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PREFACE

The management of sediments is a significant issue in all industrialized countries. Millions of cubic meters are dredged every year just for the maintenance of canals and harbors. Moreover, for many decades, waterways have been exposed to a wide variety of contaminants, still present in bottom sediments. In many cases dredged materials are perceived as a waste that has to be managed properly and disposed off. On the other hand, the beneficial reuse of sediments can optimize the management of natural resources in many engineering fields. The valorization of dredged materials as a resource represents an important technical and economic interest.

The aim of the International Symposium on Sediment Management (I2SM) is to get together academics, professional figures and public agencies involved in sediment issues to review recent advances on sediment management research and engineering aspects.

The previous editions were held in Lille (France, 2008), in Casablanca (Morocco, 2010) and Alibaug (India, 2012). The 2014 edition, the 4th one, is being held in Ferrara (Italy), September 17-19. It has been organized by Ferrara Fiere Congressi, Politecnico di Milano - Department of Civil and Environmental Engineering - Environmental Section and the École des Mines de Douai.

More than 100 contributions from 38 different countries have been accepted for oral presentation or poster display. The conference timesheet includes a plenary session with invited speakers and 11 sessions in parallel, over a three-day period. The major themes covered are:

- Characterization and monitoring
- Sediment and contaminant fate and transport
- Ecological impact assessment and Risk
- Sediment management and Decision-analysis tools
- Remediation of contaminated sediments
- Beneficial reuse of sediments (civil engineering, environmental restoration, products manufacturing, etc.)

Other themes (Emerging pollutants in sediments; Natural attenuation, capping and storage of sediments; Dredging operation; Mechanical treatments and dehydration; Policy and sediment quality guidelines) are also discussed in a common session. Two special sessions are also scheduled, one of which about the management of sediments in dams and the other one about policy and practice in the remediation of contaminated sediments in different countries.

The Editors also wish to thank the contributors, the members of the scientific committee and the local organizing committee, who allowed the successful event.

Luca Bonomo
Sabrina Saponaro
ABSTRACT

In Flanders (Belgium), approximately 12 000 kton of dredged sediments has to find a destination every year. A possible application is the use of dredged sediments as a raw material in brick production. Despite the fact that several examples in neighboring countries show that this is application is feasible, some socio-economic and technical limitations interfere with the use of dredged materials in brick production in Flanders.

In the present study, the limitations and barriers, from the consumers’ point of view were analyzed, based on a survey held in Flanders. The survey dealt with the risk perception of citizens with respect to environmental problems in general and (contaminated) sediments in particular and with their the willingness to pay for bricks produced from traditional raw materials (clay) and from dredged sediments.

The Decree on Materials management considers dredged sediments as a secondary resource, that can be used as a resource for building materials as long as they comply with certain criteria. Technical problems, such as the dewatering of sediments, have been solved during the last few years, but the real valorization of dredged sediments in high-grade applications is still very limited.

The survey indicated that consumers in Flanders are rather suspicious with respect to bricks produced from dredged sediments and their risk perception is mainly determined by the possibility of a bad bargain, the social acceptance of the product, the connotation with contaminated river sediments and personal characteristics such as flexibility and independence. The willingness to pay for bricks made from dredged sediments is mainly influenced by the age of the respondents, as well environmental awareness, and the respondents’ belief in their ability to influence environmental problems. More than 50% of the respondents indicated that they had insufficient knowledge on this topic, despite the fact that 60% of the respondents had a higher education degree. Sensitization and information of customers is of primary importance to make dredged-sediment-derived bricks a successful product.
SUSPENDED SEDIMENT DELIVERY INTO THE KUBANNI RESERVOIR, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA

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ABSTRACT

In an attempt to assess the suspended sediment delivery into the Kubanni reservoir, a continuous monitoring of the four tributaries contributing sediments into the Kubanni reservoir, Ahmadu Bello University, Zaria from 2011 to 2012 was carried out. The monitoring was done by measuring their discharges using the 1200 and 900 v-notch weirs for the Malmo and Tukurwa streams and the velocity-cross-sectional area method for Maigamo and Goruba streams. Water samples were collected for onward analysis in the laboratory to derive the suspended sediment concentrations. Products of the sediment concentrations and discharges gave the sediment loads and a rating relation between sediment loads and discharges was used to determine the sediment yield of the contributory tributaries. The summary statistics including the channel suspended sediment yields of the four tributaries is increasing progressively with the Malmo stream having the least (248.29 tons/yr) and the Goruba stream having the highest (12880.55 tons/yr). There is a significant difference between the suspended sediment yields of the four tributaries. The research revealed that the suspended sediment yield of the Malmo tributary has reduced almost by half tribute to the efforts of the University administration in their afforestation and reduction of farming activities within the sub-basin. It was suggested that these efforts should be maintained and continuous monitoring of the tributaries encouraged.
Numerical simulations of suspended load transport in a Peruvian reservoir

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ABSTRACT

Numerical modeling of sediment transport in reservoirs, especially for sudden events such as flushing, is still a challenging research topic. In the present study, suspended load transport and sediment flushing are in a Peruvian reservoir. Situated in the Peruvian Andes, the watershed is affected by high erosion rates and the river carries high amounts of suspended sediment. The annual volume of sediment is estimated to be more than 5 Million m³. According to the World Bank experience, the most adapted remedial measure for this project is regular full drawdown flushing.

This study aims to investigate the reservoir sedimentation by means of numerical models. Annual sedimentation and pressurized flushing are particularly investigated. To understand and evaluate different aspects related to reservoir sediment management, one and three-dimensional modelling are applied. HEC-RAS one-dimensional model is firstly used to define the sediment transport over a long time period. It shows bed evolution as well as sediment deposition and erosion during the simulation period. The results show that the reservoir losses more than half of its capacity in only five years. As such, a removal measure seems crucial to ensure the sustainability of the whole project. The three dimensional Flow3D model is then used for simulating the pressurized flushing of the reservoir.

The dam operators flush water regularly while maintaining the reservoir water surface level to guarantee the performance of the outlets and more to avoid their clogging by consolidated sediments. This process is called partial or pressurized flushing. The results of three dimensional model show that during pressurized flushing, the existing sediments above the outlet opening wash out till creating an empty funnel shaped crater. The remaining sediment deposits reach the angle of repose, and then no more sediment will be flushed out through the bottom outlet except a small quantity with a weak concentration. The peak appears normally at some stage during the first minutes. The concentration then decreases rapidly for the remaining period of the flushing and becomes zero progressively afterward.
DEVELOPMENT OF MAGNETIC ACTIVATED CARBON AND BIOCHAR FOR PAHS REMOVAL FROM RIVER TYNE SEDIMENT

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ABSTRACT

Addition of activated carbon (AC) or biochar (BC) to sediment to reduce the chemical and biological availability of hydrophobic organic contaminants is a promising in-situ remediation technology. But concerns about leaving the adsorbed pollutants in place hinder the wider application of this innovative remediation approach. Magnetic carbon could be used as a recoverable sorbent to address these concerns. Two kinds of magnetic activated carbon (MAC) and two kinds of magnetic biochar (MBC) were successfully produced in this study, and their adsorption of PAHs from water was only slightly lower than for the pristine sorbents. The MAC and AC with the highest activated carbon-water partitioning coefficient ($K_{AC}$) were used for laboratory scale remediation trials of PAHs contaminated River Tyne sediment. A 98% reduction in aqueous PAHs was achieved by the amendment of 8.1% (w/w, equal to 5% AC content) magnetic activated carbon or 5% (w/w) pristine activated carbon within 3 months. At the 3 month time point, 77% of the MAC was retrieved with a magnetic rod. Hexane:acetone extractable sediment PAH concentrations were substantially lower in the treated sediments as compared to unamended River Tyne sediment, which may, however be due to the known difficulty of extracting AC and MAC associated PAHs with standard analytical procedures. A slight rebound of aqueous PAH concentrations was observed following the MAC recovery after 5 months, but aqueous PAH concentrations then dropped again after 6 months, perhaps due to the presence of the unrecovered 23% MAC. The observed results are broadly consistent with numerical modelling results, with measured aqueous PAH concentrations being somewhat lower than the modelled results. Future work will investigate the relative ecotoxicity of the AC and MAC treated sediments with the AC-sensitive species Lumbriculus variegatus, as well as the use of lower MAC doses and improved MAC recovery techniques.
THE EFFECT OF URBAN ACTIVITY ON MERCURY CONTAMINATION IN ESTUARINE SEDIMENTS (PATOS ESTUARY, BRAZIL)

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ABSTRACT

A high concentration of mercury in the Patos estuary (Southern Brazil) sediments was first registered in 1998 after an accident in the Rio Grande port with a tanker transporting a large volume of sulfuric acid. That pollution of the sediments by mercury was considered a lone act and was explained by the precipitation of mercury occurring in the discharged sulfuric acid. However, later investigations found high concentrations of mercury in the suspended particulate matter of urban effluents, in soil in the center of the town and in shallow water deposits close to the urban area.

Since 1998, periodic monitoring of the quality of estuarine sediments has been carried out by dredging of the shipping canal from the Rio Grande port downstream to lagoon inlet. The aim of the current study was to characterize spatial and temporal changes in mercury concentration in estuarine sediments during the monitoring period of 1998-2012, to learn about the causes of mercury concentration variability and to estimate the relative contribution of dredged sediments to mercury content in adjacent coastal marine deposits.

Our study have established that suspended particulate matter of domestic and runoff effluents of the town of Rio Grande contain high concentrations of mercury, up to 21.0 mg/kg. Sediments from the shallow part of the estuary are also highly enriched in mercury in areas close to urban effluent discharge sites (up to 17.2 mg/kg). It has also been found that urban soils are strongly polluted with mercury (up to 25.0 mg/kg), and the polluted area covers more than 30% of the town area.

Increased input of polluted particulate matter to the estuary since of 2003 was obviously caused by anthropogenic factors. The most probable cause was associated with construction activities, which perturb urban soils and deposits of man-made land in the town. The most extensive reconstruction activity that could have increased particulate matter mobility and its fluxes was a change from cobblestone pavement in the center of the city to asphalt pavement, which started in 2003. The smoother asphalt pavement does not retain fine soil particles during rains; this fine coarse material enriches runoff in large quantities. Besides regular reconstruction and civil work, the non-authorized expansion of man-made lands using urban soil and various waste products still continues in Rio Grande.

The distribution of mercury in the estuary sediments has also undergone changes since 2004. Besides a permanently high concentration of mercury close to the town center, high concentrations (about 1.0 mg/kg) were also found in the sectors of navigation channel close to the lagoon outlet. As a whole, during the sampling period 1998-2007, applying the Brazilian legislation the mercury concentration in sediments exceeded the Tolerant Effect Level (0.15 mg/kg) and the Probable Effect Level (0.71 mg/kg) in 32 and 14% of samples, respectively. In 4% of the samples, the mercury concentration was above 1.0 mg/kg. Most of the cases of exceeding sediment quality standards fall within the period after 2004.
Study of the physical and environmental properties of raw sediments and dehydrated by the addition of polymers for use in road construction

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ABSTRACT

The results presented in this article undertaken in the framework of the European research project PRISMA « PRomoting Integrated Sediment MAnagement » of which the main objective is to improve the pretreatment and treatment processes of dredged sediments, and to promote their use in civil engineering. The objective of this study is to explore the possibility of developing, of the sediments dehydrated by the addition of polymer and raw sediments in road engineering. The aim is to evaluate the effect of the dehydration’s sediment bed drying technology with and without the addition of polymer, on the physics-chemical, geotechnical and environmental characteristics of sediments. The got results show that the dehydration of the sediments by the polymer addition causes a change on their characteristics.
ABSTRACT

Oceanic ships are getting larger and costs of dredging are increasing, which largely justify the research on new practices for harbor entrance maintenance. In fact, the sedimentation of sands transported along coast reduces the navigable depth and requires a continuous dredging to ensure the entry of the vessels in secure conditions.

As new practice for reducing the dredging operations it is proposed a sediment fluidization system, which can maintain the required water depth by pumping water under the bed of the port entrance. Conditions to cause the sediment/fluid mixture to behave as a fluid could be achieved by the introduction of pressurized sea water through the sediment deposition. This results in heavily loaded fluid that can be removed by environmental currents. In this way erosion and deposition can be driven to maintain nautical depth and on the basis of monitored environmental currents.

Sand fluidization as opposite to sediment dewatering could be applied to mobilize depositions in the intertidal zones, when suitable currents take place to remove low depths barrier to navigation and harbor entrance. In the case of nautical depth maintenance, pump systems similar to dewatering system could be applied to create the fluidization and controlled by means of Acoustic Doppler Current Profilers to monitor tidal and long shore currents.

An application of the fluidization system was analyzed on the commercial harbor of Ravenna (Italy), by means of the numerical code Mike21. A first analysis indicates that the fluidization system can be used instead of dredging operations for removing the clean sediments from the entrance of the harbor by means of coastal currents.
Effects of flooding on the contamination of floodplain sediments of the Middle Odra River with available fractions of Cd and Pb (western Poland)

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ABSTRACT

During the flooding events an extra load of trace metal content may be added to the fluvial sediments. Consequently those sediments act on the one hand as the ultimate sinks for trace metals and on the other hand as secondary source of trace metals contamination. Especially Cd and Pb are considered as one of the most significant trace metals affecting floodplain sediment properties. Furthermore exposure to both metals can lead to synergistic effects and they can be highly toxic for living organisms.

In this study changes of the total (mineralized in HNO₃) and available (0.05M CaCl₂, 0.05M EDTA and 0.1M HCl extractable) concentrations of Cd and Pb in fluvial sediments were analyzed. The sediment samples were collected after the flood in 2010 from surface (0-30 cm) and subsurface (30-60 cm) layer of the Middle Odra River (western Poland). The concentrations of metals were determined using the technique of atomic absorption spectrometry with flame atomisation (F-AAS). To calculate the pollution level in study area geo-accumulation index (Igeo) were estimated. The measurements of physico-chemical parameters (grain size fraction analysis, Eh, pH, organic matter and calcium carbonate contents) and their influence on trace metals concentrations were also performed.

The determination of total concentrations of Cd and Pb and indices of geoaccumulation (Igeo) revealed high contamination of studied fluvial sediments detected in the sediment samples characterized by high content of coarse and very coarse-grained sand fraction and high content of organic matter. It was found that after the flooding total and available fractions of Cd could increase in surface and subsurface layer while the percentage participation values for the available fractions could decrease. In the case of Pb the total concentrations, available concentrations and the percentage participation values for the available fractions could increase insignificant after the flood in both layers. It has also been stated that total and available fractions of Cd and Pb could be strongly positive correlated with the physico-chemical parameters which could change after the flood. The concentration of Cd and Pb could increase along with the Eh values, the content of organic matter, the content of calcium carbonate and the participation of very coarse-grained fractions (from 2000 to 1000 µm).
Characterization and geochemical modelling of metallic trace element release from treated dredged sediments.

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ABSTRACT

Waterways are generally recognized as the most economical and less polluting means of transport. 4 to 6 million m³ of sediments are to be dredged from waterways in Walloon Region to improve and promote this mode of transport. However about 65% of these sediments are polluted by heavy metals or organic compounds and are classified as waste materials according to the Walloon legislation (AGW 30/11/1995).

In this context and in the framework of an ERDF funded project (SOLINDUS) an experimental treatment platform was developed to treat sediments by a mineralurgical treatment in order to reduce contamination and enable their beneficial reuse. The process relies on a granulometric separation (considering that contaminants are generally concentrated in fine fractions) followed or not by a flotation step.

The aim of this research is to study the behavior of residual trace metals contained in the treated sediments. Indeed, these sediments still contain heavy metals (sometimes above the legal limit) and in order to reuse them (e.g. in landscape management), the environmental risks have to be evaluated, and particularly pollution risks of groundwater. In this purpose, laboratory experiments are conducted in parallel of geochemical modelling. Indeed, geochemical modelling is a useful tool to understand leaching processes of trace metals and to predict long term behavior of the sediments.

The experiments conducted on the first sample of this study comprise analysis of total trace metal content (aqua regia digestion followed by ICP-OES analysis), BCR sequential extraction, batch leaching experiments with ultrapure water and in function of pH (TS 14429) and saturated column experiment (TS 14405).

Geochemical modelling is conducted with PHREEQC v.3.0. The model allows inorganic speciation and mineral solubility calculation. It includes the generalized two layer model to consider surface complexation of ions to hydrous ferric oxides. The sorption of cations on organic matter (humic and fulvic acids) is taken into account by the use of the WHAM model. In order to apply both models, the quantities of crystalline and amorphous Fe(hydr)oxides and of Al(hydr)oxides are estimated by selective extraction following ISO 12782-1,2,3, while the amounts of humic and fulvic acids in the solid phase are estimated following ISO 12782-4.

This methodology will be further applied to other samples of treated sediment. In addition to be a useful tool for environmental risk assessments, the understanding of the leaching phenomena provided by modelling could also help to improve the treatment process.
valorization of dredging sediments on a subgrade layer: performing of an experimental plate

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abstract

The valuation of dredged sediment remains for years a major challenge for the state. It mainly concerns marine and river sediments. Concerning the river sediments, they have a particular physico-chemical composition with higher levels of organic matter and lower levels of minerals relative to marine sediments. Moreover, compared with other parts of French territory, the sediments of the Nord-Pas de Calais region are considered contaminated. This is why researches are initiated to find ways of development of sediments in civil engineering.

The case studied for the purposes of this contribution is to focus on providing a solution for the use of dredged sediments in road sub-base layers, while maintaining a general valuation methodology, reproducible on the industrial scale, and interesting point economically. For this, we started doing different formulations with the addition of lime and hydraulic binder in order to have more compact and more efficient mechanical characteristics.

Once we have validated the choice of formulation, we move to the study of feasibility on the industrial scale. This corresponds to the realization of an experimental plate road and making the mechanical monitoring on cores samples taken in different periods, as well as the environmental monitoring by the study of water runoff and the leaching.

From the results, it will definitively validate the value of dredged sediments in subgrade layer as well as their industrial feasibility.
ABSTRACT

Environmental dredging of sediments removes mass quantities of contaminants from a waterway, but dredging has issues with resuspended contaminants and residual contamination that can provide risk exposure for wildlife and people. Finding suitable area for disposal of dredged sediments can also be an issue. Thus, in the past two decades, the US has changed its approach to remediating contaminated sediments. Rather than relying solely on dredging, many remedies have used a combination of dredging/excavation, capping and monitored natural recovery. The first U.S. contaminated sediment active capping project was a 2004 U.S. EPA pilot-scale demonstration study on the Anacostia River. Since then, there have been numerous successful installations in North America of active caps over contaminated sediments. The most commonly used capping amendment materials are granular activated carbon and organophilic clay. Amendments can be introduced to a capping layer in bulk, in a geotextile mat or in a gabion mattress.
Sediment Quality Assessment in the Mekong River: Metal Mining and Pollution Risk

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Abstract

Mining-induced heavy metal pollution in river systems is one of the main environmental problems resulting from watershed development and resource utilization. This research investigates bed sediments in the mainstream of the Lancang (Upper Mekong) River and its 11 tributaries. The aim of this project is to examine the spatial distribution of heavy metals in the river (Cu, As, Pb, Zn, Cr), as well as to assess the level of heavy metal contamination using the Single Factor Index and the Potential Ecological Risk Index. The results show that:

(1) the heavy metal in sediments steadily decreases from upstream to downstream on the Lancang River network, while the heavy metal contents contained in the tributaries’ bed sands are distinctly different from those in the mainstream.

(2) The Single Factor Index results indicate that sands in Jiuzhou are seriously contaminated by As and Pb due to their high regional geological background. The two tributaries, the Heihui River and the Mengjia River, have been heavily polluted by As and Cu respectively. Furthermore, massive pollution in the Bijiang River has led to the highest levels of Pb and Zn pollution. The other sampling sites, except for a few heavy metal elements at moderate pollution level, are considered “pollution-free” in the mainstream and tributaries.

(3) Cross-referencing results against the Ecological Risk Index reveals high potential ecological risk factors on the mainstream at Jiuzhou (high As content) and at the Bijiang tributary (high Pb content). The ecological risk values for other sites are all low (below 40), and risk indices for all tributaries investigated are very low (less than 150), so there is little overall potential ecological risk of heavy metals.

We believe the conclusions in this paper will help provide a scientific reference for pollution control during basin development.
ABSTRACT

The lagoons of Grado and Marano are located in Friuli Venezia Giulia Region (Italy), close to the border with Slovenia, and in the northern area of the Adriatic Sea. The lagoons of Grado and Marano are subject to both natural and anthropogenic pollution of water and sediments. Both lagoons, but the Grado Lagoon in particular, have long been subject to natural pollution by mercury and related compounds due to the transport and leaching of cinnabar containing tailings from exploitation of the mercury mine in Idrija (Slovenia). Actually, the mine had been exploited for about 500 years, from 1500 yr until the 70's. The river Hydra (Idrija), is the main tributary of the river Isonzo (Soca) toward which mining tailings and Hg-polluted waters flow. The Gulf of Trieste is the final acceptor the Isonzo River and, given the sea currents, the Hg pollution included the lagoons of Marano and Grado. In addition, both the lagoons had been overcome by Hg disposal from industrial activity. Alluvial deposits sampled at the river to see confluence area contain outstanding concentrations of mercury with the highest values reaching thousands of mg kg⁻¹ that affect the quality of the overlaying water column as well. In particular, the assessment of lagoon waters and sediments were carried out during the decade 2002-2012. The base level of total mercury in the sediments of the both lagoons is about 0.13 ± 0.04 mg kg⁻¹, in agreement with the UE standard (0.3 mg kg⁻¹) for environmental quality of coastal marine, lagoon and pondal sediments (UE Directive 2000/60), and definitely lower than that reported by Acquavita (2012) (up to 18 mg kg⁻¹, with a medium value of about 4.6 mg kg⁻¹ and a average value of 4.2 mg kg⁻¹).

Moreover, a concomitant bioaccumulation of mercury and methyl-mercury in both natural and cultured populations of bivalves was observed. At the end of the last century, studies showed that Hg was present in the hair of fishermen and people that regularly consumed fish from the lagoons of Grado and Marano. In particular, a recent epidemiological study aimed to determine the level fetal and prenatal exposure to mercury in children in the region of Friuli Venezia Giulia revealed that the concentration of Hg in hair and breast milk was higher in women that spent most part of their pregnancy period in one of the lagoon municipalities. The variability of the Hg levels probably did not depend as much on the quantity of the consumed fish as rather on its origin.

