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Petroleum hydrocarbons – necessity of monitoring in dredged material in the Polish coastal zone

Węglowodory ropopochodne – zalecenia badań w urobku czerpalnym w polskiej strefie przybrzeżnej

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Abstract: Petroleum hydrocarbons (PHCs) are toxic for the water organisms and may last for a very long time in sediments. The Baltic Sea is an area exposed to PHCs due to highly developed shipping. In Poland, there is lack of legal standards specifying guidelines regarding handling dredged material containing PHCs, excavated in waterways, roadsteads, and in port basins, and there are no standards specifying their acceptable concentration in sediments. Therefore, petroleum hydrocarbons in the excavated dredged material are rarely examined at the Polish coasts. In years 2009-2018 only 4% of sediments were examined in terms of their content. Studies indicated that only sediments from the open sea did not contain PHCs, , while others were very or moderately contaminated with PHCs. The collected results clearly indicate that sediment should be monitored in terms of PHC content; in most cases, it should not be thrown back to the sea. It may usually be stored onshore, but only on wastelands, mainly in industrial and transport areas. Some sediments may also be used within clearer lands, i.e., forests wood- and bush--covered lands, recreation and leisure areas.

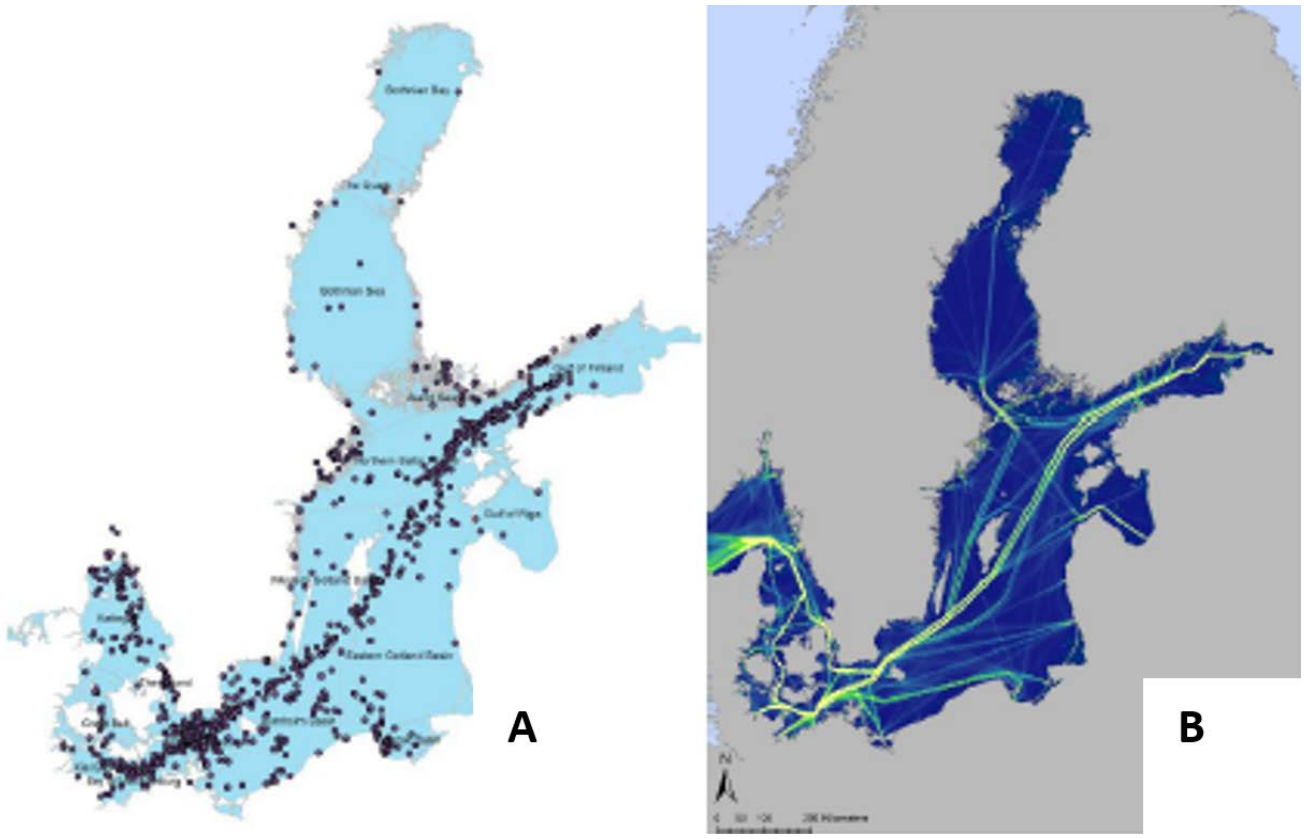
Keywords: petroleum hydrocarbons, dredged material, Poland (Baltic Sea), hazardous waste

