PROCESSES INFLUENCING THE TRANSPORT AND FATE OF CONTAMINATED SEDIMENTS IN THE COASTAL OCEAN pdf

1: Contaminated Sediment Management

Bothner, M.H., and Butman, Bradford (eds.), , Processes influencing the transport and fate of contaminated sediments in the coastal oceanâ€"Boston Harbor and Massachusetts Bay: U.S. Geological Survey Circular , 89 p.

All four themes require attention in the development of an effective management strategy: Organization of the report around these four themes was considered necessary for the committee to make a coherent analysis and respond most directly to the statement of task. This chapter examines the first two themes-regulatory realities and stakeholder interests-external forces that are sometimes influential 1 The regulatory realities theme encompasses both regulatory and legal challenges, whereas the stakeholder interests theme corresponds to political challenges. The last two theme areas are both concerned with chemical challenges. All four themes address management and technological challenges. Page 45 Share Cite Suggested Citation: Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies. The National Academies Press. The decision maker has greater leeway in dealing with site-specific considerations see Chapter 4 and remediation technologies see Chapter 5. It is apparent that each of the four considerations narrows the choice of management strategies and that failure to consider any of them could undermine the effectiveness of a management plan. The remainder of this report is devoted to an examination of the four essential considerations and an analysis of the issues requiring attention and the opportunities for formal changes that could facilitate the management of contaminated sediments in general. The analysis encompasses many of the lessons learned from the case histories summarized in Appendix C. The first consideration, regulatory realities, is paramount. The regulatory framework dictates many of the choices facing decision makers, and attention to its nuances can save time and money. As summarized in Chapter 1 and addressed more thoroughly in Appendix B , a confusing array of federal and state statutes govern, and often impede, decision making in contaminated sediment management. For the project proponent to achieve the project objective e. In some cases, legislative constraints may frustrate the achievement of an optimum balance among risks, costs, and benefits. Consideration of competing stakeholder interests is key to the timely implementation of solutions, which can be delayed for years or even decades if major disputes arise see Table Although many decisions associated with the management of contaminated sediment are driven purely by engineering and fiscal considerations, other aspects of the process are value driven. Remediation endpoints, balancing of various risks, and political acceptability are among the more notable value-driven components of the management process. But these values are rarely absolute. Therefore, it is essential that project proponents involve stakeholders early in the decision-making process to ensure that various viewpoints and concerns can be clarified and consensus building can begin. Project-specific considerations include information-gathering and engineering related to the site in question. These must be handled properly for management efforts to be successful. Project-specific considerations include source control, site characterization, and characterization of the nature and extent of contamination. The key challenge is to determine the types and levels of analysis requiredâ€"that is, to identify the amount of information and engineering that is both necessary and feasible to support site-specific judgments. Further constraints on possible solutions are imposed by the state of the art in remediation technologies. But resources are always limited, and treatment technologiesâ€"the most effective solutions for eliminating contaminants rather than simply containing themâ€"evolve slowly with time and are very expensive. To make the best of a less-than-ideal situation, therefore, the decision maker must select appropriate, available, and affordable technologies and optimize their effectiveness as part of an overall remediation system or process. A fundamental flaw is the apparent inability of regulatory agencies to implement mandated procedures designed to ensure that management decisions reflect an appropriate balance of risks, costs, and benefits. This is a shortcoming of governing statutes and regulations, not a criticism of the regulatory agencies charged with their implementation. Although the committee focused primarily on scientific and technical issues, it also recognized that the best management approaches cannot be implemented without a supportive regulatory framework. This section examines key limitations of that framework with respect to the evaluation of disposal alternatives, the timeliness of decision making, cost allocation, and the shortage of placement options. The ability of agencies to translate sometimes highly technical data into sediment management decisions is not fostered by the regulatory process. As the capabilities for detecting chemical contaminants increase, the level of detail can also be expected to rise. Unfortunately, understanding how the information can best be used in decision making has not kept pace with advances in science, which will make future decision making even more difficult. Evaluation of Placement Alternatives A lack of coherence is evident in current procedures for evaluating placement and management alternatives. The regulatory process under MPRSA places primary emphasis on the intrinsic toxicity of the constituents of dredged material. The process involves biological testing of dredged material to determine if the material proposed for dumping beyond the baseline of the territorial sea will cause unreasonable degradation or endangerment of the marine environment or human health. However, the procedures do not consider fully site-specific conditions e. The counterpart procedures under the CWA consider chemical and physical as well as biological characteristics in assessing whether the discharge of dredged material will cause unacceptable adverse impacts. Although far from a risk-based process, these procedures at least do not specify absolute pass-fail criteria, and they are geared to the identification of the least environmentally damaging alternative that is also practical. Risk reduction is emphasized under the Superfund remedial action program. Site-specific remedies are chosen based on "exposure assessments" during the feasibility study, and remedial alternatives are identified based on their capability to reduce risks of exposure to an acceptable level. But there are no risk-based cleanup standards for underwater sediments at present. The final selection now involves choosing the most cost-effective alternative. In sum, each set of regulations uses a different approach to assess remedial alternatives, and none considers fully the risk posed by contaminated marine sediments. Although inconsistency alone is not necessarily a major problem, when it is coupled with insufficient attention to risk, it can impede the cost-effective management of contaminated sediments. Cost effectiveness is further impeded by the failure of the MPRSA and Superfund to consider fully the practicality of remedial alternatives, including their economic and technological viability. The CWA does take these issues into account, although, perhaps, it does not emphasize them sufficiently 3 Risks need to be considered