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Dangerous compounds in the dredged material from the sea – Assessment of the current approach to the evaluation of contaminations based on the data from the Polish coastal zone (the Baltic Sea)

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ABSTRACT

It has been shown that the current approach to the assessment of contamination in the sediments obtained during the dredging works in the Baltic countries indicates the presence of "non-contaminated" dredged material. The concentration limits of heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs) have been exceeded only in 1% of the samples obtained during the dredging works (2005–2015) within the Polish coastal zone. After 2008, no contaminated sediments have been found. Also, in the remaining Baltic countries, sediments are very rarely contaminated. As a result of this assessment, the sediments can be stored in the sea or have a practical application. However, it has been questioned whether the large cost of determining the numerous chemical parameters is justified. It has been proposed to carry out simple screening tests. Following the preliminary screening, the decision on more detailed (and expensive) chemical tests of individual pollutants would be made.

1. Introduction

Dredging works are carried out in order to maintain the appropriate navigational depths of waterways, roadsteads and harbours. They include a number of activities related to the preparation of the dredging works, the actual dredging works such as sediment extraction, its transport and storage (both at sea and on land), as well as the sediment "cleanliness" assessment, its purification and/or utilisation for other purposes (Bolam and Rees, 2003; Boniecka et al., 2014; Staniszewska et al., 2014, 2016a; Staniszewska and Boniecka, 2015, 2017).

Annually in Europe, about 200 million m^3 of sediment is dredged out of port channels (Petrenko et al., 2002; Bolam and Rees, 2003; Simonini et al., 2005; Leipe et al., 2005; Bellas et al., 2007; Bray, 2008; Frenzel et al., 2009; Kapsimalis et al., 2010). In the Baltic Sea countries, sediments are mainly deposited at sea, at the so called offshore dump sites. At present there are over 200 offshore dump sites, the greatest concentration of which is in the Danish straits (Fig. 1).

Storing the dredge sediment at sea is not without significance for the marine environment and the organisms living in it. Dredging works and dumping the dredged material may cause physical disturbances (changes in the seabed topography at the site of extraction and deposition, changes in the sediments' granulometry, suspension and dispersion of the fine grained fraction often over considerable distances, imbalance between sediments' deposition on the seabed and their erosion), chemical disturbances (resuspension of pollutants into the waterbody) and biological disturbances (direct burying or destruction of the seabed inhabiting specimens, destruction of spawning grounds, and disturbance of fish migration routes). Usually, these are the short-term effects that occur at the time of the work, which do not significantly affect the life in the waterbody or the deterioration of water quality in the vicinity of the nearest beaches or bathing areas. Also, the pollutants accumulated in the sediments in the stable environment threaten only the local organisms feeding on the seabed. However, during significant storm surges, the redepositing of fine sand may occur in areas that are too shallow. Such transportation may cause the spread of fine particles, including the contaminants present within them, to larger areas and depths (Petrenko et al., 2002; Bolam and Rees, 2003; Simonini et al., 2005; Leipe et al., 2005; Bellas et al., 2007; Bray, 2008; Frenzel et al., 2009; Kapsimalis et al., 2010; Boniecka et al., 2014; Staniszewska et al., 2014, 2016a; Staniszewska and Boniecka, 2015, 2017).

An important stage in dredging works is the assessment as to whether the sediment is "clean" or "contaminated", which determines its future. The extracted sediment, in order to be re-deposited in the sea, on land or re-used in practical applications should be "non-contaminated". Therefore, one of the most important steps in dredged material management is to determine the permissible concentrations of

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Fig. 1. The storage sites of the dredged sediments in the Baltic Sea according to HELCOM (2010a).

the toxic substances within the sediment or other criteria governing its proper storage or use (SMOCS, 2012; Staniszewska et al., 2014; Staniszewska and Boniecka, 2017).

The basic contaminants of the dredged material have been selected by the Convention on the Protection of the Marine Environment of the Baltic Sea, a list of which was prepared in 1992 in Helsinki and included in the HELCOM Recommendation 13/1 1992 which is based on the Helsinki Convention (1992). The listed substances include:

- metals (As, Cd, Cr, Cu, Hg, Zn, Ni and Pb),
- Polycyclic Aromatic Hydrocarbons (PAHs): benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene,
- Polychlorinated Biphenyls (PCBs).

This list has been extended in the latest Guidelines for the Disposal of Dredged Material (2015), which contains two lists of substances recommended for testing. The primary list includes substances subject to obligatory testing (in line with the HELCOM Recommendation 13/1, 1992) and the secondary list includes substances recommended for testing only when justified based upon local information on potential or historical sources of contamination such as: organochlorine and organophosphoric pesticides, organotin compounds, petroleum hydrocarbons (PHCs), dioxins (PCDD/F).

Guidelines which are not fully comprehensive result in the differences among the Baltic countries in the number of obligatory determined parameters. The maximum number of determined compounds and/or groups of compounds in the Baltic countries is 24 whereas in Poland it is 10 (SMOCS, 2012). In all the countries, however, there is a uniform approach to the assessment of sediment contamination, namely whether the permissible concentrations of the substances selected for testing have not been exceeded.

The aim of the study was to collect existing data and to assess the degree of "contamination" of the dredged sediments deposited in the Polish coastal zone (southern part of the Baltic Sea) in the years 2005–2015. An assessment has been made of the current approach in the Baltic countries as to the classification of the dredged material as being contaminated, in the context of the results obtained and the new knowledge on the sediment's pollutants. It has been hypothesized that the current method of assessing the dredged sediments “contamination” is inappropriate. A simplified and more economical approach has been proposed to carry out a comprehensive sediment evaluation.

2. Materials and methods

In the study, data on concentrations of pollutants [heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs)] in the sediments obtained during the dredging works conducted between 2005 and 2015 within the Polish coastal zone of the Baltic Sea has been gathered. The data has been provided by the entities managing the dredged material in Poland: Dredging and Underwater Works Company Ltd. (PRCiP, Gdańsk), the Maritime Office in Gdynia, the Maritime Office in Szczecin, Port of Gdynia Authority S.A., Marine Sailor civil law partnership. The presented data has also been taken from the reports on the assessment of the sediments' purity at the stage of dredging works prepared at the Maritime Institute in Gdańsk.

2.1. Characteristics of sampling sites

1263 sediment samples obtained from dredging works off the coast of Poland were tested between 2005 and 2015. This number of samples was related to the planned dredging works of the amount of about