UNIVERSITÀ POLITECNICA DELLE MARCHE

SCIENZE
DISVA - DIPARTIMENTO DI SCIENZE DELLA VITA E DELL'AMBIENTE

Approccio Weight of Evidence nel monitoraggio ambientale e nella classificazione del rischio in ambiente marino

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Sedimenti marino-costieri: gestione e valorizzazione della risorsa

BiG Blue Italian Growth Technology Cluster

Napoli, 3 luglio 2023

1

Weight Of Evidence (WOE) for risk assessment of pollution in the marine environment: criteria for elaboration of individual Lines Of Evidence (LOEs)

CRITICAL ISSUES IN RISK ASSESSMENT OF CHEMICAL POLLUTANTS

Interpretation and significance of complex datasets of heterogeneous results

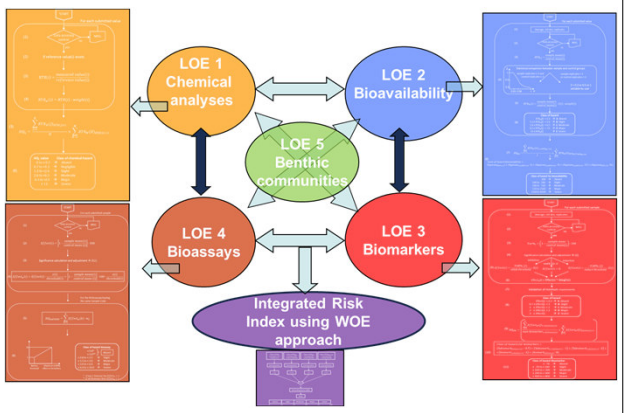
Integration of different typologies of data

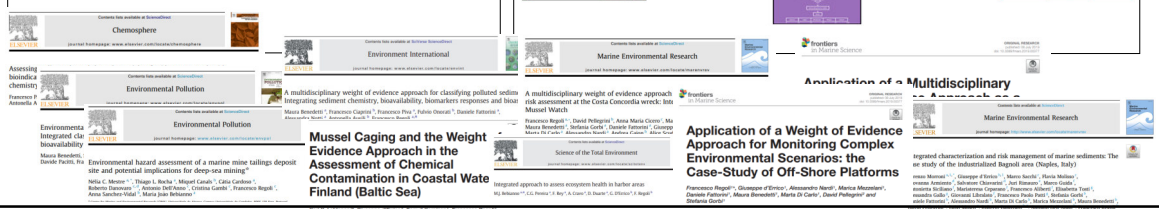
Qualitative and quantitative evaluations: indices and scales development

Synthetic risk characterization/communication

Wide validation (sediments, harbors, petrol-chemical sites, incidents, remediation areas, deep-sea mining, natural seepage, etc.…)

INTEGRATED MODELS FOR RISK ASSESSMENT





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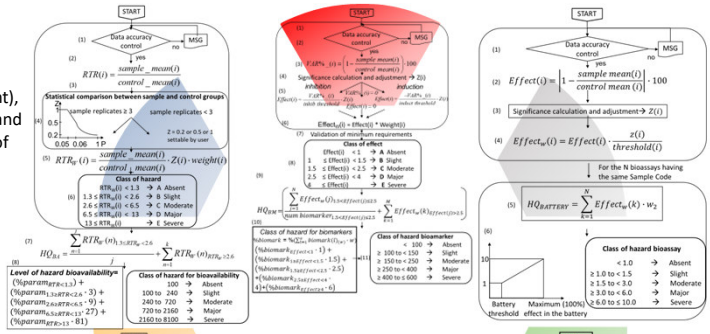
Weighted elaboration of different LOEs and integration into WOE and class of Risk

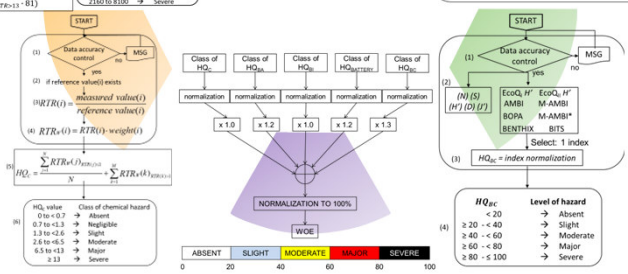
Bioaccumulation:
number, typology (weight), magnitude (thresholds) and statistical significance of accumulated chemical



Cellular effects (biomarkers):
number of varied biomarkers, toxicological relevance of endpoints (weight), magnitude of variation compared to specific thresholds and statistical significance of variations

Ecotoxicological bioassays:
no «pass-to-fail» criteria
batteries of ecotoxicological bioassays, each with a specific weight depending on the biological endpoint, and a threshold based on species sensitivity and assay conditions. Cumulative effects are calculated on a scale ranging from 0 to 10

Chemical analyses:
no «pass-to-fail» criteria
number, typology (weight) and magnitude (thresholds) of exceeding chemicals