more fully to ensure that they are not underestimated or overestimated Similar inconsistencies and inattention to risk are evident in the permitting processes for sediment placement. Page 48 Share Cite Suggested Citation: As an example of the anomalies created, the current regulatory regime does not adequately address risk management, focusing instead on the type of activityâ€”removal, containment, or treatment. This misdirected attention can lead to wasted time, energy, and expense, not to mention the possible failure to reduce the risks to human health and the environment. The problem could be overcome, in part, by the development of a consistent or parallel set of risk-based regulatory requirements for evaluating dredged sediments that do not differentiate absent a compelling technical justification among inland, estuarine, and ocean placement but do take into account site-specific biological, chemical, and physical conditions that bear on risks to the environment and human health. To be complete, the regulatory scheme must also consider the relationship between environmental and economic costs and benefits. The overall effect of these changes would be to raise the regulatory focus from mechanical details i. Timeliness of Decision Making Another problem posed by the current regulatory framework is the potential for unnecessary delays. Timely decision making is important to minimizing costs, given that delays can impose both economic and environmental costs. Page 49 Share Cite Suggested Citation: The regulations, which have evolved over many years, have led to widely varying time frames for decision making. Superfund remedial response can often take many years to identify and implement. Permit decisions under the MPRSA and CWA can be made within a few months of the application when small quantities of uncontaminated dredged material are involved and placement alternatives are identified, but decision making can take many years for larger navigation dredging projects or for projects with complex problems of sediment placement. The Port of New York, for example, recently had to wait more than three years to obtain a maintenance dredging permit. One problem is the multiplicity of federal and state regulatory and resource agencies involved in the management of dredged sediments. Another problem is that the USACE, as lead agency, is confronted with difficult decisions when the placement of contaminated sediment is controversial and stakeholders have been unable to arrive at a clear consensus. A federal interagency working group, under the auspices of the Maritime Administration, recently recommended a series of steps to improve the timeliness of decisions concerning dredging permits Interagency Working Group on the Dredging Process, A National Dredging Team composed of seven federal agencies was formed to implement the recommendations of the interagency report and to serve as a forum for resolving dredging issues. Regulatory reform initiatives pending in the U. Congress range from broad-based reforms to specific reforms to realign or consolidate permitting authority under the CWA. Timely decision making can be facilitated by interpreting regulations based on the intent of the underlying statute s. The EPA has shown a willingness, on occasion, to be flexible, within legal constraints, in the application of regulations. This was demonstrated in the Port of Tacoma case history, where CWA restrictions on avoidable discharges of dredged material were interpreted in such a way that implementation of an innovative and ultimately successful cleanup plan was permitted. In the Port of Tacoma case, the EPA expressed a preference for near-shore disposal only "in conjunction with projects that otherwise would be permitted as commercial development" which otherwise would be permissible and would require separate fill projects. This approach enabled the EPA to approve the Tacoma project as one that minimized physical impacts to the near-shore environment by averting filling solely for the purpose of sediment disposal. Page 50 Share Cite Suggested Citation: But this commendable focus on underlying objectives is discouraged rather than promoted by the current regulatory framework, which, as demonstrated by the examples given earlier in this section, tends to specify rigid criteria and procedures. One way to promote the achievement of objectives is to emphasize risk-based end-points rather than specific processes. The development of site-specific, environmentally acceptable end-points may provide risk-based performance standards. In the meantime, flexible interpretations of the regulations may be helpful. Cost Allocation Cost allocation is another area in which regulations may hinder efficient decision making. This provision creates a bifurcated approach to cost sharing, in that the federal government pays for most usually 75 percent 6 of new-work dredging and, with the help of a trust fund that collects user fees, all maintenance dredging. But the government does not pay for the costs of sediment placement on land. The project cooperation agreement also creates two unfortunate incentives. Second, an approach that places the full cost of land-based placement on the project sponsor creates little incentive for the sponsor to seek out opportunities for the beneficial use of sediment, which usually add to the project cost and may benefit a party other than the proponent. Beneficial uses are discussed later in this chapter. Cost allocations for dredging are also inconsistent. Ports are not required to share directly in the costs of maintenance dredging, but federal requirements under WRDA compel local sponsors to share in the costs of new-work dredging, with the percentage depending on channel depth. In any case, problems with the cost allocation scheme for sediment placement must be addressed. To ensure that decisions are not distorted by ill- 6 Costs of new-work dredging are shared by local sponsors and the federal government, and the cost-sharing percentage is based on channel depth. In most cases, the federal share ends up being 75 percent. Page 51 Share Cite Suggested Citation: At the same time, it would be helpful if consistent approaches to cost-benefit analysis were applied. Currently, an elaborate system of weighing costs and benefits must be used for new-work dredging. Cost-benefit analysis for maintenance dredging is applied inconsistently, and alternatives for the placement of dredged material are initially based on compliance with environmental regulations in which cost is one factor in decision making see Chapter 2. Issues of cost need to be addressed systematically because an inconsistent or incomplete consideration of costs can encourage an irrational allocation of scarce resources. Shortage of Placement Space Even if the changes outlined above were made, there would still be the problem of limited placement space for contaminated dredged materials, an issue that defies easy answers. Although the development of risk-based strategies for regulating the placement of contaminants in dredged material may reduce the quantity of material requiring land-based management, local ports and other private dredging proponents will always be faced with a shortage of placement sites on land. Constraints include dwindling open space, the logistics of transportation and other handling issues, and public opposition to the placement of contaminated materials near populated areas.

2: Shore - Wikipedia

USGS OFR , Processes influencing the transport and fate of contaminated sediments in the coastal ocean - Boston Harbor and Massachusetts Bay.

