard units.

Show 10 entries

Water chemistry

Module 2 - SediquaSoft®

For each analyzed parameter, the Ratio To Reference (RTR) is calculated toward several normative limits or international guidelines, and further corrected (RTRw) according to the typology of pollutants (i.e. hazardous or priority). By differently weighting parameters with $RTR < 1$ from those with $RTR > 1$, the cumulative Hazard (HQ) discriminates even moderately polluted sites (close to reference values); increases according to number and magnitude of exceeding parameters; is not lowered by measurement of several "not exceeding" parameters. The cumulative HQ is assigned to 1 of 6 classes of hazard identified with different colours and the model output provides, for each of considered guideline, the HQ value, and additional information on parameters. The model also elaborate the TRIX index which is not integrated in the final elaboration, but can still provide useful indication on water quality assessment.

LOE 2 Water chemistry

LOE1

Sediment chemistry

Module 1 - SediquaSoft®

For each analyzed parameter, the Ratio To Reference (RTR) is calculated toward several normative limits or international guidelines, and further corrected (RTRw) according to the typology of pollutants (i.e. hazardous or priority). By differently weighting parameters with $RTR < 1$ from those with $RTR > 1$, the cumulative Hazard (HQ) discriminates even moderately polluted sites (close to reference values); it increases according to number and magnitude of exceeding parameters; and it is not lowered by measurement of several "not exceeding" parameters. The cumulative HQ is assigned to 1 of 6 classes of hazard identified with different colours and the model output provides, for each of considered guideline, the HQ value, and additional information on parameters.



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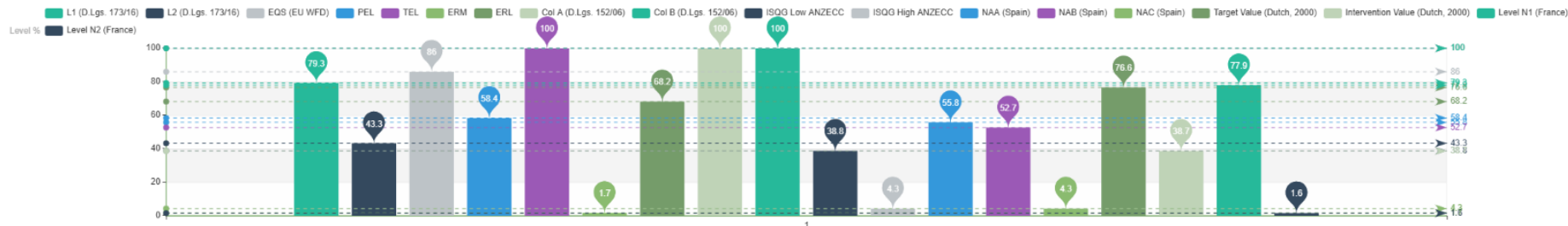


PROCESS



LOE 1 Sediment chemistry

Bar Graph



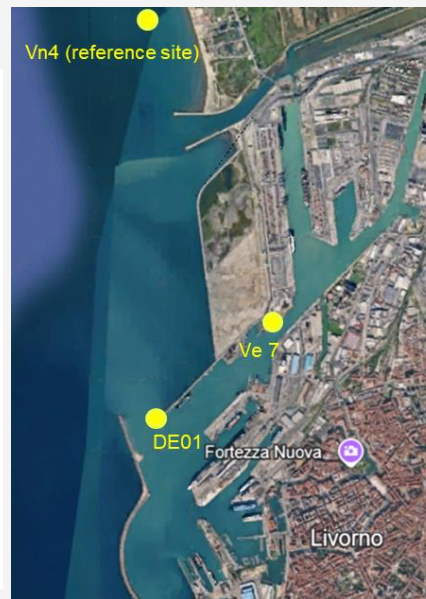
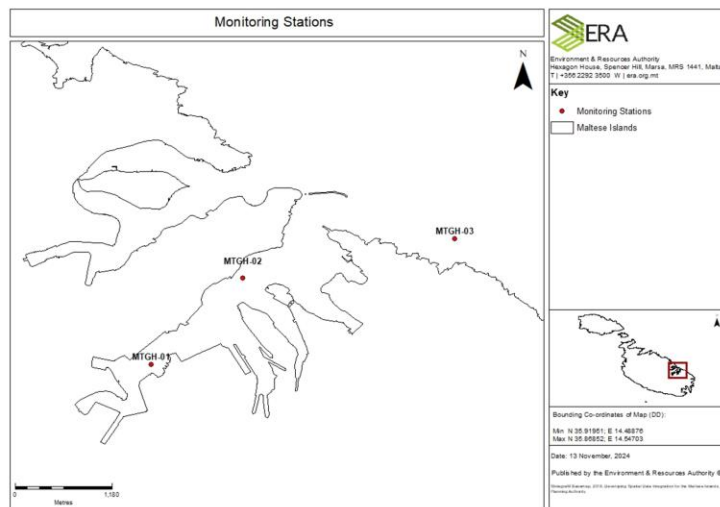
Added different international Thresholds, including italian , Spanish and French action levels for sediment management

