Quality assessment of sediments: state of the art in Italy and perspectives using biomarkers approach

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Principal uses of dredgings are:

- To keep water navigable (i.e. waterways, harbour, canals)
- For artificial nourishment of the beaches where sand has been lost because of coastal erosion.

Dredging sites are located in:

Coastal areas

Off-shore sea

•continental shelf reservoirs

River canals and Mouths

Harbours

Highly polluted areas

European Directives

Sediments are included in Marine Strategy; Water quality is defined by the application of the WFD (DL 152/2006)

National Laws

In Italy, dredging in harbours and resuspensions for pipe-lines depositions are ruled by the Decree Law (January 24th, 1996)

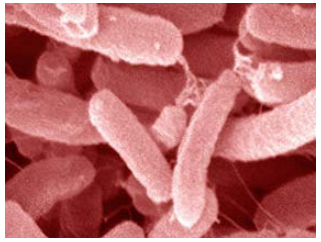
Harbours inside SIN are ruled by

DL November 7th, 2008

Decree Law January 24th, 1996

According to this Decree, dredgings are authorized after:

- Physical (grain-size, density, water content) analyses
- Chemical (nutrients TOC, TN, TP, pesticides, PCBs, PAHs, total hydrocarbons, trace elements Al, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) analyses
- Microbiological (*E. coli*, Salmonella sp., Sulphur-reducing Clostridia) analyses



Principal problems of the DL are:

1) The absence of evaluations of possible effects on biota (i.e. sediment toxicity, toxic substance leaching).

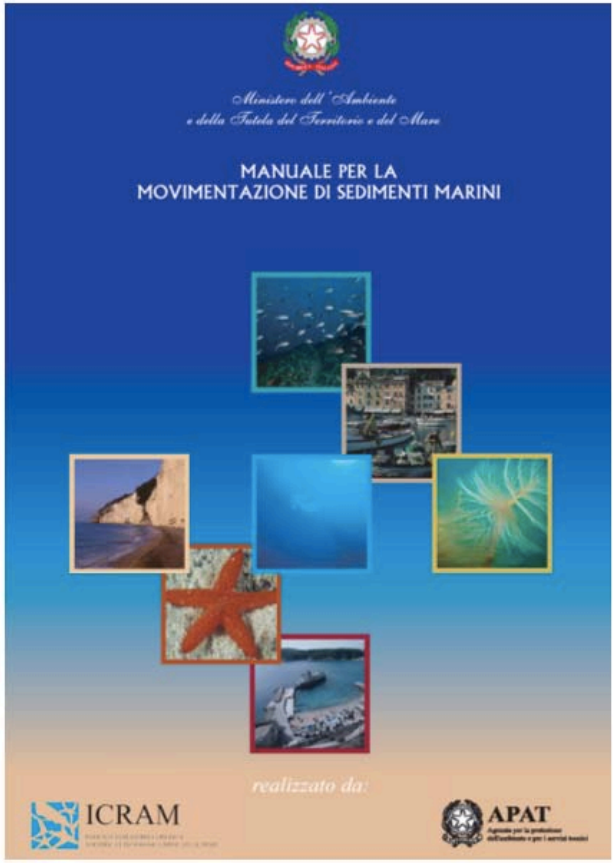
2) The absence of reference values for risk evaluations.

For this reason, results are compared to:

- i) quality standards for sediments (very restrictive) (DL 152/2006, Tab. 2/A);
- ii) standard concentration limits for soils (not suited for this matrix)

(DL 152/2006, Tab. 2, Col. A/B, title V);

- iii) guideline defined by the Italian Environmental Research Institute (ISPRA, *Istituto superiore per la protezione e la ricerca ambientale, ex ICRAM*).



ISPRA (ex ICRAM) Guideline, 2006

According to ISPRA Guideline

Sediment quality is evaluated by a multi-step process taking into account results obtained both by chemical analysis and ecotoxicological tests.

Compared to D.L. January 24th 1996, ISPRA Guideline:

1. proposes a different sampling strategy;
2. adds parameters that integrate physical-chemical analysis (i.e. TBT, mycetes);
3. includes ecotoxicological tests (that are not ruled);
4. But the principal strength is the development of a rationale criteria for the evaluation of results.