The range of factors governing transport and contaminant concentrations in marine systems requires that assessment procedures and methods be site specific. A reasonable understanding of site dynamics is also necessary to evaluate the proposed methods of characterization and methods of site assessment in terms of cost effectiveness and scope. This chapter deals with contaminant sources, transport processes, and methods of site characterization. This chapter outlines how appropriate attention to these issues can help control costs and enhance the effectiveness of sediment management. However, the discussion is not intended to provide comprehensive, step-by-step guidance or to evaluate all methods that may be applicable. The emphasis is on the need for a systematic approach that couples site-specific information with remedial efforts. For each project, the time and resources required for source control and site assessment need to be weighed against the projected benefits of these activities, the availability of quantitative data, and the need to proceed with site management. Source control is advisable in all situations. Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies. The National Academies Press. Failure to control the source of contamination leads to the recontamination of newly exposed sediments, in which case remediation efforts have to be considered unsuccessful. Source control is not, however, easy or inexpensive. In some cases, contaminant source s cannot be identified. Even if they can be pinpointed, some types of contamination, such as atmospheric fallout, are difficult or impossible to control. Another difficulty is the question of who is responsible for source control. From the standpoint of both economics and fairness, the costs of prevention and control ought to be borne by the polluter s and internalized into their production costs. But those responsible for sediment contamination are not always and sometimes cannot be held to that standard. Thus, under current regulations, the burden for source control is not distributed equitably, which means that some sources of contamination are not controlled at all. Source control is used more often in environmental remediation projects, which are usually funded by the government i. In Superfund site cleanups, a legal mechanism may be available to force upstream sources of contamination to bear an appropriate share of remediation costs and even to require the abatement of ongoing releases. However, in navigation dredging projects, the local port authority or other dredging proponent usually has little leverage over upstream polluters and, in the case of atmospheric deposition, virtually none over polluters outside the watershed. Thus, contamination may persist, leading to a continuing need to dredge and redredge contaminated sediments, which is costly and politically unacceptable. Source control could be encouraged in navigation dredging projects through regulation, as long as the question of who pays is resolved in a manner that is acceptable to all parties. A port cannot be expected to finance source control as well as sediment remediation allocation of remediation costs is discussed in Chapter 3 when it is not responsible for the initial contamination. The primary focus needs to be on the development and implementation of state and federal pollution prevention programs aimed at reducing or eliminating the sources of sediment contamination. Regulators have long recognized that the identification of upstream sources of contamination is essential for the progressive improvement of water quality. The logic of this approach applies equally to contaminated sediments. Page 64 Share Cite Suggested Citation: In situations where watershed planning has failed and identifiable upstream sources have contributed disproportionately to sediment contamination downstream, the EPA could be authorized to recover an appropriate share of cleanup or disposal costs from the responsible parties. One chapter describes how the water program Office of Water will permit municipalities and industrial facilities to meet SQC. The EPA has also initiated an inventory of sites and sources of sediment contamination using information from national databases. Understanding these factors can help minimize project costs, foster the development of efficient and effective sampling plans, and assist in the selection of optimum remedial schemes. This section outlines the primary factors. The distribution of contaminants in the coastal marine environment is determined by complex interactions among meteorological, hydrodynamic, biological, geological, and geochemical factors. Interactions within and among these factors result in a transport system with wide variations, both spatial and temporal. This variability complicates site assessment surveys and requires that care be taken to specify the frequency and location of field samples. Usually the time scales range from hours to months and are reasonably 1 This approach, although it might be difficult to implement, could be designed to address sources of sediment contamination. Although resolution of source control problems is outside the scope of this report, these issues warrant further attention. Both documents are in development as of this writing. Page 65 Share Cite Suggested Citation: The patterns are sometimes disturbed, however, by high-energy storms, which can displace large amounts of sediments and significantly alter the distribution and availability of contaminants. Thus, comprehensive site assessments need to include consideration of the effects of both long-term, periodic variations and infrequent, but often high-energy, aperiodic events. Beyond the issue of spatial and temporal variability, assessment of coastal marine sites can be further complicated by the inherently nonlinear behavior of the transport system affecting the distribution and availability of contaminants. System response seldom displays simple functional dependence on force magnitude. Thus, evaluations typically need to consider other factors, such as the history of disturbances or antecedent conditions. For example, the effects on water-column mixing, of winds of identical velocity and duration vary greatly depending on the direction and magnitude of tidal conditions. These and other nonlinear tendencies are particularly pronounced in the processes that govern the transport of fine-grained, cohesive sediments. Fine-grained silts and clays inorganic particles less than 60 micrometers in diameter , because of their relatively large surface-area-to-volume ratio and electrochemical character, are the favored adsorption sites for most contaminants found in coastal areas Gibbs, ; Moore et al. These sediments enter the system from a variety of local, upstream, and offshore sources and can be transported initially as discrete particulates suspended in the water column. Larger, sand-sized particles are moved closer to sources by sedimentation, whereas fine-grained particles are readily dispersed. With time, individual particles come together to form larger-diameter aggregates as a result of either physicochemical coagulation or biologically mediated agglomeration. In the water column, the sizes of these aggregates and their associated settling velocities are controlled by the balance between collision and breakup forces induced by flow-associated