In the lagoon system there is a marked accumulation of contaminated sediments within the navigation channels. Regular maintenance of these channels is critical for assuring safe
navigation through the lagoons. However, in the last fifteen years the removal of the accumulated material from the navigation channels became more demanding due to the new environmental norms that require the sediments to be treated and disposed as waste. At present, the overall characterization of sediments was ended, several dredging and containment of polluted sediments were carried out, and monitoring of the environmental and health effects were assessed. Thus, the ordinary management requires to define the goals of sustainable management as definite criteria of sediment quality, for environmental purposes and health, morphological recovery of the lagoon system and cost-effectiveness of sediment restoration technologies and performances. It would be therefore necessary to present a suitable management protocol that would bring together the decision-makers.
ECOTOXICOLOGICAL EVALUATION OF THE RELATIONSHIP BETWEEN THE ACID VOLATILE SULFIDES (AVS)- METALS AT SEDIMENT COLUMN

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ABSTRACT

Sediment are natural and essential components of ecosystems, providing habitat and substrate for variety of organisms, as well as playing roles in number of essential ecosystem functions and services and in the hydrological cycle. Contaminated sediments may create a negative impact at the high levels of toxic and hazardous materials included to the environment or human health. Contaminated sediments is a global problem and can be a major impediment to restoration efforts in degraded aquatic environment. Observations of anoxic sediments show a common sulfide-rich zone at depth which includes a variety of precipitated and dissolved iron and sulfur speics. Adding HCL to this material result in the evolution of H2S gas that is derived from the “acid volatile sulfide(s)” (AVS) component of sedimentary sulfides. When the improvement with acid is done on the sediment layer, the sulphide mineral which are released as a result of this operation are defined as acid volatile sulphide. Heavy metals which are generally associated with AVS are called simultaneously extracted metals (SEM) (Cu, Pb, Cd, Zn, Ni, Cr and Ag). The amount of AVS which is described as acid volatile sulphide, can be indicator of the potential toxicity in the sediment layer since of it can indicate the exceed in metal concentration. The determination of acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) in sediments AVS can be a key binding phase for controlling bioavailability of toxic cationic metals in anoxic sediments. Chemical analysis of pollutants in ecosystems alone can not provide evidence for toxicological consequences in biota. Only an integrated approach considering environmental chemical, toxicological and ecological concepts may be suitable for understanding ecotoxicological effects in contaminated ecosystems, such as sediments. Ecotoxicology as an interdisciplinary environmental science deals with the interactions between environmental chemicals and biota, thereby focusing on adverse effects at different levels of bilogical organisation. Toxic effects of anthropogenic compounds in bioata and ecosystems are investigated in close connection to their environmental chemistry and fate in the environment. Whereas practical aspects of ecotoxicology are mainly focused on regulatory issues (registration of chemicals) and thus to testing of chemicals in standardized tests, the focus of ecotoxicological research is aimed at an understanding of toxicological phenomena in a variety of biota, populations and the ecosystem as a whole. Thereby, diverse aspects such as mechanisms of toxic action and ecological processes in contaminated systems are regarded.
ABSTRACT

The sediment problem is a global problem. The rivers and harbour areas are the subject of continuous silting up, dredging works are therefore necessary and generate large amounts of often rich in toxic substances muds. The valorization of these sediments has already been the subject of research in road materials and concrete. In the case of marine sediments, the presence of chlorides may be penalizing for the durability of cementitious materials. That is why the authors have suggested to use these sediments as filler in organic matrices. The matrix chosen in this work is a biosourced polymer developed at the laboratory and protected. Marine sediments are extracted from Dunkerque (France) harbour. They are added to the matrix in proportions ranging from 0 to 20%. The objective of this preliminary study is to verify the feasibility of such material through the impact of the presence of sediments on the mechanical properties of the composite. The parameters studied are the percentage of embedded sediments and the age of the composite. Assessed mechanical characteristics are hardness and mechanical resistance and the module for tensile and flexural stresses. The results obtained show that, as it was predictable, the incorporation of sediment increases the hardness and stiffness of the material. Tensile and flexural strength decrease but maintain acceptable values. The increase in the density remains reasonable: an increase about 10% occurs for 20% of added sediments.
VALORISATION OF CLAYEY SEDIMENTS FROM AGGREGATE DEPOSITS. 
INFLUENCE OF THE ADDITION OF RUBBER FILLERS ON THE THERMAL 
BEHAVIOUR

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ABSTRACT

Currently, due to progressive exhaustion of aggregates resources, exploited deposits are 
more clayey and washing residues that constitute a significant loss of profit (20–40%) 
represent increasingly large quantities. They are currently poorly valued and often rejected 
in settling tanks. Previously, works conducted in the laboratory have already shown the 
interest of their transformation into cellular concretes by proteinic foaming. However, if the 
cell structure remains away from the water invasion thanks to the protein film, thus 
inducing a considerable slowdown in water transfers and a reduction of the heat transfer 
coefficient, the presence of clay, even stabilized with cement, causes sensitivity to water 
which results in a decrease of thermal insulation capacity. This is why it has been made an 
addition of non-sorptive inclusions in the form of rubber fillers obtained by aspiration during 
the granulation of waste of the automotive industry. The amount of addition was limited to 
10 % in weight to not modify the viscosity of the mixture. 
Studies have shown the positive impact of rubber fillers on the thermal conductivity of 
clayey cellular concrete. For example, the thermal conductivity is 0.35 W/m.K for the dry 
material. It reaches 0.17 W/m.K for 10% of rubber. In the presence of inclusions of rubber, 
thermal conductivity remains low even for important water contents.
A SEDI-BAR TEST FOR MEASURING CONSISTENCY OF SEDIMENTS

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ABSTRACT

Consistency and sensitivity of soft soils and sediments are important properties for geo-environment design as for as sediment management. Usually these properties are deduced from the determination of undrained shear strength Su using different laboratory and field tests namely fall cone test, vane shear test, cone penetrometer test, unconfined compressive test, shear box testing. Recently full flow penetrometers are used in offshore engineering. Based on the concept of full flow of soils around a horizontal diameter, the T-bar test offers new opportunities as shown and demonstrated in this paper. A continuous profile of Su during penetration, pulling out and repeated cycles can be obtained. Su determination needs only the use of T-bar factor. A Sedi-bar test is developed specially for soft soils and sediments and implemented for thin layers. But in laboratory testing, Sedi-bar must be carefully used. The conditions of Sedi-bar use are clearly reported from laboratory tests performed on kaolin clay and further on sediments. Conclusions are drawn and Sedi-bar test developments and future investigations are proposed for contaminated sediments characterization.
APPLICATION OF “WEIGHTED” CRITERIA BASED ON LINE OF EVIDENCE APPROACH TO EVALUATE AND CLASSIFY THE SEDIMENT QUALITY IN THE HARBOUR OF TRAPANI

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ABSTRACT

The characterization of marine sediments is of crucial ecological and ecotoxicological importance. National guidelines elaborated by ISPRA are based on an integration of chemical and ecotoxicological results to classify sediments in quality classes, considering a pass-to-fail approach relative to chemical limits and the worst ecotoxicological result bioassays. In the present study, a quantitative Weight Of Evidence (WOE) model (Sediqualsoft®), which integrates both chemical and ecotoxicological data using weighted criteria, was applied in the harbour of Trapani (Sicily, Italy) during a sediment characterization project finalized to dredging activities: the obtained results were compared to classification based on ISPRA guidelines. The application of Sediqualsoft® model, largely reduced the volumes of sediments assigned to the worst quality classes, while increasing those of class B2, that may be disposed in aquatic confined facilities. The reason of this difference was in many cases the slight exceeding of limit chemical values for individual compounds and/or the elevated sensitivity of the sea urchin bioassay: according to ISPRA guidelines, the worst (chemical and ecotoxicological) result influenced the whole judgment. On the other hand, the application of integrated criteria allowed to better weight the number, magnitude and typology of exceeding chemicals, as well as the relative importance of each individual bioassay in the overall evaluation of sediment quality class.
FORMULATION OF A COMPACTED CLAY LINER FOR SOLID WASTE LANDFILL FROM A MATERIAL OF SEDIMENTARY ORIGIN

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ABSTRACT

Waste containment systems and/or management structures are the most common method to dispose solid waste worldwide; specially in landfills. Most engineering landfill lay over natural or constructed low permeability clay layer known as engineer clay liner or compacted clay liner. A specific value of permeability is expected to be achieved. Commonly a minimum value of $1 \times 10^{-9}$ m/sec is required by the majority of governments and/or environmental agencies. An experimental investigation was performed in this project to evaluate the hydraulic conductivity using a sedimentary local soil as candidate for compacted clay liners. Soil samples known as “sedimentary clay of Saida” were obtained and analyzed from location in the Saida region (west of Algeria). The first part of the program consisted in obtaining the basic geotechnical properties of the soils (Atterberg limits, specific gravity, and saturated hydraulic conductivity). The second part consisted in the study of the hydraulic conductivity parameters.

The geotechnical tests (Atterberg limits, activity, CaCO₃ and organic matter) and Proctor tests allow us to advance the suitability of the soil studied for use as a landfills’ clay liner. Permeability tests with water, under a compressive stress of 125 kPa, at dosages of 1%, 2% and 3% of bentonite respectively given coefficients of permeability $k$ of $20 \times 10^{-11}$ and $8.51 \times 10^{-11}$ and $4.75 \times 10^{-11}$ m/sec. These values are consistent with what is required by regulation.

With 1% bentonite, sedimentary clay of Saida meets the criteria to be used as clay liner for landfills.

A comparative study of the permeability of the material to natural leachate and water was conducted under compressive stress of 125 kPa and 250 kPa. Under the compressive stress of 125 kPa, the present study confirms earlier work with increased permeability to leachate in comparison with water. The opposite effect occurs under the compressive stress of 250 kPa.
Bench scale removal tests of uncharacterized organic matter in marine sediments using surfactants and chemical oxidants

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ABSTRACT

Feasibility of using surfactants and chemical oxidants was investigated to degrade organic matter in fine grain sized (<63μm) marine sediments existed in the highly eutrophic and semi-closed marine area where water circulation is very limited. The organic matter rich coastal sediment was subject to this study and a various combination of hydrogen peroxide as oxidant and Triton X-100, Tween 60 and Tween 80 as surfactant was attempted to find out which combination was effective in reducing the amount of organic matter in the marine sediment. Organic matter removal efficiency was tested by determining total organic carbon (TOC), chemical oxygen demand (COD) and loss of ignition (LOI) contents on three sediment grain size fractions (>63μm, >32μm and <32μm fractions). Our treatments were able to reduce organic matter up to 58% of TOC, 73% of COD and 56% of LOI in all three fractions. The best destruction performance of organic matter was achieved with a mixture of 5M hydrogen peroxide and 0.5% Tween 80 (1:1 v/v) and washing solution: sediment (3:1 v/w).
EVALUATION OF SEDIMENT TOXICITY AND RISK ASSESSMENT FOR BENTHIC ORGANISMS: A CASE STUDY

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ABSTRACT

Sediment quality benchmarks are intended to predict sediment toxicity but often are derived in a manner that does not necessarily reflect cause-effect, concentration-response relationships. Therefore, although generic benchmarks can be considered useful for screening purpose, care should be taken before using them to define need for remediation. Instead, as reported in several guidelines, the real need for remediation should be evaluated considering site-specific condition and risk assessment. We present and summarized the approach adopted to evaluate risks of sediment-associated DDx to benthic invertebrates, considering several lines of evidence including (1) toxicity studies performed on field collected sediments, (2) evaluation of site specific ecological conditions, (3) review of toxicity testing and benthic invertebrate community assessments from major DDT-contaminated sites, and (4) extrapolation of aquatic toxicity data to sediment using the equilibrium partitioning approach. The results are discussed as evidences to support the decision making process for the management of a contaminated sediment case study.
ABSTRACT

As part of a series of investigations carried out by ENVIRON in a freshwater system, 210Pb and 137Cs analysis was undertaken to better understand the sediment accumulation rate and to evaluate historical trends of contaminant loading in sediments. Activities were performed investigating several sites, chosen to span a range of likely sediment accumulation rates. Coring activities were performed on silty sediment using a light weight gravity corer, with the aim of obtaining undisturbed samples. Results show that concentrations of contaminant concentrations have overall declined significantly in the last 40 years: the most significantly elevated concentrations occur in the period of the mid-1960s.

The poster presents adopted methods, results and considerations about the chemical loading in sediment and temporal trend.
ABSTRACT

In Europe, legislation for the protection of the aquatic environment typically requires the achievement of defined environmental quality standards in water. Recently, progress has been made towards the development of an EU regulatory framework for sediment risk assessment, including the development of similar standards for sediments. The definition of sediment benchmarks and, more generally, their use in the evaluation of contaminated sediment is challenging since the toxicity and bioavailability of contaminants can be strongly influenced by a variety of site-specific parameters and conditions. If remedial decisions are taken based on the outcome of a comparison with generic benchmarks this can have strong implications for the management of contaminated sites, in particular the costs of cleanup and the potential unintended consequences of unnecessary actions. The presentation will discuss the relevance and significance of an EU-wide approach and the need for a European risk assessment framework that allows for flexible, realistic and site-specific risk assessment in the evaluation and management of contaminated sediment sites. Experiences and results from a case study will be presented.
HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELING: THE TOCE RIVER AND PALLANZA BAY CASE STUDY

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ABSTRACT

Understanding sediment transport is crucial for predicting sediment and contaminant transport in surface water systems. Computational Fluid Dynamics (CFD) models are extremely powerful instruments able to provide deep knowledge of sediment fate and transport dynamics. To date, numerical modeling represents the leading reliable technique for what-if scenario assessments, especially for temporal long term applications. As part of a series of investigations carried out by ENVIRON in Lake Maggiore (Italy), a detailed hydrodynamic and sediment transport model was developed to quantify the transport of sediment and DDT contaminant in the Toce River (downstream Pieve Vergonte) and the Pallanza Bay (Lake Maggiore). Among the 3D CFD codes available to model flow and transport in river and estuarine systems, EFDC (US Environmental Protection Agency) was selected for the implementation of this work because it is public domain, extendable, and has a thoroughly tested hydrodynamic solver. An extensive field campaign was leaded in 2009 overall the study site to achieve the characterization of water quality, suspended and bedload sediment composition and chemistry. Hydrodynamic measurements (in river and lake velocity, temperature, turbidity, conductivity) and several SedFlume cores were used for an event based calibration (March 2009 sediment pulse event). Using flow and sediment load boundary conditions provided by the EROsion and Deposition Estimation model (ERODE model, Politecnico di Milano) the 1982-2009 time series was simulated to (i) reproduce the sediment deposition pattern and thickness in the Bay, (ii) estimate the long term sediment and contaminant mass balance into the Bay, (iii) quantify the effects of extreme events (50, 200, 500 years Return Interval) on sediment flux closed to the Toce mouth. The EFDC model, furthermore validated using ongoing monitoring activities data, will be used to evaluate climate change scenarios impacts on the Pallanza Bay sediment supply and deposition dynamics.
The effect of wastewater treatment plants on the evolution of pollution level in Patras Gulf, Greece

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**ABSTRACT**

Patraikos Gulf used to receive untreated industrial and municipal wastewater until the operation of the two wastewater treatment plants along with their discharging submarine pipelines for industrial (mid of 90s) and municipal (mid of 2000s) wastes. The level of Gulf pollution was assessed in both time periods, before and after the operation of treatment plants, by monitoring sediments, seawater and marine organisms (*Pinna squamosa*, an indigenous bivalve). Metals and POPs were determined in all samples as well as nutrients and microbiological indicators in seawater samples. Sediments were assessed by two criteria: Sediment Quality Guidelines (SQGs) and Contamination Degree. The results show that the operation of wastewater treatment plants in conjunction with the appropriate discharge of treated wastes have reversed the process of pollution burden and contributed to the ecosystem reclamation.

**Keywords:** marine ecosystem monitoring, SQGs, Contamination Degree, Patraikos Gulf, remediation
ENHANCED ELECTROKINETIC DECONTAMINATION OF Hg POLLUTED SEDIMENTS DREDGED FROM AUGUSTA BAY (SOUTHERN ITALY): PRELIMINARY TESTS

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ABSTRACT

The aim of the research is to apply biosurfactant-enhanced EK technology to marine sediment contaminated by high level of Hg dredged from Augusta bay (Italy). In this work, we carried out preliminary batch tests using different novel biosurfactants in order to find the optimal Hg extracting agent. In addition a technical test was performed to evaluate the optimal operating features of the EK bench-scale apparatus.

Batch experiments were conducted using four single sugar esters as biosurfactants, a mix of sugar esters and EDTA salt at different concentration. Extracted Hg was determined by ICP-MS. EK preliminary test was performed using a bench-scale apparatus where the main central tube was filled with the sediment specimen. A constant potential difference of 30 V was applied to sediments by an electrodes-power supply system for total period of 30 h. Deionized water was used as processing fluid during the EK experiment and current intensity and electrosmotic flow were monitored during the test.

Main results from batch tests show that the nature and the amount of the enhanced product significantly influenced the Hg extraction, and the maximum extraction efficiency was observed for the biosurfactant solution Sinerex SMO 20 - Doblyn ANX. In this case, Hg extraction was shown to be 50-fold higher than for the 0.2M EDTA solution, and about 17-fold higher than for Sinerex SMO 20 that is very similar to tween 80. The reduction of current intensity and electrosmotic flow with time observed during the preliminary EK test highlights the necessity of using conditioning agents during the treatment. Data demonstrates the good working features of the experimental apparatus.

Overall, preliminary results show that EK treatment jointly with biosurfactants such as sugar esters could be a better choice for remediation of Hg-polluted sediments. The results obtained are of scientific and practical interest, however the optimal dosage of biosurfactants should be investigated by means further experiments aimed at investigating the effect of the mixture concentration on biodegradability, electrosmotic flow and contaminant removal.
ABSTRACT

The aim of this work is to study the stabilization potential of dredged sediment treated with hydraulic binders, as a part of the European SETARMS program (Sustainable Environmental Treatment and Reuse of Marine Sediments), that investigates the potential uses of marine dredged sediments as a new material resource for road building. For that, various chemical extractions (single, sequential and kinetic extractions) were performed, on raw and treated materials (after 180 days of maturation), in order to determine the mobility of metallic elements, and then to assess the environmental risk. The main results obtained are:

- **Single extraction:** After treatment, the mobility of all of element of interest increases (2 to 52%). With dilute HCl extractions, mobility values from 10 to 39% were noticed in the raw sediment, but for each element, the mobility was enhanced after treatment (mobility values up to 52%).
- **Sequential extraction:** After treatment, for all the elements of interest, the acido-soluble fraction increase suggesting that the treatment modifies the geochemical distribution and might increase the metal mobility under acidic condition.
- **Kinetic extraction:** Whatever the element is, the mobility is higher for the treated sediment than for the raw material (up to 69 %). Besides, the mobility associated to the slowly compartment increases, whatever the element is (up to 72%), compared to the values observed for the raw sediment.

The HCl, sequential and kinetic extractions shows a significant increase of mobility of all the studied elements after the treatment with hydraulic binders. All these tests suggest that the elements are not stabilized, which might be related to the weakening of the sediment matrix due to the high pH induced by the hydraulic binders treatment. However, all these results have to be confirmed by further tests performed on various sediments and at longer maturation time.
ABSTRACT

The delta of the Neretva River is one of the main agrarian regions of Croatia. The alluvial plate occupies an area of 120.7 km². The remaining 291.1 km² is composed of karst hills and smaller agricultural platforms that surround the alluvial plate. The delta has been subjected to agricultural reclamation since the 18th century, but the greatest transformation occurred from the 1950s to the 1980s when the majority of the wetlands were transformed into agricultural land. The Neretva River basin is moderately urbanized with very little industry and mining activities since the early 1990s. Therefore, agriculture remains the main source of soil and sediment pollution.

In the survey of this area, 18 chemical elements (K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Br, Rb, Sr, Y, Zr and Pb) were analyzed on the < 2 mm fractions by the Energy Dispersive X-ray Fluorescence (EDXRF) method for 390 soil and 116 sediment samples. Each sampling point was characterized by its GPS coordinates enabling the production of factorial maps for the measured elements by using Arc View 9.3 software.

The human intervention into the delta of river Neretva started in 1880-ies when the flow of river was regulated. The soil melioration started by transfer of river sediments into swamp zones. Additional reduction of swamp area has been accomplished by channels digging and using the resulting material for the generation of fields. Therefore, we decided to treat data on the soil and sediment concentration levels as a unique data base.

