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Dredges' management: Comparison of regulatory frameworks, legal gaps and recommendations

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Abstract

This work deals with an environmental issue affecting particularly the Mediterranean coastal countries, that of dredges handling, and investigates how it is nationally designed and regulated. The described legislative frames are based upon relevant European regulatory systems and highlight the differences in the legislation between the Northern European and the Mediterranean countries. The report has been based on legal information supplied by specific national dredging policies that are considered accurate. Each European coastal region has developed its own dredging management system for port areas, taking into consideration its special needs and regional characteristics. In comparison with the North, it is scoped that the Southern areas are barren of a general legal dredging plan, dealing with dredges and their disposal, and consequently, they follow non-cohered practices. The Mediterranean Sea is surrounded by many countries with different legal strategies; however, its physical protection and its sustainable development could be achieved only by following a unified and well-planned approach. The establishment of a Mediterranean regulatory framework adopting some of the existing relative legislative formulas will ensure the sustainability of dredges exploitation and their proper disposal at a non-border level.

Keywords: dredging, management, legislation, disposal, Mediterranean Sea

1. Introduction

"Dredging" generally refers to the process whereby sediment is disturbed (moved, removed or extracted, transported or relocated) from the bed of any waterway and as a result the disturbed bed matter is defined as dredged material (Department of Environment and Heritage Protection, 2017). Dredging is classified as capital, maintenance or remediation dredging, according to its purpose (Ports Australia, 2014).

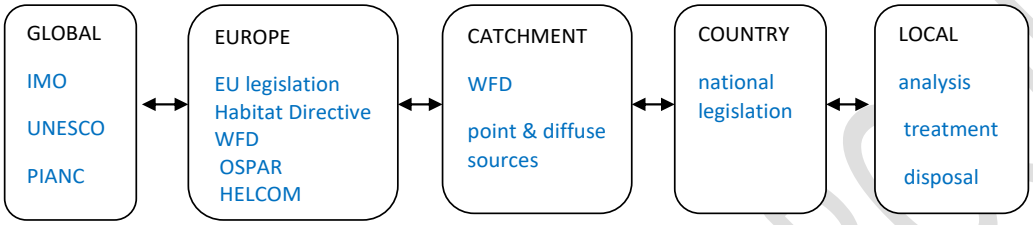
The procedure is extremely valuable for sustaining the functionality of harbors and waterways through the maintenance of the existing water channels, port berths and marinas, given the shallow natural depth of many tidal water-bodies and high rates of shoaling. For the construction of a new navigation channel - capital dredging - or the extension of an existing port, dredging actions are needed. Remediation projects, such as flood mitigation in areas where natural tidal waters befall or removal of sediment surplus caused by transit boats, belong to common dredging purposes. It is an undeniable fact that dredging covers the most fundamental economical sectors ranging from commerce to tourism, meaning that its management needs to be enforced with applicable rules and regulations.

The extracted dredged material from both capital and maintenance dredging programs requires re-use or relocation or disposal at an appropriate site. This process is related to difficulties in proper handling and affects the fate of the final disposal areas. To the potential environmental impacts from the dredging procedure and the disposal of dredged material, the following consequences are included: surface and groundwater contamination from runoff and leachates, high use of water resources for material processing, terrestrial habitat loss and species displacement, disturbance of potential acid sulphate soils and associated runoff/leachate issues, health and safety issues associated with handling of material, and decreased air, noise and aesthetic quality of an area (Ports Australia, 2014).

A range of factors, such as the volume of the dredged material, the sediments quality and toxicity, the dredging timing and duration, the dredges transport and way of disposal, determine direct and indirect effects on environment. Taking into consideration the contingent adverse ecosystem's response, a correct designation of an area as a dumping site is essential and secures that dredging management will be in line with natural processes. According to the environmentally friendly options for the disposal of dredged material, the use of the dredged sediment as a "fertile" soil or the relocation for beach nourishment are the most natural strategies, if risk assessment studies allow for. Noticing that a large amount of dredged material may be, at least to an extent, polluted through human activities, certain environmental constraints need to be strictly applied, especially for depositing these "negatively charged" sediments. For heavily polluted sediments a special treatment is a must-follow option before the dredges can be allocated back to nature (SMOCS, 2011).

