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ASSESSMENT OF THE POTENTIAL OF MALTA LAKE SEDIMENTS IN POZNAN TOWARDS THEIR USE FOR AGRICULTURAL PURPOSES

Summary

Malta Lake is a popular recreational area for people living in Poznan city and surroundings. Every four years, reclamation works are carried out which include draining the water, adjusting shores and dredging sediments. In this study, the characteristics of Malta Lake bottom sediments are presented with reference to their potential use as a fertilizer. Obtained data from two measurement points demonstrated approximately neutral pH, the organic matter content 11,2% d.m. and 19,8% d.m. as well as a low concentration of heavy metals, which classify sediments as uncontaminated (according to Regulation of Minister of the Environment of 16 April 2002 [1]). Thus, based on the results, it can be assumed that the concentration of heavy metals is not the limiting factor of their use for natural purposes, including agricultural and forest soil improvement.
***Key words**: sediments, heavy metals, agriculture, Malta Lake, Poland*

OCENA POTENCJAŁU OSADÓW DENNYCH JEZIORA MALTA W POZNANIU W KIERUNKU ICH ROLNICZEGO WYKORZYSTANIA

Streszczenie

Jezioro Maltańskie to popularne miejsce wypoczynku mieszkańców miasta Poznania i okolic. Raz na cztery lata dokonuje się prac rekultywacyjnych polegających na spuszczaniu wody ze zbiornika, porządkowaniu brzegów i bagrowaniu osadu dennego. W pracy przedstawiono charakterystykę osadów dennych zbiornika pod kątem późniejszego wykorzystania ich w kierunku nawozowym. Badania dwóch stanowisk wykazały zbliżony do obojętnego odczyn osadów, zawartość materii organicznej 11,2% s.m. oraz 19,8% s.m., a także stężenie metali ciężkich klasyfikujące niniejszy osad jako niezanieczyszczony (zgodnie z Rozporządzeniem Ministra Środowiska z dnia 16 kwietnia 2002 r. [1]). Na podstawie otrzymanych wyników można przyjąć, że stężenie metali ciężkich nie stanowi czynnika ograniczającego ich wykorzystania w celach przyrodniczych, w tym na gruntach rolniczych i leśnych.
***Słowa kluczowe**: osady denne, metale ciężkie, rolnictwo, Jezioro Malta, Polska*

1. Introduction

Malta Lake is an artificial water tank with the area of 60 ha, and an average depth of 3,13 m, formed in 1952 as a result of damming the Cybina river. The Lake is situated on the right bank of the Poznan city, 1,5 km from the Old Market Square. Malta and areas located in its nearest neighborhood are attractive places for both passive and active recreation due to the appropriate land development. The recreational facilities include many attractive objects, such as track racing, ski slope, zoological park, as well as leisure center. Every four years the water is drained and the bottom sediments are collected in order to elutriating grounds and adjusting shores [2, 3].

Sediments collected from the bottom of water tanks are rich in organic matter. Gałka et al. [4] indicate the presence of valuable nourishments absorbed by plants, such as magnesium, phosphorus, potassium, nitrogen, and organic carbon in Młyny tank sediments. Some researchers [5] emphasize that natural fertilizers like bottom sediments may provide a promising alternative to mineral fertilizers.

However, Ciesielczuk et al. [5] pointed out that the sediments may be contaminated by heavy metals, which could be directly associated with e.g. the nature of catchment. There are many reports in the literature indicating the negative effect of heavy metals on plants, including cultivated plants [6, 7, 8, 9]. Therefore, due to the rural nature of the catchment area of the river Cybina and urban anthropopression it is necessary to determine the heavy metals concentration in the bottom sediments before attempting their use as a natural fertilizer.

During the reclamation works of Malta tank in 2004/05, bottom sediments were deposited in municipal dumping in Suchy Las [10]. It could be treated as a waste of their ecological potential. The policy of sustainable development implies economic progress, including agriculture improvement with minimizing the negative environmental impact. According to this principle, it is aimed to make an effort in order to increase the efficiency of fertilizer with reducing the financial costs and environmental impacts. Thus, acquired sediments could be a valuable source of organic matter creating favorable conditions for the cultivation of certain consumable plants.