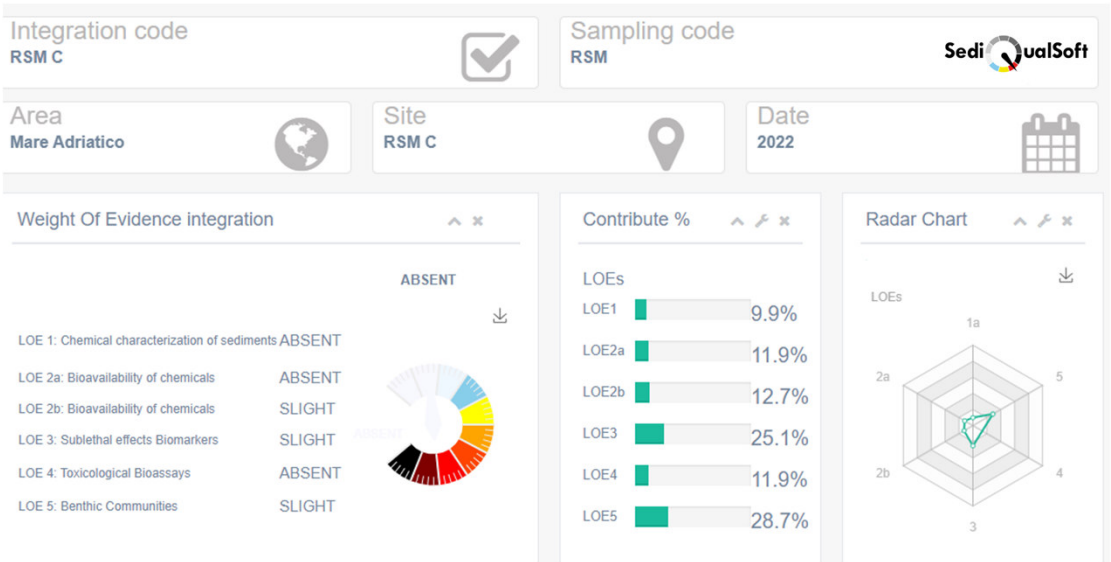


Benthic communities:
elaboration from the list of observed species and individuals, of all the already available community descriptors, indices of taxonomic diversity and ecological indicators, to select the more appropriate descriptor, according to the investigated area

WOE elaboration and integration of LOEs: normalization to a common scale of Hazard Quotients and assignment of a different weight depending on their ecological relevance,

3

3



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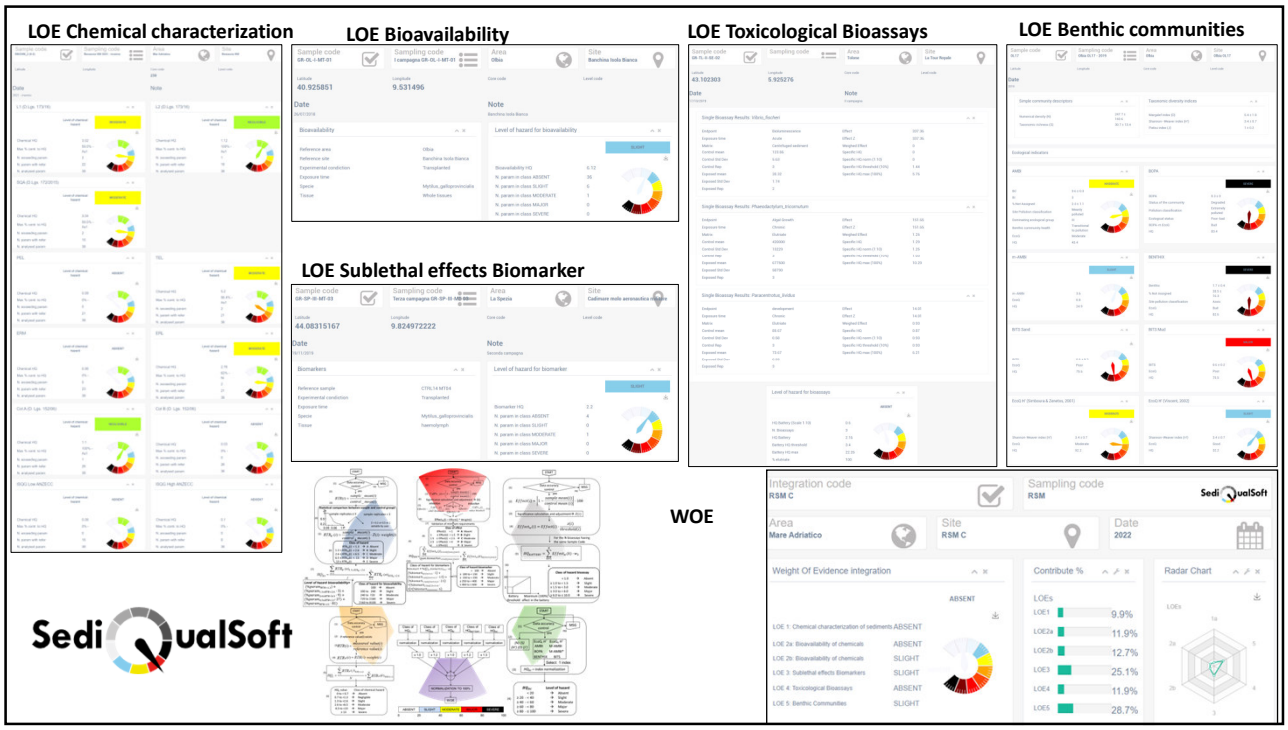
LOE Chemical characterization
LOE Bioavailability
LOE Toxicological Bioassays
LOE Benthic communities
LOE Sublethal effects Biomarker
WOE
SediQualSoft
Integration code
RSM C
Sampling code
RSM
Area
Mare Adriatico
Site
RSM C
Date
2022
Weight Of Evidence integration
Contribute %
Radar Chart
ABSENT
LOE1 9.9%
LOE2a 11.9%
LOE2b 12.7%
LOE3 25.1%
LOE4 11.9%
LOE5 28.7%

5


Rospo Field
Offshore Platforms
N
25mt
50mt
100mt
Chemical analyses
LOE 1
Sediments collection
Ecotoxicological tests:
V. fischeri
P. tricornutum
A. tonsa
P. lividus
LOE 4
Analyses of benthic communities
LOE 5
Weight of evidence
LINES OF EVIDENCE
LOE 1: Sediments chemistry
LOE 2: Bioavailability on sentinel organisms
LOE 3: Biomarkers on sentinel organisms
LOE 4: Ecotoxicological tests
LOE 5: Analyses of benthic communities
Bioaccumulation test with H. diversicolor
LOE 2
Bioaccumulation of chemicals
LOE 2
Biomarkers analyses
LOE 3
M. galloprovincialis
20 sampling points for each offshore platform