shear. This force balance continuously changes as the particles migrate through differing flow regimes caused by horizontal advection and turbulent mixing. The process continues as long as flow energy and the associated boundary shear stresses are high. As energies decrease as in many estuaries and dredged channels , aggregates settle to the sediment-water interface, forming a loosely consolidated, high-water-content surficial deposit NRC, , often referred to as a "fluff layer. Cohesive sediments tend to consolidate slowly because of the weights imposed by the cyclic loading of surficial materials and because of a response to the increasing burden imposed by persistent net deposition acting in combination with the varying surficial load. This process favors the development of a column of sediment in which physical strength and associated erodibility vary significantly with depth. Page 66 Share Cite Suggested Citation: The sediment-water interface represents a relatively distinct chemical boundary separating the generally oxygenated water column from an anoxic sediment column. This transition, typically occurring within a few centimeters of the interface, favors reducing conditions within the body of the sediment column and the dominance of facultative and anaerobic bacteria. Changes in pH an indicator of acidity and Eh a measure of oxidizing potential associated with this transition can directly affect sediment contaminant availability, altering the degradation of organic matter and providing a sink for selected trace metals. The latter process can be particularly pronounced in sulfate-rich seawater, resulting in the precipitation of trace metals by sulfides in the anaerobic pore waters and the subsequent down-gradient diffusion from surficial, aerobic sediments to the deeper anoxic pore waters. The rates of degradation of organic matter are also affected by the shift from oxidizing to reducing conditions within the upper levels of the sediment column the redox gradient , with more effective microbial degradation of bioavailable compounds of concern e g. These processes slow significantly within the deeper anoxic regions of the sediment column, often resulting in contaminant half-lives on the order of years. The tendency of fine-grained materials to assimilate and concentrate nutrients and organic substances attracts a diversity of macrobiota, particularly within the upper 20 to 40 centimeters cm of the sediment column. The activities of these deposit and filter-feeding organisms significantly modify sediment fabric by burrowing and altering surface roughness, internal porosity, and physical strength. These modifications, known as bioturbation, can be expected to alter contaminant transport pathways and the overall erodibility of the sediment deposit. The combination of physical transport, chemical interactions, and biological processing results in sediment deposits typically characterized by horizontal gradients that are weaker than vertical gradients. The depositional sequence described above favors the formation of a mobile, near-surface layer of material overlying a reasonably well-consolidated and virtually immobile interior Hayter, ; Ross and Mehta, , Bohlen, The mobile layer, which is subject to diffusive or advective processes, is generally confined to the immediate sediment-water interface and is seldom more than 2 to 4 cm thick. Boundary shear stresses produced by the prevailing flows are sufficient to displace only the upper portions of this region, including the fluff layer and a thin underlayer no more than 1 to 2 millimeters mm thick. Displacement of the entire mobile layer requires boundary shear stresses that occur only during major storms. The deeper interior region, below the mobile layer, is even more resistant to transport and can be considered immobile in the absence of loadings extreme enough to produce mass failure of the entire deposit. This vertical gradient in erodibility has profound implications Page 67 Share Cite Suggested Citation: The variety of factors affecting sediment erodibility makes it difficult to predict the response of a given deposit to a specified range of forces. Deposition rates, chemical environment, and biological activity can vary significantly, both spatially and temporally. This complexity directly affects the fabric of the sediment column and typically precludes the development of a generally applicable transport algorithm. As a result, erosion rate models require site-specific data. The application of site-specific formulas can be complicated further by the sensitivity of a given region to disturbances. Typically, the first storm of the season, acting on a sediment surface formed during an extended period of low transport energy, displaces a significantly larger mass of sediment than subsequent events. These differences in response are often difficult to specify quantitatively, complicating the development of predictive numerical models for site assessment or management. This approach expands on the one outlined in Chapter 2 , Figure The remainder of this chapter outlines the elements of this approach. The committee views this kind of approach as having the best potential for achieving overall cost effectiveness and for clearly focusing on survey and remediation efforts. Focus means having a clear definition of project objectives, the satisfaction of which is the sole purpose for acquiring survey data, characterizing contaminant distributions and availability, and designing and selecting remedial schemes. None of these activities is an end in itself; each is justified only to the extent that it contributes to the fulfillment of project objectives see Box Use of Historical Data To ensure the cost-effective management of contaminated sediments, site characterization needs to begin with a review of the past and present uses residential, commercial, and industrial of waterways and adjoining lands. An understanding of past uses can place some bounds on the range of contaminants stored within the sediment column and highlight important geographical or archeological features of the site. The knowledge of present contaminant discharges and local transport dynamics can provide an immediate indication of the long-term effectiveness of a contaminant removal strategy and the overall advisability of proposed uses of the site. Source control is an important element in the management of contaminated sediments. Although data gathering requires resources, failure to identify the historical features of a site can also result in wasted time and money. The committee developed the following list: An understanding of site history, existing conditions, and dynamics is needed for the design and implementation of a successful management plan. The process of site assessment is complex and expensive, but it is possible to obtain the information necessary for making informed decisions. There is always some uncertainty associated with any decision; if one waits until all uncertainty has been eliminated, then no decision will ever be made. Data gathering must focus on meeting specific needs; data gathering is not an end in itself. Good site assessment results in minimum-cost projects that meet cleanup objectives. Marathon Battery case history, in which remediation plans had to be redesigned to accommodate the late discovery of an old gun-testing platform see Appendix C.