In particular ISPRA Guideline

Defines different Standard reference values related to

silt levels (10%)

Different ranges of values:

< LCBs (natural concentration limit);

LCB<X< LCL (critical concentration limit);

>LCL.

Includes Ecotoxicology

Presence/ absence of toxicity

Four classes related to EC20/EC50 values
A, B, C, D

Defines particular conditions for trace elements

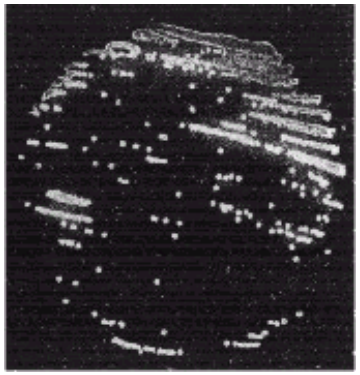
Background levels higher than LCL

Effects on biota are evaluated by ecotoxicological tests performed *in vitro* on:

1. **Sediment;**
2. **Interstitial water;**
3. **Leachates.**

Ecotoxicological tests have to be performed at least on three species owing to different taxonomic groups (at least one species for the solid phase and another for the leachate).

AN EXAMPLE OF POSSIBLE BATTERY



V. fischeri

P. lividus

C. orientale

Sediment classifications & allowed possible uses

Sediments could be classified into six different quality classes which are associated to different management possibilities ranging from beach nourishment to authorized waste disposal.

Sediment quality

Good

Bad

A1	Beach nourishment
A2	Uses in harbour areas and underwater bottoms nourishment
B1	Reutilization is possible with limits. Deposition in contolled areas
B2	Reutilization is possible with limits. Effluents treatments and decontamination
C1	Reutilization is not allowed
C2	Critical conditions. Hazardous material

Attention Level

Low

High

From A1 – good quality, low attention to C2 – bad quality, high attention

Problems (1)

- 1) Legal values of the Guideline.

In spite of its great value, ISPRA Guideline has not a legal effectiveness so its application is facultative

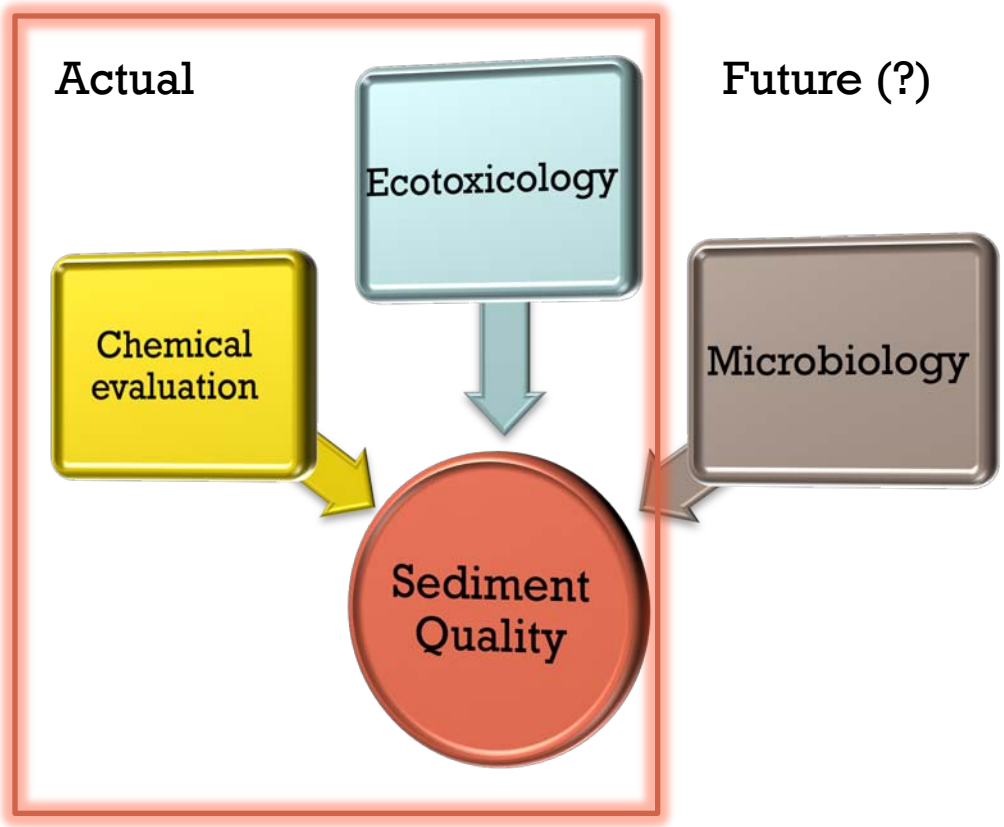
Furthermore, sampling strategy (i.e. grid size, number of cores per each grid unit, thickness and levels of samples along the core) and parameters to detect on collected samples are quite different compared to the prescriptive Decree Law (January 24th, 1996).