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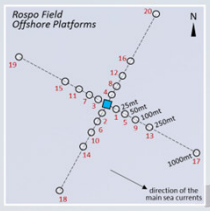
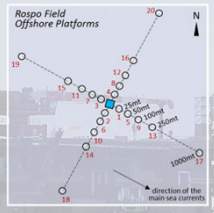
Chemical analyses of sediments

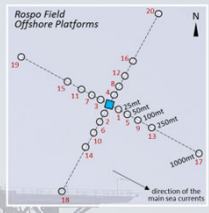
- 3 platforms
- 60 sampling sites
- ca 60 analytes (trace metals, PAHs, aliphatic hydrocarbons, pesticides)
- Total of 3600 analyses to interpret….
- Normative Guidelines (EU Sediment Quality guidelines, L1 and L2 limits of the Italian Decree on sediment management, DM173/2016)



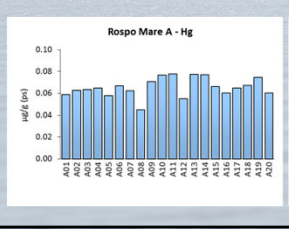
RSM-A

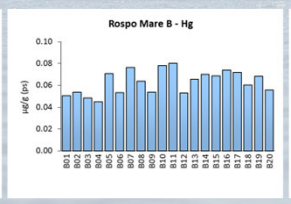


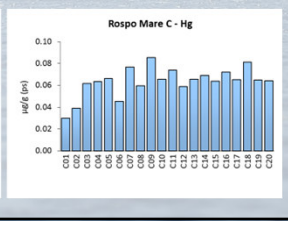
RSM-B



RSM-C

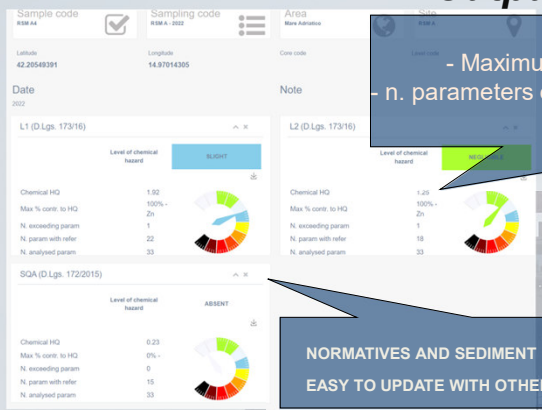






7

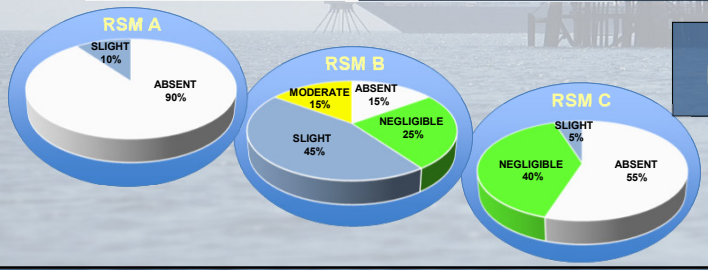
Output of Chemical Module



- HQ value
- Maximum % contribution given to HQ by a single analyte
- n. parameters exceeding the reference, with a reference, and analyzed
- class of chemical hazard

NORMATIVES AND SEDIMENT QUALITY GUIDELINES

EASY TO UPDATE WITH OTHER REFERENCES



Not significant differences as a function of platform, distance, current according to EU-SQA

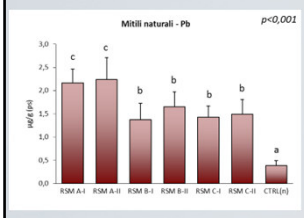
8

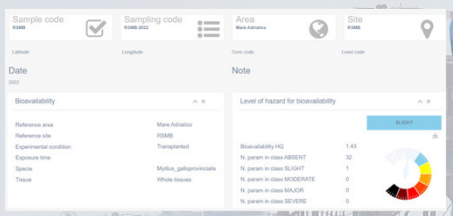
Bioaccumulation in mussels and polychaetes

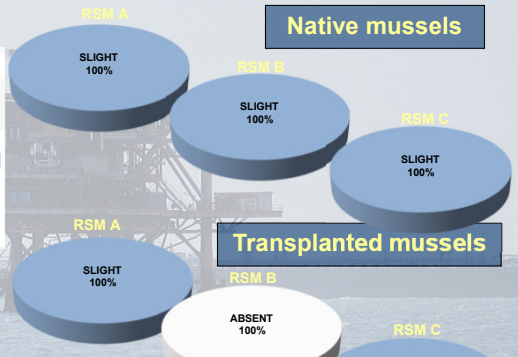
- 3 platforms, native mussels, transplanted mussels, laboratory exposed polychaetes (4 weeks)

- 34 analytes (trace metals, PAHs, aliphatic hydrocarbons)

