International Journal of Maritime, Trade & Economic Issues *pp. 59-66*
Volume I, Issue (1), 2013

Evaluation of Anthropogenic Pollution in Harbour Areas

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Abstract:
Harbors are coastal areas with significant anthropogenic pollutant loads causing ecological and human health risk. Seabed sediments have the potential to act as final trap of any contaminant introduced in the seawater column. Environmental quality improvement and decision making process achievement ask for quantification, control and elimination of marine contaminants. The necessary procedure steps include implementation of suitable legislative framework, adoption of an environmental management scheme that would eliminate environmental impacts and enhance operating efficiency, and application of the powerful tools of environmetrics and bio indices allowing to anthropogenic and natural impacts to be successfully revealed.

Key Words:
Environmental impact, geostatistics, harbor, index, pollutant, sediment

***JEL Classification**: K32, Q50*

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1. Introduction

Harbors are relatively small, semi-closed coastal marine areas hosting a wide range of polluting activities. They act as sinks for the input of particulates. Due to their shape, harbors have the tendency to accumulate contaminants as water mixing with the “open” sea is rather limited. Particulate matter introduced to the water column is finally deposited to the sea bed. Consequently, sediment studies can provide detailed information about the pollution history of the area, sediment being archives of environmental pollution trend. Further, the effectiveness of conventions and regulations to control and eliminate the environmental input of pollutant loads can be revealed with dated sediment cores measurements, providing useful information on temporal changes in pollutant inputs.

Sediments play a double role regarding pollution potential. Contaminated sediments can be treated for remediation purposes, either in place or excavated, applying an environmentally friendly way that will finally improve the ecological status of the area. Harbour sea bed sediment can be dredged and deposited in another site without any treatment, acting as secondary pollution sources. Under different physicochemical conditions, the solution/solid equilibrium is influenced allowing contaminant remobilization and re-introduction in the marine ecosystem. These mechanisms present a significant importance in the case of fine-grained sediments and suspended matter as they have large surface areas and high sorption capacities.

2. Tools to control and eliminate ecological risk

Marine contaminants affect seriously ecological and human health status. Recently the content of various contaminants in the marine environment show a decrease trend due to a reduction in inputs caused by environmental awareness and onset of conventions, directives and regulations. However, even banned toxic chemicals are still introduced as a result of recycling process and long-range atmospheric transport.

Nevertheless, nowadays the legislative framework is much more powerful offering a number of international conventions, European Union directives and regional regulations aiming to the control and prevention of the marine pollution. Waste and hazardous material dumping is banned. Oil spillages are regulated and in case that the incident affects coastal waters or protected habitats then the polluter is responsible for remediate actions.

In the following the major laws for marine pollution prevention and control will be listed.

International legislation

- International Convention for the Prevention of Pollution of the Sea by Oil, 1954;
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, INTERVENTION 1969;
- International Convention on Civil Liability for Oil Pollution Damage, 1969;
- Convention on the Prevention of Marine Pollution by Dumping from Ships and Aircraft, Oslo 1972;
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, London 1972;
- Convention on the Prevention of Marine Pollution from Land-based Sources, 1974 (Paris Convention) – 1988 Amendment;
- Protocol to the International Convention on Civil Liability for Oil Pollution Damage, 1976;
- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78);
- United Nations Convention on the Law of the Sea, 1982;
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989;
- International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC);
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992;
- Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris 1992;
- International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances (HNS) by Sea, 1996;
- Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS);
- The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. Dredged Material Assessment Framework, 2000 (DMAF-LC);
- The International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001;
- The Oslo-Paris Convention on the Protection of the Marine Environment of the North-East Atlantic: Revised Guidelines for the Management of Dredged Material, 2004 (OSPAR);
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004;
- The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009.

European legislation

- European Commission's Integrated Pollution Prevention and Control Directive, 1996 (IPPCD);
- Water framework Directive, 2000;
- Environmental Liability Directive 2004/35/EC;
- Marine Strategy Framework Directive 2008/56/EC.

Regional legislation

- The Barcelona Convention for Protection Against Pollution in the Mediterranean Sea, 1976;
- Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, Kuwait 1978;
- Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, Abidjan 1981;
- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, Jeddah 1982;
- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Cartagena 1983;
- The Convention of the Protection, Management and Development of the Marine and Coastal Environment of the Eastern Africa Region, Nairobi 1985;
- Convention for the Protection of the Natural Resources and Environment of the South Pacific Region, Noumea, 1986 (SPREP);
- Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific, Lima1988;
- The Protocol on Environmental Protection to the Antarctic Treaty, or the Antarctic Environmental Protocol, or the Madrid Protocol, 1991;
- Convention on the Protection of the Marine Environment of the Baltic Sea Area, Helsinki 1992;
- Framework Convention for the Protection of the Marine Environment of the Caspian Sea, Tehran 2003.

Apart from the above listed conventions, protocols and directives there is also national legislation for own initiatives.

3. Environmental Management System

Following the dominant trend for a holistic approach, nowadays port sectors are able to apply an Environmental Management System that offers the means for eliminating environmental impacts while operating efficiency is enhanced. The term Environmental Management System stands for"a set or system of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency" (US EPA, 2009). Environmental management aims to achieve and maintain a balance between environmental, legislative and commercial interests. The implementation of an EMS in a harbor area offers the necessary tools for proactively managing the environmental footprint, improving environmental performance, preventing pollution and saving energy and natural resources (CEC, 2000; Stapleton *et al.*, 2001). Nowadays, it is well recognised that an EMS framework has numerous benefits (AAPA, 2003).