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3: Marinna Martini

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Carleton, James N Project Period: September 1, through August 31, Project Amount: The latter is the most abundant, ubiquitous, and understudied class of organic contaminants in aquatic sediments. The term UCM is derived from traditional gas chromatography and refers to a hump of unresolved, and hence unidentified, hydrocarbons in gas chromatograms. Unfortunately, the ability to follow environmental weathering of petroleum in the environment has been hindered with traditional techniques once resolved compounds such as normal and branched alkanes are removed or degraded. This acronym is used because orthogonal gas chromatographic separations are used in both analytical dimensions by employing stationary phases with different selectivity. The thermal modulator uses a stream of cold gas to trap eluent from the first-dimension column and then hot gas to desorb, spatially compress, and inject these portions into the second column. Injection into the second column is very fast and produces a peak width on the order of 80 ms. Narrow peaks allow fast chromatography in the second dimension, where as many as 10 separate peaks have been observed in a 5 s chromatogram. With this increased separation capability, my research group was involved in several laboratory and field-based studies on studying petroleum hydrocarbons in the environment. Numerous petroleum-related projects were studied in this project. Here, we will highlight are results from accidental oil spills from the Bouchard , Bouchard 65, and Florida and several laboratory-based biodegradation experiments. We will also present work that investigated the petroleum hydrocarbons seeping from the Santa Barbara oil seeps Santa Barbara, California. The latter occurred on April 25, , when the barge Bouchard spilled approximately , liters of No. To gain a better understanding of the natural processes affecting the fate of the spilled product, we collected and analyzed oil-covered rocks from Nyes Neck beach in North Falmouth, Massachusetts. In one study, which is in press in Environmental Forensics, we presented results from the analysis of samples collected on May 9, , and 6 months later, November 23, Along with standard GCxGC analysis, we employed unique data visualization techniques such as difference, ratio, and addition chromatograms to highlight how evaporation, water washing, and biodegradation weathered the spilled oil. These approaches provide a new perspective to studying oil spills and aide attempts to remediate them. In the other manuscript on the Bouchard oil spill, which was recently submitted to Organic Geochemistry, we closely examined changes in the distribution of petroleum hydrocarbons on rocks collected at Nyes Neck in early June We then compared these data to the radiocarbon content of bacterial phospholipids found on the rocks. This study revealed that bacteria were respiring only n-alkanes and incorporating this petroleum-derived carbon into the bacterial biomass of a predominantly algal microbial community during intrinsic bioremediation. We have also investigated two local sites in Cape Cod where studies on the long-term fate of petroleum hydrocarbons in salt marsh sediments are underway. The barge Florida spilled approximately , L of diesel fuel on September 16, , and marsh sediments near Wild Harbor were severely impacted. A sediment core collected in revealed that oil still persists at sediment depths of 8 to 20 cm. On October 9, , the barge Bouchard 65 spilled an undetermined amount of its cargo also diesel fuel and contaminated Winsor Cove, which is located about 4 km north of Wild Harbor. We believe that the environmental conditions at the two sites have lead to these differences. Significant amounts of naphthalenes and larger aromatics remain at the Wild Harbor site, because the oil resides in buried anoxic sediments and are not fully exposed to environmental weathering mainly water washing. At the Winsor cove site, aromatics are greatly reduced in concentration because the oil remained in the near-surface sediments where water washing has likely occurred. At both sites, branched and cyclic alkanes comprise the majority of the remaining petroleum hydrocarbons. The n-alkanes at both locations have been biodegraded. We are currently preparing one manuscript and a book chapter on this work. To investigate how bacteria biodegrade diesel fuel in the marine environment, we compared the weathering patterns that can be generated in laboratory cultures to what we observe in Winsor Cove. By incubating some of the original Bouchard 65 fuel oil with marine microbes, we were able to confirm some preliminary hypotheses regarding the recalcitrance of some compounds that we find in Winsor Cove. We believe that compounds, called C5- and C6-decalins, have very complex structures that protect them from microbial attack. This is a very exciting result, because we can now use these compounds as markers of diesel fuel, even when microbes extensively degrade other components of diesel fuel. A manuscript on this work is also being prepared. To gain some perspective on the weathering of oil that naturally seeps into coastal waters, we analyzed samples collected in or near the Santa Barbara oil seeps. These oil seeps are considered some of the most active in the world. Currently, widespread seepage of hydrocarbons occurs at offshore faults in the waters of the Santa Barbara basin. Estimates of the amount of hydrocarbons migrating into the environment are approximately 37 tons per day, with the gaseous emissions making up 65 percent of this total 24 tons per day. We found that the inventory of petroleum hydrocarbons in both samples was remarkably similar. The latter allowed us to use the amount of tar found in the sediment record as a proxy for emissions of methane from the seeps. A manuscript on this work will be submitted shortly to Nature. In another project, we analyzed samples of oil seeping directly into the ocean, floating on the surface, and on the beach. This study revealed that weathering processes have different kinetics. In particular, evaporation can occur very quickly, whereas water washing is slower. A manuscript on this work will be submitted in the next 3 months. By exploiting n-alkanes as reference solutes in both dimensions, we were able to calculate retention indices that were insensitive to the uncertainty in the enthalpy of gas-stationary phase transfer for a suite of representative components. This work has been recently published in Analytical Chemistry Arey, et al. The resulting two-dimensional retention indices can then be used to estimate the liquid vapor pressures, aqueous solubilities, octanol-water partition coefficients, and vaporization enthalpies of a wide range of petroleum hydrocarbons, which, in turn, can be used to investigate phase transfer processes affecting petroleum hydrocarbon mixtures in the environment. One key result of the powerful relationships developed from these retention indices is that the exact compound structure of each hydrocarbon in each complex mixture does not have to be fully identified to model the effects of phase transfer processes on the complete mixtureâ€”only the retention times for both dimensions need to be known. This dramatically expands the number of compounds that can be used to model processes like water-washing or gas washing, which are typically limited to less than 20 compounds that are within one or two compound classes in traditional gas chromatography. The support from this project also allowed me to continue my efforts in understanding the fate of organic compounds in the ocean and to disseminate these results to the general public and government. In the past few years, I have been interviewed by local and national media print, radio, and television , written several editorials on the need to ban flame retardants in the United States, provided expert testimony on oil spills to the State of Massachusetts and United States Coast Guard, advised the U. Journal Articles on this Report:

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4: Sediment Transport and Deposition - Environmental Measurement Systems

Processes influencing the transport and fate of contaminated sediments in the coastal ocean - Boston Harbor and Massachusetts Bay Open-File Report