Streszczenie: Węglowodory ropopochodne (PHCs) są toksyczne dla organizmów wodnych, a w osadach mogą być bardzo trwałe. Morze Bałtyckie jest obszarem narażonym przez PHCs ze względu na silnie rozwiniętą żeglugę. W Polsce brak jest norm prawnych określających wytyczne dotyczące postępowania z urobkiem wydobywanym na torach wodnych, redach i w basenach portowych zawierającym PHCs oraz norm określających ich dopuszczalne stężenie w osadach. Dlatego u wybrzeży Polski węglowodory ropopochodne bada się rzadko w wydobywanym urobku. W latach 2009-2018 przebadano na ich zawartość tylko ok. 4% osadów. Jedynie osady z otwartego morza nie zawierały PHCs, natomiast pozostałe były średnio lub bardzo zanieczyszczone przez PHCs. Można je składować na lądzie, jednak na nieużytkach głównie na terenach przemysłowych, komunikacyjnych. Część można również wykorzystać w rejonach czystszych gruntów tj.: lasy, grunty zadrzewione i zakrzewione, tereny rekreacyjno-wypoczynkowe. Zebrane wyniki jasno wskazują, że osad powinien być kontrolowany na zawartość PHCs i w większości przypadków nie powinien być ponownie zrzucany do morza, a niekiedy może być praktycznie wykorzystany na lądzie.

Słowa kluczowe: węglowodory ropopochodne, urobek czerpalny, Polska (Morze Bałtyckie), odpad niebezpieczny

INTRODUCTION

Petroleum hydrocarbons (PHCs) derive from crude oil and the products of its distillation (petrol, kerosene, furnace oil, fuel oils, lubricating oils, etc.). They are often complex substances composed of hundreds to thousands of individual hydrocarbons (aliphatic and aromatic). PHCs find their way to the sea mainly with sewage, river waters, atmospheric deposition, and as a result of ship exploitation and oil tanker disasters. However, only about 10% of oil contamination originates at sea and about 90% comes from land [25,37]. Hydrocarbons with up to 20 carbon atoms in a particle, with a boiling point below 270°C usually remain in water due to their low solubility, and because of their high volatility, they tend to evaporate to the atmo-



Ryc. 1. Distribution of oil spills (A) and shipping density (B) in years 2008-2013 in the Baltic Sea according to the Baltic Marine Environment Protection Commission [2].

sphere. Heavier hydrocarbons, more toxic for water organisms, tend to cumulate in demersal sediments. They have favourable conditions there - low temperature and oxygenation, very durable [17,34]. Thus, they may constitute a long-term threat to organisms, particularly bethnic ones.

The Baltic Sea is an area exposed to petroleum hydrocarbons due to intense shipping covering as much as 15% of the world transport [22]. It is estimated that annually from 21 to 55 thousand tons of these contaminants reaches the Baltic Sea, 2-3 times more than reaches the North Sea and the Atlantic Sea [27]. This results in the contamination of waters - during accident-free sea transport - within a range of 1 to 120 µg dm-3, highly dependent on the intensification of maritime traffic, oil transport and localisation of ports (Fig.1) [2,14,22,28].