In this regard, the environmental effects of dredging activities can be minimized with proper licensing in order to prevent and reduce the negative influence on marine and coastal zones. Environmental impact assessment and management plans must precede licensing for a dredging activity. Unfortunately, up to now there is no universal legislation and jurisprudence in the European Union and specifically in the Mediterranean Sea countries.

Handling of dredged material is at the borderline of water, soil and waste policies, and, consequently the relevant legislation is rather complex. Several European regulatory frameworks, such as the EU Landfill Directive, the EU Waste Framework Directive and the EU Water Framework Directive are currently being implemented. Deregulation on a national level and harmonization on a European level are needed to arrive at an adequate and straightforward legislative framework (Köthe and de Boer, 2003). According to Sednet (2004), legislation affecting the management of dredged material operates at different spatial scales, ranging from the local managers to the global level (Fig. 1). Furthermore, future revision of regulations should take into consideration new data regarding priority toxic substances that contribute much to the degradation of the marine environment quality.



IMO: International Maritime Organization, PIANC: Permanent International Association of Navigation Congresses, WFD: Water Framework Directive, OSPAR: Oslo-Paris Convention, HELCOM: Helsinki Convention

Figure 1. Spatial scales related to sediment issues and regulations (Sednet, 2004)

The present work includes a brief presentation of quantitative and qualitative aspects of dredged materials, information regarding the relative legislation in European level and suggestions for the management of dredged material under the framework of marine environment and human health safeguard. Dredges management is affecting the most Mediterranean countries and this influence has extensively arisen during the last decades, due to the lack of a relevant regulatory framework. The individual national practices for dredges disposal are not only considered into a specially adapted legal status, but also depend on individual anthropogenic interventions. The objective of this article is to review relevant national approaches and the legislative framework in the European Union, in order to introduce the best practices that should be applied. Suggestions for dredging actions and related problems encountered in closed gulfs and seas with high socio-economic and touristic activities, or ecologically sensitive areas, e.g. the Mediterranean Sea, are discussed.

2. Methodology

The Northern European countries have already integrated in their national legislation, rules for the handling of dredged material. Every national regulation, dealing with the management of dredges, refers to the whole procedure from dredging to disposal including all the obligatory steps in between. These frameworks are reviewed and assessed.

On the other side, countries in the Mediterranean area are still without a relative legal framework, so they manage dumping of the dredged material by *the Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircrafts or Incineration at Sea*, i.e. the Dumping Protocol of Barcelona Convention (Carette, 2011). For instance, Spain covers the lack of relative legal framework by using criteria and deriving action levels about disposal of the dredged material at sea from other European countries (Alvarez-Guerra *et al.*, 2007). In Greece, no mandatory plan with specific requirements exists related to dredged material operations and, as a result, misunderstandings combined with lack of institutionalized strategies remain an intractable problem (Velegrakis *et al.*, 2015). The following review the most organized legal forms for dredging operations in Europe and delineate the frames upon which countries with inadequate regulated system should be based.

3. Results and Discussion

3.1 The Netherlands

The Dutch environmental regulation prioritizes the final destination of dredged material beginning from relocation, straight reuse or beneficial use, after proper treatment, and ending to land or sea disposal. Approximately 90% of the dredged material derives from marine sediments and is disposed back at sea due to its low pollution or clean composition. In particular, the port of Rotterdam is the largest in Europe and is connected to the North Sea. About 20 million m^3 need to be dredged each year to keep the port navigable. A confined disposal facility, named Slufter, was built in 1987 dedicated for the storage of the polluted dredged material stemmed from this area. Realizing that dredged material is assumed as a constituent of the aquatic horizon, the first step of relocation has to be in strict compliance with the standards of the Dutch legislation. Depending on the actions needed different criteria are applied. Particularly, the guidelines for disposal of dredged material differ from those evaluating sediment quality or recycling of dredged material. The chemical analyses of the common substances in dredged sediments, as heavy

metals, PCBs and mineral oil, remains an obligatory process before the disposal, according to the existing regulatory framework in the Netherlands. The handling of marine dredges depends on the outcomes of the analyses and is guided by comparison between the results and the statutory limit values.