Sediment refers to the conglomerate of materials, organic and inorganic, that can be carried away by water, wind or ice 3. While the term is often used to indicate soil-based, mineral matter e. Most mineral sediment comes from erosion and weathering, while organic sediment is typically detritus and decomposing material such as algae 4. Sediment particles come in different sizes and can be inorganic or organic in origin. These particulates are typically small, with clay defined as particles less than 0. However, during a flood or other high flow event, even large rocks can be classified as sediment as they are carried downstream 6. Sediment is a naturally occurring element in many bodies of water, though it can be influenced by anthropogenic factors 8. In an aquatic environment, sediment can either be suspended floating in the water column or bedded settled on the bottom of a body of water. When both floating and settled particles are monitored, they are referred to as SABS: Suspended And Bedded Sediments 4. Suspended Sediment vs Suspended Solids Fine sediment can be found in nearly any body of water, carried along by the water flow. When the sediment is floating within the water column it is considered suspended. The main difference between the two is in the method of measurement 2. Despite the similarity in meaning, the data provided by the different measurement methods are neither interchangeable nor comparable 2. While acceptable for homogenized or well mixed samples with very fine sediment, the TSS measurement often excludes larger suspended particles, like sand 2. Due to the incomparability between suspended sediment measurements and total suspended solids measurements, the U. What is Sediment Transport? Sediment transport is the movement of organic and inorganic particles by water In general, the greater the flow, the more sediment that will be conveyed. Water flow can be strong enough to suspend particles in the water column as they move downstream, or simply push them along the bottom of a waterway Transported sediment may include mineral matter, chemicals and pollutants, and organic material. Another name for sediment transport is sediment load. The total load includes all particles moving as bedload, suspended load, and wash load Sediment can be carried downstream by water flow. Bedload is the portion of sediment transport that rolls, slides or bounces along the bottom of a waterway This sediment is not truly suspended, as it sustains intermittent contact with the streambed, and the movement is neither uniform nor continuous Bedload occurs when the force of the water flow is strong enough to overcome the weight and cohesion of the sediment While the particles are pushed along, they typically do not move as fast as the water around them, as the flow rate is not great enough to fully suspend them Bedload transport can occur during low flows smaller particles or at high flows for larger particles. In situations where the flow rate is strong enough, some of the smaller bedload particles can be pushed up into the water column and become suspended. Suspended Load If the water flow is strong enough to pick up sediment particles, they will become part of the suspended load. While there is often overlap, the suspended load and suspended sediment are not the same thing. Suspended sediment are any particles found in the water column, whether the water is flowing or not. The suspended load, on the other hand, is the amount of sediment carried downstream within the water column by the water flow Suspended loads require moving water, as the water flow creates small upward currents turbulence that keep the particles above the bed The size of the particles that can be carried as suspended load is dependent on the flow rate Larger particles are more likely to fall through the upward currents to the bottom, unless the flow rate increases, increasing the turbulence at the streambed. In addition, suspended sediment will not necessarily remain suspended if the flow rate slows. Wash Load The wash load is the portion of sediment that will remain suspended even when there is no water flow. The wash load is a subset of the suspended load This load is comprised of the finest suspended sediment typically less than 0. The wash load is differentiated from the suspended load because it will not settle to the bottom of a waterway during a low or no flow period Instead, these particles remain in permanent suspension as they are small enough to bounce off water molecules and stay afloat However, during flow periods, the wash load and suspended load are indistinguishable. Turbidity in lakes and slow moving rivers is typically due the wash load 8. When the flow rate increases increasing the suspended load and overall sediment transport , turbidity also increases. While turbidity cannot be used to estimate sediment transport, it can approximate suspended sediment concentrations at a specific location What is Sediment Deposition? When the flow rate changes, some sediment can settle out of the water, adding to point bars, channel bars and beaches. Sediment is necessary to the development of aquatic ecosystems through nutrient replenishment and the creation of benthic habitat and spawning areas These benefits occur due to sediment deposition â€" when suspended particles settle down to the bottom of a body of water. This settling often occurs when water flow slows down or stops, and heavy particles can no longer be supported by the bed turbulence. Sediment deposition can be found anywhere in a water system, from high mountain streams, to rivers, lakes, deltas and floodplains. However, it should be noted that while sediment is important for aquatic habitat growth, it can cause environmental issues if the deposition rates are too high, or too low. Settleable Solids The suspended particles that fall to the bottom of a water body are called settleable solids As they are found in riverbeds and streambeds, these settled solids are also known as bedded sediment 8. The size of settleable solids will vary by water system â€" in high flow areas, larger, gravel-sized sediment will settle out first. Finer particles, including silt and clay, can be carried all the way out to an estuary or delta Salt ions can cause suspended sediment to aggregate and sink to the seafloor. In marine environments, nearly all suspended sediment will settle. This is due to the presence of salt ions in the water. Salt ions bond to the suspended particles, encouraging them to combine with other particles in the water As the collective weight increases, the sediment begins to sink to the seafloor. This is why oceans and other marine ecosystems tend to have lower turbidity levels greater water clarity than freshwater environments While estuaries and other tidal areas may be considered marine, they are not necessarily clearer than freshwater. Estuaries are the collection point for suspended sediment coming down river. Furthermore, in a tidal zone, the constant water movement causes the bottom sediment to continually resuspend, preventing high water clarity during tidal periods The clarity of an estuary will depend on its salinity level, as this will assist with particle deposition Why are Sediment Transport and Deposition Important? Many ecosystems benefit from sediment transport and deposition, whether directly or indirectly. Sediment builds aquatic habitats for spawning and benthic organisms It is also responsible for providing nutrients to aquatic plants, as well vegetation in nearshore ecosystems such as floodplains and marshes Without sediment deposition, coastal zones can become eroded or nonexistent. Sediment and Aquatic Life Sediment deposition creates habitats for aquatic life. While too much sediment can be detrimental, too little sediment can also diminish ecosystem quality Some aquatic habitats are even grain-size specific. Many spawning habitats require a specific sediment size e. Sockeye salmon and other fish require specific sediment materials like gravel to create its spawning bed redd to protect eggs without smothering them. Oregon Department of Fish and Wildlife Too much sediment deposition can also bury habitats and even physically alter a waterway. Excessive levels of suspended load tend to have negative impacts on aquatic life. Suspended sediment can prevent light from reaching submerged vegetation and clog fish gills 8. If a body of water is continually exposed to high levels of sediment transport, it may encourage more sensitive species to leave the area, while silt-tolerant organisms move in 8. On the other hand, too little sediment transport can lead to nutrient depletion in floodplains and marshes, diminishing the habitat and vegetative growth While water clarity is often heralded as a benchmark of water quality, low amounts of turbidity can protect aquatic species from predation In addition, too little sediment deposition can lead to the erosion of riverbanks and coastal areas, causing land loss and destroying the nearshore habitats 10, Where Does Sediment Come From? Sediment comes from geologic, geomorphic, and organic factors The amount, material and size of the transported sediment is a sum of these influences in any particular waterway. Sediment transported in rivers with headwaters from a mountain range often include glacial silt, while a body of water surrounded by swampland will be inundated with decomposing organic material Sediment and Geology Glacial silt comes glaciers scraping over erodible materials. This silt is then carried away by wind and rivers. The exact nature of the sediment is dependent on location, and the geology of that location Glacial-type sediment is common in mountain ranges, while low-lying rivers are more apt to collect soil-based sediment. In high-flow waterways, sediment transport will include local gravel, pebbles and small rocks. Harder rocks are less likely to become sediment, while soft rocks erode quicker and are easily carried away by flowing water The physical make-up of transported sediment is strongly influenced by the geology of the surrounding environment. Specific geologic elements are typically localized, such as basalt near volcanic plate boundaries, or limestone in historically shallow marine regions Sediment transport is often responsible for intermixing these geologic features by carrying mineral particle far away from their origin. Mountains streams full of glacial silt can transport that sediment all the way into a tidal bay