Problems (2)

2) Absence of reference values for microbiological results

Guideline could include reference criteria for microbiological data evaluation.

… The sediment classification process could be integrated including microbiological results.



Problems (3)

3) Absence of criteria for the beach nourishment compatibility (i.e. colour compatibility and mineralogy evaluations).

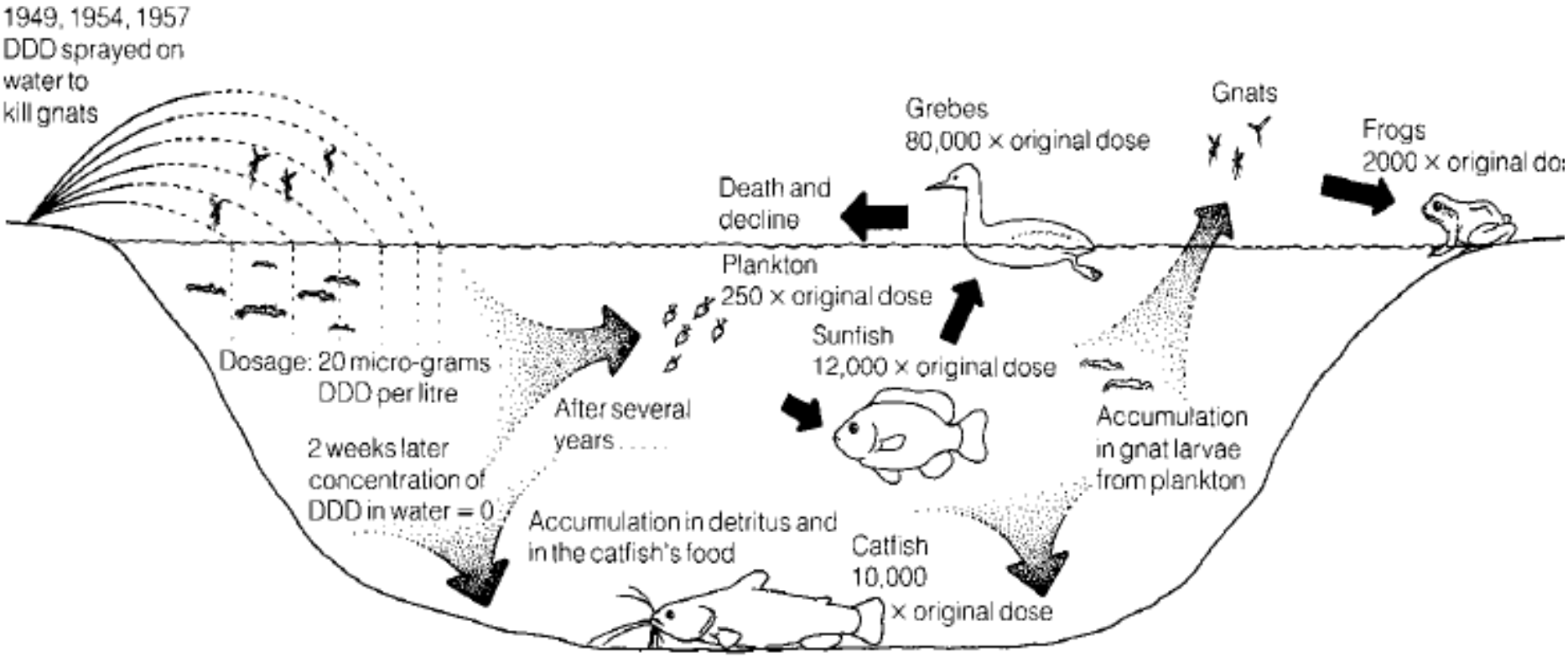
How mineralogy and colour compatibility between dredged sediments and destination beaches have to be defined?