The aim of the study was to determine the basic characteristics of Malta Lake sediments, including the pH, organic matter content and heavy metals concentration, constituting a potential limiting factor in the use of bottom sediments in agricultural areas.

2. Materials and methods

2.1. Fieldwork

Malta sediments samples were collected from two sites located in the littoral zone (Figure 1). Selected measurement points differed from each other with the respect to the distance from the main transport routes and the Cybina River mouth which, due to a strong anthropopression may be a potential source of pollution.

The upper layer of the sediments (approximately 20 cm thickness) were collected using Purckhauer Soil Sampler (PKH). In the next step, the material was purified and homogenized. The fieldwork was conducted in November 2012.

2.2. Physicochemical measurements methodology

Evaluation of the sediments potential for natural purposes, was based on determination of the main sediments properties, such as pH, total content of organic matter and the heavy metals concentration. The pH was measured by potentiometer method, while the content of organic matter was determined by thermogravimetric method with carbonates regeneration. The samples were calcined at 550°C for 3 hours. The heavy metal content was determined using Varian Vista MPX Inductively Coupled Plasma (ICP) Spectrophotometer. The samples were mineralized earlier in the concentrated nitric acid using the CEM Mars 5 Microwave.

2.3. Calculation methodology

In order to determine the level of the heavy metals contamination in the bottom sediments, the geoaccumalation index (**I_{geo}**), contamination factor (**C_f**) and degree of contamination (**C_{deg}**) were calculated [12]. Igeo is helpful to compare the contents of xenobiotics in the studied material with its natural, pre-industrial amount in environment. It was calculated by the formula:

$$\mathbf{Igeo} = \log_{10}\frac{C_n^i}{1{,}5\ B_n^i},$$

where:

C_n^i – the concentration of heavy metals in sediments,

B_n^i – defined geochemical background for a given heavy metal.

Sediments classification was based on the Table 1 suggested by Choiński (2010) [12]

Table 1. Geoaccumalation index (I_{geo}) values and corresponding sediments quality [12]

Tab. 1. Wartości indeksów geoakumulacji (I_{geo}) odpowiadające jakości osadu dennego [12]

Class	I_{geo}	Sediments quality
0	$\mathbf{I_{geo}} \le 0$	Uncontaminated
1	$0 < \mathbf{I_{geo}} \le 1$	Uncontaminated to moderately contaminated
2	$1 < \mathbf{I_{geo}} \le 2$	Moderately contaminated
3	$2 < \mathbf{I_{geo}} \le 3$	Moderately to heavily contaminated
4	$3 < \mathbf{I_{geo}} \le 4$	Heavily contaminated
5	$4 < \mathbf{I_{geo}} \le 5$	Heavily to extremely contaminated
6	$5 < \mathbf{I_{geo}}$	Extremaly contaminated

contamination factor ($\mathbf{C_f}$) and degree of contamination ($\mathbf{C_{deg}}$) were calculated by the formula:

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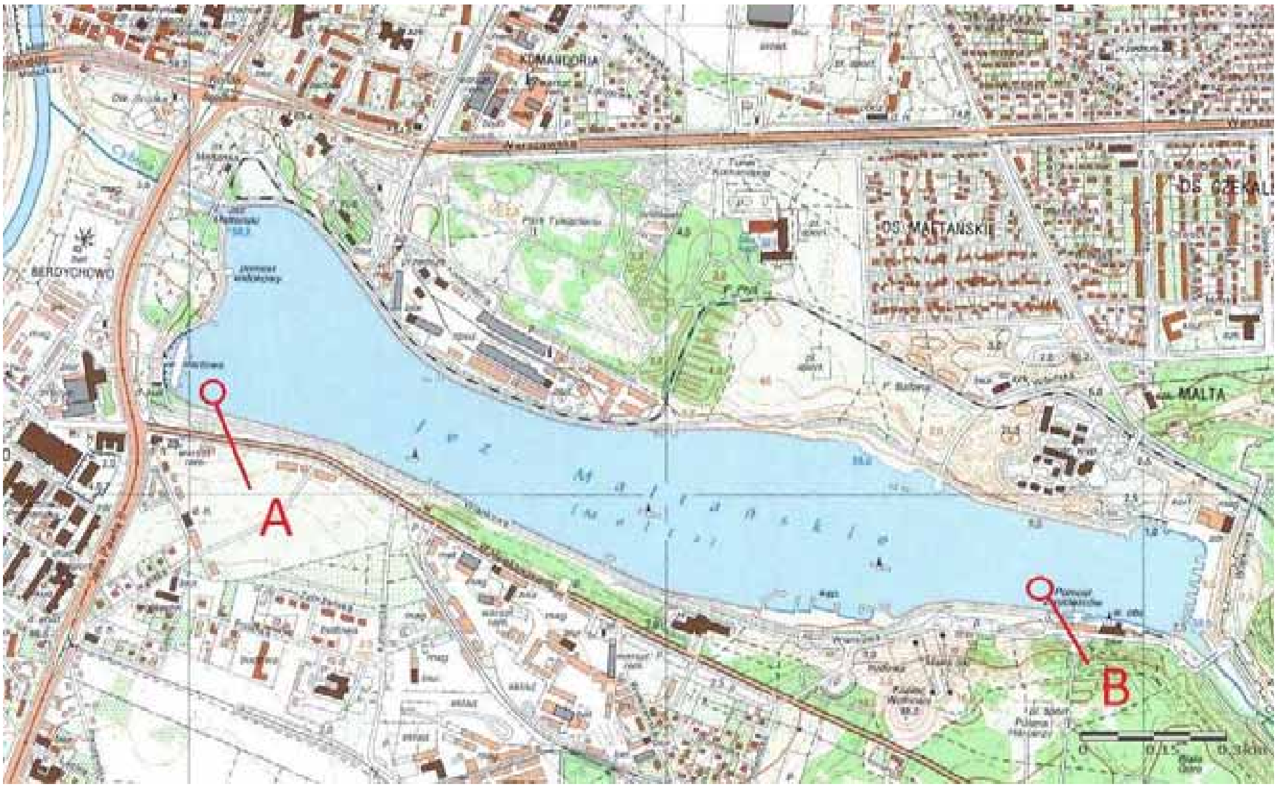

Figure 1. The location of measurement points (A and B) [11]

Rys. 1. Usytuowanie punktów pomiarowych (A i B) [11]

The assessment of contamination according to C_f and C_{deg} was based on the Table 2 and Table 3 suggested by Choiński (2010) [12].

Table 2. Contamination factor values and corresponding description [12]
Tab. 2. Wartości współczynników zanieczyszczenia odpowiadające jakości osadu dennego [12]

Contamination factor	Description
$C_f^i < 1$	Low contamination factor
$1 \le C_f^i < 3$	Moderate contamination factor
$3 \le C_f^i < 6$	Considerable contamination factor
$6 \le C_f^i$	Very high contamination factor

Table 3. Degree of contamination values and corresponding description [12]
Tab. 3. Wartości stopni zanieczyszczenia odpowiadające jakości osadu dennego [12]

Degree of contamination	Description
	Low degree of contamination
$8 \le Cdeg < 16$	Moderate degree of contamination
$16 \le Cdeg < 32$	Considerable degree of contamination
$32 \le Cdeg$	Very high degree of contamination

3. Results

The concentration of heavy metals in environmental samples is shown in Figure 2. The geochemical background for sediments located in Wielkopolska was also considered as a datum level. Thus, it was possible to a complex assessment of enrichment of the analyzed system in heavy metals.

Sediments from a measurement point A were characterized by a slight increase in the level of chromium, while sediments from a measurement point B showed excess levels of both chromium and copper in relation to the geochemical background. The pH of the sediments from both of the measurement points was approximately neutral (7,2 and 7,1 for A and B respectively). The contents of organic matter reached the levels of 11,2% d.m. and 19,8%d.m. for measurement points A and B respectively.

Table 4 shows geoaccumulation indexes, contamination factors and degrees of contamination for studied elements. Geoaccumulation indexes (I_{geo}) were negative in cases of all studied elements for sediments collected from measurement point A, which indicate no significant contamination.

Similar results were obtained for sediments from measurement point B, with the only difference in the case of copper (I_{geo} = 0,07), which indicate a moderate sediments contamination with this element. Calculated contamination factors (C_f) demonstrate similar trends. According to this parameter, contamination of sediments in measurement point B with copper is moderate. Moreover, obtained contamination factor for chromium suggests a moderate contamination for both measurement points A and B. Other studied heavy metals demonstrate very low contamination of sediments (C_f <1).