Table 1 presents the maximum levels of contaminants for sea disposal, as they were revised by the Dutch Center for water management (RWS) in corporation with the Dutch National Institute for Public Health and the Environment (RIVM) in 2008. The Netherlands is the only country using only one set of action levels. Sea disposal of dredged sediments is only permitted for materials with level of pollution below the referred values; otherwise dredged material should be disposed of in the Slufter (Sednet, 2001).

Table 1. Maximum level of contaminants (in mg kg^{-1} dw) for dredges disposal at sea in the Netherlands (RWS, 2008)

Parameter	Sea - Slufter Limit
Metals (mg kg^{-1})	
Arsenic (As)	29
Cadmium (Cd)	4.0
Chromium (Cr)	120
Copper (Cu)	60
Mercury (Hg)	1.2
Nickel (Ni)	45
Lead (Pb)	110
Zinc (Zn)	365
Organic Pollutants (mg kg^{-1})	
Mineral oil C_{10-40}	1250
Sum of 10 PAHs (naphthalene, anthracene, phenanthrene, fluoranthene, benzo[a]anthracene, chrysene, benzo(k)fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene)	8
Hexachlorobenzene	0.02
Sum DDT+DDD+DDE	0.02
Tributyltin (TBT)	0.25
Sum of 7 PCBs (28, 52, 101, 118, 138, 153, 180)	0.1

A new edition of the related legal basis for relocation of dredged material, is currently under designation, and takes into account ecological and chemical parameters, including TBT (Hakstege, n.d.).

3.2 Finland Legislation

Disposal of dredged material at sea in Finland is regulated by the Water Act 264/1961, which remains the unique legal core concerning sediments. This main Finnish legislation contains provisions on groundwater extraction associated with the maintenance of a good quantitative state of groundwater (EDMS, 2007). For dumping at sea, criteria relied on relative data from the Netherlands in an initial phase (OSPAR Commission, 2008). The Ministry of Environment published in 2004 instructions for handling of dredges, which introduce the legal basis, the regulations and the licensed procedures pertaining to dredging and deposition (Ministry of the Environment, 2004). This Environmental Rule supplies guidance for the evaluation of sediments pollution and curbing of possible environmental consequences. The management of dredges is described in the national instructions by a two-value system (table 2) and proposes a double action treatment, i.e. deposition at sea or on-shore (Terramare Oy, 2009).

If the pollutants concentrations are below AL1, the dredged material is considered harmless for aquatic environment, thus sea dumping is allowed. When the determined values are between the first (AL1) and the second level (AL2), the extracted sediments are classified as “grey zone” due to their possible contamination. In this case, dumping into the Baltic Sea must be further studied via a case-by-case decision for final disposal. Accordingly, dredges that contain substances with values that surpass AL2, are interdicted for sea disposal, unless if the alternative on-shore deposition seems a high-risk option (SMOCS, 2011).

3.3 Denmark Legislation

The Danish Ministry of the Environment established on 1st October 2005 specific Action Levels (AL) for dredging of unprocessed materials. The exploitation of raw materials requires special permission and is allowed only in areas that have been delimited as deposition areas after an environmental assessment (SMOCS, 2011). Basic parameters, being analyzed as requisites of a regular risk assessment, cover the following aspects: overflow of fine-grained sediments at the time of dredging and removal from the seabed, extension and thickness of the deposition area, possible influence on marine flora and fauna (SMOCS, 2011).

The recent adopted Danish ALs accord with the imperatives of the Oslo and Paris Convention (OSPAR) and are associated with the related data from adjacent countries, the Netherlands and Finland. Action Levels for dredged material applied in Denmark are presented in table 2, along with the corresponding levels from Finland. The double-pole approach of the ALs creates two general categories: the lower Action Levels (AL1), which refer to expected no-impact on the environment, and the upper Action Levels

(AL2), which correspond to international official levels based on ecotoxicological data.

The results of the chemical analyses of the dredged material, prior to dredging, reveal if the existing concentration levels permit or exclude disposal. Taking into consideration that dumping is carried out in particular sites, the "throwing out" process is completed without further testing only for mixtures of low-toxicity, meaning below the lower action levels. For dredges with pollutant concentrations between the two ALs, the exact volume of the material to be dumped and the concentration of each pollutant should be considered. Normally, dumping at sea will be precluded when the concentrations of the chemical elements surpass the upper ALs. As a consequence, a land deposition of the dredged material is applied after an in-depth risk analysis for each dredging case study. The screening of pollution status, according to the Danish dredging regulations, is carried out not only for toxic metals but also for the known organic pollutants, such as PCBs and TBT.