The results were compared to the Dutch pollution standards because these standards include soil and sediment evaluations and consider both human and eco-toxicological effects. Spatial anomalies in the natural distributions of chemical elements, such as outliers and hidden structures of elevated concentrations, which can potentially present a risk to human health, were evaluated using GIS based multivariate statistics. Nine environmental and anthropogenic factors controlling the variability of elements in soils and sediments were identified. The geological factor (containing positively correlated variables: Ti, V, Mn, Fe, Ga, Rb, Y, Zr and negatively correlated Ca) is the most dominant describing 34.5% of total variance. Two additional natural factors are geomorphologic factor describing 7.6% of total variance (contributed by negatively correlated K and Ca) and chromium factor describing 5.8% of total variance, which is partially controlled by anthropogenic contribution. The six environmental degradation factors describing 34.8% of total variance are related to agricultural activities. They include historical or current use of Cu, Zn, As, Br and Pb based pesticides, and deep soil salinisation indicated by elevated Sr concentrations.
ENVIRONMENTAL RISK ASSESSMENT OF DREDGED SEDIMENTS FROM ENGLISH CHANNEL

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ABSTRACT

Each year about 57 million tons of sediments are dredged from the English Channel harbours. 90% are directly dumped into the sea. As sea disposal is becoming more and more regulated, the management of dredged sediments is now an environmental and economical challenge for the ports authorities. In this study, as a part of the INTERREG IVA - SETARMS project (Sustainable Environmental Treatment and Reuse of Marine Sediments), the 13 sediments (referred hereafter as SA to SM) selected for the project are characterized, focusing on the determination of the total concentrations and the estimation of the mobility of As, Cd, Cr, Cu, Ni, Pb and Zn. The total concentrations of the studied elements in the sediments are determined by ICP-AES after acid digestion. According to the French and English thresholds references (GEODEa and CEFASb), disposal at sea is prohibited for the 13 sediments. The PCAc analysis differentiates the samples. 9 sediments (SB, SC, SF, SG, SH, SI, SJ, SK an SM) constitute an homogeneous group, while the others 4 sediments are characterized by high concentration of different elements, As for SL, Cd and Ti for SA and Sd and Cd, Cu and Zn for SE. Enrichment factor (EF) are calculated to better estimate the sediments contamination. According to the EF values obtained, enrichment of As, Cd, Cu Pb and Zn (EF>2) are noticed for the 13 sediments. These results are consistent with the possible sources of inorganic contaminants (industrial and mining activities mainly) in the English Channel area outlined in the literature. For these elements, the mobility was investigated by single chemical extraction, using HCl (1 mol/L). The results obtained show that the elements for which enrichment is suspected (As, Cd, Cu, Pb, and Zn) are also quite mobile (mobility often up to 40%), which confirm the potential environment risk associated to these concentrated elements in the sediments. The 13 sediments studied are different regarding their total levels in As, Cd, Cr, Cu, Ni, Pb and Zn although disposal at sea is prohibited (without further studies) according to the current regulations. Most of these high levels are related to significant enrichment and important mobility that suggest a risk for the environment. This highlights the need of alternative solutions to sea immersion at sea, such as reusing the dredged sediment, as well as the need of further investigation for a better assessment for each sediment.
ANALYSIS OF POSSIBLE USE OF SEDIMENTS FROM DREDGED EUTROPHIC RESERVOIR ON AGRICULTURAL SOILS

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ABSTRACT

Rzeszów Reservoir located on the Wisłok river in south-eastern Poland within an industrialized area, was constructed in 1973. During exploitation, large areas of the reservoir have silted up and have been gradually transformed into land. Its volume decreased from 1.79 to 1.1 mln m³ and its mean depth from 1.5 to 0.6 m. The reservoir was restored in 1987 and 1996 when about 300 cubic meters of the sediment were yielded each time. Despite the reclamation, the reservoir is still heavily silted and its utility functions are strongly limited. Due to the situation, dredging and disposal of 500 cubic meters of the bottom sediment have been planned. The aim of the study is to analyze the contamination and possibility of agricultural use of the dredged material. The paper presents the results of research into the quantitative analysis of both potentially toxic and biogenic substances in a set of sediment samples collected during the last five years. Moreover the source of organic matter in bottom sediments has been evaluated using stable carbon and nitrogen isotope and elemental ratios. Samples from at least 3 sampling sites located along the axle of the reservoir were analyzed. Standard analytical procedures were used in field and laboratory works.

Silica is the predominant component of the sediment (ca. 67% DW) and organic matter content was about 10% DW. Biogenic compounds: total organic carbon, total nitrogen and total phosphorus averaged 2.31%, 0.21% and 0.031% DW respectively. The origin of the Rzeszów reservoir bottom sediments is mixed. The unexpectedly high proportion of the autochthonous material is the result of eutrophic processes.

PAHs contents were relatively low. The highest concentration ever noted was 0.164 ppm in the case of benzo(k)fluoranthene. Benzo(a)pyrene contents were less than 0.14 ppm. The PCBs concentration levels ranged from 0.0006 to 0.003 ppm and were below standard values. The sediment is moderately contaminated by heavy metals (Cu, Cd, Cr, Zn, Ni, Pb). Mean concentrations of all metals exceeded the geochemical baseline and the TEC level, The PEC value has not been exceeded in any of the samples analyzed.

The characteristics of researched sediments indicate that they are not suitable for agricultural use due to contamination and lack of fertility. However, they can be used for non-agricultural land reclamation. Remediation of the dredged material could result in the removal of these metals, but due to the significant amounts of dredged materials the process may prove to be an unprofitable operation.

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CEAMAS PROJECT: CIVIL ENGINEERING APPLICATIONS FOR MARINE SEDIMENTS

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ABSTRACT

Management of dredged sediments is an issue for many European countries. At the same time, there is a concomitant increase in demand for construction materials with regional to sub-regional deficits in suitable sources to supply the market. The use of dredged marine sediments in civil engineering applications could provide potential solutions for both issues, however existing EU legislation for handling dredged material is complex and from a policy perspective, dredged material is dealt at the intersection of EU Water, EU Waste and EU Marine Strategy Framework Directives. Procedures and contaminant thresholds to authorize relocation of these sediments at sea or in land vary considerably from one country to the other and there are no harmonized regulations at EU level.

In this context, the CEAMaS project aims to bring about a major improvement regarding the widespread uptake of practices involving the beneficial reuse of dredged marine sediments. This will be accomplished by providing new and enhanced tools, methods, services and detailed knowledge on established and innovative civil engineering applications. Key outputs will be a common European reuse methodology applicable to all ports and sediments backed
by a European Resource Centre which will provide the focal point for knowledge capitalization and raising awareness of sediment reuse options.

With the support of funding under the INTERREG IVB ERDF programme and with CD2E as Lead Partner, the Technical University of Delft, the University College of Cork, the Cork Institute of Technology, the Ecole Centrale de Lille, the University of Lille 1, the Belgium Building Research Institute and the BRGM cooperate to propose environmental, economic, technical, social and regulatory solutions to issues of the current management and reuse of dredged sediments.
THE COMBINATION OF BIO-BASED AND CHEMO-PHYSICAL APPROACHES TO RECOVER DREDGED SEDIMENTS TO TECHNO-SOILS

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ABSTRACT

Chemo-physical treatments to remove salinity and metal contamination from dredged sediments were applied in combination to bio-based approaches exploiting here isolated and enriched autochthonous microorganisms that were massively inoculated in the sediments to remove the Total Petroleum Hydrocarbon contamination. Eco-toxicological assays were exploited to estimate the effectiveness of the remediation of the matrix over time. In fact, the only chemical characterization of polluted matrices does not allow to predict its real toxicity eventually related to the original pollutants, on their degradation intermediates and on the synergic actions of the both. Higher plants were exploited as indicators of the quality of the treated sediments and used both for the continuous monitoring of the remediation processes and also for the evaluation of the eco-safety of the final product. Biological parameters such as germination and root elongation were evaluated as well as the genotoxicity by means of cytological analysis of mitotic behavior of root meristems, based on the detection of chromosomal aberrations in mitotic cells, and of micronuclei formation, detectable in inter-phase cells.

The combination of the Chemo-physical and the Bio-based approach was able to remove the organic contamination (TPH) and the excess of sodium salts that eventually render the sediment a waste matrix. At the same time the sediments were detoxified and acquired biochemical traits of techno-soils eventually suitable for their safe re-allocation.
ABSTRACT

Sediments develop both potential source in aquatic environment and carrier for heavy metals. Heavy metals develop significant toxic effect to aquatic organisms; thereby influencing human health through food chain. For this reason, remediation and/or treatment studies are required to determine the extent of contamination, spreading mechanisms and transformations of heavy metals in contaminated sediments to prevent environmental risk factors that may occur.

In this study, physicochemical and mineralogical analysis of the samples, collected from Yeşilirmak, Kızılırmak, Mert, Abdul Rivers and Kurupelit sea regions, were carried out to determine the extent of the total metal contamination in sediment layer. Seasonal results showed that Total Carbon (TC) (9714-17698 mg/kg), Total Inorganic Carbon (TIC) (6888-15355 mg/kg) and Total Organic Carbon (TOC) (2340-2812 mg/kg) concentrations were low in Yeşilirmak River and Kurupelit sea region while TC (57907 mg/kg), TIC (39564 mg/kg) and TOC (19823 mg/kg) concentrations were high in Mert Stream. Seasonal studies were also conducted to determine the extent of heavy metal contamination in the samples collected from the Yeşilirmak, Kızılırmak, Mert, Abdul Rivers and Kurupelit sea regions. Findings obtained from 5 stations which were contaminated with heavy metals were compared with the baseline earth crust rock and enrichment factors in Abdul region. The extent of heavy metal contamination was as follow: Yeşilirmak> Kızılırmak> Kurupelit> Abdul> Mert.

In the main goal of this study, different remediation and/or treatment alternatives were investigated for batch methods of sequential extraction, potential leaching and soil washing/extraction methods to remove heavy metals (Cu, Pb, Cd, Fe, Al, Cr, Cu, Zn, Mn, Sr). In exchangeable phase (F1), carbonate phase (F2), Fe-Mn oxidation phase (F3), organic phase (F4) and residue phase (F5) which were determined via sequential extraction method, depending on the metals mobility, the removal of heavy metals from sediments was found as: residue>Fe-Mn oxidation>organic>carbonate>exchangeable phase. According to the total concentrations of each Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn, Mn ve Sr metals, a recovery rate of 83-127%, 92-123%, 83-112%, 84-106%, 91-105% were obtained from Kızılırmak, Mert Rivers and Kurupelit sea region, Yeşilirmak and Abdul river sediments, respectively.

In Potential leaching method, with respect to the mobility of metals, heavy metal removals from sediment layer were determined as: Cu>Ni>Cd>Cr>Zn>Mn>Sr<Al>Fe depending on the total metal context.

Soil washing/extraction method was used in a laboratory batch and column system to remove heavy metals from the contaminated sediments using 0.1M Na2S2O5 and 0.01
Na₂EDTA mixture. Depending on the total metal content and the complexation with Na₂EDTA, heavy metal removal rates by applying batch and continuous soil washing/extraction methods were found as: Cu>Ni>Zn>Pb>Mn>Fe>Al, and Mn>Cu>Ni>Zn>Fe>Al, respectively.

In conclusion, for the remediation and/or treatment of heavy metal contamination from contaminated sediments; the removal of heavy metals from sediments by sequential extraction, potential leaching and soil washing/extraction was found as 95-110%, 1-81%, and 1-43% respectively depending on the metal mobility and mineralogical structure of sediments.
ABSTRACT

Drydocks have been increasingly used for the construction, maintenance, and repair of ships, boats, and the watercraft along the sea coast in South Korea. In a dry dock, large quantities of particulate pollutants containing antifouling paint and metallic particles are emitted into the bottom particularly during repair, maintenance and cleaning of vessel hulls. The drydock bottom is flooded frequently with seawater and the adjacent sea becomes naturally contaminated with drydock sediment. These deposited particulate pollutants pose significant health threat to the local populations who consume fish and shellfish taken from the adjacent sea area. In order to develop an efficient separation method for butyltins and metals laden solids from the excavated materials from the bottom of a drydock, we investigated selected size distribution of grains, magnetic properties of each grain size fraction, and butyltin and toxic metal contents in each size fraction were determined for the bottom sediment deposited in a dry-dock located in Busan, southwestern coast of Korea. We found that high levels of TBT occur concurrently along with high level of Cu, Zn, and other metals, and were also found to exhibit high magnetic susceptibility. The co-occurrence is probably due to the major chemical elemental components of layered paint fragments usually applied to the ship’s hull. The efficiency of magnets to separate those butyltins and metals laden particles was found to rich in the 63-125, 500-1000 μm size fraction. Using these findings, we are currently designing bench scale size and magnet separation pilot system to develop a commercial system to be used in small drydock facilities around the nation.
ABSTRACT

Marine bottom sediment in busy urban harbors in South Korea is often found to be highly contaminated with polyaromatic hydrocarbons (PAHs) from various sources and pose significant health concerns for the local human population as well as marine wildlife. Therefore it is necessary to decontaminate the PAHs from the bottom sediment either in situ or ex situ. In this study some collateral effects for PAHs in marine sediment, caused by chemical oxidants and surfactants to PAHs in contaminated marine sediments, were evaluated. Hydrogen peroxide was used as chemical oxidation reagent for Fenton-like reaction. Surfactants including Triton X-100, Tween 60 and Tween 80 were used to enhance the solubility of PAHs as washing reagents. A combination of using various concentrations of hydrogen peroxide and surfactants was evaluated to degrade PAHs in contaminated marine sediments and was yielded 0-30% removal of PAHs in the sediment for 1 hr duration of the treatment. The largest amount of removal was found in the case of applying 5M hydrogen peroxide and 0.5% Tween 80. The 30% reduction of PAHs in sediment are found to satisfy the government regulatory limit for most PAHs contaminated harbor marine sediments in South Korea. Using these findings, we are currently designing bench scale pilot system to develop a commercial system to be used in harbors around the nation.
STUDY OF CONTAMINATION AND SPECIATION OF HEAVY METALS IN THE OUED OF FEZ AND OUED SEBOU

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ABSTRACT

In the city of Fez, several activities, including tanning and brassware, generate releases of heavy metals in surface waters. These releases alter the quality of receiving streams and may mortgage the use of water downstream, particularly the production of drinking water and irrigation. These metals are partly related to suspended solids and sediment in the bed of the receiving streams. This study aims to determine the level of contamination of these sediments, not only by their total metal content, but also by their speciation. The technique used is the speciation of the acid titration developed by Petit et al (2009), based on monitoring the dissolution of the material sought in response to additions of more and more concentrated acid. Initial results show an enrichment of sediments in several metals, mainly nickel, chromium and lead to downstream of the city of Fez. This enrichment is attenuated downstream, but is still clearly demonstrated after several tens of kilometers. Speciation shows that much of the chromium and nickel is associated with little reactive phases, but only downstream of discharges from other phases, more responsive, probably carbonate, and are also present. Lead, like copper and iron appears to be related to a phase-type oxide-hydroxide, not very reactive in the test conditions, but which is nevertheless capable of releasing these metals into the water column in case of changes chemical conditions of the environment.
THREE DIMENSIONAL SIMULATIONS OF SEDIMENT FLUSHING DURING COMPLETE DRAWDOWN IN THE BARASONA DAM RESERVOIR (SPAIN)

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ABSTRACT

Reservoir sedimentation is a one of the serious problems affecting the majority of the reservoirs in the worldwide. By transporting sediments into the tail water, their accumulation in the reservoir is reduced significantly. However, the global number of sediment flushing through bottom outlet is limited primarily due to high maintenance cost and water consumption. This research focuses on sediment flushing during complete drawdown throw bottom outlet to convey sediments past a dam. The main goal of the project is to establish general design criteria for optimal flow conditions in which both sediment depositions and water consumption decreased and the resulting abrasion damages in the bottom outlet are kept at a minimum. In this paper numerical simulation of sediment flushing during complete drawdown in the Barasona dam were performed by using Flow 3D software. Validation of the numerical model has been made using prototype data. For the assessment of sedimentation rates and deposition patterns, there exist five high resolution bathymetric surveys. Furthermore, sediment cores were extracted after emptying of the Barasona reservoir by the Spanish Water Authorities in order to obtain physical and chemical features of the deposited material. The computational simulations agree well with the prototype measurements and show that the Flow 3D is a promising tool for simulations of sediment flushing during complete drawdown in the dam reservoirs.
K NEAREST NEIGHBOR APPROACH TO ESTIMATING THE FALL VELOCITY OF SEDIMENT PARTICLES

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ABSTRACT

Drop velocity estimating is one of the most important issues in sediment sciences, which helps in dealing with modeling sediment transport. While, many conceptual, empirical, and statistical methods have been proposed for estimating and forecasting, rarely a single model (an experimental equation) is found as the best estimating model in all hydraulic and sediment conditions experienced in sediment modeling. A solution for this problem is to use data fusion approach to combine advantages of individual models to improve an estimation skill. As a matter of fact, data fusion provides better estimations than could be achieved by the use of individual estimation models. This paper presents a comparative assessment of five different methods of data fusion by applying them in six laboratory data sets. Furthermore, a new statistical method based on the non-parametric K- nearest neighbor model is presented as an alternative method for data fusion. Results of data fusion approach is thoroughly analyzed and discussed. The results demonstrate that the use of proposed data fusion model could significantly improve the accuracy and precision of estimations in comparison with the use of single models or even conventional data fusion methods.
GEOCHEMICAL CHARACTERIZATION OF COASTAL SEA, RIVER AND STREAM SEDIMENTS IN PENINSULA ISTRIA, CROATIA

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ABSTRACT

Samples of coastal sea, river and stream sediments in peninsula Istria, northern Adriatic Sea, Croatia have been collected and analysed for 17 chemical elements: Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Br, Rb, Sr, Y, Zr, Pb and U using EDXRF as an analytical tool. Samples have been taken from uninhabited bays, marinas and ports, rivers’ and streams’ floors and banks.

It has been shown that there were no significant contributions to the concentration of heavy metals from anthropogenic sources except for bays with marinas and ports. These were identified as «hot spots» for elements Cu, Zn, As and Pb used, alone or in compounds, as biocide in antifouling paints.

Concentrations of all 17 chemical elements measured in samples from rivers and streams drainage areas showed little variation among samples and they were similar to those from corresponding bays. The results of principle component analysis and discriminant function analysis confirmed the hypothesis that river and stream drainage areas represent main source of material for bays sediments.

A special attention was paid to the National Park Brijuni, an archipelago of 14 islands located near western coast of peninsula Istria. It is shown that the surface sediments in the National Park Brijuni are mainly of the Class 1 except 5 samples (out of 35 investigated locations) where the sediment is Class 2.
Assessment of the hazard posed by metal forms in water and sediments

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ABSTRACT

This study aimed to describe the prevalence of forms of heavy metals (Zn, Cu, Pb, and Cd) in the ecosystem of the Utrata river, to determine the mobile forms and bioavailability of metals. To extract the dissolved forms of metals in the water of the Utrata we used PHREEQC2 mathematical model. The waters of the river show a high percentage of mobile and eco-toxic forms of zinc, copper and lead. The percentage of carbonate forms for all the studied metals was low (< 1%). The content of carbonates in the water and the prevailing physical and chemical conditions (pH, hardness, alkalinity) reduce the share of toxic metal forms, which precipitate as hardly soluble carbonate salts of Zn, Cu, Cd and Pb. Copper in the water in 90% of cases appeared in the form of hydroxyl compounds. To identify the forms of metal occurrence in the sediments we used Tessier’s sequential extraction, allowing to assay bound metals in five fractions (ion exchange, carbonate, adsorption, organic, residual), whose nature and bioavailability varies in aquatic environments. The study has shown a large share of metals in labile and bioavailable forms. The speciation analysis revealed an absolute dominance of the organic fraction in the binding of copper and lead. Potent affinity for this fraction was also exhibited by cadmium. The rations of exchangeable Zn and Cu forms in the sediments were similar. Both these metals had the lowest share in the most mobile ion exchange fraction.
APPLICATION OF NANO ZERO VALENT IRON SUPPORTED WITH NATIVE CLAY AND CARBOXYMETHYL CELLULOSE FOR REMEDIATION OF Ni AND Pb POLLUTED SEDIMENT

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The aim of this study was to investigate the possibility of using supported nanoscale zero valent iron with native clay (NC-nZVI) and carboxymethyl cellulose (CMC-nZVI) for immobilization of Ni and Pb in contaminated sediment from the Nadela river basin (Serbia). The assessment of the sediment quality based on the pseudo-total metal content (Ni and Pb) according to the corresponding Serbian standards shows its severe contamination that requires disposal in special reservoirs and, if possible, remediation treatments. Stabilisation treatment has proven to be effective for the remediation of wastes contaminated with metals and can lead to the beneficial and economically feasible use of sediment. The hazardous potential can be minimized by converting the contaminants into forms which are less soluble, less mobile or less toxic. A microwave-assisted sequential extraction procedure was employed to assess Ni and Pb potential mobility and risk to the aquatic environment. According to the results of sequential extraction procedure Ni showed medium risk to the environment in comparison to the Pb which represents high risk to the environment. The contaminated sediment, irrespective of the different speciation of Ni and Pb, was subjected to the same treatment. Ultra-fine powder of nanoscaled zero valent iron has a strong tendency to agglomerate into larger particles, resulting in an adverse effect on both effective surface area and catalyst performance. To address this issue, supported nanoscale zero valent iron with native clay (NC-nZVI) and carboxymethyl cellulose (CMC-nZVI) were synthesized by the sodium borohydride reduction method and used for immobilisation of Ni and Pb in contaminated sediment. In order to determine the long-term behaviour of sediment – NC-nZVI mixtures and sediment – CMC - nZVI mixtures, leaching tests were performed in accordance with ANS diffusion test (ANS, 1986) in the period of 90 days. Treatment efficiency was also evaluated by measuring the cumulative fractions of metals leached, effective diffusion coefficients - De and leachability indices - LX. The LX values in NC-nZVI and CMC-nZVI mixtures were higher than 9, suggesting the mixtures are acceptable for "controlled utilization" (specific utilization such as quarry rehabilitation, lagoon closure, road-based material, etc.). Based on effective diffusion coefficients – De metals showed low mobility (De in the range $10^{-9}$ to $10^{-10}$ cm$^2$s$^{-1}$) depending on the NC-nZVI and CMC-nZVI content. In this study, leaching tests undertaken on sediment-nanomaterial mixtures showed that the concentrations of heavy metals in the leachates were far below the regulatory limits, thus the samples can be classified as non-hazardous material. Generally, the test results indicated that applied immobilizing agents were effective in immobilizing Ni and Pb in contaminated sediment.
Acknowledgement: This work has been produced with the financial assistance of the EU (Project MATCROSS, HUSRB 1002/214/188) and the Ministry of Education, Science and Technological Development of the Republic of Serbia (projects number III43005 and TR37004). The contents of this document are the sole responsibility of the University of Novi Sad Faculty of Sciences and can under no circumstances be regarded as reflecting the position of the European Union and/or the Managing Authority.
Learning from the Past to Enhance Contaminated Sediment Remedy Evaluation, Selection, and Implementation

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ABSTRACT

Remediation, or cleanup of contaminated sediment, has been performed for several decades with the aim to reduce potential risks to human health and the environment. As would be expected, there are valuable lessons to be learned from past projects, including positive and negative aspects, which can help inform current and future projects around the world. Many of the lessons learned have been considered and recognized in recent guidance documents and studies.