As the Baltic Marine Environment Protection Commission [2] advises, from 2010 the number of observed oil spills has fallen below 150. 1998-2002 this value has remained in the range of 170-300. It must also be noted that in the last decade these were usually small spills <1 m^3. This downward trend probably results from the legal regulations treating the Baltic Sea as a „special area". MARPOL (1973/1978) and the 1992 Helsinki Convention prohibits any discharge (...) into the Baltic Sea [23, 24]. The pressure from oil spills must be kept at a low level in order to reach a Good Environmental Status (GES) in accordance with the Baltic Sea Action Plan (BSAP) and Marine Strategy Framework Directive (MSFD) [15]. In surface sediments, the concentration levels of aliphatic and aromatic petroleum hydrocarbons are usually higher than in the water, remaining at a level of several dozen mg kg-1 m^2 [20]. In the areas very exposed to oil-deriving pollutants, i.e., port areas, concentration levels of the total amount of PHCs reach a few hundred mg kg-1, and in the areas of oil rigs, even up to several thousand mg kg-1 [29]. It should be emphasized that the concentration of petroleum hydrocarbons in sediments does not significantly correlate with the decreasing oil spills observed in the last decade. [2,28]. Since 2010, the concentration levels of hydrocarbons in sediments have maintained a similar level, dependent on the location related to human activity (ports, platforms) or the sediment type (sorptive) [14,28,44].

In waterways, roadsteads and in port basins the sediment from the bottom of water reservoirs is regularly excavated, i.e., so-called dredging works are carried out to keep adequate navigable depth. A particularly important stage of these works is assessment whether the sediment is, „clear" or „contaminated" which determines its further fate.

The excavated sediment should stay „uncontaminated", so that it can be deposited back into the sea, onshore or used in numerous practical ways [38-42]. In Poland, there is a lack of legal standards specifying detailed guidelines for handling dredged material containing petroleum hydrocarbons and there are no standards specifying their acceptable concentration in sediments. As far as sediments in Poland are concerned, specific contaminants from this group are monitored, i.e., polycyclic aromatic hydrocarbons (PAHs) [31].

Tab. I. Acceptable concentration levels of petroleum (mineral oil index) in the dredged sediments in countries of Baltic Sea [mg kg^{-1}] [35,38-40].

COUNTRY	ACCEPTABLE MAXIMUM CONCENTRATION LEVELS
Estonia	100 (p.1) 5000 (p.2)
Finland	50 (p.1) 1500 (p.2)
Germany	sediment < 20µm 300 (p.1) 1000 (p.2)
Latvia	100 (p.1) 400 (p.2)
Lithuania	20-200 sand, <500 sludge (p.1) 200-1500 sand, 500-1500 sludge (p.2) >1500 sand/sludge (p.3)
Russia	180< clean sediment 3000 < sediment moderately contaminated
Denmark, Poland, Sweden	no regulations

p. - zones with various contamination load.

The purpose of this paper is to indicate the necessity of monitoring PHCs in dredged sediments in the Polish coastal zone in view of their later storage in the sea or practical uses onshore.

Legal regulations regarding petroleum hydrocarbons in the catchment area of the Baltic Sea

A specific legal regulation characterizes the content of petroleum hydrocarbons using a summary parameter the mineral oil index, which determines the content of hydrocarbons within the C10 to C40 carbon atoms range mainly includes the compounds with a boiling point of >150°C [17,19].