PROCESSES INFLUENCING THE TRANSPORT AND FATE OF CONTAMINATED SEDIMENTS IN THE COASTAL OCEAN pdf

5: Contaminated Sediments Seminar : Speaker Slide Copies

Processes influencing the transport and fate of contaminated sediments in the coastal ocean: Boston Harbor and Massachusetts Bay Circular Prepared in cooperation with the Massachusetts Water Resources Authority, U.S. Coast Guard, and Woods Hole Oceanographic Institution.

However, neither EPA nor any person contributing to the preparation of this document makes any warranty, expressed or implied, with respect to the usefulness or effectiveness of any information, method, or process disclosed in this material. Nor does EPA assume any liability for the use of, or for damages arising from the use of, any information, methods, or process disclosed in this document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Environmental Protection Agency Washington, D. Contaminated sediments may pose risks to both human and environmental health. Such sediments may be found in large sites, such as the harbors of industrialized ports. However, they are also frequently found in smaller sites, such as streams, lakes, bayous, and rivers. This list was subsequently evaluated for specific information regarding sediment contamination, response, action, methods, and performance goals. Twenty percent of these RODs, from 69 sites, addressed potential sediment contamination. Of these 69 sites, remediation was selected for 49; no remediation was selected for 20 i. Of the 49 sites where remediation was selected, 30 chose excavation with treatment as the remedy. The remaining 19 sites utilized excavation followed by disposal containment. Additional evaluations focused on the prevalence of contaminants of concern at all 69 sites. The second most prevalent contaminant group was volatile organic compounds VOCs. Other organic compounds frequently identified were polynuclear aromatic hydrocarbons PAHs and polychlorinated biphenyls PCBs. Cleanup goals varied between sites due to site specific applications of ARARs and risk assessment. Its primary components are interstitial water and soil particles. Interstitial watercan comprise up to 90 percent of the total volume of unconsolidated, top sediment horizons and close to 50 percent of deeper, more compacted sediments. Soil particles found in sediments are derived from surface erosion of soils in the watershed, bank erosion, and redistribution of the bed load in waterways. Sediments vary widely in particle size distribution and are generally finer in texture than their source soils. Segregation of particle size occurs within the water body as a result of currents such that the smaller particles accumulate in quiescent zones and coarser particles are found where the current is greater. Organic matter, another important component of sediment, may range from near zero to greater than 10 percent of the sed iment solid phase. Minor but not necessarily unimportant components of sediments include shells and other animal parts, plant detritus, sewage, and industrial wastes such as metals, other inorganic chemicals, synthetic organic compounds, and oil and grease. Sediments are a very important part of aquatic ecosystems and in and of themselves should not be considered a problem. Sediments can become a problem when contaminated. Contaminants enter the water body from point sources such as municipal and industrial effluents , non-point sources such as agricultural and urban runoff , and other sources such as spills, leaks, and dumping of wastes. Common contaminants of concern include halogenated hydrocarbons PCBs, dioxins, many pesticides, etc. The physical and chemical characteristics of sediments exert a great deal of influence upon the bioavailability of sediment contaminants. These characteristics vary greatly from site to site. As a result, site characteristics should impact remediation decisions. The primary physical characteristic is texture, or the distribution of sand, silt, and clay sized particles. Generally, sandy sediments have little attraction for either toxic metals or synthetic organics pesticides and industrial organics. Fine textured sediments such as silt and clay have a much greateraff inity for all classes of contaminants. Another very important physical property is the organic matter content, including humic material. Humic material is important in two respects: Measurement of sediment in situ water content is also usually important to remediation decisions. The chemical properties of sediments also greatly affect the mobility and biological availability of contaminants. Important chemical analyses include pH, oxidation-reduction, salinity conditions, and sulf ide content as well as the amount and type of cations and anions, and the amount of potentially reactive iron and manganese. Contaminants may be mobilized or immobilized as the physical and chemical environment of the sediment changes during remediation operations. For example, metal carbonates may release their metals if the pH is reduced during removal and treatment. Understanding the influence of the sediment chemical environment, and controlling changes in this environment, are important to the selection of disposal alternatives for contaminated sediments. Material that settles to the bottom of a body of water. EPA Office of Water: Office of Science and Technology Washington, D. Addressing the toxicity of sediments and any potential threat they pose to human health and the environment is an important step in the remediation process. Several kinds of tools are available to use in making decisions concerning sediment quality assessment and desired levels of remediation. Primary tools include environmental regulations and sediment assessment methods. Under CERCLA, Superfund remedial action must meet any federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements ARARs. Environmental regulations can be a source of ARARs and should be