Table 2. Guidelines for sediment disposal at sea in Finland and in Denmark (Ministry of the Environment, 2004; SMOCS, 2011).

Substance	**Action Level 1**		**Action Level 2**	
Metals (mg kg^{-1})	*Finland*	*Denmark*	*Finland*	*Denmark*
Arsenic (As)	15	20	60	60
Cadmium (Cd)	0.5	0.4	2.5	2.5
Chromium (Cr)	65	50	270	270
Copper (Cu)	50	20	90	90
Mercury (Hg)	0.1	0.25	1	1.0
Nickel (Ni)	45	30	60	60
Lead (Pb)	40	40	200	200
Zinc (Zn)	170	130	500	500
Organic Pollutants (mg kg^{-1})				
Polycyclic aromatic hydrocarbons (PAHs)				
Naphtalene	0.01		0.1	
Anthracene	0.01		0.1	
Phenanthrene	0.05		0.5	
Fluoranthene	0.3		3	
Benzo[a]anthracene	0.03		0.4	
Chrysene	1.1		11	
Benzo[k]fluoranthene	0.2		2	
Benzo[a]pyrene	0.3		3	
Benzo[ghi]perylene	0.8		8	
Indeno[123-cd]pyrene	0.6		6	
Sum of 9 PAHs		3*		30*
Polychlorinated biphenyls (PCBs)				
Each of PCB28, PCB52	0.001		0.030	
Each of PCB101, PCB118, PCB138, PCB153, PCB180	0.004		0.030	
Sum of 7 PCBs		0.020**		0.200**
Other organics				
Mineral Oil	50		1500	
DDT + DDE + DDD	0.01		0.03	
Tributyltin (TBT)	0.003	0.007	0.200	0.200
Dioxins and furans (PCDD and PCDF) (in ng WHO-TEQ kg^{-1})	20	-	500	-

**Sum of 9 PAHs: anthracene, benzo[a]anthracene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, fluoranthene, indeno[1,2,3-cd]pyrene, pyrene, phenanthrene.*

***Sum of 7 PCBs: PCB28, PCB52, PCB101, PCB118, PCB138, PCB153, PCB180*

3.4 United Kingdom (England and Wales)

Disposal of dredged material falls under the authority of the Ministry of Agriculture, Fisheries and Food (MAFF) for England and Wales, the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) for Scotland, and the Department of the Environment for Northern Ireland (DOE(NI)). Disposal at sea is regulated and requires a special Food and Environmental Protection Act (FEPA) disposal permission from all the above-mentioned governmental bodies. Since 1985, the management of dredged material in United Kingdom was based on FEPA II, which represents the general legal form for the handling of the dredged sediments in England and Wales. In 1995, guidance values were updated, while in 2003 an amendment of action levels was accomplished, which is in force without any further modifications until today (table 3). Both England and Wales deal with dredging and disposal via a developed system of evidence. The credibility of their

system emerges from bioassays and overview of the past that the disposal areas carry among the years.

Table 3. Action Levels for dredged material in the United Kingdom (MMO, 2015)

Substance	Action Level 1	Action Level 2
Metals (mg kg^{-1})		
Arsenic (As)	20	100
Cadmium (Cd)	0.4	5
Chromium (Cr)	40	400
Copper (Cu)	40	400
Mercury (Hg)	0.3	3.0
Nickel (Ni)	20	200
Lead (Pb)	50	500
Zinc (Zn)	130	800
Organic Pollutants (mg kg^{-1})		
Polycyclic aromatic hydrocarbons (PAHs)	-	-
Polychlorinated biphenyls (PCBs)	0.010* (0.020**)	0.139*
Tributyltin (TBT)	0.10	1.0

** Sum of 7 PCBs ** Sum of 25 PCBs*

Whenever dredging activities are needed, the involved agencies have to apply for a license. Management of dredges and permission of disposal follow the OSPAR Guidelines and are similar to the Danish system.