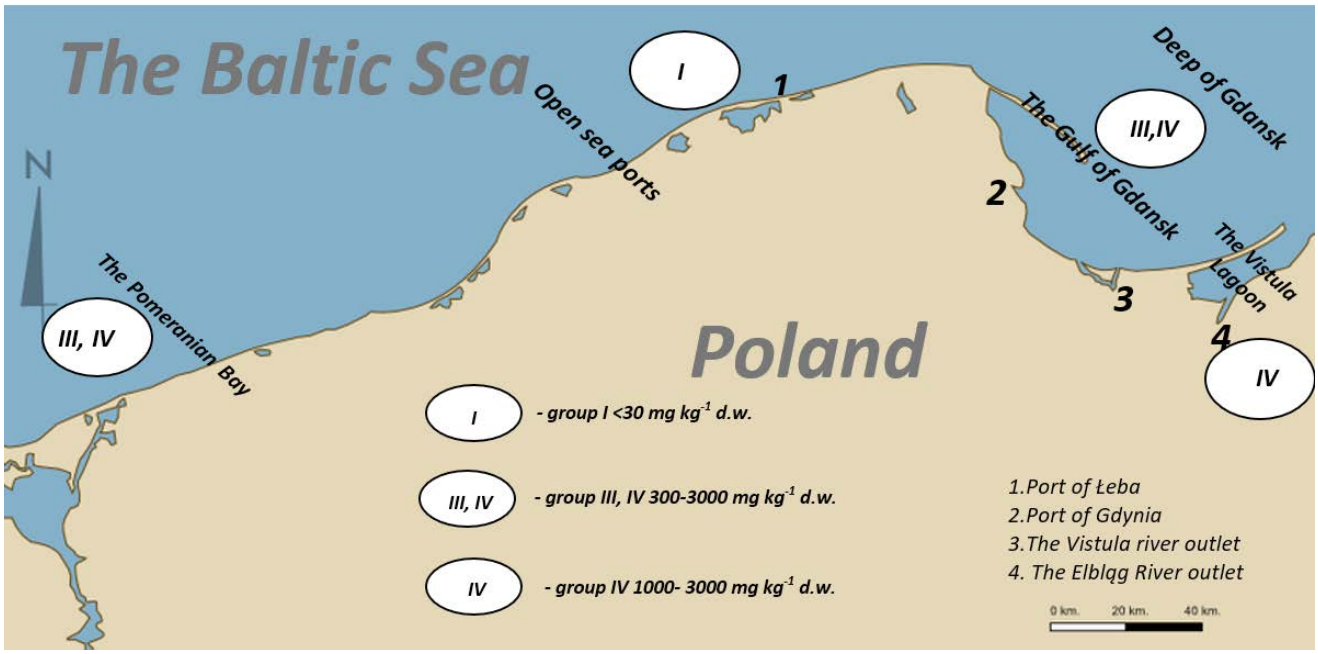
The Helsinki Convention, which is of great significance for the area of the Baltic Sea, lists petroleum hydrocarbons as priority harmful substances [23]. For countries of the European Union, the provisions regarding priority substances in waters, sediments, and organisms in the water environment, i.e., the Water Framework Directive – WFD (2000/60/WE) and Directive 2013/39/UE of 12 August 2013 (Journal of Laws UE L 226 of 24/08/2013, p.1) [16,46] are binding. The provisions of these regulations have been implemented to the Polish legal system as part of the Regulation of the Minister of Environment of July 21, 2016 on the methodology for classification of the condition of surface water bodies and environmental quality standards for priority substances (Journal of Laws, item 1187) [33]. This document provides limit values of water quality indicators from the group of substances particularly harmful for water environment (specific synthetic and non-synthetic contaminants), applying to the surface water bodies of all categories. For the petroleum hydrocarbons, they are ≤ 0.2 mg dm-3 for waters of high and good status - I and II. For waters of a lower status, the value of this parameter has not been provided.

An overarching document which in turn applies to the identification of the priority substances in dredged material in the water catchment areas of the Baltic Sea is the HELCOM Guidelines for the Disposal of Dredged Material (2015) [21]. This document recommends the identification of petroleum hydrocarbons in dredged material when there is a suspicion of current or historic local sources in the area of conducted works. However, the concentration limit values are not mentioned there. This is regulated by national provisions, which results in various limit values regarding acceptable concentration levels of petroleum hydrocarbons in dredged sediment being applicable in the water catchment areas of the Baltic Sea (Table I). They have a wide numeric range of 20 to 5000 mg kg-1 m^2 and, among others, they are dependent on the sediment type (sand, silt, sludge), and pollution level of the area (clean, polluted-industrial area). In some countries, like Denmark and Poland, there are no standards specifying detailed guidelines for handling dredged material containing petroleum hydrocarbons and there are no standards specifying acceptable concentration of this parameter in sediments [35,38, 39, 40].