Port authorities can use various management techniques in their effort to achieve an environmental management system, like:

- *Port Environmental Review System – Self Diagnosis Method (PERS-SDM).* It is designed and developed by EcoPorts Foundation; EcoPorts being since 1st January 2011 integrated within the structure of the European Sea Ports Organization (ESPO). PERS and SDM are recognized as well established EcoPorts tools. They have been up-dated and re-launched as part of the services that ESPO offers to all ports that are part of its broad membership. PERS is based on international professional best practice information and helps ports in implementing an EMS. Based on internationally recognised professional best practices, PERS is considered as a port specific system, developed by ports for ports (ESPO / EcoPorts 2009). SDM is an audit tool that estimates port performance (SDM Self Diagnosis Method, 2003).
- *ISO 14001 – EMAS.* They are both voluntary tools. The ISO 14000 family provides means to detect and control environmental impacts with a continuous improvement of the environmental performance. ISO 14001 (ISO, 1996 a, b) is an international standard that establishes requirements for environmental management systems. ISO 14001 supplies all the requirements needed for the development of an environmental policy and the identification of environmental aspects. Furthermore, it helps in the definition of measurable environmental objectives along with the implementation of suitable programs to achieve these objectives. EMAS refers to the EU Eco – Management and Audit Scheme which is a management tool to evaluate, control and improve environmental performance (IEMA, 2011). In addition it helps in communicating environmental achievements to stakeholders and society.
- *The British Standard 7750 (BS7750).* It was designed to characterize the environmental management system, assess its performance and describe policy, practices, objectives and targets. BS7750 was developed to be compatible with EMAS and ISO14001, being voluntary initiative as well.
- *The British Standard 8555 (BS 8555).* It describes the way for implementing a generic environmental management system, including the management of environmental performance evaluation. It is voluntary initiative. BS8555, unlike EMAS and ISO14001, is not a certificate standard but is designed to offer guidance for the implementation of an EMS on a phase to phase basis.

4. Monitoring by environmetrics and ecological/biomarker indices

The need to assess policy performance and estimate the management effectiveness is well recognised. This can be accomplished by a monitoring procedure (Wooldridge, 1999) that would evaluate environmental status and anthropogenic impacts. Monitoring provides with a large data set that has to be treated accordingly. It includes data of chemical contaminants content, mainly heavy metal, organometallics, organic material and petroleum hydrocarbons, as well as various physical and oceanographic parameters. The use of environmentrics seems to be very promising for a proof awareness, inspection and prediction of the whole situation. The application of statistics methods allows the determination of pollutant sources, provides information for pollutant relationships, investigates pollution trends, helps in identifying pollution dispersion, and in general facilitates data querying, Geostatistics are considered as a promising tool in order to successfully reveal man-made and natural impacts. The most frequently used methodologies include principal component analysis, cluster analysis and partial least square analysis.

In addition, ecological/biomarker indices can provide with valuable information assisting in decision making in any kind of environmental protection subjects. Bio-indices able to show biological degradation due to the presence of chemical contaminants are the following:

- *AZTI's Marine Biotic Index* (Borja *et al*., 2000). It is the average of species scores, where each species has been assigned a score according to its sensitivity to anthropogenic stress. It is considered as a significant tool in marine environmental quality studies (Salas *et al*, 2004).
- *The Benthic Quality Index* (Rosenberg et al, 2004). It is based on the fact that sensitive species tend to become dominant in relation with the more tolerant ones during secondary succession.
- *The Benthic Response Index* (Smith *et al.*, 2001, 2003). It uses an abundance-weighted pollution tolerance score to differentiate multiple levels of effect.
- *The Relative Benthic Index* (Hunt *et al.*, 2001). It is based on toxicology and natural history factors related to the responses of marine benthic communities to anthropogenic and natural changes.
- *The Index of Biotic (Biological) Integrity* (Karr, 1981; Weisberg *et al.*, 1997; Van Dolah *et al.*, 1999; Thompson and Lowe, 2004). It estimates the biological integrity of a habitat using samples of living organisms. Also, it evaluates the effects of anthropogenic activities on biological systems.

5. Marine spatial planning

Marine spatial planning is regarded as a significant tool for sea use management (Douvere *et al.*, 2007; Maes, 2008). Marine spatial planning is a comprehensive, integrated, ecosystem-based and transparent planning process. It analyses and allocates both spatial and temporal distribution of anthropogenic activities in marine areas. Its main aims include the achievement of ecological, economic and social objectives that have been listed through a political procedure in most cases. Thus, it achieves to identify areas for various kinds of activities in a way that conflicts among uses are eliminated, and environmental impacts are reduced. Nowadays, marine spatial planning is considered as a rapidly evolving topic, very promising for all those that use and appreciate the marine environment.

6. Conclusions

Harbors are regarded as hot spots acting as secondary polluting sources for the coastal zone. The ecological and human health risk caused by marine contaminants should be quantified, controlled and eliminated. Nowadays there is a well developed legislation regime aiming to the prevention and control of marine pollution. Port authorities, by using various management techniques, have the potential to adopt an environmental management system that offers the tools for environmental impacts elimination and operating efficiency improvement. The assessment of policy performance and the estimation of management effectiveness can be achieved through a monitoring procedure. As a result the application of both geostatistics and ecological/biomarker indices could be of a great help.

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