Generally, the disposal permission and relocation is decided after a case by case inquest. Sediments with concentrations below AL1 are not in fact under suspicion for their impact on marine environment and are characterized of no interest. A double further treatment is enforced for materials with pollutants concentrations between AL1 and AL2, such as supplementary sampling and testing, potential analysis by bioassays or an appropriate disposal strategy. Specific remediation is needed for material lumbered up with high concentration of pollutants, generally above AL2. In this case no disposal at sea is allowed and the dredges ought to be subjected to special treatment. The sediment quality values reflected by the action levels are only one part of the approach for sea depositing. Biological tests conjugated with chemical analyses have been developed recently and their incorporation into risk assessment procedures allowing disposal licensing is underway (Sednet, 2001).

3.5 Spain

In the Mediterranean Sea no current legal document for dredged material is available. Spain, specifically, uses the called CEDEX guidelines (Table 4) from the Centro de Estudios y Experimentación de Obras Públicas. The concentrations of pollutants are determined in the sediment fraction < 63 μm, expressed on a dry basis (Röper and Netzband, 2011). The CEDEX guidelines are not a legislative framework, meaning that their application is indicative, and their violation causes no legal effects.

Table 4. Sediment quality guidelines for marine sediments in Spain (Casado-Martínez *et al.*, 2006)

Substance	AL 1	AL 2
Metals (mg kg^{-1})		
Arsenic (As)	80	200
Cadmium (Cd)	1.0	5.0
Chromium (Cr)	200	1000
Copper (Cu)	100	400
Mercury (Hg)	0.6	3.0
Nickel (Ni)	100	400
Lead (Pb)	120	600
Zinc (Zn)	500	3000
Organic Pollutants (mg kg^{-1})		
Sum of 7 PCBs (PCB 28, 52, 101, 118, 138, 153, 180)	0.030	0.1

According to Table 4, two categories of Action Levels - named AL1 and AL2 - exist for the evaluation of sediment contamination. The used Action Levels characterize the dredged material (CEDEX, 1994) and focus on the presence of toxic concentrations for organisms based on physicochemical standards (Casado-Martínez *et al.*, 2006).

If the contamination level does not exceed AL1, only the physical impact of disposal is under consideration. If the contamination level stands between AL1 and AL2, disposal is held synchronized with an appropriate monitoring program based on an effect analysis. Exceedance of AL2 is translated to preclusion or permission for sea disposal with concurrent implementation of alternative treatment methods. In case that at least three metals surpass the guidance value of AL1, a fourth metal, i.e. arsenic, needs to be analyzed in addition. Similarly, if exceedance of AL1 for the seven PCBs occurs, determination of additional organic parameters, i.e. other PCBs, mineral oil, etc., should take place (Röper and Netzband, 2011).

3.6 Italy

Dredging in Italy is an issue with great economic importance, due to the increased coastal evolution of the country. The Institute of Environmental Protection and Research (ISPRA) acts under the supervision of the Italian Ministry of the Environment and the Protection of Land and Sea (Ministero dell'Ambiente e della Tutela del Territorio e del Mare) since 2008 and is responsible for dredges disposal. In the absence of a relevant law devoted to sediment characterization and disposal, nourishment activity is acceptable when the dredged material accords with the indicative quality standard described in the national Decree-Law No. 367/2003 (Petrucci *et al.*, 2011). In 2006 the ex Agency for Environment Protection and Technical Services with the contribution of the ex Central Institute for Scientific and Technological Research applied to the Sea (ICRAM – APAT), a governmental agency of the Italian Environmental Ministry, has indicated two concentration limits (Table 5), the basis chemical level (LCB) and the limit chemical level (LCL) for metals and some organic compounds (ICRAM – APAT, 2006). This manual includes physicochemical and biochemical criteria for dredged material categorization and guidelines for an appropriate management.

Table 5. National guidelines for sediments by the Italian Ministry of the Environment (ICRAM – APAT, 2006).