This presentation will provide an overview of the history of contaminated sediment cleanup during the past 30 years, based primarily on projects from the United States, and highlight some of the more important lessons learned and how they have informed subsequent projects. Several of the more important lessons learned, advancements in technology, and implementation protocols will be examined in more detail. The presentation will include the following topics:

- The importance of effective source control in remedy effectiveness, along with the challenges of achieving adequate control
- The industry’s acknowledgment of the Four Rs (residuals, resuspension, release, and risk), described and discussed in the context of completed environmental dredging projects
- Advancements in environmental dredging techniques, such as bucket designs and hydraulic dredging equipment, as well as improvements in survey and equipment location accuracy, resulting in better controls and volume reduction for recently completed projects
- Recent case studies regarding the effectiveness of resuspension controls, including silt curtains and rigid containment systems
- Recognition of the effectiveness of sediment capping and monitored natural recovery
- Development of effective in situ treatment technologies

Through the findings and recommendations of this presentation, conference participants will gain a better appreciation for the range of contaminated sediment cleanup experience in the United States and lessons learned, allowing them to improve on the planning and implementation of future projects.
HISTORICAL ACCUMULATION OF HEAVY METALS IN TWO MEXICAN WATER BODIES

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ABSTRACT

The accumulation and enrichment of mercury (Hg), lead (Pb), and cadmium (Cd) were studied in four sediment cores, two from Laguna de Zempoala, central Mexico, and two from Laguna de Miramar, southeastern Mexico. Sediment cores were ²¹⁰Pb and ¹³⁷Cs isotope dated and organic and inorganic carbon contents, texture, and aluminium (Al), iron (Fe), and manganese (Mn) concentrations were analyzed to evaluate the historical tendencies of the trace contaminants in these water bodies. Metal concentrations in Laguna de Zempoala could be associated to the content of organic matter (OM), as well as the Fe and Mn concentrations, while in Laguna de Miramar, metal concentrations were mostly associated to the content of OM. The profiles of Pb described the higher emissions of this metal due to consumption of leaded gasoline in the 1970’s and the reduction in Pb emissions in more recent years; a recent increase in the concentration of Pb in Laguna de Zempoala was attributed to logging activities and forest fires in the area. The profiles of Hg showed variations that could be related to deforestation activities in Laguna de Miramar. Metal concentrations were above threshold effect levels (TEL) and below probable effect levels (PEL). Trace metal enrichment factor (EF) showed little enrichment for the different metals in all sediment cores except for Pb in Laguna de Miramar. The enrichment of some metals in recent years suggests the need to define specific environmental policies or actions to reduce emissions and environmental exposure.
PHYTO-DEHYDRATION OF POLLUTED SEDIMENTS IN AN ARTIFICIAL POND

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ABSTRACT

In a former plant using for the production of biogas the manure collected in the rural district, an artificial pond of about 2.6 hectares and 4 meters of depth was filled by the fine solid fraction residual after the digestion process.

The sediment is characterised by a water fraction of about 80% and the remaining solid fraction is made by sand (15%), lime (60%) and clay (25%), without any significant vertical stratification. The pH is around 8 and the electrical conductivity around 2.5 ms cm⁻¹. The concentrations, on a dry weight basis, of organic carbon and nitrogen are around 25% and 5%, respectively. The only heavy metals present in high concentrations are the copper (around 1200 mg kg⁻¹) and the zinc (around 4000 mg kg⁻¹).

The first target of the remediation is the reduction of the water fraction (dehydration), to avoid that during heavy rains the spillage from the lagoon reaches the adjacent river. Secondary targets are related to the transformation of the quality of the sediments, increasing progressively the aerobic conditions of the whole mass and decreasing the methane emissions. As final target a naturalization of the area is under evaluation, with the creation of a new habitat for the protection of the birds presents in the region.

The phytodehydration will be obtained by means of trees, shrubs and herbs adapted to the wetland environment, “planted” on the surface, by floating frames. The frames, realised in organic material, will be fixed to the lagoon borders to avoid the movement of the plants under the pressure of the wind. The space arrangements of the different species, will guarantee a high resilience to the system and a continuous evapotranspiration activity.

In this paper we present the results obtained in the pilot phase, where we tested and evaluated the dehydration capacity of different species and genotypes.
INFLUENCE OF THE ROTATIONAL SPEED OF A GRANULATING PLATE ON THE PROPERTIES OF AGGREGATES MADE OF DREDGED SEDIMENTS

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ABSTRACT

The granulation process appeared for over a century and has experienced rapid expansion in recent years due to the need to control the properties of products more and more complex. Granulation technology is to stir solid particles coupled to a liquid supply for creating a link between the colliding particles. This process is carried out wet, dry, thermal extrusion and sintering without the presence of liquid phase.

The process of wet granulation was the subject of many contributions in recent years, especially concerning the mechanisms that contribute to the formation of grains. However, this process is still complex to the extent that it is still impossible to predict grain quality from the knowledge of the process variable and characteristics of the materials used.

The final goal of the present work is to explore the feasibility of granulating dredged sediments using a granulating plate. The process variables of granulating plate include the rate of stirring, the granulation time, the inclination angle of the plate and the speed of wetting liquid. The mix variables include the powder mass and its composition (dredged sediment in our case), the mass of binder (cement) and the mass of the wetting liquid (water in our study).

This paper aims to show the influence of the rate of granulation on the characteristics of aggregates made with marine dredged sediment from the port of Dunkirk.
SEDIMENT MANAGEMENT IN RESERVOIRS IN ORDER TO REDUCE SHORELINE EROSION: THE CASE OF NESTOS RIVER, GREECE

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ABSTRACT

Nestos River is the 71th biggest transboundary river in the world. At early nineties, two hydroelectric reservoirs, at the locations “Thisavros” and “Platanovrysi”, in the Greek part of the considered river basin, were constructed. In a previous work, the authors have found that the construction of these reservoirs induced a dramatic reduction (more than 80%) in the sediment yield that reaches the outlet of Nestos River basin. This resulted to a major increase in the erosion rates at the river delta and the adjacent shorelines. In the present paper, the effect of sediment dredging or flushing from the Platanovrysi Reservoir downstream is investigated, in order to evaluate the increase in the sediment budget that reaches the outlet, which can contribute to the reduction of shoreline erosion. For this purpose, a mathematical model is modified accordingly in order to take into account sediment dredging or flushing. A wide series of parametric simulation scenarios is performed, aiming to identify the optimum periods to that dredging or flushing can be applied for maximising the sediment amount that reaches the basin outlet. A definite classification of the months into “effective” and “ineffective”, as well as into “consistent” and “inconsistent” with respect to the total amount of sediment that reaches the basin outlet, is made. It is also found that the considered river has a maximum transport capacity regardless of the further increase of the dredged or flushed sediment quantity from the identified limiting value. Finally, flushing is identified to be slightly more effective than dredging.
INNOVATIVE METHOD OF SEDIMENT REMOVAL FROM WATER DAM HRUSOV ON DANUBE RIVER

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ABSTRACT

Construction of major hydroelectric plant is inevitable for efficient management of water courses especially during extreme hydrological conditions. Operation of such sizeable hydroelectric plants brings high demands on management and maintenance alongside numerous advantages. This contribution is dealing with clogging and colmatage of water reservoir Hrušov which is a part of one of the most important water systems on Danube River. Due to significant clogging of Hrušov reservoir in 2011 were taken measures to remove bottom sediments. This contribution describes problems of clogging of the reservoir by the sediments, processing of bottom sediments removal as well as evaluation of efficiency of measures that were realized by the Progroupe sediment removal a.s. company.
AGRICULTURAL EXPLOITATION OF CANAL DREDGING SEDIMENTS: APPLICATION IN SAÔNE-ET-LOIRE (FRANCE)

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ABSTRACT

In France, 6 millions cubic meters of sediments are annually withdrawn from the waterways. In 2011, 76% of withdrawn sediments by VNF were re-used, whose 12% in farming. In order to develop agricultural use, the CEREMA has, in 2011, started studying the agronomic value of uncontaminated dredged sediments.

55 samples were made from 11 sediments storages, in 6 different French “Régions”. Environmental quality was assessed by analysing total contents of trace metals, total hydrocarbons and 16 US-EPA list polycyclic aromatic hydrocarbons. Tests were carried to determine toxic effects upon cereal seed germination. Agronomic value consists in fertilising value or in capacity in restructuring skeletal soils.

After this agronomic and environmental assessment, an agricultural parcel in Saône-et-Loire French “Département” was fertilized with dredged sediments from the waterway called “canal du centre”, in 2011 October. An experimental process has been developed with the actors involved. Tritical, a wheat and rye hybrid, was seeded on the experimental parcel, divided in three sectors:

1. a “control sector” traditionally fertilised with chemical fertilizers.
2. a “sediment+nitrogen” sector, where the enrichment is composed by nitrogen and sediment.
3. a “sediment sector” with only a sediment input.

The amount of sediment to be spread was calculated in order to satisfy the needs of the culture with nutrients, based on total contents in the sediments. Three sampling sets were made: at the emergence of the seedlings, in spring and at harvest. For every three sampling sets, 6 samplings were made on both cereal aerial parts and roots, in order to analyse their trace metals total contents. 54 samples were made during the culture. After the harvest, the crop yield was calculated for each three sectors. N,P, K bioavailabilities in the sediment were estimated by laboratory experiments.

The 55 sediment samples show that 89% of samples are not contaminated. Phytotoxicity tests show no effect on seed germination. 89% of analysed samples have similar nutriments rates than other materials used as agricultural enrichments. This experiment demonstrates that sediments can be used as fertilizer.

30 tons per hectare of sediments were put on the field, without disturbing the seedlings emergence. No difference were noticed for the trace metal rates in the cereals of the three sectors.

Respectively 25% and 50% yield loss were found in the “sediment+nitrogen” and “sediment” sectors regarding to the grains weight and relatively to “control sector”. The low N, P, K biodisponibility found in the “canal du centre” sediments could explain it.

Beyond the question of fertilization, every sizing of the particles of Saône et Loire sediment sample show an equilibrium, according to agronomic value, while only 58% of samples in
whole France are equilibrated. However the added material thickness allowed by the french regulation isn't enough to permit restructuring skeletal soils. In 2014, further investigations will improve the agronomic value knowledge of the dredged sediments, by experimenting on lysimeters. They aim at increasing the crop yield of sediment-added soils by taking into account the nutrients bioavailability and assessing the eventual environmental and sanitary impacts of the mixture sediment+soil in case of sediments adding in order to restructure skeletal soils.
MANAGEMENT OF DREDGED RIVER SEDIMENT: APPLICATION IN THE RHÔNE-ALPES REGION – FRANCE

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ABSTRACT

Dredging in rivers leads to maintain the navigation depth and prevents floods or hydrodynamic disorders.

The dredged sediments are mainly composed of inorganic materials with natural or anthropogenic, organic or inorganic elements. Depending on the quality of these materials and the profile of equilibrium sedimentary of the bed of the watercourse, a part of the dredged sediment extracts returns to the river, the remainder is managed on shore. In France, article 3 of the Charter of the Environment states that all person must prevent attacks he may cause to the environment or, alternatively, limit the consequences. The responsible for the management of rivers must define the uses according to the sediment characteristics, taking into account the regulatory context. To assist them in this process, a doctrine of management of dredged sediment was conducted in the Rhône-Alpes region in France. In order to develop the doctrine, a work group with the CETE de Lyon and the official services in charge of water and waste regulation has been established to:

1. divide rivers into sectors according to the analysis of anthropogenic pressures on the territory and existing data on sediment quality,
2. identify the typology of sedimentation and management of sediment in the territory,
3. implement sampling and analysis strategies depending on point 1 and 2.

Three sectors have been identified and mapped in the area. Zone 1 corresponds to watercourse sediments which show no anthropogenic contamination. In general, these rivers are located in mountainous areas, around the head of the watershed. In zone 3, sediments are contaminated or likely to be. The limit of the zoning can be changed based on experience feedbacks and the evolution of anthropogenic pressures. A second area is an intermediate area between zones 1 and 3. The three types of sedimentation deposits come from navigational dredging of section, at the confluence and alluviation of rivers.

Four types of sediment management can be identified: sediments are 1) released in the river with deficit area, 2) used in physical planning, 3) recycled through licensed facilities or 4) sent for a storage facility. Sampling and analysis strategies have been developed for each zone and for each typology of sedimentation. The number of samples to be performed depends on the thickness, volume of sediment to be dredged and the presence of layers of identifiable materials.

An analytical framework defining environmental, geotechnical and health acceptability's criteria for each sediment management is proposed. The analyzes help to evaluate the contamination, the dangerousness and impacts of sediment. Moreover analyzes of total content of trace metals, hydrocarbons and polycyclic aromatic hydrocarbons will be systematically carried out. Analyzes of leaching of metals listed above give us an idea of the impacts on the water. Besides ecotoxicological tests are made for sediments of zones 2 and 3. Risks on health are calculated using direct exposure scenarios. For use in road
construction and physical planning, mechanical characterization of sediments must be included. Other analyses can be carried out depending on the type of management considered. The protocol of characterization of sediments will be tested on the Rhone-Alpes region area to valid the operational approach, from the characterization of sediments to the choice of management strategy.
ABOUT A POSSIBLE USE OF DREDGED MARINE SEDIMENTS (RADES HARBOR, TUNISIA) IN PAVING BLOCKS CONSTRUCTION.

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ABSTRACT

The management of huge amounts of dredged marine sediments presents an environmental and economic issue for harbors' authorities. This study focuses on the use of Tunisian marine sediments as replacement of sand in paving blocks' manufacturing. The environmental characterization was assessed using the inductively coupled plasma-optical emission spectrometer method (ICP-OES) and showed-up that Rades-harbor sediments are considered as non-hazardous wastes. Consequently, they can be used without decontamination step.

Different mixes were conducted, where a given sand mass was replaced by the same sediments mass. About 80 samples were manufactured in the laboratory scale. Compressive strength measurements were determined from laboratory-made pavers at 7 and 28 days. The 12.5 % ratio of sand substitution appeared to be the most successful considering visual and mechanical aspects. Therefore, Rades harbor sediments may be suitable as a new source of construction material.
FORMULATIONS OF A ROAD MATERIAL WITH A MARINE DREDGING SEDIMENTS AND SANDS, TREATED WITH HYDRAULIC BINDERS

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ABSTRACT

In order to guarantee a draft sufficient for the exploitation of the harbor infrastructures and the inland waterways, the managers of the latter are brought to regularly carry out operations of maintenance which consist in dredging important quantities of sediments. In France, volumes resulting from the operations of dredging represent each year approximately 50 million m³ for the ports and 6 million m³ for the river systems. In order to improve compactness of materials a granular addition was recommended. The use of a dredged sand, to supplement the granular mixture containing sediments, allows a better management of the two types of dredge spoils. In this study, the objective was to formulate a new material containing marine sediments of dredging and dredged sand, by using various binders and by varying their percentages.
USE OF SOLID WASTE AS ADSORBENT FOR STABILIZING TRACE METALS IN POLLUTED SEDIMENTS

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ABSTRACT

The presence of toxic metals in water, soil, and sediments has become a worldwide problem in the past decades. The use of low cost adsorbents for remediation of toxic ions is therefore an important area of research and development. The present study investigates the possibility of using bauxite extraction residues (bauxaline and bauxsol) as amendments for the treatment of multi contaminated sediments. Red mud has been largely studied for removal of toxic heavy metals and anions from wastewater. It is often used as amendment to remediate contaminated soils, acid mine drainage and, reduces the leaching of soil nutrients. Thus, heterogynous nature of red mud makes it, an interesting material for treatment of multi contaminated sediments. A pilot scale experiment was conducted for three months to stabilize As, Cd, Cu, Mo, Ni, Cr and Zn in a multi-contaminated sediment sample using 5% bauxaline and 5% bauxsol. pH, ionic conductivity, and leached metal concentrations were measured regularly during this experiment. The results showed that after 3 months of treatment, Cd, Cu, Zn and Ni can be effectively immobilized but increased leaching of As, Cr and Mo was observed as compared to control. The leachates were then evaluated for acute toxicity using estuarine rotifers Brachinous plicatilis. Red mud can be an inexpensive choice for remediation of sediments due to its ready availability and low cost.
IS SEDIMENT MANAGEMENT REALLY ABOUT MANAGING SEDIMENT?
A 21ST CENTURY PERSPECTIVE

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ABSTRACT

We tend to conceptualize sediment management in terms of linear objectives: port maintenance, human health and ecological risk, remediation options and beneficial use. This line of thinking has led to localized scopes, having to address competing multiagency objectives, countless studies, litigation over costs and allocation of responsibility, protracted timelines and very few real successes. For most situations, the traditional “dredge, haul and landfill” approach is still the industry standard, paradoxically so when sustainability and green remediation are asked to be considered. That approach fails to manage the resource dynamically or structurally take into account the end-use, water-dependent industries or adjacent human and built environment.

Integration, sustainability, urban revitalization, adaptive management, climate adaptation and ecosystem services are terms which have entered the discussion in the literature and in major recent conferences such as the European Union SedNet (Lisbon, Portugal 2013), signifying a shift to a broader management approach. However, sediment management is still not routinely applied in the overall context of these larger global challenges. Getting to widespread implementation of the broader approach that focuses less on sediment, and more on larger objectives is still problematic. Recent cases such as the Passaic River, New Jersey, the Gowanus Canal, New York, and Portland Harbor, Oregon in the USA and Port of Venice, Italy underscore, the difficulties in advancement from a behavioral perspective i.e. we keep doing the same things over and over again. Generally, we practitioners have been reluctant to view sediment management from an all-in cost perspective, utilizing tools such as Life Cycle Analysis and Multi-Criteria Decision Analysis or accept interim, incremental measures that reduce risk on expedited timelines.

A collective decision is needed to move beyond artificial and localized site boundaries to manage the physical, natural and social/political systems cohesively from a catchment perspective that integrates source control, the ability to handle a wide range of contaminants and concentrations, ecological restoration and economic revitalization. The management objective should be for all sediment to be used locally and beneficially. Available in-situ and ex-situ technologies can use sediment as a raw material for the creation of marketable products for urban revitalization, while destroying or removing the contaminants and thereby potentially extinguishing liability. The United States Environmental Protection Agency’s New York/New Jersey Harbor Sediment Decontamination Program, the Life.SediPort.SIL Program Recovery of Dredged Sediments from the Port of Ravenna, Italy and SETARMS (Sustainable Environmental Treatment and Reuse of Marine Sediments) are examples of ex-situ sediment treatment programs that should be integrated/implemented in sediment management decision-making. A psychological shift to adopt such technology is not unprecedented. Engineering
practices and government policies that were standard and acceptable in the past are the reason that the remediation industry now exists. The decisions and actions by those involved in sediment management today will be the legacy left to future generations.
PROJECT GREEN SITE “SUPERCritical FLUID TECHNOLOGIES FOR RIVER AND SEA DREDGE SEDIMENT REMEDIATION” – LIFE 10 ENV/IT/343 –

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ABSTRACT

Green Site project aims at demonstrating the effectiveness of an innovative technology for the reclamation of sediments coming from dredging. This new technology involves the use of fluids at a supercritical state for the extraction of organic pollutants from the sediment (1st phase) and the use of supercritical water for the oxidation (2nd phase) of the hydrocarbons and organic compounds extracted before. At the end of the process a clean sediment and some clean water will be obtained.
DESIGN METHOD OF CIVIL ENGINEERING MATERIALS WITH EVOLUTIONARY ALGORITHM.

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ABSTRACT

The Scientifics previsions are more and more alarming in terms of environmental impact and the protection of environment is now included in priority actions of authorities, and construction companies.

The civil engineering domain uses each year millions of tons of granular material. With the shortage of this resource, opening new quarries, due to environmental constraints, is more and more difficult.

In this order, it’s important to explore new granular material sources for the Civil Engineering domain.

The use of alternative materials, like the valorization of dredged sediment for example, could constitute an interesting solution.

However, for concrete, road materials ...the classical design methods developed on the bases of standard material are not adequate; more over the approaches proposed remain in few cases empirical.

In this work, to design the discussed material using alternative resources, Genetic Programming algorithm method is explored. Before applying this methodology to design the materials, an attempt is made to use this method to optimise the granular skeleton of discussed materials.

This contribution aims to use one of evolutionary algorithms, able to generate useful solutions to optimize, mixes with objective to enhance mechanical performances of the materials. These search heuristic techniques find application in engineering domain and any other fields and have proven themselves.
THE PROBLEM OF SEDIMENTATION IN THE RESERVOIRS OF ITALIAN LARGE DAMS.

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ABSTRACT

Results of the activities of the ITCOLD working group: ‘Sediments in reservoirs of Italian large dams’ continuing the work of the previous group are reported. The total amount of silting of Italian reservoirs has been estimated referring to more than 400 reservoirs. Reservoirs with a decrease of storage volume less than 5%, have been classified as without silting, in accordance with the degree of uncertainty intrinsic to the measurements. Data from both the Alpine area (northern Italy) and the Apennine area (central and southern Italy including islands) were gathered. Almost half of the reservoirs are devoid of noticeable silting. The current specific legislation has been resumed (national, regional, European). An University research for the re-use of sediments, some case histories of removal of sediment and the importance of specific environmental problem in management of silation are reported. Sediments recovery is a strategic goal in reservoir management. The need of a sustainability-oriented approach to building materials design and production represents a further reason to focus on new strategies, products and processes. Campo Tartano reservoir removal of sediments to recover part of the reservoir volume, with partial fluitation is reported. Experiences of project management of sediments for three reservoirs in Lombardia to recover/ maintain live storage are presented. Then experience of sediment management, in the reservoir Occhito is reported.
ZERO ENVIRONMENTAL IMPACT PLANT FOR SEABED MAINTENANCE

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ABSTRACT

The paper shows designing, prototyping and testing carried out since 2002 on an innovative plant for seabed maintenance, characterized by zero environmental impact and planned especially for harbour areas. The core of the technology is made up by a jet-pump device called "ejector". The ejector has been sized through both laboratory experiments and fluid-dynamic simulations. In 2005 the first full-scale experimental plant was designed and carried out in the port of Riccione (Italy). The results of the experimental campaigns demonstrated the functionality of the system itself, the cost-effectiveness and low environmental impact if compared to the use of the dredge. Finally, in 2011 the first industrial plant has been realized in the Portoverde Marina (Italy). This plant is characterized by better performances in automation and control higher than the first experimental plant. By these features it is possible to increase plant reliability and ensure a further reduction of the management costs.