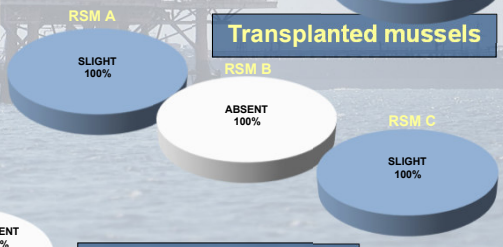
-Total of 5500 analyses to interpret



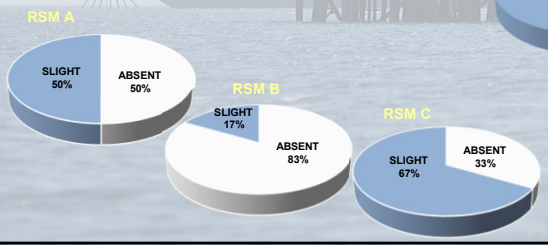




Native mussels



Transplanted mussels



Laboratory exposed
Hediste diversicolor

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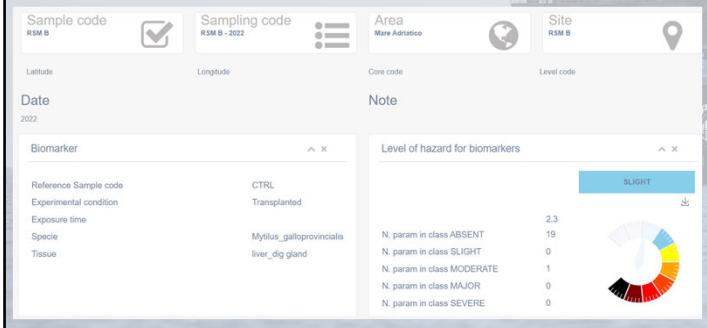
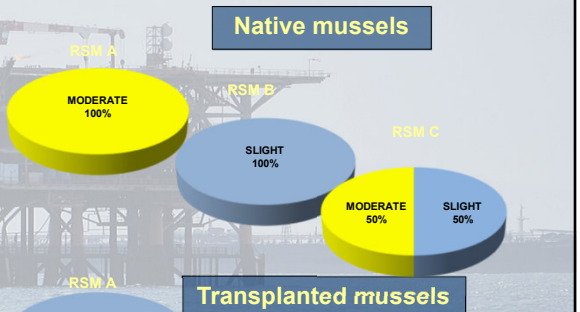
Biomarkers in native and transplanted mussels

- 3 platforms, native mussels, transplanted mussels (4 weeks)

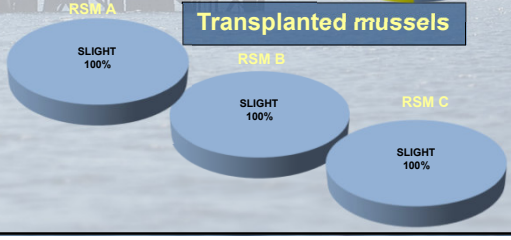
- 16 biomarker pathways (Metallothioneins, acetylcholinesterase, immune parameters, lysosomal responses, antioxidants and TOSC, lipid peroxidation, DNA damage)

-Total of 576 analyses to interpret





Native mussels



Transplanted mussels

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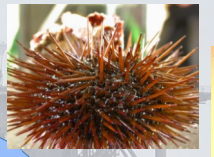
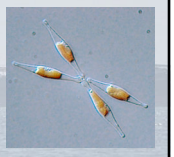
Ecotoxicological bioassays

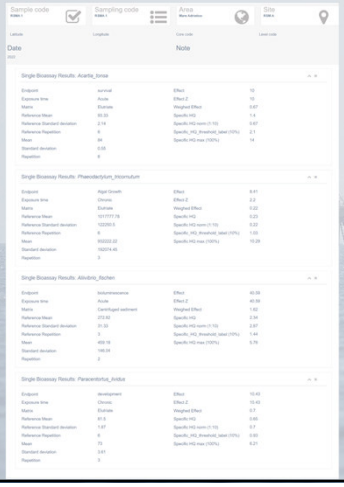
- 8 sediment samples for each of the 3 platforms

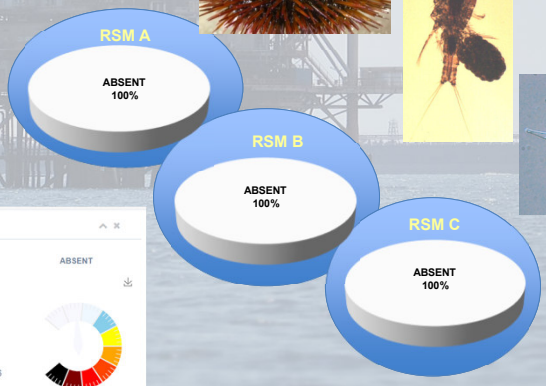
- 4 bioassays (*Vibrio fischeri, Phaeodactylum tricornutum, Paracentrotus lividus, Acartia tonsa,*)

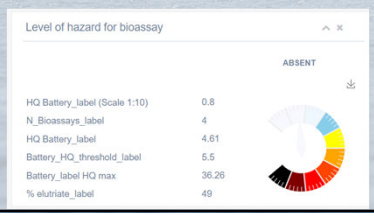
-Total of 400 analyses to interpret











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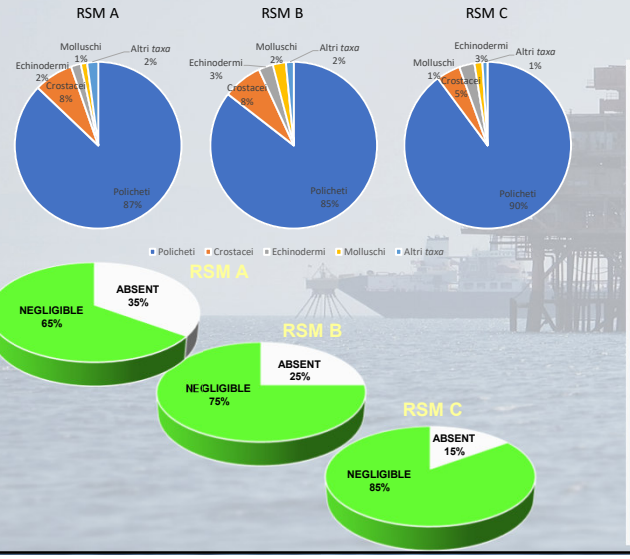
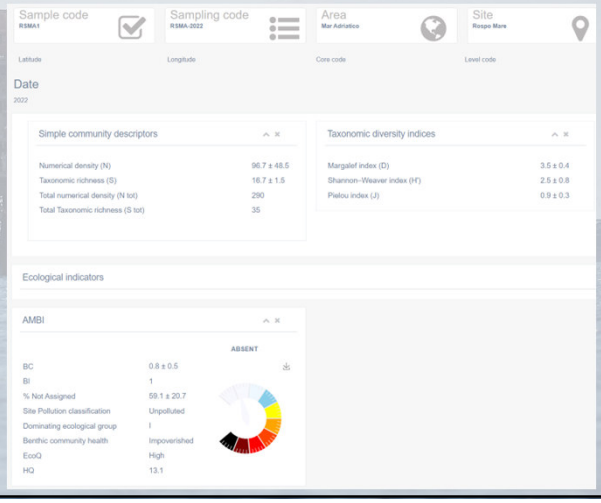
Benthic Communities