Guideline *vs* Law

ISPRA Guideline proposes for the first time in Italy objective criteria well-sized for sediment classification in different dredging areas including harbours.

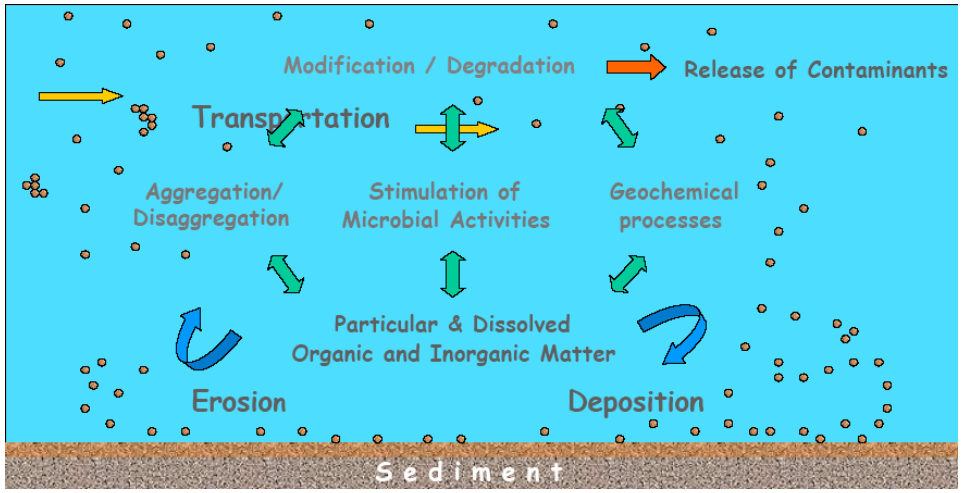
Criteria are easy to apply and clear to understand also by not specialized operators, nevertheless, with the exception of some Regions which recognized to the ISPRA Guideline a legal value (DGR 255/09), its application is strongly supported by the Ministry but not jet prescriptive and a complete and exhaustive Law ruling sediment characterization is lacking in Italy.

It is well known by the literature that sediment represents an enormous potential reservoir for contaminants which could enter in the food chain.