Keywords: Seabed maintenance, Dredging zero environmental impact, Jet pump, Industrial dredging plant, Automation and control.
IMPROVEMENT OF ELECTROKINETIC REMEDIATION OF HEAVY METALS AND 
PAHS FROM DREDGED MARINE SEDIMENT

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ABSTRACT

Sediments are dredged from harbors and channels in order to maintain navigation depths. However these sediments are usually contaminated by organic and inorganic contaminants. A large volume of contaminated sediments are typically disposed in sea but highly contaminated sediments are rather disposed in lagoons, in land or in confined disposal facilities. So, reuse solutions can be suggested if these materials are treated before. Electrokinetic (EK) remediation can be a promising treatment for the removal of cationic heavy metals from low-permeable matrices such as sediments but is limited for PAHs which are nonionic and have a low aqueous solubility.

Electrokinetic experiments were conducted under a constant potential gradient (1 V.cm⁻¹) with various processing fluids in order to improve the decontamination of artificially contaminated sediments with heavy metals (Cd, Cr, Cu, Pb, Zn) and five PAHs. Results revealed that adding a strong inorganic acid (nitric acid) into the aqueous fluid was more effective than adding a weak acid (citric acid) to remove heavy metals from the sediment, but the complexing citric acid was promising for longer treatments.

Concerning PAHs, an anionic surfactant (sodium dodecyl sulfate SDS) and a nonionic surfactant (Tween 20) were tested to mobilize, solubilize and favor their EK migration. In all experiments, the low weight PAH (phenanthrene) was better extracted than the other PAHs. But using simultaneously SDS and citric acid or Tween 20 and citric acid improved the extraction of high weight PAHs, because the electro-osmotic flow was higher with the mixture surfactant + acid than when surfactant was used without acidification of the medium. Thus EK treatment with a combination of a surfactant and citric acid was the most effective to extract simultaneously PAHs and heavy metals. Consequently, this mixture was also tested on a real dredged sediment from a Norman (France) harbour disposal site. Over the different electric conditions tested, the treatment with a periodic voltage is recognized as a promising solution to remove both PAHs and heavy metals from the sediment.
EFFECTIVE USE OF DREDGED SOIL FOR RECLAMATION OF AIRPORT ISLANDS

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ABSTRACT

Management of dredged soil is very important geotechnical issue in port construction and operation. In many cases, dredged soil is dumped into reclamation facilities and the sediment is improved by vertical drains such as PVD (prefabricated vertical drains) and SD (sand drains) with preload/vacuum to accelerate consolidation. This classical technology requires a long consolidation period before land use.

Effective use of dredged soil has been attempted, particularly, in construction of manmade island for airport facilities. In this study, a typical case history was studied from the Tokyo Haneda Airport. The development of the Tokyo Haneda Airport is a history of land reclamation since 1931, in particular, the offshore expansion project started from 1984 was an epoch-making project, in which a dredged clay deposit in ultra-soft state was converted into an airport island. In this stage, dredged clay was consolidated with vertical drains to be overconsolidation state by preloading.

After the offshore expansion project, three runways (A, B and C-runways) have been in operation. To meet significant increase of passenger demand, the fourth runway named as D-runway was newly constructed and inaugurated in 2010. The remarkable features of D-runway are a hybrid structure consisting of reclamation section and piled pier section, and an elevation higher than 17 m. The piled pier section was adopted inside a river mouth to prevent from flood.

Various technologies accumulated through previous airport constructions were applied to the D-runway project. Lightweight treated soils of dredged clay were effectively used. Cement treated soil was placed along the seawalls of the reclamation section. To efficiently conduct large-scale placement, pneumatic mixing method was useful. Air-foam treated lightweight soil of dredged clay was placed as backfill at the joint structure between the reclamation and piled pier sections, because more lightness was strongly required to ensure the stability.
METHODOLOGY OF CHARACTERIZATION AND VALORIZATION OF THE MARINE
SEDIMENTS IN CIVIL ENGINEERING

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ABSTRACT

The geographical position of Grand Port Maritime de Dunkerque (GPMD), associated significant dynamics hydrosedimentary characteristic of the strait of Pas-de-Calais and the presence of large sandy benches, contributes largely to the fast fattening of the port. Consequently, many dredging operations of maintenance are committed annually by the GPMD.

The sediments coming from the part of the confined areas regularly present concentrations in polluting elements higher than the thresholds authorized for the immersion of these products at sea. Insofar as the accumulations reached increasingly critical proportions to ensure the safety and the navigation of the ships, it was necessary to dredge part of these areas. The volume of non-submersible sediments estimated to dredge on 2015 is about 500,000 m³ in situ.

The sector of elimination of the non-submersible sediments being located at ground, a treatment by mud tanks was produced to ensure a pretreatment and a dehydration of the sediments.

The objective of our study is to establish a general methodology of valorization which aims are providing a step of physical, environmental and mechanical evaluation of alternative materials elaborated from waste (dredging sediments) intended to be used in the field of civil engineering (road engineering, construction of the concrete block & landscape mound).

On the basis of this step we consider a study of formulation of the marine sediments with various hydraulic binders for use in a sat of roadway in order to fill the conditions of use, the environmental impact of the mixtures considered will be studied through tests of leaching by applying the methodological guide of acceptability of alternate materials in road engineering.
ENVIRONMENTAL MONITORING OF OFFSHORE PLATFORMS: AN ASSESSMENT OF SEDIMENTS ALTERATIONS BASED ON THE FRECHET DISTANCE

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ABSTRACT

In the last century, non-renewable resources exploitation has strongly increased to meet the global growing demand for energy. The oil and gas industry is now truly global, with operations conducted in every corner of the world. In Italy there are about 1200 productive wells and 124 offshore platforms, whose 112 in the Adriatic Sea. Oil and gas exploration and production operations may have potential impacts on the environment; these impacts may be avoided, minimized and mitigated, through proper tools of environmental monitoring. In this context since 2000 ICRAM, now ISPRA, has been carrying on a national monitoring plan concerning the environmental impact of the PFW (produced formation water) discharge in the Adriatic Sea (about 40 offshore platforms). The study of the marine environment surrounding a platform is based on the observation of the chemical, biologic and physical parameters and on the analysis of their variations over the space and time. The spatio-temporal monitoring of these parameters, in addition, it is useful to assess the possible correlation between the PFW discharge and the environmental status. The monitoring performed by ISPRA is based on the field measurements of three different matrixes, water, biota and sediments. The sediments are monitored along a transept of four stations oriented in accord with dominant stream; the four stations are located at 0, 25, 50 and 500 meters from the platform, to study the area closed to the structure and a point potentially not impacted. In each platform are collected 8 sediments samples, because both superficial (0-2 cm) and sub-superficial (8-10 cm) sediments are examined.

In this work we test a method to perform a spatial analysis of the sediments alterations; the analysis is restricted on the survey of 2004, when 35 platforms are monitored. The sediments of the investigated area are first analyzed on the basis of sedimentological point of view, this analysis is followed by a statistical overview of the sampled sediments to get a global characterization of the area. The second step of the study is focused on the analysis of the possible alterations of the sediments, point the attention on the situation of each single platform. A Fréchet distance based method is developed, using the mathematical formulation as a tool to evaluate the dissimilarity between the grain size distributions relative to the different sampling points. In order to optimize the method respect to the characteristics of the analyzed granulometric data, a variation of the classical Fréchet distance is implemented, called segmented Fréchet distance. The tested method permits to underline the dissimilarity between two grain size distributions induced by a global scattered variation in all grain size distribution or by a punctual significant difference, determined by a variation of the entity or the position of the granulometric peak and it is also useful to elaborate in an effective way the large amount of data collected during a monitoring survey.
The application of the optimized Fréchet distance based method (segmented Fréchet distance) permits to obtain a complete analysis of the possible alterations of the sediments sampled surrounding the monitored platforms, but not to identify the nature of the sediments, thus it is mandatory a preliminary sedimentological analysis to define the sediments features of the investigated area, followed by a statistical analysis to obtain a global scale view of the collected data. For this reason the results of the proposed method have to be always explained in accord with the known sedimentological characteristics of the analyzed area, also to consider the eventual limits of the method.
ABSTRACT

Beach nourishment has been carried out for several years as a way to counter the coastal erosion, and is considered one of the main coastal management tools. The sediment used for nourishment can have different origins, coming for instance from riverbeds, quarries, or relict sand deposits. Using relict sands has several advantages: it guarantees a higher availability of large quantities of sediments whose composition is potentially similar to the beach’s native; in addition, the use of relict sands is economically advantageous, especially when using large volumes of sediment. However, it is known that dredging for beach nourishment may have significant physical and biological effects on the marine environment, especially in highly biodiverse environments and sensitive habitats such as the Mediterranean marine system. Within this framework, ISPRA has carried out different environmental monitoring studies related to dredging and beach nourishment in order to assess the impact of dredging on the marine environment. In different dredging sites direct and indirect investigations were carried out (seafloors morphology and bathymetry, surface sediments grain-size and chemistry, water column chemical-physical characteristics and particulate matter and studies on the benthonic and demersal fish communities). In this paper we present the result of grain-size investigations carried out in the Torvaianica site (Central Tyrrhenian Sea), where there is a relict sand deposit, covered by a muddy layer of recent deposition. This site was dredged in May 2006, instead the related environmental surveys were performed before (May 2004) and after dredging (October 2006, April 2007 and September 2007). We present and discuss the results with the aim of highlighting the variations induced by dredging activities for beach nourishment. In particular, this paper focuses upon the physical impact in term of grain size variation of surface sediment induced by relict sand extraction.
ABSTRACT

2,4-dichlorophenoxy acetic acid (2,4-D, pKₐ = 2.8) is used extensively as herbicide in agricultural practices. Its sorption behavior on both untreated and soils treated to significantly remove specific components (organic and Fe-Mn oxides and hydroxides phases) were investigated under oxic and anoxic conditions. The chemical and structural heterogeneity of the soil components were characterized by elemental analysis, x-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FT-IR). Co-existence of the various components seems to either mask sorption sites on the untreated soil surfaces or inhibit interlayer diffusion of 2,4-D. All sorption data conforms to the Freundlich description and pseudo second-order kinetic model. There was a strong-positive correlation between sorption capacity Kᵃ, and surface area (r² ≤ 0.704) but a negative correlation was uncovered with both pH and organic carbon (r² ≤ - 0.860). The results indicate that 2,4-D is preferably sorbed under oxic rather than anoxic conditions and greater on soils containing a high Fe-Mn content. The adsorption of 2,4-D was found to be reversible with desorption occurring more rapidly under anoxic conditions. The study suggests that stimulation of Fe III reduction could be utilized for the bioremediation of 2,4-D contaminated site.
SUSTAINABLE REUSE AND RECYCLING OF DREDGED CANAL SEDIMENTS IN SCOTLAND - TOWARDS ZERO WASTE AND A CIRCULAR ECONOMY?

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ABSTRACT

Scottish Canals (SC) is responsible for 220km of inland waterways - the Caledonian, Forth & Clyde, Union, Crinan and Monkland Canals. Formerly part of British Waterways, SC became a standalone public body in 2012, assuming dredging responsibilities in Scotland. SC is legally responsible for ensuring that canals maintain a minimum navigable depth (1.06m-4.11m), ensuring the safe passage of recreational and commercial craft, meaning maintenance dredging must regularly take place across the network.

Previously, sediment was sent to landfill, or placed along the banks. Scotland’s Zero Waste Plan (2010) set challenging recycling targets of 70%, with maximum 5% to landfill by 2025 for all Scotland’s waste. A Knowledge Transfer Partnership between Scottish Canals and the University of Strathclyde is investigating means of diverting dredged material from landfill by identifying cost-effective options to reduce, reuse or recycle sediment.

Dredging on Scotland’s canals faces a number of challenges – their Scheduled Ancient Monument status; geographic range and isolated location; transportation and disposal costs; escalating Landfill Tax; and historical contamination from industrial activity.

Mercury contamination in the Falkirk area was a major issue addressed during construction of the Millennium Link project, in which the Forth & Clyde and Union Canals were reconnected by the Falkirk Wheel and reopened for public use following their fall into disrepair. Contaminated sediment was dewatered and lime-stabilised, and sent to a specially engineered landfill monowell. Monitoring studies are evaluating the long-term environmental performance of this area.

The Partnership is examining a range of industrial symbiosis options to reuse/recycle material, running trials alongside active dredging works. Proposals include land-spreading for agricultural/ecological benefit and landfill restoration for energy crop production. Laboratory trials demonstrated its use to partially replace aggregate in concrete for wall repairs or emergency flood measures. Future trials include co-application with compost or anaerobic digestion of green waste. The potential benefits of this approach include diversion from landfill, renewable energy, reduction of primary aggregate use, reduced transport, carbon footprint, and a move towards the circular economy.
PHYTOREMEDIATION TECHNIQUES APPLIED ON VENICE LAGOON’S SEDIMENTS: PRELIMINARY RESULTS OF A MESOCOSM AND FIELD STUDY

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ABSTRACT

The proposed study aims to investigate the potential of phytoremediation for the treatment of mildly polluted sediments using autochthonous halophytes. Sediments and plant species were collected from tidal flat and saltmarshes in the Venice lagoon. Two different activities were carried out: 1) mesocosm experiments; 2) in-situ monitoring activity.

1) A preliminary characterization of sediments was carried out in an area located in the central part of the lagoon (“Lago dei Teneri”) identified on the basis of previous monitoring activities and bibliographic data. Samples were collected in 6 stations and analysis of sediment (grain size, nutrients, organic and inorganic pollutants) and pore water (nutrients) led to the identification of the site used as sediment source for the mesocosm trials. Experiments in mesocosm were carried out using squared-base PVC pots (volume 45 L) as unitary modules. During two different experimentations, lasting 4 and 6 months respectively, three species of local halophytes (Spartina maritima, Puccinellia palustris, Phragmites australis) harvested in a lagoon plant nursery were evaluated separately. Sediment was used “as it is” or enriched with vermicomposting. Outcomes have shown some positive results in terms of decreasing of metals content, in particular for the enriched sediment with S. maritima.

2) A preliminary desk-study activity led to the identification of 4 artificial saltmarshes. A presurvey sampling activity was carried out (9 stations) in order to identify the most appropriate area for a detailed characterization. The identified saltmarsh was sampled in two different sites, both including bare and vegetated areas. Sediment and vegetal biomass were collected in each area. Grain size and nutrients were analyzed in sediments and inorganic pollutants were analyzed in both sediment and vegetal biomass. The influence of factors such as location of samples, vegetation coverage and vertical profile of sediment is evaluated and obtained results are discussed.
NON-STANDARDISED LABORATORY TEST METHODS TO INVESTIGATE METAL(LOID)S IN SEDIMENTS AND SURFACE WATER - SPECIATION, FRACTIONATION, FATE AND IMPACT

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ABSTRACT

To assess the fate and behaviour of metal(loid)s in aquatic systems as well as (potential) impacts on associated biota, a comprehensive investigation of different aspects including, e.g., mobility, transformation, transport processes, availability and bioaccumulation, is needed. Since the mobility and toxicity of substances depend on their speciation, the investigation under close to environmental conditions is inevitable to understand key mechanisms and processes that govern "in situ" changes. Standardised methods and test systems, for e.g., construction materials in hydraulic engineering, provide the possibility to obtain comparable results. However, results from these tests may only be linked via sophisticated assessment procedures to environmental quality standards. How, e.g. construction materials investigated under standardised laboratory conditions perform under environmentally relevant conditions (e.g., low redox in contact with sediments) is seldom addressed. Standardised test systems are, with few exceptions (e.g., OECD 308 [1]), not designed to deliver information on the transformation and fate of substances. To address these questions, complex laboratory tests systems are needed. The presentation will deliver an overview on different non-standardised experimental setups applicable to study the transformation and fate of metal(loid)s in sediments and the overlaying water bodies. Furthermore, a method comparison will be given and pros and cons will be figured out.

Exemplary, methods suitable to address the speciation of metal(loid)s under close to natural or field conditions will be presented, including e.g., Diffusive Gradient in Thin Films (DGT [2]), sediment Peeper [3], the Sediment or Fauna Incubation Experiment (SOFIE [4]), microprofiling and micro sampling system (Missy [5]) or various (commercially available) mesocosm systems.

With respect to investigations on the (bio)accumulation, different approaches to determine the total element content will be compared, including standard procedures of microwave (MW) assisted digestion as well as the direct quantification technique electrothermal vaporisation (ETV) coupled to inductively coupled plasma-mass spectrometry (ICP-MS) [6]. The advantages and drawbacks of off-line (MW digestion) and on-line (ETV-ICP-MS) techniques will be considered.
A sustainable sediment management approach is aimed at minimizing short-term exposures and resource use during all steps and at controlling or eliminating long-term exposure risks. Where possible, waste hierarchy and beneficial re-use should be prioritized. In this study the effectiveness of different sediment management technologies is investigated, with the objective of optimize the whole sediment management process. The experimental activity presented was funded by SOGESID S.p.A (a Company that supports Public Administrations in planning and coordinating interventions according to the necessities of environment, territory and society) and assessed different treatment techniques of sediments from the Italian Port Areas of La Spezia and Livorno. The experimental activities were referred to two approaches, named Line 1 and Line 2, for which different pilot plants were used. In particular, Line 1 was aimed at maximizing the re-use of sediment for environmental restoration, while Line 2 was aimed at achieving suitable geomechanical properties for Re-cycle in Confined Disposal Facilities (CDFs).

Concerning Line 1, n°3 batches of about 2 m³ each were grabbed. Line 1 experimental activity was executed in the 3V Green Eagle facility located in Grassobbio, Bergamo, by means of two pilot plants. First, a Soil&Sediment Washing Pilot Plant was used in order to maximize the re-use of sand and gravel via grain size separation. For the fine fraction, according to the sediment contamination two different options were tested. In case of non- or slightly-contaminated sediments, the pelitic fraction was thickened and consolidated in a centrifuge decanter, adding binders to achieve silt consolidation for re-cycle. Highly contaminated fine fractions were obtained by doping sediments with HCs and the water suspension of silt and clay was sent to a Wet Oxidation (WO) pilot plant. WO is an advanced chemical oxidation at high temperatures and high pressures, which allows to treat non-biodegradable and toxic organic compounds, obtaining CO₂, water and biodegradable compounds. The WO pilot plant allowed to verify the detoxification of the fine fraction organic contamination according to the respective management hypothesis.

In case of Line 2, n°4 batches of about 2 m³ each were treated. Line 2 was conducted at Trevi facility in Cesena, by means of a Pneumatic Flow Mixing (PFM) Pilot Plant, an innovative mass consolidation process of dredged sediments. The PFM technique allows the “plug” pneumatic transport of the dredged sediment, which is inserted inside a duct and driven by pressurized air; moreover, a binder (usually, cement) is added to the dredged sediment before or during transport. This consolidation technique enables to cut costs thanks to the extreme simplification of the process (one single dredging/consolidation/disposal process) and to displace huge amounts of sediments, thanks to the employment of suitably equipped barges, thus reducing working times.

The results obtained allowed to assess the effective possibility to maximize the reuse of sediment minimizing consumption of resources and time.
INVESTIGATION OF METAL CONTAMINATION IN THE MIDDLE GREAT LETABA AND SHINGWEDZI CATCHMENT BY USING STREAM SEDIMENTS AND SOIL GEOCHEMISTRY, GIYANI, SOUTH AFRICA

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ABSTRACT

The study investigates the areas that are severely affected by mining pollution and natural contamination on the water resources. The study investigates the impact of mining on soil and water resources of the area. Representative sediment and soil samples were collected from the study areas and analysed by S-XRF. Both soil and stream sediments exhibit elevated concentrations of As, Cr and Cu which are of environmental concern. The sediments were dried at room temperature, crushed and milled to -75µm fraction. The metal concentrations in the stream sediments were higher than the geological background and the required concentrations outlined in the international sediment quality guidelines. It is evident that gold is preferentially concentrated in or associated with sulphides metals in rocks of the Giyani Greenstone Belt. As and Cu concentrations are expected to delineate significant gold bearing rocks or sources. The study shows As and Cu anomalies are due to anthropogenic activities (mining), whereas Cr, Ni and Mg are from non-anthropogenic geologic source. The elevated concentration of the high temperature metals such as Cr and Ni in stream sediments as well as soil is attributed to non-anthropogenic geological source. The greenstone belt rocks particularly the mafic and ultramafic units in general show elevated Co, Cr and Ni, associated with Mg. Minerals such as zircon, monazite, ilmenite, barite, cassiterite, scheelite and sphene are sources of these metals. The presence of As and Cu in the stream sediments is evidence that the sources of these metals are sulphide minerals associated with the gold source. This study, therefore, shows that the elevated concentration of metals such as As, Cu, Cr, and Ni, in stream sediments and soil which may affect the human health as well as negatively impacting the ecosystem of the area has its sources from both natural and anthropogenic process and this must be discriminated before liability is assigned to the mining activity in and the surrounding of an area.
A NEW MICRO PROFILING AND MICRO SAMPLING SYSTEM FOR INVESTIGATIONS AT THE SEDIMENT WATER INTERFACE

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ABSTRACT

Within aquatic systems, especially the rapidly changing conditions at the sediment water interface (SWI) are important factors operating the exchange between the sediment and the overlaying water. This includes nutrients as well as organic and inorganic contaminants. A fast decline of oxygen and the (related) gradients of, e.g., the redox potential or the pH value can cause a change of the availability of analytes within a short spatial distance. To gain a better understanding on the biogeochemical processes and the key factors that govern the fate of emerging substances at the SWI, methods with a high resolution are required. In particular, the availability of numerous micro-sensors and -electrodes (e.g., O2, redox potential, pH value, H2S, N2O) improved considerably the possibilities to study these heterogeneous and often dynamic aquatic environments at sub-millimetre scale. Apart from that, the methods available for the analysis of chemical species at the SWI are based on pore-water sampling, either performed by application of passive/equilibrium sampling (e.g., diffusive gradients/equilibration in thin-film (DGT/DET) or dialysis), squeezing or centrifugation of core slices or rhizon/filtration techniques. Drawbacks of these approaches are often the requirement of either the installation of the sampling devices at the sampling site and/or labour intensive preparation procedures (e.g., slicing and centrifugation or re-elution from/digestion of the accumulation gels) that may influence the environmental conditions at the area studied and/or the characteristics of the samples taken. Beside this, only few techniques allow a spatial resolution at a millimetre or sub-millimetre scale and are not capable to capture fine-scale differences.