Contamination of harbor sediments and dredged sediments with petroleum hydrocarbons - the situation in the countries in the Baltic Sea's water catchment areas

General information regarding sea waters of the Baltic Sea indicates their good condtiion in terms of petroleum hydrocarbons contamination which means that natural conditions have been disturbed to a small degree (PHCs ≤ 0.2 mg dm-3); [28,33]. Based on a large project of the Sustainable Management of Contaminated Sediments in the Baltic Sea (SMOCS, 2007-2013), which consisted in collecting information regarding concentration levels of hazardous sediments in the Baltic countries, it may be said that the PHC concentration levels are usually below the reference values applicable in specific countries. At the coast of Estonia, PHC concentration at the coast of Estonia was on average between 38.4 and 314 mg kg-1 m^2 and even the highest concentration of 1909 mg kg-1 recorded in the port of Hundipea was within the safe limits of the specified threshold values for urbanized areas: 5000 mg kg-1 m^2 for this country. In the harbors of Lithuania, in most cases PHC concentration levels were below the reference values for the country. The highest measured PHC concentration in dredged material was 545.2 mg kg-1 m^2 [45]. In Sweden, where there are no guidelines as such, the PHC concentration levels in harbor sediments ranged from 90 to 400 mg kg-1. It must also be noted that the maximum value was recorded in the sediments of the port of Falkenberg (780 mg kg-1 m2). The highest petroleum hydrocarbon concentration levels in harbor sediments were measured in Russia. They were usually higher than the reference values applicable in this country (3000 mg kg-1 m^2). The highest PHC concentration was measured in the port of Lomonosov 4617 mg kg-1 m^2. For Denmark, Finland, and Germany there are no available information regarding petroleum hydrocarbon concentration levels in dredged harbor sediments [35,38-40].

It must be noted that the collected information cannot be treated as equally valuable because ranges of PHCs' limit



Ryc. 2. Division of the Polish coastal zone areas depending on petroleum hydrocarbon contamination according to the Regulation of the Minister of the Environment of 1 September 2016 on the method for assessment of land surface contamination (Journal of Laws 2016, item. 1395) (based on data from Table II; group classification as in Table III) [30].

concentration values in dredged sediments in the Baltic countries vary significantly (Table I). For example, if we refer the obtained PHC concentration levels in dredged sediments to the standards applicable in Latvia, they would exceed the acceptable values of > 400 mg kg-1 in all Baltic countries. On the other hand, the PHC concentration measures in the port of Hundipea in Estonia (which remains at a safe concentration in this country) would indicate sediment contaminated with petroleum hydrocarbons (Table I) [35,38-40].

Contamination of harbor sediments and dredged sediments with petroleum hydrocarbons - the situation at the Polish coasts

Petroleum hydrocarbons in dredged material are rarely examined at the Polish coasts. In years 2009-2018, around 4% of sediments were examined in terms of their content. PHC concentration levels in the surface sediments of the Gdańsk Bay in the area of the ports of Gdańsk, Gdynia had values up to 1321 mg kg-1 m², and in the harbors of the Pomeranian Bay (Szczecin, Świnoujście), the Vistula River (Elbląg, Tolkmicko, Frombork, Krynica Morska, Kąty Rybackie), at the Vistula outlet, the Gdańsk Deep were slightly lower and reached 630 mg kg-1 m². Relatively high PHC concentration levels, reaching 3,500 mg kg-1 m² were measured in the river Elbląg (Table II, Fig. 2). This is probably a result of more intense shipping and atmospheric deposition from the burning processes in this area, as well as the type of organic matter in the sediment, beneficial for the sorption of PHCs [43]. Additionally, a high proportion of mono- and dimethylphenanthrenes (around 90 ng g-1 m²), compounds indicating oil-deriving substance contamination, demonstrates the increased oil-deriving substance contamination of the sediments in the harbors of Gdynia-Gdańsk, the river Elbląg, the Vistula Lagoon harbors [3,26]. In the open sea harbors (Łeba) PHC concentration levels in relation to the surface sediments of the bay areas were lower (Table II). This results from the presence of another sediment type in this area, mainly sands with small sorptive capacity, and from the hydrodynamic conditions prevailing there - sea currents, winds, sediment transport along the coast, promoting diversity of its lithologic composition [4-13].