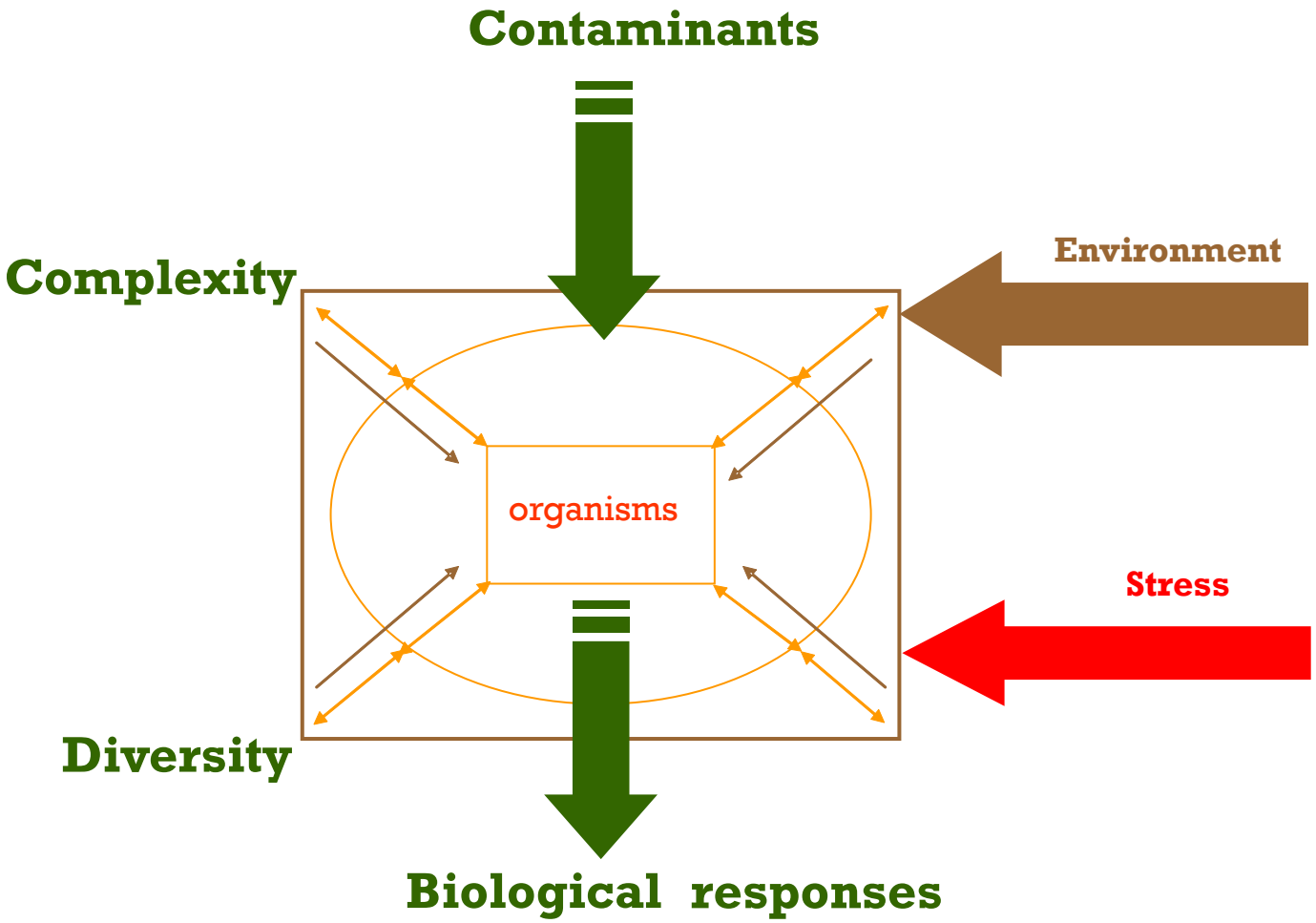
Sediment-associated trace elements and organic contaminants constitute a direct risk to benthic organisms representing sources of contamination to higher trophic levels during dredging and/or resuspensions.

- A lot of new chemicals are commercialized by the industry *per* year and metabolites produced after their discharge are not jet well-known.



- For this reason, lists of chemicals of interest to detect in harbour sediments could be notably improved
- As example antibiotics and their metabolites, drugs, nanoparticles and a lot of other new generation chemicals of potential hazardous for biota could be included.

Monitoring the effects on biota during and after dredging procedures could better focuses the occurrence of significant impacts.