Via the combination of a micro profiling system with a new micro filtration probe head connected to a pump and a fraction collector, a micro profiling and micro sampling system ("missy") was developed that enables for the first time a direct, automate sampling of small volumes (<500 μL) at a spatially high resolution of a few millimetre to sub-millimetre scale. The capability of the missy system was demonstrated by investigating trace metalloid distributions along depth profiles of a freshwater sediment core. Pore water samples, obtained by the micro sampling system, were analysed by means of inductively coupled plasma-mass spectrometry. Thereby, it was possible to directly link the multi element information on the concentrations of metalloid(s) to gradients of the O2 concentration and the redox potential measured in parallel.

Beside the investigation of natural processes, the technique enables to investigate (potential) effects of anthropogenic disturbances (e.g., pollutants or mechanical disturbances). Due to an increased use of engineered nanoparticles (ENPs) in numerous products and applications, they were chosen as an example for emerging substances, potentially entering aquatic systems. By investigating questions concerning fate and transformation of ENPs in sediments, the applicability of the missy system was demonstrated.

Within the presentation (i) a detailed description of the missy setup will be given, (ii) exemplary depth profiles of element distributions will be presented in relation to O2 and redox potential measurements. Finally, (iii) results of the application of the missy system to investigate the fate of ENPs in sediments will be presented.
ENVIRONMENTAL MONITORING OF EFFECTS RELATED TO LAYING OF MARINE CABLES AND PIPELINES: A PROPOSAL OF A METHODOLOGICAL APPROACH

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ABSTRACT

Coastal areas are complex systems where both marine ecosystems and human activity interrelate, often raising several conflicts. The economic activities may, sometimes, disturb the functioning and stability of marine ecosystems. The global growing demand for energy and the need to connect mainland with offshore environments are forcing energy companies to enhance their underwater cable and pipelines networks in order to allow an effective, continuous and reliable transport of energy resources. The installation of these infrastructures must take into account the possible environmental disturbing actions, such as the excavation activities for cables burial. The main impacts associated with this kind of infrastructures are: the removal or modification of the benthic biocoenoses in the area of interest, the increased turbidity and the possible remobilization of hazardous substances, the decrease of photosynthetic activity and, in general, other disturbances on marine organisms.

Within this framework, since 2007 ISPRA has performed different environmental monitoring programs related to laying of power cables and pipelines. Direct and indirect investigations (seafloors morphology and bathymetry, surface sediment grain-size and chemistry, water column chemical-physical characteristics and particulate matter and benthic communities) were carried out in order to understand and define potential impacts relating to the laying of cables. The sampling strategy depends on the techniques used for cable/pipeline laying, the duration of the activities and the previous health state of the marine environment.

The large collection of environmental data, gained in different environmental contexts, and the comparison with the extra-Mediterranean experiences have provided the basis to create and propose a methodological approach to monitor the effects of laying of cables and pipelines.

In this study we present ISPRA methodological approach proposal, that is structured in different monitoring phase to be carried out before, during and after cables or pipeline installation in order to evaluate the short, medium and long term effects. Special attention is paid to areas colonized by sensitive habitats present in the Mediterranean marine-coastal system, e.g. P. oceanica meadows, corals and “tegnûe”.
A COMPARATIVE GEOCHEMICAL CHARACTERIZATION OF CURATIVE MUD IN MAJOR ESTONIAN DEPOSITS

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ABSTRACT

Thanks to its specific geological and geomorphological characteristics, Estonia has several important deposits of lake and marine curative mud, with public health and commercial benefits. At present, five deposit areas, containing about 174 320 tons of healing mud, are in active use. However, the mud resources are underutilized if compared to their earlier use during the 20th century. In this paper, we present the pilot study for complex geochemical characterization of Estonian curative mud deposits. The study uses range of analytical methods to provide insights in two contexts: (1) the curative substances as well as (2) the broader ecosystem services of the sediments and muds. We reviewed the regional history of curative mud and the existing scientific rationale for the public and commercial applications of mud for healing purposes. Spatial distribution of organic matter and heavy metals of Haapsalu Bay surface sediments were mapped using inorganic methods: thermogravimetric analysis and energy-dispersive X-ray fluorescence spectrometry. Also, the average concentrations of selected heavy metals in all Estonian curative mud deposits were compared against the Estonian and international reference values for soils and sediments, to provide insights in the current pollution levels. In assessing the ecosystem services of curative mud in Estonia, the main challenge is in finding the relevant indicators for evaluating ecosystem stability in time using bio-geo-chemical innovative methods.
ABSTRACT

Mercury mining in Asturias (Northern Spain) has been carried out since Roman times; all mines were definitively abandoned in the 1970’s. Asturias is a historical mercury mining district, where mining activity has had periods of great development which have left an environmental legacy in the form of abandoned mine facilities and spoil heaps. As a consequence of the intense mining and smelting activity a significant geochemical dispersion of Hg and As throughout the area has occurred by mobilization of these pollutants from the abandoned mines and spoil heaps. Los Rueldos mine site is located 2 km northeast of the town of Mieres (Central Asturias). The mineralization is included in the northwest margin of the Coal-bearing Central Basin, in a zone of intense tectonic deformation. The mercury deposit is constituted mainly by cinnabar, although native mercury are also occasionally found; specific (arsenopyrite, orpiment and realgar) and non-specific (As-rich pyrite) arsenic minerals are present in the paragenesis of the Hg ore deposit. Arsenic mobility and availability in the environment are strongly affected by the association of As with solid phases in soils and sediments; for this study, a specific sequential extraction method to evaluate the As geochemistry in stream sediments downstream of Los Rueldos site has been applied. Also, phase associations of As in different grain size fractions of stream sediments were studied. A representative sample of sediments was collected in a small watercourse of acidic mine drainage flowing from an abandoned mine gallery. The applied sequential extraction methodology is based on the successive application of selective extractions to quantify Hg and As associated to different phases in the samples. The different fractions to be considered in the sequential extractions are:

i) in the case of Hg (Fernández-Martínez and Rucandio, 2013): “Labile Hg species”, “Hg bound to humic and fulvic complexes”, “elemental Hg and bound to crystalline oxides” and “Hg sulfide and refractory species”;

ii) in the case of As (Larios et al., 2012): "Readily available As", "Strongly adsorbed As onto mineral surfaces", "As associated with Al oxyhydroxides", "As bound to organic matter", "As incorporated into amorphous Fe oxyhydroxides"; As associated with poorly crystalline Fe (hydr)oxides and labile sulphides" and "As coprecipitated with refractory minerals".

Results show relatively low presence of Hg and As in the most mobile forms: lower than 5% of the total content for “labile Hg species” and lower than 0.5% for “readily available As". In addition, the high correlation between As and Hg contents indicates a similar origin.
for both elements in these sediments. The acidic pH of water accumulated at Los Rueldos mine gallery favors heavy metal dissolution including Fe; thus, As is mainly associated with Fe oxyhydroxides in all size fractions in the studied sediment sample.
SILICICLASTIC SEDIMENTATION OF THE INNER CONTINENTAL SHELF AS A SOURCE AREA OF SANDY SEDIMENTS FOR THE RECOVERY OF ERODED BEACHES ON THE ISLAND OF SANTA CATARINA, SC, BRAZIL

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ABSTRACT

Beach nourishment describes a process by which sediment (usually sand) lost through longshore drift or erosion is replaced from sources outside of the eroding beach. The applicability of this process has been repeated in several eroded or erosion beaches of the world, considering also the beaches of Brazil, a country in South America with about 9,000 km length of coastline facing the Atlantic ocean. The state of Santa Catarina with 538 km-long coastline is one of seventeen Brazilian coastal states, highlighting in its Central coast the island of Santa Catarina. This island is a typical coastal island, elongated northeast-southwest, with a predominantly subtropical humid climate, and a micro tidal regime (< 2 m). The geographical coordinates are 27°22'45" and 27°50'10" south latitude and 48°21'37" and 48°34'49" west longitude. Throughout its 174.3 km total perimeter, the island of Santa Catarina exhibits a diversity of coastal ecosystems, in which can be found 117 sandy beaches, dunes, lagoons, rocky coasts and mangrove swamps. The length of the island is 52.5 km; the maximum, medium and minimum widths are 18.8 km; 7.6 km and 1.3 km, respectively and the total area is approximately 399 km².

In this study are considered 16 beaches of the Northeast and Southeast coasts of the island, composed dominantly by sands of medium/coarse to fine grained. The main beaches eroded of these coasts are Barra da Lagoa, Moçambique and Santinho (Northeast coast) and Armação, Campeche and Joaquina (Southeast coast). Aiming to looking for possible sources of siliciclastic sediments to recovery of eroded sandy beaches have been developed in Brazil the “Programa de Avaliação da Potencialidade Mineral da Plataforma Continental Jurídica Brasileira (REMPAC)”, which has as an objective to locate, map and determine the geometry (shape and volume) of sand bodies in the regions of the inner and middle continental shelf, with a view to the solution of geotechnical and environmental issues related to recovery and urbanization of sandy beaches. In this sense, the collection of 108 samples of surface sediments along the isobaths of 10 and 50 m over 18 profiles transverse to the coastline of island of Santa Catarina was done,
revealing the predominance of fine sand (up to 90%), medium sand (75%), very fine sand (up 70%), coarse sand (up 48%) and very coarse sand (up 12.5%). The texture of the inner continental shelf adjacent to the island of Santa Catarina showed the predominance of fine to medium sandy sediments in depths closer to the coast and muddy (silt) in greater depths, probably related to the smaller hydrodynamic energy and sediment supply present in the sandy coastal plain and beach system of the island of Santa Catarina. Thereby the sandy sediments of the inner continental shelf can be used for recovery of eroded beaches, respecting their grain size and mineral potential.
BIO ASSAYS AS INTEGRATED TOOL FOR THE RISK ASSESSMENT OF COMPLEX SAMPLES

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ABSTRACT

It is well known that sediments serve as a sink and as a source of contaminants, and thus play an important role for the water quality. Most contaminants are introduced in the sediments by runoff in the water bodies leading to a close link between both compartments. Sediments contamination is characterized rather by a complex mixture of chemicals than single compounds due to multiple sources and possibility of accumulation and long residence times.

Chemical analysis of sediments cannot easily be used for risk assessment because the total concentration in the sediment is a poor measure for the environmental risk of these compounds. One other shortcoming of this approach is the limitation to a small set of selected chemicals which are regulated and measured. On the other hand it is impossible to identify and quantify all chemicals present. Bio assays may serve as an integrated tool for the determination of the environmental impact of complex mixtures.

Although the usefulness of bio assays has been proven, most guidelines still rather focus on selected chemicals than at a measure for the overall effect.

This work exemplary shows some results from a project which investigates the possibility of using bio assays in the assessment of construction products with the aim of a harmonization of test methods.

Leaching tests are used for determination of the fraction of chemicals which can be released to environment during usage of the products. One product which has been investigated was granular ethylene-propylene-diene monomer rubber (EPDM), which is cross-linked with sulfur. This granular material is used for the construction of artificial turfs for outdoor usage. These eluates show toxic effects to aquatic organisms. Besides zinc none of the regulated compounds showed levels above limit values of the German groundwater protection directive. Analysis using GC-MS in the scan mode tentatively identify non-regulated compounds as e.g. mercaptobenzothiazole and its degradation products, thiourea and piperidine.

Although such deep chemical analysis can never be routine, a more comprehensive understanding of the cause of toxicity is necessary. Bio assays should be the first step and would also easily allow to re-test a product if certain banned chemicals have to be replaced by new non-regulated ones.

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BATCH TESTS FOR THE OPTIMIZATION OF PAH BIOREMEDIATION IN MEDITERRANEAN TOURIST PORT SEDIMENTS

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ABSTRACT

A large volume of materials needs to be dredged every year from ports, in order to maintain an adequate depth. These sediments are frequently contaminated by different organic or inorganic pollutants, among which Polycyclic Aromatic Hydrocarbons (PAHs) represent a serious hazard for humans and animals and can lead to the sediment rating as hazardous waste involving the need to treat them before their disposal.

The overall target of ENPI CBC-MED MAPMED project (Management of port areas in the Mediterranean sea basin) is to improve the environmental sustainability of tourist coastal areas in the Mediterranean countries. The present work aims to evaluate the best conditions of PAHs bioremediation by comparing in slurry aerobic batch tests: bioaugmentation, nutrients and different surfactants addition (saponins and Tween 80).

Sediments used for the experimental tests were collected from two Mediterranean tourist ports: El Kantaoui (Tunisia) and Cagliari (Italy). Sediments dredged from the ports were sieved in order to remove large particles and stored at 4°C. The slurry was prepared by adding artificial sea water, reaching 10% dried solids. Aerobic batch tests were made in double, in 500 ml mechanical stirred bottles and lasted 7 days or more. Fluorene, phenanthrene, fluoranthene, pyrene and benzo(a)pyrene were added at the concentration of 40mg/kgss. Parallel abiotic tests were performed, and losses resulted negligible.

The experiments conducted without amendments showed in both sediments, after 5 days, complete fluorene and phenanthrene degradation, while pyrene and fluoranthene degradation was slower and showed a 3-day lag phase. Moreover, fluoranthene was not completely removed after 10d. Benzo(a)pyrene was only removed of about 20% in El Kantaoui sediments. Regarding the amendments, the best results were obtained with nutrient regulation (C:N:P ratio 100:10:1) and bioaugmentation, which increased removal rates and reduced the lag phase for fluoranthene and pyrene, in both sediments. Benzo(a)pyrene removal was only slightly increased in Cagliari sediments.

The effect of the two surfactants differed: phytogenic saponins affected positively PAHs removal while synthetic Tween 80 gave only a slight improvement in El Kantaoui sediments; for Cagliari sediments the effect of both surfactants was negative. These results are in line with previous observations suggesting a strong dependence on the specific sediments properties.
SETTING REMEDIAL ACTION OBJECTIVES TO MANAGE CONTAMINATED SEDIMENTS – USING A PRAGMATIC RISK ASSESSMENT APPROACH LINKED TO THE END SITE USE

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ABSTRACT
Sediment remediation is currently being undertaken in Esquimalt Harbour, Canada, at the largest non-military, solid-bottom dry dock on the west coast of the Americas. As part of the project, an intertidal marsh was constructed as a habitat offset disturbance to aquatic habitat at the facility. The area selected for the habitat offset was an intertidal inlet, Dunn’s Nook, on the west shore of Esquimalt Harbour, Vancouver Island, Canada, where the construction of a causeway restricted natural tidal flushing. The habitat design included filling to improve tidal flushing and planting species typical to west coastal marshes. Dunn’s Nook was subjected to industrial development and operations since the early 1900’s and was as a result contaminated with metals, polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB). To support planning for construction of the marsh, an evaluation of potential risks associated with the sediment contamination to the constructed habitat was undertaken, and remedial action objectives (RAOs) were developed to determine the extent of remediation needed.

It is common to rely on generic numerical regulatory benchmarks as RAOs. Based on a direct application of the probable effects level (PEL) sediment quality guideline (SQG) for metals, PAHs, and PCBs, the estimated excavation volume was 3,200 m³ for excavation and disposal. An evaluation of the site-specific factors that control the bioavailability of metals and PAHs found that PEL values would be suitable site-specific RAOs. In comparison, the PEL value for PCBs was found to be overly conservative and an alternative RAO was developed using a pragmatic application of risk assessment tools that explicitly linked the risk of exposure to representative species expected to use the constructed habitat. This alternative RAO resulted in an estimated excavation volume and remedial costs that were 25% of the original estimates.
PROTECTING THE PRESENT WHILE CLEANING UP THE PAST: ENVIRONMENTAL MANAGEMENT PLANNING FOR A HARBOUR-WIDE SEDIMENT REMEDIATION PROGRAM

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ABSTRACT

A program of sediment remediation is currently being undertaken in Esquimalt Harbour on Vancouver Island, Canada, as part of a long-term strategy to address sediments that have been contaminated by a long history of naval and industrial activity, dating back to the mid-1800s. This remediation program is one of the largest being undertaken on the west coast of Canada, and will be implemented in a phased approach that will initially target areas of higher contaminant concentrations. Longer term remediation and management of other areas of the harbour will be based on the results of ongoing updates to a human health and ecological risk assessment.

Environmental assessment (EA) and development of an environmental management framework for the remediation project are key components of the project planning stages. The EA is important to assist stakeholders in (i) understanding the specific and cumulative environmental impacts of the project, which is intended ultimately to provide an environmental benefit; (ii) determining whether the project is likely to result in significant adverse environmental effects that may outweigh the benefit of the project, and (iii) understanding appropriate mitigation strategies and plans required to remove or reduce the chance for adverse environmental effects, and the potential implications of those strategies on the design, construction, cost and schedule of the project. An environmental management plan (EMP) provides a framework through which potential environmental risks identified by the EA can be managed during implementation and performance monitoring objectives against which the project will be assessed. The presentation will discuss the development of environmental protection targets in the context of an active harbour with significant environmental and cultural resources, and the balancing of costs and schedule implications of mitigation strategies with the broader goal of environmental clean-up.
QUANTITATIVE AND QUALITATIVE EVALUATION OF SEDIMENT AND CONTAMINANT TRANSPORT IN THE SAMME RIVER CATCHMENT (BRABANT REGION - BELGIUM)

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ABSTRACT

In Wallonia (Belgium), the maintenance of waterways is currently exclusively managed in a curative way. When local sediment accumulations are detected in waterways, bathymetric surveys are conducted in order to quantify the volume of sediment to be removed and chemical analyses of samples allow the characterization of sediment quality. Collected data only allow a short-term management of the matter generated by dredging operations. Medium- or long-term planning of dredging operations is currently not feasible, due to a lack of knowledge on sediment fluxes and associated pollutant transport. In particular, issues related to the interactions and mixing of recent and older sediments, or to the input of sediment from unnavigable waterways into larger navigable waterways, are poorly understood. Operational tools allowing the assessment of the effectiveness of preventive measures to be implemented in order to improve the management of sediment in Walloon waterways also have to be developed.

This research project aims at contributing to the development of such tools and focuses on the Samme river basin (Seine catchment – silty Brabant Region), deemed to be representative of Walloon issues. The Samme river is categorized as an unnavigable waterway. It runs along the old Brussels-Charleroi canal and flows into the new Brussels-Charleroi canal at the foot of the Ronquières inclined plane. The sediments of the bed of the Samme river are characterized by a high concentration of micropollutants (mainly PCBs) and contribute to the contamination of a greater volume of sediments in the new Brussels-Charleroi canal, significantly increasing the cost of periodic dredging operations in the canal.

The methodology developed is based on (I) an assessment of within-catchment sediment and pollutant transport and (II) an extended monitoring of sediment and pollutant fluxes at the outlet of the catchment. The origin of the Samme riverbed sediments contamination by PCBs is poorly understood. Chemical analyses of the sediments of the bed were carried out along the linear course of the Samme river and its main tributary in order to identify the source of pollution. However, numerous connections between the old canal and the Samme river contribute to the transfer of stream sediments and pollutants between both systems and complicates the identification of the source of PCBs. Surveys conducted in the bed of the Samme river and the old canal also made it possible to evaluate the availability of sediment in the catchment.

At the outlet of the catchment, different methods of river sediment sampling (automatic samplers, turbidity sensors, Time Integrated Samplers, sediments traps) are currently being implemented in order to (I) monitor in a quantitative fashion the amount of suspended matter carried by the Samme river into the Brussels-Charleroi canal, (II) evaluate the associated fluxes of pollutants (temporal variability) and (III) evaluate the possibility of setting up a system of retention of the sediments in the Samme catchment.
TOTAL, DEGRADABLE, LABILE, PERCOLABLE, COLLOIDAL, SOLUBLE FRACTIONS OF HYDROPHOBIC ORGANIC CONTAMINANTS IN FIVE SEDIMENTS BEFORE AND AFTER AEROBIC AND ANAEROBIC MATURATION

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ABSTRACT

Five sediments contaminated with TPH, PAHs and PCBs were studied in the laboratory for 18 months in aerated conditions and 12 months in saturated conditions. The so-called “labile” and “recalcitrant” Tenax extractable fractions were measured by 13 successive extractions during 61 days. The cumulative amount of percolated contaminant emitted by a standard column test has been measured before and after maturation. The colloidal dissolved organic matter was fractionated into different components according to a standard protocol, as fulvic acids, humic acids, neutral and hydrophobic compounds. Dissolved concentrations were measured by passive samplers in HDPE film for 46 days at the laboratory. The dissolved concentrations were compared with concentrations calculated by different published equations.

These studies show that:
- Hydrophobic organic compounds are low or not degradable in 18 months in aerated condition, and not degradable in non aerated condition;
- The fraction degraded in 18 months in the laboratory is moderately consistent with so-called «fast» (Tenax extraction) for PAHs and not for PCBs fraction;
- The percolable fraction is controlled by the colloidal organic carbon and in particular by humic acids and hydrophobic neutral compounds. It is greatly reduced by a maturation period of 18 months, also corresponding to the disappearance of humic acids;
- The "true" dissolved fractions are very low, probably due to the presence of black carbon. They can be measured either by the method of passive samplers, or by a simple method of flocculation of colloids in the eluates with aluminum sulfate (with higher detection limits);
- The calculation of emission concentrations from current models underestimates the concentrations emitted, largely by not taking account of vectorization by organic colloids;
- The transfer of contaminants vectorized by colloids should be studied by fieldwork;
- The hazard classification of these materials relies on the total contents of organic contaminants, while the very slowly desorbable fraction prevails, and that a very little part can be mobilized.
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SYSTEMS BIOLOGY IN THE STUDY OF XENOBIOTIC EFFECTS ON MARINE ORGANISMS FOR EVALUATION OF THE ENVIRONMENTAL HEALTH STATUS: BIOTECHNOLOGICAL APPLICATIONS FOR POTENTIAL RECOVERY STRATEGIES

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ABSTRACT

A deep knowledge of risk factors affecting the environments and their impact on animals will allow to produce an applicative transfer for the realization of concrete actions aimed at protection and conservation of the marine ecosystems, as well as providing new items for defining effective action plans for the management of contaminated sediments.