Assessment of the petroleum hydrocarbon contamination of the dredged sediments at Polish coasts in view of their storage in the sea, onshore, and their practical applications.

Dredged material excavated at the Polish coasts is usually (if it is contaminated as per the binding regulations) stored in the sea or onshore [38-42]. When the dredged material is stored at sea, there are no guidelines regarding monitoring of. This is all the more important because around 60% of the dredged material is deposited to the sea dumping sites (data from 1990-2018). Currently, there are 9 sea dumping sites at the coasts of Poland, where around 21 million m³ of sediments were deposited,which have actually not been examined in terms of the petroleum hydrocarbon content. Storing dredged material in the sea may cause a real threat to the environment, first when the material is dumped, and later while it is stored. Organic contaminants cumulated in sediments may undergo resuspension to a water column or together with the fine-grained sediment, they may spread to larger areas and depths [38]. The remaining dredged material, around 40% at Polish coasts is used practically, mainly for artificial shore nourishment (infilling), occasionally for alterations of ports, modernization of quays [38,39,41]. Primarily, the way of handling dredged material is determined by its chemical characteristics, indicating existing or non-existing loads

Tab. II. Concentration ranges of petroleum ranges [mg kg-1 m²] identified in samples of seabed sediments collected from the river Elbląg; from waterways to ports of the Vistula Lagoon (Elbląg, Tolkmicko, Frombork, Krynica Morska, Kąty Rybackie), the Ports of Gdynia and Łeba.

STUDY AREA	VISTULA LAGOON		GULF OF GDAŃSK	GULF OF POMERANIA VISTULA OUTLET THE GDAŃSK DEEP	OPEN SEA
	THE RIVER ELBLĄG	PORTS OF THE VISTULA LAGOON	PORT OF GDYNIA		PORT OF ŁEBA
Petroleum hydrocarbons	394.0 - 3543.8 n=10	7.79 - 523.9 n=40	27.0 - 1321 n=18	298 - 630 n=15	5 - 31.6 n=24
References		43	8.18 PRCP, 2014*	35	5-13

n – the amount of examined samples
* – data provided by the PRCP – Dredging and Underwater Works Company (pol. Przedsiębiorstwo Robót Czerpalnych i Podwodnych), Gdańsk.

Tab. III. Acceptable values of petroleum hydrocarbons' concentration levels [mg kg-1 m²] of the earthen parts of soil (<2 mm) in the soil or earth, under the guidelines set out in the Regulation of the Minister of the Environment of 1 September 2016 on the method for assessment of land surface contamination (Journal of Law 2016, item1395) [30].

	ACCEPTABLE CONTENT OF RISK-CARRYING SUBSTANCES, DIVIDED INTO GROUPS AND SUB-GROUPS OF LANDS			
for depth of 0–0.25 m below ground level				
Land classification	I	II	III	IV
Sum of hydrocarbons C12-C35	30	50	300	3000
for depth exceeding 0.25 m below ground level				
	I, II, III		IV	
Water permeability	$\geq 1x10^{-7}$	$< 1x10^{-7}$ m/s	$\geq 1x10^{-7}$ m/s	$< 1x10^{-7}$ m/s
Sum of hydrocarbons C12-C35	1000	3000	1000	3000

* groups of land:
I: residential areas, built-up areas, ongoing construction areas, agricultural built-up areas, recreation and leisure areas, etc.; II: arable lands, orchards, permanent meadows, permanent pastures, lands under ponds and ditches, family allotment sites, etc.; III: forests, wood- and bush-covered lands, wood- and bush-covered lands in utilized agricultural areas, wastelands, other (than listed in group I) recreation and leisure areas, utilized ecological lands, etc.; IV: industrial areas, utilized surface mining areas, transport areas.

of heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) [31]. Clear sediment may be used, e.g., for beach nourishment. When the contaminated dredged material is identified, it needs to be separated from the uncontaminated one and stored at a dedicated part of the storage site onshore (silting field), protected from the contaminants' migration to the ground waters and from the infiltration with atmospheric precipitation [38,39,41].