- 20 sediment samples in triplicate for each of the 3 platforms

-Total of 180 communities samples to interpret





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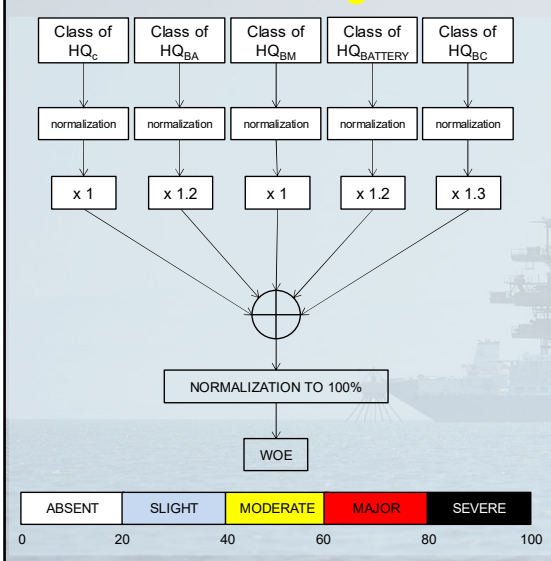
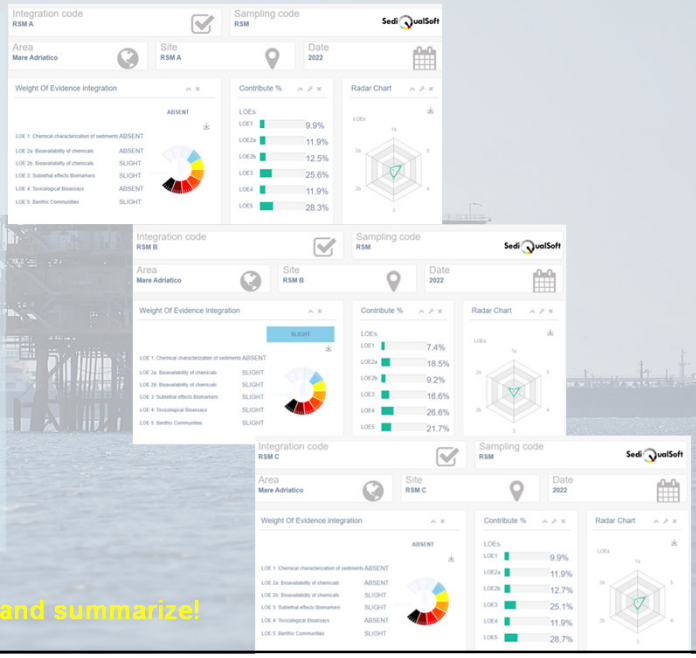
Flow chart for integration of various LOEs into WOE and class of Risk





More than 10.200 analyses to interpret….and summarize!

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Easy comparison between different years and/or sites

	2016		2019		2022	
	RSM A	WOE	RSM A	WOE	RSM A	WOE
LOE1 (Chimica dei sedimenti)	ASSENTE	BASSO	ASSENTE	ASSENTE	ASSENTE	ASSENTE
LOE2a (Biodisponibilità nei mitili)	BASSO		BASSO		ASSENTE	
LOE2b (Biodisponibilità nei policheti)	BASSO		BASSO		BASSO	
LOE3 (Biomarker nei mitili)	BASSO		MEDIO		BASSO	
LOE4 (Batteria di saggi ecotossicologici)	ASSENTE		ASSENTE		BASSO	
LOE5 (Comunità bentoniche)	BASSO		ASSENTE		BASSO	

	2016		2019		2022	
	RSM B	WOE	RSM B	WOE	RSM B	WOE
LOE1 (Chimica dei sedimenti)	BASSO	BASSO	BASSO	BASSO	ASSENTE	BASSO
LOE2a (Biodisponibilità nei mitili)	BASSO		BASSO		BASSO	
LOE2b (Biodisponibilità nei policheti)	BASSO		BASSO		BASSO	
LOE3 (Biomarker nei mitili)	BASSO		BASSO		BASSO	
LOE4 (Batteria di saggi ecotossicologici)	ASSENTE		ASSENTE		BASSO	
LOE5 (Comunità bentoniche)	BASSO		ASSENTE		BASSO	

	2016		2019		2022	
	RSM C	WOE	RSM C	WOE	RSM C	WOE
LOE1 (Chimica dei sedimenti)	TRASCURABILE	BASSO	TRASCURABILE	ASSENTE	ASSENTE	ASSENTE
LOE2a (Biodisponibilità nei mitili)	BASSO		BASSO		ASSENTE	
LOE2b (Biodisponibilità nei policheti)	BASSO		ASSENTE		BASSO	
LOE3 (Biomarker nei mitili)	BASSO		BASSO		BASSO	
LOE4 (Batteria di saggi ecotossicologici)	ASSENTE		ASSENTE		ASSENTE	
LOE5 (Comunità bentoniche)	BASSO		ASSENTE		BASSO	

14

Easily adapted to local/regional/national specificities

frontiers in Marine Science

Mussel Caging and the Weight of Evidence Approach in the Assessment of Chemical Contamination in Coastal Waters of Finland (Baltic Sea)

Kari K. Lehtonen[1*], Giuseppe d'Errico[2], Samuli Korpinen[1], Francesco Regoli[3], Heidi Ahkola[1], Tanja Kinnunen[1] and Anu Lastumäki[1]

TABLE 3 | Elaborations with levels of hazard assigned to the different LOEs and the final WOE.