Despite the recent technological advances in the field of recovery of marine environments, the impact of different strategies of intervention on natural ecosystems are still largely unknown. The aim of the paper is to present the expected research activities and preliminary results of an Italian National research project which will investigate the modifications of biological processes in the aquatic species subjected to different levels of contamination obtained through technically reliable and cost-effective water and sediment management strategies.

To achieve this aim, the project is articulated into seven phases within two main WPs, the first referred to the analysis to be performed in natural environments, and the second in laboratory experiments. Each phase will be developed through the synergic collaboration among the 8 research units involved in the project. The present paper describes some of the results obtained in the first year, mainly based on field monitoring.
INTEGRATING SUSTAINABILITY IN PARTICIPATORY DECISION-MAKING
(INSPRIRED): ASOPOS SEDIMENT MONITORING

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ABSTRACT

Sustainable development refers to ‘meeting the needs of present generations without jeopardizing the ability of futures generations to meet their own’. Due to the importance of sustainable development, there is an increasing need to provide decision-makers with specific sustainability indicators in order to plan and implement effective public policies. The Asopos River runs through the regions of Viotia and Attiki in Greece and empties into the South Evoikos Bay (Attiki). Due to the operation of approximately 700 companies in the area, the water table of the river in the north and east is contaminated with environmental impacts on soil, sediments, underground and surface waters in the surrounding areas. Currently, the Ministry of Environment has initiated policy measures in order to increase water quality standards and provide local communities with higher quality drinking water. However, all these efforts focus solely on studies that mainly focus on Cr(VI) in water. In this study, more environmental indicators will be measured in the area. Sediments were sampled concurrently with river water samples from the same spots. These sediment samples were tested for their geochemistry (XRD, TOC, pH, PZC and REDOX potential). They were also tested for heavy metals, organochlorine pesticides, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs). Validated methods found in the literature were used. Finally, the toxicity of these samples was tested with various techniques. Initial measurements suggested that the diffuse pollution is not as high as it was anticipated. However, there seems to be some hot-spot areas where some of the measurements were out of the normal distribution of values found in the majority of the areas. This suggests the presence of various polluting sources with different frequency, occurrence time, and magnitude.
HEAVY METALS IN BOTTOM SEDIMENTS OF CASTILSERAS ARTIFICIAL WATER RESERVOIR (ALMADÉN, SPAIN)

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ABSTRACT

The Almaden mining district (Southern Central Spain) is well known as one of the most affected areas by mining activities developed during more than two millenniums. During the last 30 years, the artificial water reservoir of Castilseras built on the Valdeazogues River has been receiving runoff waters from the most important Hg mines of the district and from other small mines mostly of Pb-Zn. This water basin has become an important sedimentary trap and, consequently, a preferential accumulation site for heavy metals associated with fine particles carried by the tributary water flow. This study, which is part of a monitoring programme on the aquatic environment in the area, focuses on a preliminary characterization of grain size and heavy metals distribution in bottom sediments of the Castilseras reservoir.

Sediments from twelve sampling points were collected by grab in two field campaigns accomplished in 2013. Silt and clay fractions are predominant in sediments and the mean size decreases following the water flow direction. Major element concentrations are high compared with other mercury mining areas ranging from 15.8 to 10.4 % for Al, from 5.17 to 3.05 % for Fe, and from 0.21 to 0.06 %, for S. Trace element contents vary in the range 21.5-7.4 mg kg⁻¹ for Cu, 50.8-20.9 mg kg⁻¹ for Pb, 116.8-65.6 mg kg⁻¹ for Zn, 60.3-27.7 mg kg⁻¹ for Ni, 26.3-15.62 mg kg⁻¹ for Co, 666-433 Mn mg kg⁻¹ for As, 72.5-52.6 mg kg⁻¹ for Cr, 22.9-11.6 mg kg⁻¹ for Sr and 17.3 to 2.5 mg kg⁻¹ for Hg. Sediments are moderately acids within a range of pH(H₂O) from 6.72 to 6.37. In all the samples, pH(KCl) were less than pH(H₂O) thus suggesting that colloids are negatively charged and reactive minerals of Al are possibly present. For Cu, Zn, Ni and Hg a decreasing concentration gradient is apparent in the water flow direction, whereas the opposite was observed for Mn, S and Cr. A preliminary estimation of the contamination degree by applying the enrichment factor shows that only Hg contents may be associated to an anthropogenic source due to its moderate enrichment whereas the other elements only suffer a minor enrichment with respect to the background levels. Highly significant correlation found between Hg, Sr and Al contents and TOC (r=0.901, 0.850 and 0.808 at p<0.05, respectively), suggests that these elements are mainly bound to the organic matter; in addition, the correlation between Al and TOC supports the measured pH values. The low correlation between Fe and TOC (r=0.315), the medium between Fe and Al (r=0.633) with the high correlation Al and TOC implies that the concentration of metals in
sediments can not be interpreted simply as due to grain size variability. Relationships between elements and grain size show that Fe, Al, Cu and Hg are mainly associated to the clay fraction. Further investigations should be focused on mechanisms of accumulation and possibly remobilization of elements considering the most important metal carriers, i.e. fine particles and organic matter.
ABSTRACT

Large amounts of polluted sediments are dredged annually around the world in order to meet the demands of harbour development and/or to meet the demands of governmental acts to improve the aquatic environment of harbours. In order to increase the recycling potential of polluted sediments there is an increasing need to develop cost-efficient methods for remediating to levels at which the sediments are made available for re-use as non-polluted material. Electrodialytic remediation (EDR) provides such a method and has been proven a liable method for removing heavy metals from polluted sediments. EDR is based on applying a low current to the sediment in suspension, which initiates processes that acidify the sediment, subsequently desorbing, mobilising and ultimately removing the heavy metals from the sediment.

The main focus of this study was to further develop and optimise the EDR method for remediating polluted harbour sediments from Hammerfest Harbour, located in the Arctic region of Norway. The relative importance of the experimental variables; current density, remediation time, light/no light and the stirring rate and liquid-solid ratio of the sediment suspension was determined in 15 laboratory scale EDR experiments by projection to latent structures (PLS). PLS is a multivariate analysis tool in which relations between two matrices can be determined – in this study the relations between the X matrix consisting of the experimental variables and the Y matrix consisting of clean-up levels, were determined. Variable importance in the projection was subsequently used to assess the relative importance of the experimental variables to each other.

Current density and remediation time were shown to have the highest influence on the remediation of the heavy metals chromium, copper, nickel, lead and zinc in the applied experimental domain. In addition it was shown that applying time after acidification rather than the total remediation time improved the PLS model correlations and prediction powers, indicating the importance of applying a specified experimental domain that covers the remediation phase of each heavy metal in the specific sediment.

Based on the PLS modelling a site-specific remediation strategy for remediating the harbour sediments could be developed. In this case operating in the experimental domain of 0.5-0.8 mA/cm² and a remediation time after acidification of 450-570 hours was necessary to meet acceptable levels according to the Norwegian guidelines for contaminated sediments.
POTENTIOMETRIC TITRATIONS FOR THE CHARACTERIZATION OF ASOPOS SEDIMENTS INTERACTION WITH Cr(VI)

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ABSTRACT

The area of Asopos is suspected to be polluted with Cr(VI). The aim of the present study is to better understand the interaction of river sediments with Cr(VI). Sorption of ionic pollutants such as Cr(VI) on solids can change their surface charge. Understanding the acid-base behaviour of the solid can provide information that will be helpful in understanding the interaction between solids and ionic pollutants. The initial step towards this understanding is the determination of the point of zero charge (pzc) of the solids and more specifically of the sediments. Pzc is the pH at which the net surface charge of a solid is equal to zero, or in other words the charge of the positive surface sites is equal to that of the negative ones. For inorganic solids, the pzc is usually determined using either the classical potentiometric titration or the newest method “Potentiometric Mass Titration” (PMT). In the classical potentiometric titration, the pzc is the common intersection point of three surface-charging curves obtained at various ionic strengths. In the PMT, the pzc is determined by the common intersection point of titration curves of different suspensions containing various solid masses or the section point of the titration of a suspension and the corresponding solution of an indifferent electrolyte (quick scan). For Asopos river, eight sediments that were evenly-spaced along the river were obtained. They were all titrated in NaNO₃ solutions (0.03 M, 2 g sediment / 75 mL solution) both without and with Cr(VI). The titrations were performed in double-wall vessels at a constant temperature (25±0.1°C), under N₂ atmosphere. The suspensions were equilibrated for 12 h and the equilibration pH value was recorded and noted as the initial pH. Then, a small amount of base (1 M NaOH) was added to deprotonate a significant part of the sediment surface sites, rendering the surface negative. The sediment suspension was then titrated by adding automatically small volumes of a certified volumetric standard of 0.1 M HNO₃ and the pH was recorded as a function of the volume of titrant added to the suspension. The initial pH values ranged between 8.3 and 8.9. The pzc values in the absence and presence of Cr(VI) ranged from 8.3 to 9.4 and from 8.2 to 9.4, respectively. These results suggest that there is no significant interaction between the sediments and Cr(VI). Thus, the Cr(VI) contained in the sediments could be due to natural occurrence and not due to accumulation on the surface of the sediment grains.
RHEOLOGICAL BEHAVIOR OF MARINE SEDIMENTS FOR ASSESSING NAUTICAL DEPTH

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ABSTRACT

Dredging practices constitute a challenge for developing and maintaining harbor and fluvial activities. They also present a contamination risk of coastal waters which can affect the ecosystems. The unsuitability and restriction to marine disposal of dredged sediments leads ultimately the managers to provide a treatment ashore because of the great volume affected. The need for maintaining safely navigable waterways in the most efficient way leads to think about in-situ solution which keeps up the sediments. The nautical bottom concept was developed and implemented in several major ports [3]. This concept however requires dedicated measurements of the rheological conditions. In order to assess the nautical depth for dredged sediments from Le Havre (France) Harbor, shearing tests using a rheometer were carried out in laboratory. The computed viscosity curves (flow curves) are derived from each applied shear stress value versus each measured corresponding shear rate value. These curves show that this mud material will be able to flow when external shear stress exceeds about 30 Pa and this mud will lose its internal strength completely at shear stress values about 150 Pa. This means that in situ sediment conditioning will principally be applicable to this mud (mainly silt) material. The long experience of maintenance dredging in Emden (Germany) port has shown that a most effective method to achieve and to keep the navigability of corresponding mud material can be applied.
INFLUENCE OF PARTICLE STEP LENGTH DISTRIBUTION IN MODELLING BED-LOAD TRANSPORT

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ABSTRACT

Bed-load particle transport can be described as a probabilistic process characterized by both advective and diffusive behaviour. This stems from the stochastic qualities of the entrainment process along with the natural variability of particle displacements during transport caused by the highly variable shearing turbulent flow and the stochastic nature of the deposition process. In this study the particles’ step length statistics are incorporated into a bed-load transport formulation over space and time to examine the relative importance of these physical processes. The model is developed starting from the entrainment-based one-dimensional Exner equation for mass conservation. Due to variability in grain size, bed elevation and entrainment process, it follows that step length can be assumed to be probabilistic, and its statistics should account for interaction between the flow and sediment conditions and also the bed roughness characteristics. A numerical method is implemented to solve Exner equation in “steady” conditions, limiting the analysis to a sediment bed in “equilibrium”. Simulations show that tracers in the active layer are advected downstream and diffused. The simulated pattern suggests that the particles step length, together with the entrainment rate, the size of the active layer and the shearing flow, could explain the behaviour observed for particles when transported over a rough bed, as well as the delay in transport caused by a likely storage effect operated by the active layer.
DREDGED SEDIMENT DEWATERING BY ELECTROKINETIC: EFFECT OF COMBINING POTENTIAL GRADIENT AND MECHANICAL LOAD

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ABSTRACT

More than 30 million tons of sludge were dredged from French harbours and waterways per year in order to make sure the navigation conditions. Several important ports have to face a large quantity of dredging problems. Moreover, a wide diversity of pollutants can be found in these sediments such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) etc. In the past, these contaminated sediments were usually treated to immersion under the sea because of the easiness. However, this operation can't be allowed when the level contamination exceeds a fixed limit (Geode guidelines). So, depositing on land is necessary for the further sediments remediation and exploitation. On 2007, the port of Le Havre (Grand Port Maritime du Havre) built a site to deposit a large volume of sludges. Nevertheless, high cost of the land deposit and management must be considered. A low energy cost method, the mechanical press is more important used in practical application to reduce the volume and water contents than the other technologies as freeze-thaw, centrifuge force etc. Sludge dewatering by electrokinetic technique effect is a promising technology when processing time and potential gradient. In fact, because of a high water content, a low hydraulic conductivity and a low shear strength, sludges cannot be efficiently dewatered by a mechanical compression alone. It has been demonstrated that a combined electro-dewatering (EDW) is a cost-effective remediation technology when assisted by mechanical dewatering (MDW).

The experimental setup consists of a U-PVC cylindrical cell (inner diameter = 90mm, length = 205mm), a DC power supply (HQ POWER PS5005), graphite electrodes and a load device. The cell was positioned vertically under the load device. Two electrodes were placed at the ends of the sample cell. Four loading values and three electrical potential values were combined to achieve the tests. The DC power supply ranged from 0.5 to 1.5 V/cm and the mechanical load ranged from 25 to 200 kPa. The influence of electric field intensity on the consolidation and water removal efficiency was assessed. In general, more water removal efficiency needs more energy consumption. In addition to EDW, contaminants can be extracted using a quite high potential gradient.
CAN POTENTIALITIES OF HYDRO-GEOLOGIC MODELLING BE USEFUL TO ENVIRONMENTAL TECHNOLOGISTS?

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ABSTRACT

The motion of sediments in territorial systems depends on a variety of processes. Natural phenomena involve material being eroded from the valley slopes and then being transported along the water courses. The typical tools of applied geology and fluvial hydraulics enable these processes to be modelled, aiming at appropriate depictions of on-site and off-site processes. Key issues for the integrated modelling are (i) their feasibility, in light of incomplete interface between hillslope-devoted and river-devoted models; (ii) the sensitivity of the obtained results to the control parameters, whose estimation is typically not straightforward. On the other hand, potentialities of these method are that (i) sediment sources can be individuated (distributed soil erosion, landslides, …) possibly accounting for spatial heterogeneity of the catchments, and relative contributions to the total sediment budget from different sources can be quantified; (ii) volumes of sediments eroded in long or short terms can be estimated; (iii) migration of sediments transported along river streams can be computed, together with the resulting morphologic evolution of the stream bed; (iv) reaches affected by bed degradation or preferential sites for accumulation of transported sediments can be identified; (v) sediment volume balances can be set out; (vi) characteristic time scales of the processes can be assessed.

This manuscript reviews a few works by the authors, proving feasibility and relevance of sediment transport modelling in catchments and water courses. Two mountain environments were considered: the Rossiga and Tartano valleys in northern Italy. Reference was made to mountain contexts because the major intent was to analyze how hydro-geologic diseases could influence territorial vulnerability due to natural processes. The Rossiga valley was selected because of the presence of several big landslides which could possibly overload the main stream with solid material, The Tartano valley was studied aiming at a comparative analysis of the sediment yield expectable from sources of different type. Key results obtained from modelling were then interpreted and used as long as they were relevant for hazard assessment, landscape protection, scenario modelling and emergency management. A synthetic exercise is also included in the manuscript for better understanding of the modeling principles.

The quality (in terms of possible contamination) of sediments being mobilized was out of the scope of previous work. However, modelling results like those documented here can be produced also for other territorial contexts (e.g., lowland), as well as for other spatial/temporal scales (local/global, long-term). Knowledge of sediment fluxes might be of interest also to scholars dealing with risk related with sediment contamination and remediation methods.
POP in a proclaimed waste industrial receiver (Asopos River)

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ABSTRACT

Persistent organic pollutants (POPs) are toxic chemicals causing adverse human health and environmental effects. Polycyclic aromatic hydrocarbons (PAHs), Polychlorinated biphenyls (PCBs) and Organochlorine pesticides (OCPs) are important sub-categories of POPs, characterized by their persistence and long-term toxicity. River sediments can act as transient storage compartment for POPs when rivers are used as receptors of agricultural runoff, industrial and urban effluents. Asopos River in Greece was proclaimed a “processed industrial waste receiver” about 40 years ago. Sediments from sites evenly distributed along Asopos bed were collected in the dry and in the wet period. Determination of PAHs, PCBs, and OCPs was performed in the samples via standardized procedures. PCBs and OCPs were not detected in any sample. Presence of a low number of PAHs in low to moderate levels was found in about half of the sediments collected from the middle and the lower reaches of the river. Moreover, PAHs distribution and origin were evaluated based on the organic matter and composition of the sediments. Silicate minerals dominate over carbonates and organic carbon (OC) ranges from 0.4 to 3.5% with an average of 1.7%. More than 70% of the sediment organic matter has a natural origin, as it was measured using organic petrography methods. The low to moderate levels of PAHs are consistent with the composition of the organic matter present in the sediments.

Keywords: river sediments, POPs, PAHs, PCBs, OCPs, organic carbon
Urban Waterfront Rehabilitation and Contaminated Sediment Cleanup; Is There a Relationship?

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ABSTRACT

Over the next decade, sediment cleanup projects are planned in several major cities including New York, Seattle, Portland (Oregon), San Francisco, Newark (New Jersey), and many others. It is expected that several billion dollars will be expended in the process. Often the planning of these cleanup projects takes place in the absence of meaningful urban planning resulting in possible or sometimes real misalignment of objectives for the waterfront space. Moreover, the planning and design processes for the cleanups are not synchronized with the planning process for waterfront rehabilitation in general.

Sediment cleanup projects present a singular opportunity for urban planners, community members, waterfront facility owners and operators, and the proponents of the cleanups themselves to address overarching issues of public access, navigation, and redevelopment. Failure to align the cleanup and redevelopment processes can result in missed opportunities for communities and possibly even long term conflicts in waterfront use and enjoyment. Cities may miss opportunities for long term economic growth by focusing too closely on short term cleanup priorities.

This presentation will examine example recent cleanup efforts and focus on the relationship, or lack thereof, to waterfront rehabilitation. By way of this analysis, suggestions will be offered for increasing the alignment of the two activities in future cleanup efforts.
CHARACTERIZATION OF DAM SEDIMENTS IN TUNISIA FOR THEIR VALORIZATION IN BRICKS

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ABSTRACT

In arid and semi arid land, the rehabilitation of water reservoirs by sediment dredging is necessary even if it is rarely carried out because of the costs involved. In order to overcome this operation costs, an approach is developed in the present study consisting in the valorization of the dredged sediments through brick production. The studied sediments came from the dams of Joumine, Sejnane and Masri (Tunisia). Full scale laboratory and industrial experiments were conducted through physical, chemical and mecanical analysis. Three types of clay bricks were made up with dam sediments : 100% from Joumine, 100% from Sejnane and 85% from Masri mixed with 15% of sand to prevent high drying shrinkage. They have undergone several mechanical and physical test related to standard requirements for bricks. All specimens, except those of Joumine, satisfied all the standard requirements.
SEDIMENT-BOUND ORGANIC POLLUTANTS FROM HISTORICAL INDUSTRIAL SOURCES IN THE SPITTELWASSER CREEK AND THEIR IMPACT ON SEDIMENTS AND SURFACE WATER IN THE ELBE RIVER BASIN

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ABSTRACT
The Spittelwasser creek is located in Saxony-Anhalt, Germany. It discharges into the river Mulde which is a primary tributary to the river Elbe. In earlier times, waste water from the chemical industry located at the Bitterfeld-Wolfen industrial mega-site has been discharged into the Spittelwasser creek largely without previous treatment. Among the organics released, polychlorinated dibenzodioxins and furans (PCDD/F), hexachlorocyclohexane (HCH), and organotin compounds, also belong to the most relevant parameters impairing the surface water quality of the river Elbe. The transport and fate of these primarily particle-bound substances are basically a sediment issue involving the sediment reservoirs and the extended flood plain areas of the river basin.

In the scope of the realignment of the Elbe river basin management based on the EU-WFD, requirements to improve the surface water quality have been specified and reduction targets have been defined for the river Mulde.

In spite of the general need to improve the surface water quality, the knowledge of the system and the related processes was, at that time, neither sufficient to identify appropriate locations nor the extent of possible corrective actions in the Bitterfeld area and its surface water bodies. Consequently, this study has been implemented by the Landesanstalt für Altlastenfreistellung (LAF) to obtain a detailed understanding of the current state of the system and a robust basis for future decisions on corrective actions.

A large investigation program was performed for a period of one year. Water and suspended sediments were sampled at the river sections and analyzed for the organic parameters. In addition, the quantity and quality of sediment in the Spittelwasser creek and the Mulde river were investigated and the contaminants in the Spittelwasser floodplain were mapped. The data obtained enabled a comprehensive system analysis which was the basis for the identification of target locations for corrective actions and for the evaluation of their effectiveness with relation to the management objectives on the river basin scale.
USING INNOVATIVE GEOTEXTILE CONSTRUCTIONS TO ALTER HYDRODYNAMICS OF WORMER-EN JISPERWATER’S SHALLOW LAKES BY RE-USING SEDIMENT

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ABSTRACT

The Wormer-en Jisperwater area is the largest uninterrupted peaty grassland in Western Europe and one of the most important areas for wetland birds in the Netherlands. It is under European Natura 2000 protection. Due to water movement sediment particles keep in suspension and impede sunlight penetration to the bottom. Hereby growth of higher order aquatic plants and natural water quality improvement are inhibited. To bring a change in this negative pattern Tuw came up with an innovative idea. Only sediment removal is not a sustainable measure since more than 1 million m$^3$ of sediment is kept in suspension. Besides sediment removal induces further land subsidence and disturbs the balance of this water system. Therefore innovative and sustainable measures were taken to reduce hydrodynamics, sediment resuspension and turbidity in order to allow higher order vegetation to develop, enhance biodiversity and improve water quality. Together with Royal Ten Cate N.V., Tuw developed two types of light-weight geotextile constructions: the Sediment-buffer and Geo-groyne. Both design and implementation of these constructions are innovative. A modified prefabricated Geotube® is linked to a geotextile screen and a floater. The Geotube® is filled with sand to keep the construction in place and the floater is used for tensioning the screen. The Geo-groyne is designed to reduce the intensity of wave action (like a groyne) and thereby preventing sediment resuspension and transport. The construction is installed perpendicular to water currents in order to reduce those and induce settlement of sediment on the lee side. The Sediment-buffer is used for storage of sediment and nature development. The construction is fixed with poles and is used to restore damaged shorelines by connecting it to shore and filling up the space with sediment. This has many advantages compared to spreading sediment over parcels or storing it in conventional field depots. Namely, there is no need to look out for space on land where it is allowed to spread out sediment and sediment can be reused to create nature in stead. This makes it no more a burden, but an asset this way. Furthermore, both transportation and processing costs are minimized and also CO$_2$ emissions. Keeping sediment under anaerobic conditions inhibits decomposition as opposed to disposal on dry land. By an amount of 25,000 m$^3$ sediment 900 household equivalents of CO$_2$ emissions can be saved! After two successful pilots in 2013, this summer over 30 constructions are planned to be installed in order to store circa 30,000 m$^3$ of sediment. Both constructions have been functioning well under extreme weather conditions so far. The enclosed water surface behind the Sediment-buffer was totally covered by a pioneer vegetation of reedmace (Typha) by the end of the first growing season. And already two week after installation of the Geo-groyne circa 0,15 meter of sediment had settled down on the lee side.
ABSTRACT

Italy has about 8000 km of coastline, which is densely populated and has a strategic role for the national economy owing to the intense touristic, industrial and harbor activities carried out. The marine areas facing the coasts are often heavily polluted in the sediments. Many Sites of National Concern (SNCs) include sea areas, resulting in about 140000 hectares that need urgent characterization or remediation actions. On the other hand, many non-SNC sites still have to be dealt with, as well as many cases of polluted sediments in surface water bodies spread all over the national territory. No official data are available about the amount of sediments dredged in Italy, but 30 to 40 million cubic meters a year can be estimated. The number of laws pertaining to the topic also tangles the management of these materials, which somehow are perceived and managed as a waste. The development of sustainable management schemes is necessary to overcome the major issues in the sediment management.