LOE 2 Water chemistry

Details	Sample code	TRIX	SQA (freswhwater; D.Lgs. 172/2015)	SQA (marine; D.Lgs. 172/2015)	SQA CMA (D.Lgs. 172/2015)	NCA MA (RD 817/2015 - Dir. 2014/101/UE Spain)	NCA CMA (RD 817/2015 - Dir. 2014/101/UE Spain)
	803/01/25	Moderate	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
	804/01/25	Moderate	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
	805/01/25	Moderate	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
	806/01/25	Good	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT
	807/01/25	Good	ABSENT	ABSENT	ABSENT	ABSENT	ABSENT



Ports sampling strategy



Most commonly used LOEs: sediment chemistry (LOE1), water chemistry (LOE2), bioassays (LOE5)



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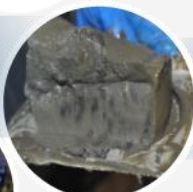
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Environmental Integrated Quality index



Chemical analyses



Sediments

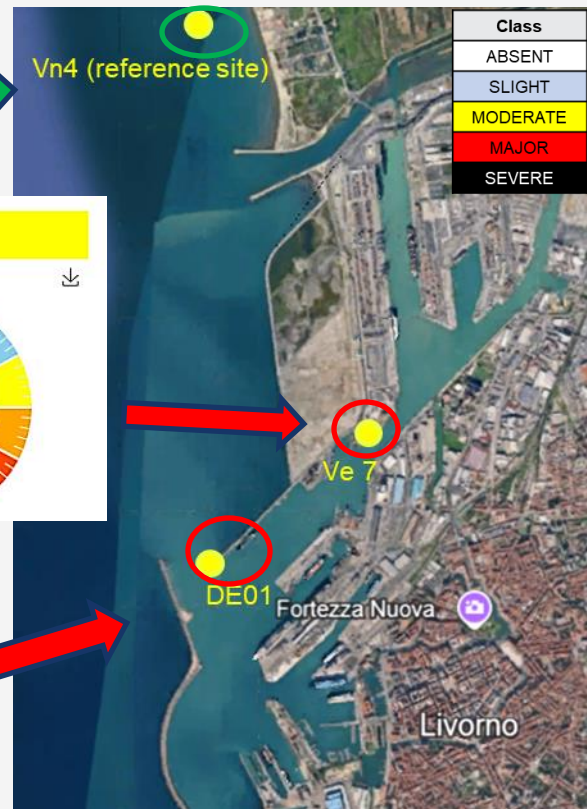
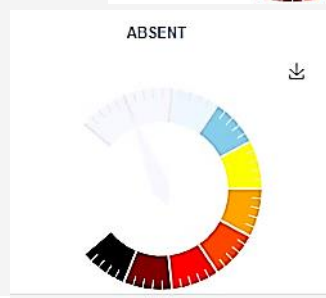
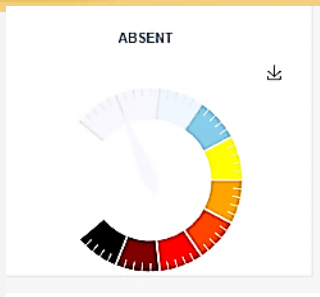
LOE 1

Ecotoxicological tests

LOE 5

Analyses of benthic communities

LOE 6



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Common data repository

Basecamp

Home Lineup Pings Hey! Activity My Stuff Find

+ New...

WP2: testing new approaches to env. assessment

Unsorted

PP Testing Data

dpa

PP2_ISPRA

TREASURE_Workplan WP2_P3-4_def.docx

TREASURE_WP2Kic koff.pptx

LOEs

LOE6 web.xlsx

LOE5 web.xlsx

...and 2 more

SediquaSoft-Treasure.mp4

Notes:
Video tutorial lines of evidence tool

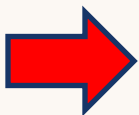
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Notes:
presentation during

TREASURE_WP2_preliminary-data_def.xlsx

TREASURE_Workplan WP2_def.docx

TREASURE_WP2 march 5.pdf





Project deliverables for WP2

CHALLENGE 2 MONITORING ENVIRONMENTAL QUALITY will results in 2 key **project deliverables** :

D2.2.1

TREASURE Environmental Impact evaluation and Hazard Management matrix (LINES OF EVIDENCE) (completed)

The deliverable reports on the methodology based on the **Lines of Evidence (LOEs) approach** for qualitative evaluation of environmental data, applied by the TREASURE partnership and describes the web-based demo tool which allows the processing and the integration of I environmental data

D2.3.1

Report on transnational application Environmental Impact evaluation & Hazard Management matrix

The document will report the work carried out in TREASURE territories and aims to provide a transnational comparative analysis of data gathered with the integrated hazard indices, providing input on validity of the LOE approach and of testing novel techniques..



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