Site	Chemical characterization	Bioavailability	Biomarkers	Benthic communities	Near-bottom oxygen	Eutrophication	Weight of Evidence integration
Kotka	HQ: 0.284 Absent -	HQ: 63.417 Major BaP–DBahA–BkF; PER	HQ: 4.229 Moderate CAT-GST	HQ: 67.174 Major	Absent	Major	MODERATE
Porvoo	HQ: 0.311 Absent -	HQ: 63.030 Major ANT–FLU; PER	HQ: 4.642 Moderate GST-LPO-CAT; GR	HQ: 46.078 Moderate	Slight	Major	MODERATE
Helsinki	HQ: 2.271 Slight 100% Zn	HQ: 14.842 Slight -;-	HQ: 2.517 Moderate -; GST	HQ: 31.326 Slight	Absent	Major	SLIGHT
Hanko	HQ: 0.28 Absent -	HQ: 29.925 Moderate -; 1-MetNAPH	HQ: 2.714 Moderate GR-GST; -	HQ: 46.377 Moderate	Absent	Moderate	SLIGHT
Parainen	HQ: 1.7 Slight 100% Zn	HQ: 59.329 Major BbF–BaP; PER	HQ: 2.008 Slight LPO;-	HQ: 48.291 Moderate	Absent	Major	MODERATE
Naantali	HQ: 2.829 Moderate 100% Zn	HQ: 80.710 Major FLU; PER–OSn	HQ: 2.402 Moderate GST-CAT; -	HQ: 49.020 Moderate	Absent	Major	MODERATE
Uusikaupunki	HQ: 1.566 Slight 100% Zn	HQ: 1.985 Slight -;-	HQ:2.42 Moderate CAT-GST; -	HQ: 9.520 Absent	Slight	Moderate	SLIGHT
Rauma	HQ: 6.18 Moderate 81.5% Zn	HQ: 64.589 Major -; PER–BaP	HQ: 2.125 Slight CAT; -	HQ: 33.676 Slight	Absent	Moderate	MODERATE
Pori	HQ: 0.293 Absent -	HQ: 0 Absent -;-	HQ: 0 Absent -;-	HQ: 50.986 Moderate	Absent	Slight	SLIGHT
Vaasa	HQ: 2.199 Slight 100% Zn	HQ: 4.296 Slight -;-	HQ: 1.0 Slight -;-	HQ: 59.938 Moderate	Absent	Slight	SLIGHT

Hazard Quotient (HQ) is provided for chemical characterization of seawater (showing the percentage of the parameter contributing most to the HQ), bioavailability (parameters showing major or severe effects), biomarkers (parameters showing moderate or major effects), and benthic communities.

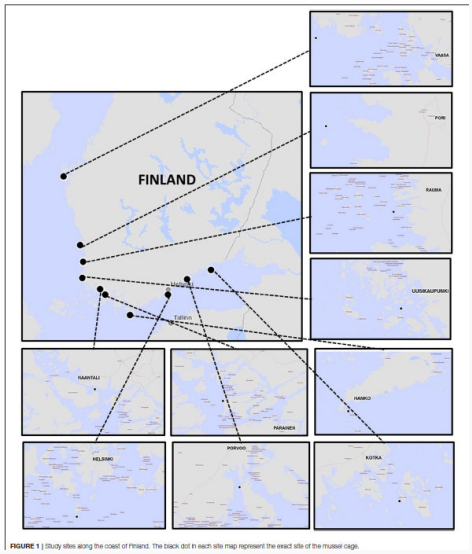

FIGURE 1 | Study sites along the coast of Finland. The black dot in each site map represent the exact site of the mussel cage.

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Weight Of Evidence (WOE) Model for risk assessment of emerging pollutants and microplastics

CRITICAL ISSUES IN RISK ASSESSMENT OF EMERGING POLLUTANTS

Very few data on their basal levels in environmental matrices

Limited characterization of their bioavailability, toxicological – ecological effects

Complex matrices (synergistic, additive, antagonistic effects), interactions with other factors (chlorination, UV, acidification, etc)

Integration of different typologies of data

Synthetic risk characterization/communication

Validation

CRITICAL ISSUES IN RISK ASSESSMENT OF MICROPLASTICS

Too generic definition of microplastics (<5mm)

Different sampling and analytical procedures provide non-comparable datasets

Unclear influence of specific characteristics (size, shape, polymer) on environmental fate and biological effects of microplastics

Integration of different typologies of data

Synthetic risk characterization/communication

Validation

PHARMASEA RESPONSE WOE MPs

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WOE MPs
https://bit.ly/woe-mps
Weight of Evidence
(WOE)
Model for Microplastics
RESPONSE
Towards a Risk Based Assessment of
Microplastic Pollution in Marine Ecosystems (RESPONSE)
WOE MPs Model
a quantitative Weight Of Evidence (WOE) model to integrate huge
amounts of heterogeneous data
TOOL USER FRIENDLY
Login
univpm20
Login
WOE MPs
Weight Of Evidence (WOE) Model for Microplastics
Copyright © 2022-2023
Forgot your password? Click here
MICROPLASTICS CHARACTERIZATION IN ABIOTIC MATRIX
MICROPLASTIC INGESTION
SUBLETHAL EFFECTS BIOMARKERS
TOXICOLOGICAL BIOASSAYS
WEIGHT OF EVIDENCE
WOE MPs
JPI OCEANS