In this work, the situation of contaminated sediments in Italy is presented, with particular focus on the scale of the problem, the management options and the major research activities carried out by either Italian universities or private companies to deal with dredged materials. The projects carried out at national level are the basis for interesting and innovative management scenarios in the next future.
THE AMORAS PROJECT – DEWATERING OF THE ANTWERP PORT SEDIMENTS: ENVIRONMENTAL EVALUATION REGARDING ACCEPTANCE, STORAGE AND REUSE OF SEDIMENTS

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ABSTRACT

To process the sediments, obtained during the dredging of the channels and docks of the Port of Antwerp, the Flemish Government in association with the Port of Antwerp have constructed AMORAS, an installation for mechanical dewatering of sediments, using the dewatering technique with membrane-chamber filter presses. At short distance of the dewatering plant a former sand quarry, filled in the ’80s with maintenance sediment of the port of Antwerp, is being transformed to a deposit area to store the dewatered sediments (filter cakes).

The acceptance of sediments at AMORAS is bounded to the chemical quality of the material and the fraction of sand. Chemical standards have been worked out to determine if and how sediments can be accepted at AMORAS. Slightly polluted material can be disposed in the underwater cell allowing constant supply and homogenization of the material. Giving the available capacity of the plant, sediments are dredged out of the cell for sand removal and further dewatering. More contaminated sediments have to be pumped directly out of the barges for processing at AMORAS. Actually only slightly polluted material is accepted at AMORAS.

Until the construction of the disposal site is finished (approximately mid-2015), the filter cakes are used as a construction material to level and profile the former sand quarry and build the base layer of the deposit site. As the dewatered sediments have a very low permeability, this material is suitable to form an aquiclude guaranteeing protection for soil, groundwater and surface water. Later more contaminated, hazardous sediments could be allowed at AMORAS, however limited by the capacity of the water treatment plant to process more polluted waste water.

Different studies investigate the possible reuse of non-polluted filter cakes in bound applications (e.g. substitution of clay in bricks, use of pozzolanic characteristics (as binder)) or unbound applications (e.g. use as impermeable liner or barrier after treatment with polymers). According to the Flemish legislation waste can be used as a raw material if complied with specific standards. Intense monitoring shows that the filter cakes comply with the raw material-standards except for total petroleum hydrocarbons (TPH). However, applications requiring a thermal treatment of the material are possible as the TPH will be incinerated. In addition, for each application in a bound application specific leaching tests have to be carried out to determine if complied with the standards for bound applications. Only few results of these tests are though actually available.
APPLICATION OF INTEGRATED NUMERICAL MODELS IN CONTAMINATED SEDIMENT SITES: EXAMPLES OF COUPLING SEDIMENT, CONTAMINANTS AND GAS FATE

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ABSTRACT

Numerical models represent a powerful tool for supporting the management and restoration of contaminant sites. Numerical models offer critical support for decision making at all stages of the clean-up process: from initial assessment, to remedial strategy selection and implementation, construction and monitoring. Numerical models are especially valuable for the assessment of contaminant transport and fate. The dynamic of contaminants are complex and characterized by different coupled physical processes. Specifically, contaminants are generally found in the water column, adsorbed to (fine) sediments or transported in the form of gas bubbles from within the sediment bed to the surface. Therefore, accurate estimate of contaminant fate requires a comprehensive understanding of the physical environment, and numerical models suitable for resolving the dominant physical processes. Here we present a number of applications of state-of-the-art integrated numerical models applied to contaminated sediment sites. Specifically, we demonstrate how flow discharge, waves, sediment properties and vegetation influence the transport of sediments, hence the fate of contaminants; and how a sand cap mitigates gas ebullition within the sediment bed and the flux of contaminants to the surface. All the models utilized in these studies are open source to encourage further developments within the user community.
THE NON-LINEAR ANALYSIS AND EVALUATION OF THERMODYNAMIC ADSORPTION OF METHYLENE BLUE BY NATURAL MOROCCAN ILLITE CLAY

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ABSTRACT

The Merja Fouarate Lake is an aquatic system that has achieved a high degree of eutrophication in recent decades. To remedy this problem, the lake system needs a dredging operation. In order to enhance the dredged sediments of this lake in the treatment of discharges from textile industry which are rich on dyes, a study of their adsorption capacity is required.

The granulometric and mineralogical study of dredged sediments from the Lake has to classify them as sediments with high clay content (50%), and which the percentage of illite phase is around 20% while that of kaolin is of 30% and smectite reaches 50%.

The approach used for this global study, which aims to model the adsorption of dyes on the dredged sediments consist on studying the adsorption of different dyes on different families of clays, and this to achieve modeling adsorption of discharges on real sediment of lake.

This work is a contribution in this larger study and aims modeling adsorption of a cationic dye which is methylene blue on illite clay from a deposit located in the region covered by the channel that feeds the Merja Lake with water, and helps in the formation of dredged sediments.

The modeling of adsorption isotherm data is important to predicting the performance of the adsorption, hence the necessity to use models explaining liquid / solid adsorption, and the equilibrium conditions of this process. The experimental data obtained in the static mode (batch), at different concentrations were analyzed using six isotherm models. To determine the best model to describe isothermic adsorption of MB on illite clay used, the non-linear model with five error functions was used to evaluate the experimental data.

The error analysis showed that the model KHAN best describes the adsorption data of MB on MINC. In addition, the nature of adsorption was determined from the isotherm parameters, and resulted to conclude that the physisorption is the appropriate mechanism for this adsorption.

Moreover, thermodynamic data obtained indicated that the adsorption of Methylene Blue on a natural illite is exothermic, spontaneous and favorable process.
APPLICATION OF LINEAR AND NON-LINEAR METHODS FOR ESTIMATING PARAMETERS OF ADSORPTION ISOTHERMS OF THE BLUE METHYlene ON A LOCAL ILLITE CLAY

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ABSTRACT

With the aim of enhancing sediments dredged from Lake Merja Fouarate who knows a great degree of eutrophication, our choice fell on the study of the possibility to use them as absorbents in the treatment of discharges from textile industries. The granulometric characterization of the sediments showed that they are clay with around 20% illite fraction. In order to model the adsorption of dyes on these sediments, our choice fell on an adsorbent which is illite clay from a deposit located in the area covered by the channel that feeds the lake with water, and the adsorbate chosen is Methylene Blue. This work involves comparing the linear and nonlinear methods to estimate parameters of two parameters isothermal, and this by using the experimental data of the adsorption of cationic dye on the local illite clay. The study focused on determining the absorption isotherms in static mode according to the method in batch. The equilibrium data were analyzed using isotherms of Freundlich, Langmuir, Timkin and also Redlich–Peterson. The determination of the model for this adsorption was performed using the determination coefficient R² and the Chi –square X². The results showed that non-linear method could be the most appropriate to obtain the best isothermic parameters. However, the adsorption of methylene blue by illite clay is described by the Timkin model with good values of R² and X².
This paper explores the mineralogical changes of four dredged sediment materials that were treated with hydraulic road binder and lime and used in the construction of test roads. The work was undertaken as part of the SETARMS project (funded by EU Interreg IVa France - England) to explore solutions for the sustainable treatment and re-use of marine dredged sediment. The sediments studied in this paper were collected from French ports along the Channel. Sediment samples were investigated immediately after dredging and after dehydration, while the test road samples were collected 30, 90 and 180 days after construction. The sand, hydraulic binder and lime were also analysed for reference. Quantitative data on mineral abundances, associations and particle size distributions were obtained with the QEMSCAN® analytical system. Mineral distribution maps reveal the associations and textures of different minerals in the samples, while changes in mineral abundances are used to monitor the stability of the materials after the test road construction.

Sediment samples were found to be relatively homogeneous with each material having a distinct mineralogical signature. The most notable change is a decrease in pyrite (FeS₂) concentrations during dehydration and after road construction. This is important because the breakdown of pyrite can lead to acidity (and heavy metal mobility) and the formation of expansive minerals by reactions with silicate and carbonate minerals in the concrete matrix. In particular, the calcium sulphate minerals (gypsum, anhydrite, thaumasite and ettringite) were found to be highest in one of the test roads after 30, 90 and 180 days. It is anticipated that data for the samples taken at 360 days (the end of the monitoring period) will also be discussed.
SEDIMENT MONITORING AND ASSESSMENT IN THE CONTEXT OF THE WATER FRAMEWORK DIRECTIVE

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ABSTRACT

The Water Framework Directive (WFD 2000/60/EC) aims to achieve the good ecological and chemical status for all waters by 2015. The chemical status protection is defined in terms of compliance with all the environmental quality standards (EQS) established for the chemical substances of the European list of priority (currently 45 + 8). The EQS are concentrations derived in water column, sediment and biota that should protect human health and the environment. The Directive 2008/105/EC and the new Directive 2013/39/EC give a useful role to sediment: Member States have the possibility to derive environmental quality standards for the priority substances in sediment compartment for specific water bodies. Furthermore, the analysis of sediments for specific priority substances is useful for the analysis of the trend in order to comply with the no-deterioration principle.

A large set of guidance documents have been developed in the context of the common implementation strategy (CIS) of the WFD (Guidance No. 25 – Chemical Monitoring of Sediment and Biota and Guidance No. 27 – Deriving Environmental Quality Standards are the most relevant for the sediment compartment). CIS Guidance No. 25 describes the conditions for monitoring chemicals in sediments, including sampling design, of ecotoxicity methods in a Triad approach, combining the three assessment methods: chemical, bioassay, and ecology. Specific references are made to toxicity identification evaluation (TIE) and effect-directed analysis (EDA), which combine biological and chemical analysis with physicochemical manipulation and fractionation techniques.

Guidance No. 27 describes the derivation of the environmental quality standards. A log $K_{ow}$ of ≥3 is used as a trigger value for the assessment of sediment effects for organic chemicals. Some substances can occur in sediments even though they do not meet these criteria so, in addition, evidence of high toxicity to aquatic organisms or sediment-dwelling organisms or evidence of accumulation in sediments from monitoring, would also trigger derivation of a sediment EQS. The methodology is also based on the TGD but has been updated with additional guidance, including that developed for pesticides. The quality standards for the sediment are derived using the equilibrium partitioning method or the assessment factor method as described for REACH, and there are additional recommendations for using mesocosm studies and higher tier methods. It should be noted that the sediment EQS can only be used for the first tier assessment; if the measured concentrations exceed the sediment EQS, and the sediment EQS is not scientifically robust for taking the final decision, site-specific assessments of the benthic community are conducted for assessing the chemical and ecological status.
The SETARMS project
Improve the assessment quality of the sediment by using the comparison of the
dredging operations regulations in different European countries

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ABSTRACT

The English Channel is acknowledged as one of the busiest shipping lanes in the world
and fishing is also a key industry. To accommodate the ever increasing size of modern
ships in European ports and waterways, and to prevent natural silt ing up of harbour
entrances, significant dredging activity is constantly required to enlarge, deepen and
maintain harbour access and achieve appropriate water depths along waterside facilities.
These dredging activities are essential for the local economy and generate dredging
materials. Sediment management faces tighter regulation and the scarcity of land for
storage. To tackle this challenge that concerns so many stakeholders on both sides of the
Channel ports managers and owners, public works companies, research labs, etc – a
Franco-British partnership was created to research common solutions, with the support of
the EU programme INTERREG IVA France (Channel) England. This partnership gathers
ports, local authorities, universities and private companies. It allows to this project to be
realistic, pragmatic and innovative.
The project is organised in 3 technical work packages:
  1 - Overview of the current situation on dredging in the Channel
  2 - Sediment characterisation
  3 - Stimulate and validate new methods to re-use dredged sediments in civil
engineering.
The objective of the work package on the “Overview of the current situation on dredging in
the Channel” is to develop the sustainable management of the dredging operations, based
on works on the economical, technical, environmental and social criteria. In order to
exchange best practices and to improve our knowledge, we studied the regulations used in
many European countries and the best practices to limit the environmental impact. We
also listed the existing governance tools which tackle the dredging operations at various
scales. The comparison of all these regulations and techniques shows heterogeneity
between countries but also some similarities. The ways used to assess the sediment are
various. Many techniques already exist to limit the environmental impact during the
dredging operations. In parallel ports managers can face difficulties to find them.
The SETARMS project: Presentation of the different means to pool the dredging operations

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ABSTRACT

The English Channel is acknowledged as one of the busiest shipping lanes in the world and fishing is also a key industry. To accommodate the ever increasing size of modern ships in European ports and waterways, and to prevent natural silting up of harbour entrances, significant dredging activity is constantly required to enlarge, deepen and maintain harbour access and achieve appropriate water depths along waterside facilities. These dredging activities are essential for the local economy and generate dredging materials. Sediment management faces tighter regulation and the scarcity of land for storage. To tackle this challenge that concerns so many stakeholders on both sides of the Channel ports managers and owners, public works companies, research labs, etc – a Franco-British partnership was created to research common solutions, with the support of the EU programme INTERREG IVA France (Channel) England. This partnership gathers ports, local authorities, universities and private companies. It allows to this project to be realistic, pragmatic and innovative. The work package on "Overview of the current situation on dredging in the Channel" was lead by the APLM. One of the objectives of this work package is to suggest pooling solutions regarding the dredging operations. So we show that we have economic means to decrease the costs of the dredging, as purchasing a dredging vessel with some ports or to launch a tending joining some ports. The Channel is divided in 2 parts, east part with big volumes and high frequencies of the dredging operation and West part with low frequency and smaller volumes.

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![Map of the English Channel and its ports.](image)

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<table>
<thead>
<tr>
<th>Port</th>
<th>Frequency of Dredging</th>
<th>Volume of Dredging</th>
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</thead>
<tbody>
<tr>
<td>Calais</td>
<td>2-4 times per year</td>
<td>400,000 m³</td>
</tr>
<tr>
<td>Boulogne</td>
<td>1 time per year</td>
<td>50,000 m³</td>
</tr>
<tr>
<td>Cherbourg</td>
<td>10 times per year</td>
<td>None</td>
</tr>
<tr>
<td>Caen</td>
<td>2-5 years</td>
<td>600,000 m³</td>
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</tr>
</tbody>
</table>

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*Calendrier annuel des périodes d'immersion*

- Janvier, Février, Mars, Avril, Mai, Juin, Juillet, Août, Septembre, Octobre, Novembre, Décembre

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![Calendar of immersion periods.](image)
« Sédimériaux » : Sustainable management of dredged sediment in France

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ABSTRACT

The SEDIMATERIAUX approach aims to provide an appropriate response and dimensioned to the issue of on land management and reuse of port and river dredged sediment. The five partners SEDIMATERIAUX approach are: the Ministry of ecology and sustainable development, the Nord-Pas Calais prefecture, the Nord-Pas de Calais regional council, the school of mines Douai, the center of development of eco-companies (CD2E).

SEDIMATERIAUX is a collective approach on a national scale, which brings together local will in the quest for innovative and operational solutions. In its content SEDIMATERIAUX includes carrying in a controlled environmental framework, several operational structures to a limited scale but significant, incorporating port and river dredged sediment: embankments, roads, aggregates fight against coastal erosion, concrete, etc. These works (road, embankment, blocks...) will demonstrate technical, environmental, economic and societal feasibility of one or more beneficial reuse of sediments and provide essential data for the regulatory evolution of on land sediment management. The objectives of Sédimétriaux approach are:

- Propose to port and river managers operational tools for sediment management,
- Produce the necessary data to the MEDDE for the regulatory framework evolution,
- Emerge and consolidate new economic waste treatment and management of sediment in a controlled environment,
- Create sustainable conditions for sharing of experiences and the capitalization of knowledge, Encourage innovation and structure the development of R & D.

Based on the SEDIMATERIAUX methodology and achievements, a euroregional resource center SEDILAB (SEDiment LABoratory) was created in June 2013 in the Nord Pas de Calais region in France. With three major strategic harbors and over 600 kilometers of waterways, this region is strongly concerned by the sediment management issue. Since several years, the Nord-Pas de Calais region leads a large reflection to find sustainable solutions on this issue and is accompanied by scientific and industrial actors. Steered by the cd2e, SEDILAB relies on site activities and on achievements over last ten years in this area; the resource center intensifies the performed activities in the framework of the SEDIMATERIAUX national approach.
SUSTAINABLE REMEDIATION OF LEAD IMPACTED SEDIMENTS IN AN ECOLOGICALLY SENSITIVE AREA

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ABSTRACT

ERM Belgium has assisted Exide Technologies with the sustainable remediation of lead impacted river sediments for their facility located near Brussels. At the facility, batteries were produced in the period 1908-1996, following which the site was acquired by Exide. Historically, the site industrial waste waters were discharged into the Dijle river branch crossing the site, resulting in lead impacted sediments. ERM performed detailed investigations to delineate the impacts in the river bed, estimated the total contaminant mass present and evaluated the potential risks associated with the impacted sediments. The total contaminant mass (lead) was estimated at about 50 tons, and remediation was required to eliminate potential migration of impacted particles towards the main river, flowing down gradient through an ecologically sensitive area (EU Habitats Directive; Special Area of Conservation).

The remedial option assessment was completed in consultation with both the Flemish and Walloon environmental authorities, as the river branch forms the natural border between both regions. Furthermore, the organization and planning of intrusive works on site were to comply with specific guidelines as the site is located within a Special Protection Area of the EU Birds Directive and a groundwater protection zone. A mandate also had to be obtained from the environmental authority that manages category 1 rivers. In order to fulfil the applicable legislation guidelines, ERM adopted the SurfUK guidelines whereby the optimum remediation solution is selected through the use of a balanced decision-making process.

In particular, a qualitative assessment was performed for social indicators covering specific neighbourhood and locality aspects and also human health and safety. Neighbourhood and locality concerns implied consideration of third party activities in the project area and respecting the valuable landscape. Transparency towards the multiple administrative bodies involved was also considered a key social indicator for this project. With respect to the economic indicators, both the direct and indirect economic costs and benefits were evaluated. A very important economic indicator proved to be the project lifespan and flexibility given the importance of a robust solution. Environmental indicators were assessed on a qualitative basis and focussed on ecology and the eco-system, covering aspects such as poisoning, loss of habitat and the impacts related to potential disruption of soil and modifying structural elements of the water body. Both short and long term effects had to be considered in the ecological evaluation.

This exercise resulted in a combined approach of focused mass removal and the installation of a capping on top of the residual impacted sediments and soil as the most sustainable solution to eliminate the potential migration risks. Main drivers for this combined approach were avoiding long distance transport of thousands of tonnes of
contaminated sediment and soil, avoiding the use of remaining landfill capacity and maximal protection of the banks along the river branch, habitat of protected bird species. The environmental impact of transport was also reduced by lagooning/dewatering the sediments on site.

The works were performed in such a way that the initial river bed level was reinstated and original vegetation re-planted on the river banks in line with the specifications of the nature and forest protection agency.

Key project figures are as follows: Remediation period (4 months), Length River Remediated (350 m), Average Capping Thickness (0.5 m), Total Capping surface (1724 m²), Total Removed Sediment Mass (876 t), Total Removed Contaminant Mass (18 t), Total Capped Soil & Sediment Volume (3120 m³), New Vegetation (150 trees).

The environmental aftercare program is ongoing since 2013 to evaluate the efficiency of the capping. The collected surface water samples do not present any concentrations for lead above the surface water quality standards, and migration of impacted sediment particles is no longer occurring. The integrity of the capping is monitored by means of regular sectional level surveys and this monitoring confirmed that the capping has settled as predicted. Finally, the original vegetation on the river bed and banks has been restored via natural seeding processes.

Overall, the works have resulted in eliminating and controlling unacceptable risks in a safe and timely manner, maximising the overall environmental, social and economic benefits.
VALORIZATION OF DAM DREDGED SEDIMENTS AS A COMPONENT OF A SELF COMPACTING CONCRETE

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ABSTRACT

This experimental work is a part of a long research on the valorization of the dam dredged sediments issued from Fergoug Dam (Mascara-West Algeria). These sediments have to be subjected to thermal treatment to become reactive with the cement and thus to obtain an artificial pozzolana. It is therefore a question of developing the calcined silt as substitutable material in part to the cement used in the composition of self-compacting concrete. The objective of the present work is to highlight its influence on the behavior of self-compacting concrete compared to that of the natural pozzolana and this, in fresh and hardened states.

The study is being conducted on three SCC, the first using 20% in volume of natural pozzolana, the second with 20% of calcined silt and the third for the sake of comparison is made with cement only.

The first results showed the possibility of obtaining SCC with calcined silt complying with the AFGC recommendations, having a good mechanical behavior which makes interesting its development as construction materials.