Substance	Italian Degree Law 367/2003	LCB	LCL
Metals (mg kg^{-1})			
Arsenic (As)	12	17	32
Cadmium (Cd)	0.3	0.2	0.8
Chromium (Cr)	50	60	360
Copper (Cu)	-	15	52
Mercury (Hg)	0.3	0.2	0.8
Nickel (Ni)	30	40	75
Lead (Pb)	30	25	70
Zinc (Zn)	-	50	170
Organic Pollutants (μg kg^{-1})			
Total PCBs	4	5	189
Total PAHs	200	900	4000

Pollutants concentrations in the dredged material up to the LCB represent a low-ecotoxicological risk or absence of anticipated toxic effects on the environment. If the concentrations surpass LCL, serious impacts are potential, and the dredges should be further evaluated (Petrucci *et al.*, 2011). A characteristic case study is the screening risk assessment conducted in sediments of the Venice Lagoon, in which contaminants levels were compared with selected Sediment Quality Guidelines (SQGs) in order to evaluate hazard quotients (Apitz *et al.*, 2007a). However, the international SQGs are useful only as pass-fail criteria, because site-specific conditions are not taken into account (Apitz *et al.*, 2007b; Leotsinidis and Sazakli, 2008).

3.6 Greece

The Law 3022/18-6-2002 (OGC 144/A/19-6-2002) which transposes the amendment of the Barcelona Convention in the National Legislation, the Law 3983/16-6-2011 (OGC 144/A/17-6-2011) which transposes the Marine Strategy Framework Directive 2008/56/EC as well as the JMD 107017/28-8-2006 (OJG 1225/B/5-9-2006) complying with the requirements of Directive 2001/42/EC on the assessment of the effects of certain plans and programs on the environment, are the main legal forms concerning the exploitation of the dredged material and the upcoming dumping. The non-existence of definition of the dredged sediments for further disposition, most of the times creates lack of clarity and the licensed procedures from the authorities ignore the potential environmental impacts from the marine aggregation (Velegrakis *et al.*, 2015). This legal gap in Greek regulatory system is ascertained also in the field of opportunistic beach nourishment, where heavy metals limits in dredged material from ports and harbors, need to be covered as soon as possible (Foteinis *et al.*, 2013).

In Greek legislation dredging operations concerning their products – dredges – are negatively treated due to absence of relative regulatory frameworks for the characterization of dredged material and the process of disposal. Dredges are determined as a waste and not as an utilizable product as a result of the Greek insufficient legal system (Foteinis *et al.*, 2013). For dredging assessment and toxicity evaluation of dredges in Greek coastal areas, a double - angle sediments evaluation based on the classification of each area by the two sets of SQGs and the calculation of the contamination factors and degree for each area, has been followed. Disposal of dredges is abandoned or permitted depending on the results (Leotsinidis and Sazakli, 2008). A similar method for the evaluation of the toxicity of metals in sediments was forced in the Bay of Thessaloniki with the usage of the two set of SQGs, the effect range-low (ERL) / effect range-median (ERM) values and the threshold effect level (TEL) / probable effect level (PEL) values (Zabetoglou *et al.*, 2002).

4. Recommendations

Many European countries have initiated special legal structures or inaugurated laws relative to polluted dredged sediments in order to eradicate the upcoming environmental impact and design the most effective dealing with the dredging fact. On the other hand, the majority of the European Guidelines with management strategies for sediments are not quite explained until now. This matter causes a misunderstanding between European and national documents, dealing with pollution of sediments and in particular with managing of dredged materials. The disunion, in a European level, of the legislation coupled with the different policy practices overlap each other, in a geographical viewpoint, ignoring the peculiarities that every marine zone possesses. Even if many countries have adopted strategy plans for the management of excavated sediments, there is no uniformity in these regulations. Through the comparative review of the legal framework of the selected countries the results are significant and clear: Mediterranean countries are in a disadvantage against the North European region due to lack of relative legal frame about the management of dredged material. It is crucial that only under a cohesive legal purview will Mediterranean be an active European part in the justification of this highly emergent environmental thesis.

In fact, the most integrated legal frameworks concerning dredging management exist in Australia and in Canada, although the differences between the open and closed sea are obvious. Taking into consideration the geomorphological characteristics of the Mediterranean

countries and the high economic impact of closed sea to the coastal regions, an establishment of legal bounds for the handling of dredging disposal is needed. The creation of a database with sediment information in the Mediterranean Sea, and an appropriate delimitation of the depositing areas, is a starting point to eliminate the statutory gap. The Mediterranean legal lack of dredges management will be defeated by a delineation of dumping action levels – at sea or on landfill. It is obvious that the protected *Natura 2000* areas should be excluded. To our opinion, Mediterranean countries belonging to European Union should become the frontiers for the Mediterranean Sea protection by creating a unified framework for dredging activities and exploitation of excavated material.

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