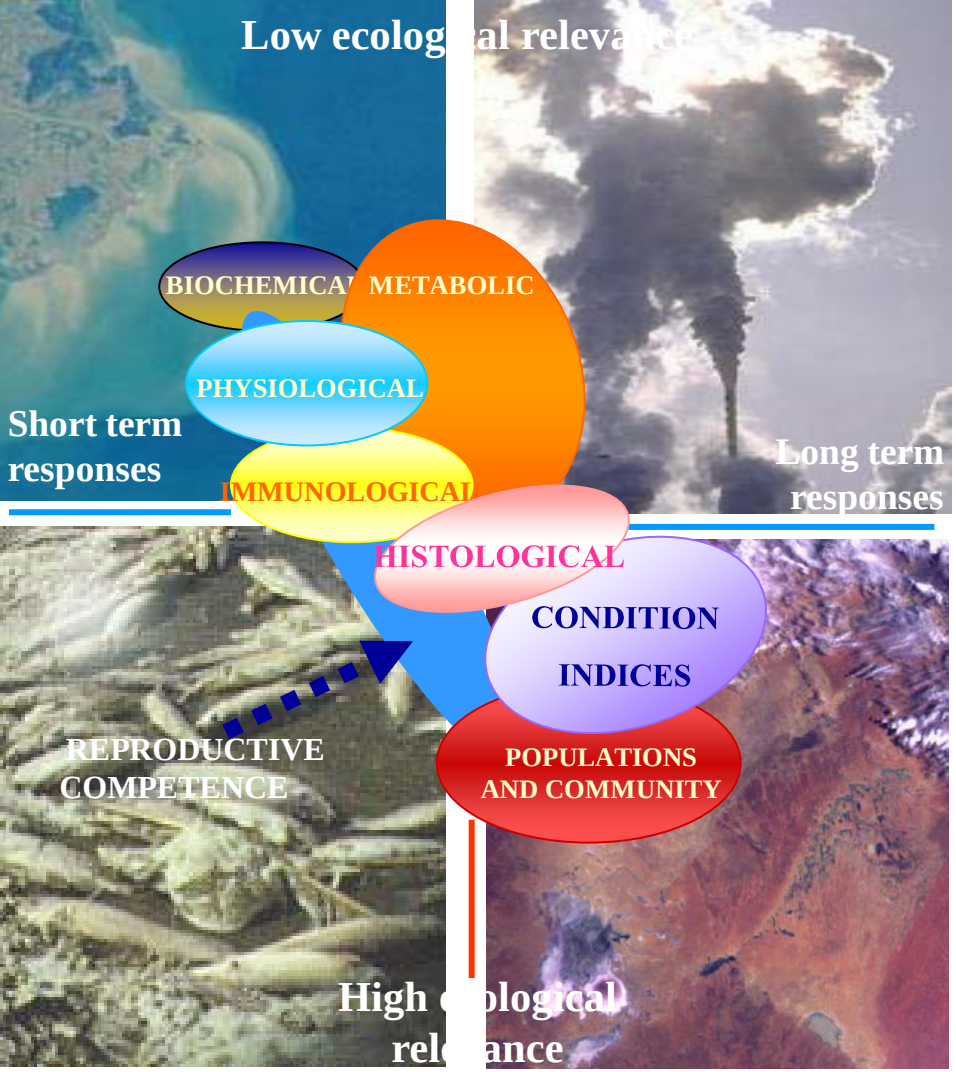


The biological responses is in fact able to integrate the complex interactions between contaminants and biological mechanism and function together with the environment itself and other source of stress

Monitoring direct/indirect effects

- Actually, monitoring programs during and after dredging are not ruled by a specific Law.
- Even if ISPRA Guideline (which indicates strategies for the evaluation of impacts both in dredging and deposition sites) is OFTEN applied for the sediment classification before dredgings, LESS FREQUENTLY is applied for monitoring programs *in itinere* and *post operam* (which are disattended).

The principal reason is represented by the great economic effort to perform monitoring programs



An interesting applications: the biomarkers approach

The application of several biological indicators of stress known as biomarkers from molecular to population and community levels will assure a complete picture of biological responses exert by an organism exposed to stress including classical (ruled) and emerging contaminants (not jet ruled).

The integration of biological responses analysis with the residue analysis of highly toxic and persistent contaminants including endocrine disruptors will make possible to address cause and effects in terms of biological responses in exposed organisms.