Other toxic compounds such as heavy metals, PAHs and PCBs, or others, for example - summary indicators which could indicate hazardous sediment, are not routinely examined in the dredged material; neither are petroleum hydrocarbons. Sometimes, in justified cases, such examinations are actually carried out. In such a situation, due to the lack of standards specifying detailed guidelines regarding handing dredged material containing petroleum hydrocarbons and no standards specifying their accepted concentration, one may resort to the Regulation of the Minister of the Environment of 1 September 2016 on the method for assessment of land surface contamination (Journal of Laws 2016, item 1395, [30]) (Table III). It does not apply to sediments, but specifies risk-carrying substances, particularly significant for protection of the earth's surface, their acceptable content in soil and earth, acceptable content in the earth, varied depending on specific features of the soil and land groups, categorized on the basis of the way of their exploitation. In this context, it is possible to ascertain whether the dredged sediment could potentially aggravate aggrevate soil parameters in the area, in which it would be used onshore.

The sediments dredged in the open sea area (Łeba) are not contaminated with petroleum hydrocarbons. On the other hand, in the Pomeranian Bay, the Gdańsk Bay, the Gdańsk Deep and the Vistula Lagoon, increased PHC concentration levels in relation to guidelines provided in the Regulation of the Minister of the Environment of 1 September 2016 on the method for assessment of land surface contamination (Journal of Laws 2016, item 1395) [30] were found. According to those guidelines, the lands were classified to classes III and IV (for depths of 0–0.25 m below ground level). The sediments from the river Elbląg flowing into the Vistula Lagoon may be classified as very contaminated; the average PHC concentration level was 10 times higher than in sediments collected in other areas of the Polish coastal zone [43]. An average petroleum hydrocarbon concentration level measured in this area resulted in the sediment being classified as class IV (for depths of 0–0.25 m below ground level). On the other hand, the maximum values of PHC concentration levels were beyond the classification [30] (Fig. 2, Table II, III).

Sediment contaminated with petroleum hydrocarbons as hazardous waste

Under the regulations applicable in Poland, contaminated sediment cannot be deposited back to the sea. There is also

a problem with its practical use as it is treated as hazardous waste. Thus, such sediment should be stored only in designated places (storage sites) onshore. Such waste is subject to the duty of neutralization in order to bring it to a condition when it does not constitute risk to both human life and health, and to the environment [38-41].

However, currently it is not specified if dredged material may constitute hazardous waste in terms of its content of petroleum hydrocarbons (there are no such regulations at national level). Up to date these requirements have only been applied to the assessment of dredged material as hazardous waste in relation to the content of heavy metals, PAHs and PCBs according with Commission Regulation (EC) No. 790/2009 of 10 August 2009 amending, for the purposes of its adaptation to technical and scientific progress, the Regulation of the European Parliament and Council (EU) No. 1272/2008 of 16 December 2008 on classification, labelling and packaging of substances and mixtures (Journal of Laws UE L 235/1 of 5.09.2009) [1]. In the light of the lack of such an assessment, the waste contaminated with the oil-deriving compounds can be stored in the sea or onshore. In Polish legislature provisions have only been made for the possibility of waste recycling (Regulation of the Minister of the Environment of 11 May 2015 on waste recycling, except for installations and devices, Journal of Laws of 2015, item 796) through removal of the oil-deriving substances [31].

In the EU, methods for recycling infilling material are increasingly more often used in the case of sediment contamination, particularly with oil-deriving substances, heavy metals and tributyltin. Such methods are based on the use of chemical, biological and physical processes to degrade, remove or inactivate contaminants. After the recycling is completed, tests of conformity with the required standards are carried out. Sediment cleaned in such a way is used practically, e.g., for sealing flood banks, in road construction industry, for brick production. However, these actions are costly, time-consuming and frequently not sufficiently effective [36, 38, 39,42].