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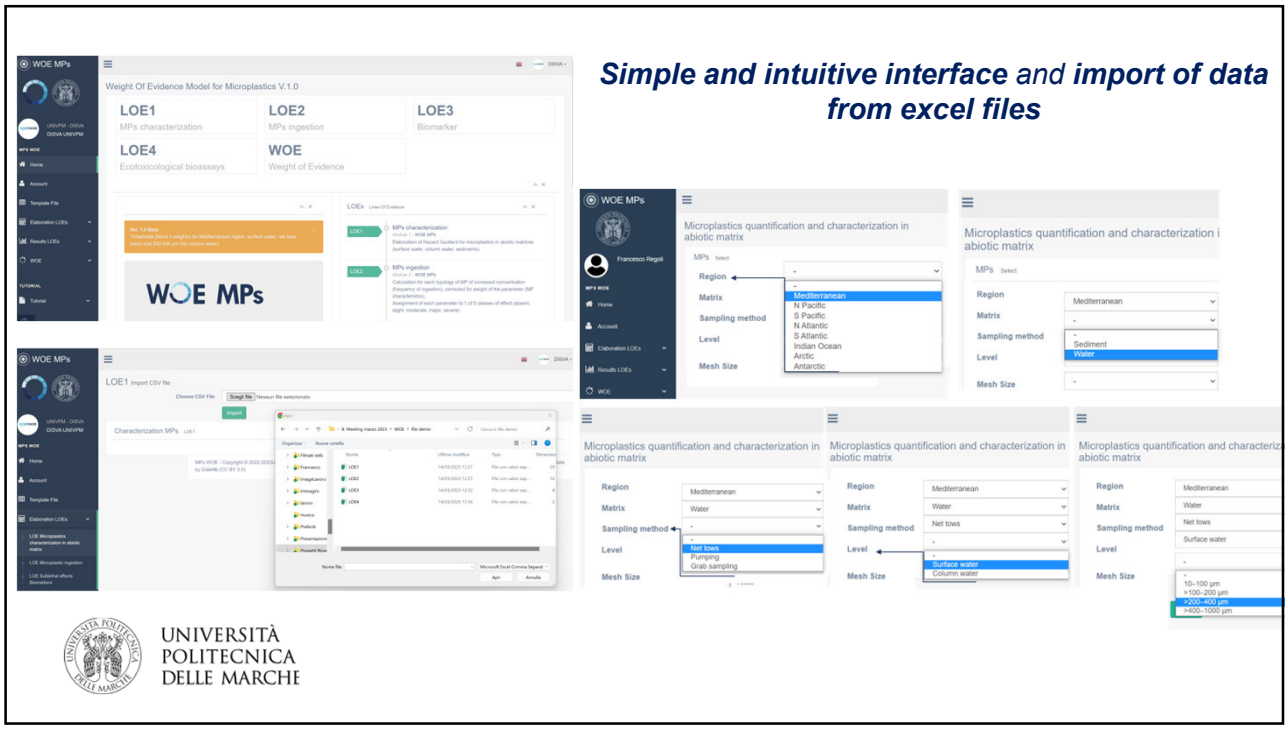
Simple and intuitive interface and import of data from excel files
Weight Of Evidence Model for Microplastics V.1.0
LOE1
MPs characterization
LOE2
MPs ingestion
LOE3
Biomarker
LOE4
Ecotoxicological bioassays
WOE
Weight of Evidence
WOE MPs
Microplastics quantification and characterization in abiotic matrix
Region
Matrix
Sampling method
Level
Mesh Size
Mediterranean
N Pacific
S Pacific
N Atlantic
S Atlantic
Indian Ocean
Arctic
Antarctic
Sediment
Water
Net tows
Pumping
Grab sampling
Surface water
Column water
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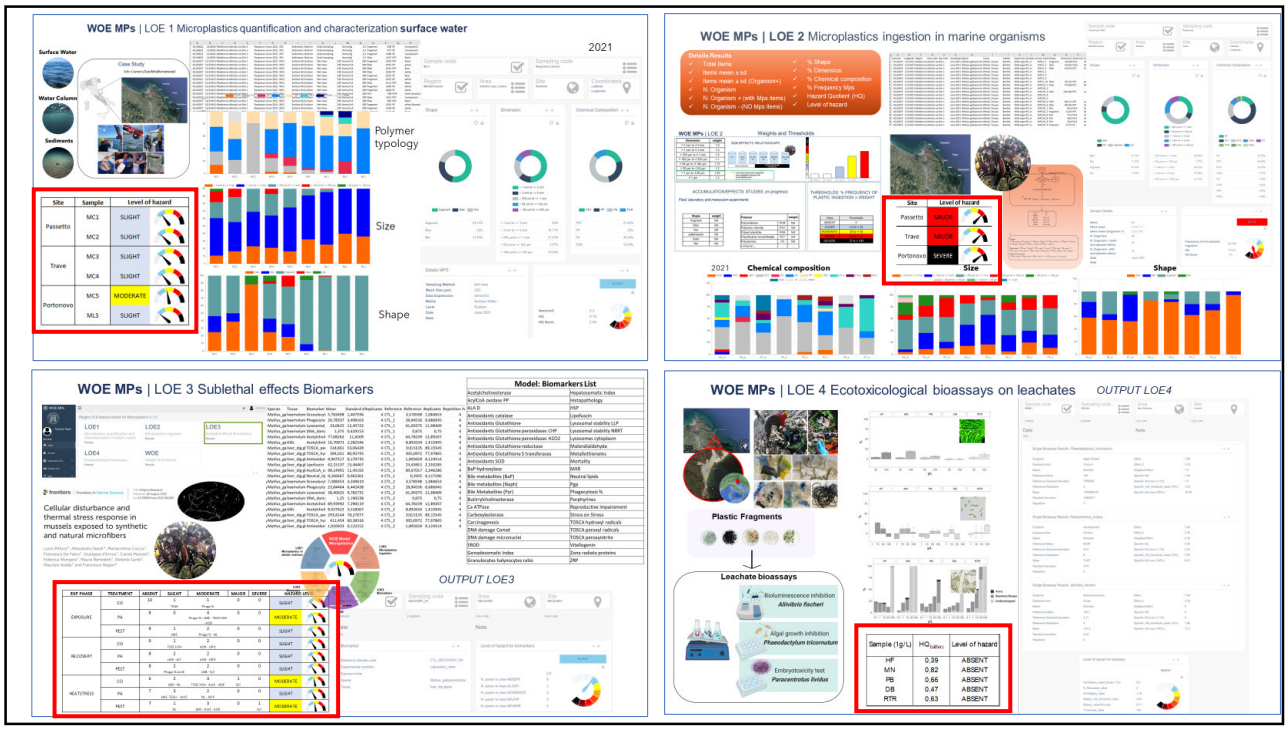
WOE MPs | LOE 1 Microplastics quantification and characterization surface water
2021
Polymer typology
Size
Shape
WOE MPs | LOE 2 Microplastics ingestion in marine organisms
Chemical composition
WOE MPs | LOE 3 Sublethal effects Biomarkers
Cellular disturbance and thermal stress response in mussels exposed to synthetic and natural microfibers
OUTPUT LOE3
WOE MPs | LOE 4 Ecotoxicological bioassays on leachates
OUTPUT LOE4
Plastic Fragments
Leachate bioassays
Bioluminescence inhibition
Aliivibrio fischeri
Algal growth inhibition
Phaeodactylum tricornutum
Embryotoxicity test
Paracentrotus lividus