Integrated Ecotoxicological Approach

BIO - phase

Biomarkers

Searching suitable species to monitor dredging impacts

CHEMI - phase

Bioaccumulation

apoptosis

Citotoxicity

ChE

Neurotoxicity

pesticides

Stress

PCD

Toxic - ED

PBDEs

Toxic - ED

MXR

MFO

HSP

Detoxification

PAH

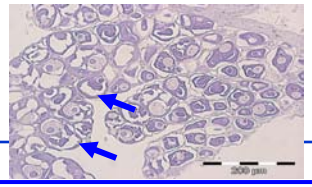
Cancerogenic ED

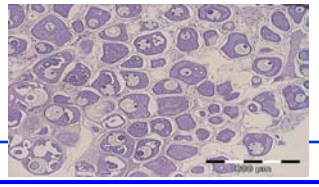
Trace elements

Toxic

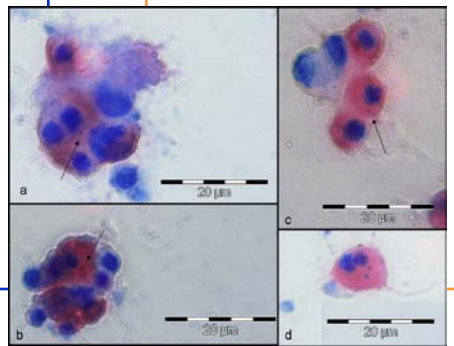
Histology

Endocrine disruption

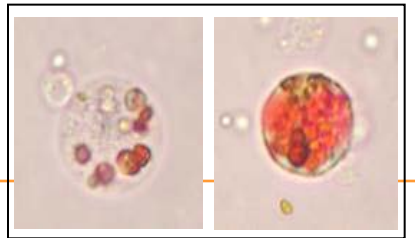




Genotoxicity



Lysosomal stability



Development of new biomarkers of early stress in unicellular and pluricellular aquatic vegetations: some case-study

Ecotoxicology

AN INTEGRATED APPROACH TO ECOTOXICITY TESTS ON UNICELLULAR ALGAL SPECIES: A CASE STUDY OF PHAEODACTYLUM TRICORNUTUM

--Manuscript Draft--

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Full Title:	AN INTEGRATED APPROACH TO ECOTOXICITY TESTS ON UNICELLULAR ALGAL SPECIES: A CASE STUDY OF PHAEODACTYLUM TRICORNUTUM
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Keywords:	ecotoxicological tests; P. tricornutum; morphological alterations; physiological alterations; growth inibition rate

Ecotoxicology

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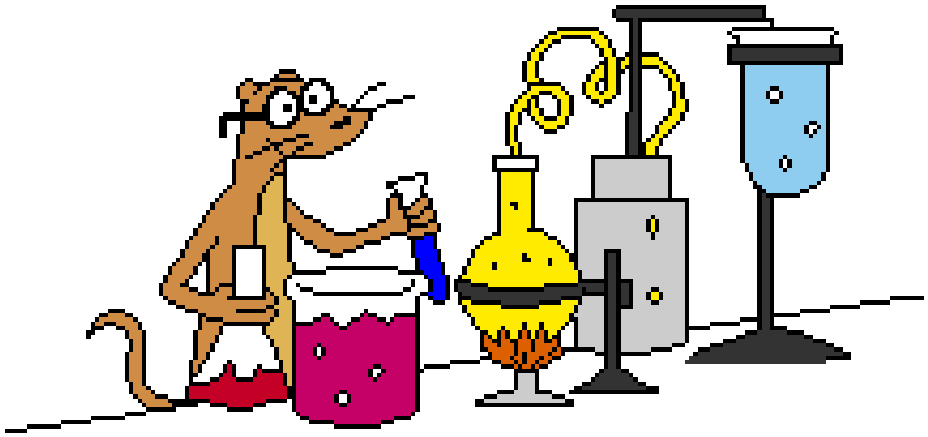
Conclusion

- In Italy legislative aspects related to sediment management and have jet to be ruled.
- Some progress from the DL January 24th, 1996 have been performed by ISPRA Guidelines that are not prescriptive.
- In spite of that, reference criteria for the evaluation of some parameters (microbiology, colour, mineralogy) are jet missing.
- Also *in itinere* and *post operam* monitoring programs are not ruled and criteria proposed in ISPRA Guideline are only occasionally attended.
- A possible strategy to reduce costs of monitoring program could be represented by the development of the biomarker approach in new and more suitable species (i.e. macrobenthos?) and new biomarkers on aquatic vegetation able to detect early stress.

Thank you for your attention



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