Due to unfavorable economic circumstances associated with recycling in Poland, for the time being some other options of storing sediments contaminated with petroleum hydrocarbons onshore - in polders, wasteland - may be considered. Most sediments dredged at the coasts of Poland met the requirements for the class IV lands: industrial sites, utilized surface mining land, transport areas. A part of them could also be used in the areas of cleaner lands (group III: forests, wood- and bush-covered lands, wood- and bush-covered utilized agricultural areas, wastelands, recreation and leisure areas, utilized ecological land, etc.) (Fig. 2, Table II, III). However, an analysis of the soil at the storage site should always be carried out, because if there soils, cleaner than the sediments dredged, storage of dreding material may cause deterioration of the earth quality [30].

It should be noted that the guidelines included in the Commission Regulation (EC) No. 790/2009 (Journal of Laws UE L 235/1 of 5.09.2009) [1], clearly classify risk caused by various oil-deriving products as toxic, carcenogenic and mutagenic. Therefore, analyzing the results presented in Table II in the context of requirements for classification of dredged material as hazardous waste, such a classification could be applied for sediment with PHC content > 1000 mg kg-1. In such a, case these compounds occur in the amount of over 0.1% in sediments, i.e., sediments; in this concentration it is considered that the waste can fall into one of the classes, e.g., it toxic, carcerogenic and mutogenic, mutogenic, as a result being classified as hazardous [32,40]. The river Elbląg or the Port of Gdynia (Fig. 2, Table II) could constitute such risk areas. In the light of the fact because only around 4% of the dredged sediments at the Polish coasts have been examined, there may be many more of such areas PHCs.

CONCLUSIONS

In waterways, roadsteads and in port basins the sediment from the bottom of water reservoirs is regularly excavated to maintain adequate navigable depth. A particularly important stage of these works is the assessment whether the sediment is „clear" or „contaminated" which determines its further fate. The excavated sediment should be „uncontaminated", so that it can be deposited back into the sea, onshore or used in numerous practical ways [38-40]. In the countries of the Baltic Sea's water various limit values regarding acceptable petroleum hydrocarbon (PHCs) concentration in dredged material are applicable. However, there are no such guidelines in Denmark, Poland and Russia.

At the coasts of Poland petroleum hydrocarbons in dredged material are rarely examined.

In years 2009-2018 around 4% of sediments were examined in terms of their content.

The material collected up to date indicates:

- the necessity of ongoing petroleum hydrocarbons monitoring in dredged sediment in the Polish coastal zone in view of its storage in the sea, onshore, or its practical applications;
- the possibility of only storing PHC-free sediments in the sea collected from open sea or using them for beach nourishment. On the other hand, the other sediments (the Bay of Gdańsk, the Bay of Pomerania, the Vistula Lagoon, the Vistula outlet, the Gdańsk Deep) were moderately or highly contaminated with PHCs. Such sediment can potentially be stored onshore on wastelands in the areas complying with the requirements under the Regulation of the Minister of the Environment (Journal of Laws 2016, item 1395) [43] for the class IV lands: industrial and transport areas, utilized surface mining land. A part of them could also be used in the areas of the cleaner group III lands: forests, wood- and bush-covered lands, wood- and bush-covered utilized agricultural areas, wastelands, recreation and leisure areas, utilized ecological areas.
- the possibility of classification of dredged material as

hazardous waste, for the sediment with PHC content > 1000 mg kg-1. In such a case these compounds occur in the amount of over 0.1% in sediments, i.e., in a concentration for which it is considered that the waste can fall into one of the following classes, e.g.,: it is toxic, carcerogenic and mutogenic; this results in classifying it as hazardous according with guidelines included in the Commission Regulation (EC) No. 790/2009.

- the necessity of examining a larger amount of dredged sediments in terms of PHC contamination. Particularly harbor sediments in river outlets require such an assessment. It is important in as much as 60% of the dredged material is deposited on the sea dumping and the rest of it, around 40% is used for beach infilling and up to date has not been monitored in terms of this parameter at the Polish coasts. Such potentially contaminated sediment may with PHCs may affect negatively the quality of marine ecosystems and cleanliness of beaches.

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