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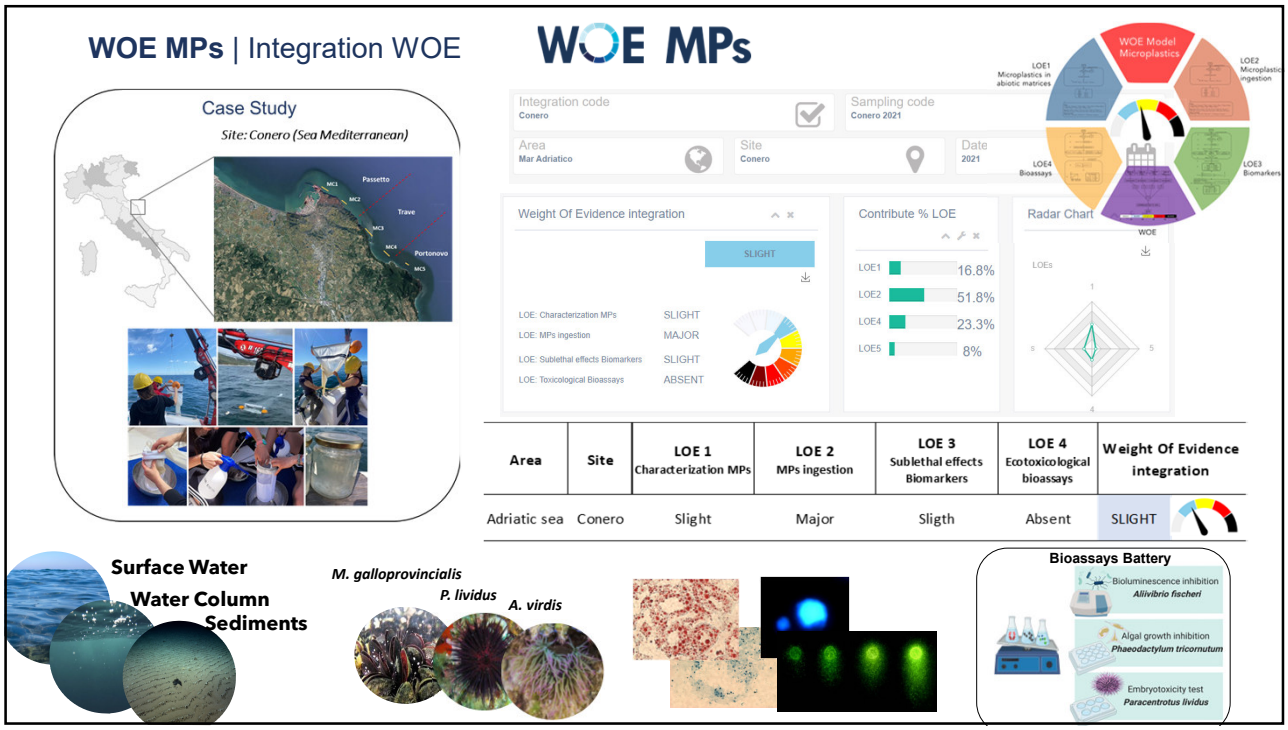
WOE MPs | Integration WOE
WOE MPs
Case Study
Site: Conero (Sea Mediterranean)
Integration code
Conero
Sampling code
Conero 2021
Area
Mar Adriatico
Site
Conero
Date
2021
Weight Of Evidence Integration
SLIGHT
LOE: Characterization MPs SLIGHT
LOE: MPs ingestion MAJOR
LOE: Sublethal effects Biomarkers SLIGHT
LOE: Toxicological Bioassays ABSENT
Contribute % LOE
LOE1 16.8%
LOE2 51.8%
LOE4 23.3%
LOE5 8%
Radar Chart
Area | Site | LOE 1 Characterization MPs | LOE 2 MPs ingestion | LOE 3 Sublethal effects Biomarkers | LOE 4 Ecotoxicological bioassays | Weight Of Evidence integration
Adriatic sea | Conero | Slight | Major | Sligth | Absent | SLIGHT
Surface Water
Water Column
Sediments
M. galloprovincialis
P. lividus
A. virdis
Bioassays Battery
Bioluminescence inhibition
Aliivibrio fischeri
Algal growth inhibition
Phaeodactylum tricornutum
Embryotoxicity test
Paracentrotus lividus

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Perspectives on WOE approach

- Importance of **multidisciplinary WOE approach** for characterizing environmental quality and risk assessment in the marine environment
- WOE models represent a fundamental **tool for summarizing and interpreting** large datasets of heterogeneous data, **singularly or in an integrative approach**
- They **do not use "pass-to-fail" approach**, enhancing the capability to discriminate different environmental conditions
- The developed model is **versatile**, **easy to update** or **adapt to local or national specificities**
- **Scientifically sound** but **user-friendly format**, to support a more comprehensive process of risk assessment and **"site-oriented" management decisions**

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Thank you

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