understood as part of the assessment and remediation process. To identify levels at which specific contaminants in sediment cause harmful effects, the EPA is developing nationally applicable sediment quality criteria using the equilibrium partitioning EqP method. The EqP approach uses water quality criteria and partitioning coefficients between sediment sorbents and pore water of specific contaminants to derive sediment quality criteria. The sediment quality criterion for a given contaminant is determined by calculating the sediment concentration of the contaminant that would correspond to an interstitial pore water concentration equivalent to the EPA water quality criterion for the contaminant. EqP-derived sediment quality criteria will soon be available for a number of non-ionic organic chemicals, and research is continuing on development of criteria for metals. EPA is also investigating other methods used to assess the quality of potentially contaminated sediments. A draft "Sediment Classification Methods Compendium" provides a description of each method, associated advantages and limitations, and existing applications. The sediment assessment methods described can be classified into two basic types: In particular, EPAis developing more sensitive toxicity tests to identify sediment problems caused by complex mixtures of contaminants. Though toxicity testing does not directly identify the problem contaminants, the use of techniques such as toxicity identification evaluation TIE allows one to identify contaminants most likely responsible for the observed toxicity. The staff on these workgroups prepared fourteen issue papers addressing such topics as the preparation of a national inventory of contaminated sites and of facilities that contaminate sediments; need for a consistent, tiered testing approach to assess sediment quality; and enforcement-based remediation. This summer, a draft Strategy will be presented to industry and environmental groups for review. EPA, Provides information on Program Office Activities relating to contaminated sediment issues, and the specific statutes under which these actitivites fall. June draft is under revision. Bulk Sediment Toxicity Test Approach 1. Mortality orsublethal effects in different sediments sites are compared quantitatively to one another or to effects observed in reference sediments. Link toxic efffects to residues e. Link chemical residues in specific organisms to sediment chemical concentrations. An AET is the sediment concentration of a contaminant above which statistically significant biological effects e. Being developed from the input of four workgroups: Assessment and Identification of Risk 2. How Will We Do an Inventory? Existing Data - General Extent of Problem vs. Army Corps of Engineers Chicago, Illinois Characterization of contaminated sediments begins with the identification of contaminants present and a description of the vertical and horizontal distributions of the contaminants within the sediments. Characterization of the sediments is also-Important, as sediment characteristics will have profound effects on contaminant availability and should impact remediation decisions. Sediment characterization should include physical and chemical characteristics but also distributions of these within the site of concern. In order to properly sample and characterize contaminated sediments, extensive planning must first be done. The sequence in the planning stage should include: Identification of sampling purposes and objectives. Compilation of available data on the site of concern. Collection of preliminary field data. Development of a detailed sampling plan. Developing a sampling plan appropriate for the site and sampling objectives increases the quality of the site characterization and minimizes characterization costs. Unfortunately, due to site variability, a systemized sampling plan applicable to all sites is not feasible. There are a number of sampling devices that are presently being used to collect sediment samples, including core samplers, grab samplers, and spoons, scoops, and trowels. There are many different types of core samplers that may be used for sediments. Some hand held units can be operated from small vessels. Some core samplers require the use of a tripod or truck mounted drill rig operated on a floating plant barge. Core sampling devices include the split-spoon, the piston-tube or Chicago tube, the vibracore, and hand augers. Grab samplers, such as the Ponar and Eckman dredge samplers, are small, lightweight, and can be operated by hand from a small boat. They only collect surface sediments top inches. They have problems with any consolidated hard packed deposits. For larger volumes of sample, sometimes needed for treatability tests, a small, commercial clamshell dredge cubic yard bucket can be used. Spoons, scoops, and trowels are only useful in shallow water. They are less costly than other samplers, easy to use, and may be useful if numerous samples are intended; their low cost allows disposal between sample sites. Core samplers are generally preferred over other samplers because 1 core samplers can sample to greaterdepth, 2 core samplers maintain the complex integrity of the sediment, and 3 core samplers do not disturbthe substrate as much as other sampling procedures. Grab samplers, on the other hand, are less expensive, easier to handle, and often require less manpower than core samplers. Unfortunately, grab samplers cause considerable disruption of the sediment. Dredge samplers promote loss of the fine-grained fraction of the sediment as well as water soluble compounds and volatile organic compounds which may be present in the sediment. Spoons, scoops, and trowels are somewhat undesirable because the reproducibility of sampling area, depth, and volume from one sampling site to another is poor. They also tend to disrupt the sediment during sampling.

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