4. Discussion

Analysis of pollution indicators clearly demonstrated a slight excess of copper concentration in sediments collected from measurement point B. Gałka [13] highlighted that pesticide residues may determine the source of the increased concentration of this element in sediments. It should be noted that the measurement point B is located near the mouth of the Cybina River, whose catchment is in 84% covered by arable land [14]. Moreover, the contamination factor for chromium suggests its minimal excess in relation to geochemical background. However geoaccumulation index considering the anthropogenic influence indicates that the impact of this element is not significant. It is worth noting that degree of contamination for sediments collected from measurement point A (C_{deg} (A) = 3,46) is lower in relation to measurement point B (C_{deg} (B) = B 4,21). Gierszewski et al. [15] pointed out that the volume of the copper and chromium accumulation sediments is correlated with the content of organic matter. This statement is in agreement with our results. According to Regulation of Minister of The Environment of 16 April 2002 (on the types and concentrations of substances that cause the output is contaminated) [1], the heavy metals concentration does not classify sediments as contaminated.

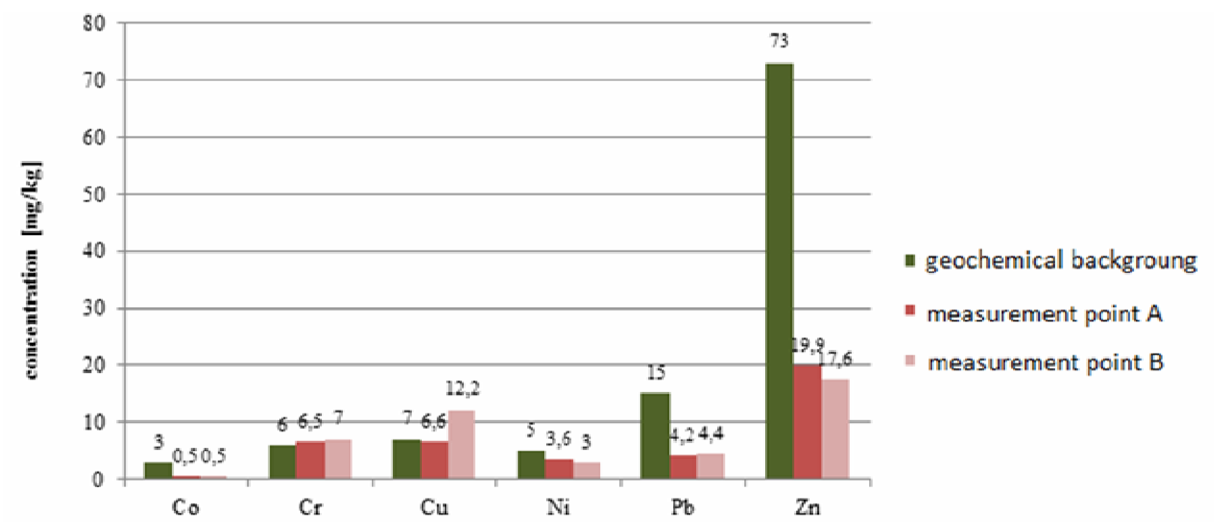

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Figure 2. The content of heavy metals in measurement points A and B with respect to the geochemical background
Rys. 2. Zawartość metali ciężkich w stanowiskach A i B w odniesieniu do tła geochemicznego

Table 4. Geoaccumalation indexes, contamination factors and degree of contamination calculated for studied heavy metals in measurement points A and B

Tab. 4. Wyniki obliczeń indeksów geoakumulacji oraz współczynników zanieczyszczenia osadów metalami ciężkimi

	Element	Geoaccumulation index (I_{geo})	Contamination factor (C_f)	Degree of contamination (C_{deg})
Measurement point A	**Co**	-0,95	0,17	3,84
	Cr	-0,14	1,08	
	Cu	-0,20	0,94	
	Ni	-0,32	0,72	
	Pb	-0,73	0,28	
	Zn	-0,74	0,27	
Measurement point B	**Co**	-0,95	0,17	
	Cr	-0,11	1,17	
	Cu	0,07	1,74	
	Ni	-0,40	0,60	
	Pb	-0,71	0,29	
	Zn	-0,79	0,24	

Source:own study / Źródło: opracowanie własne

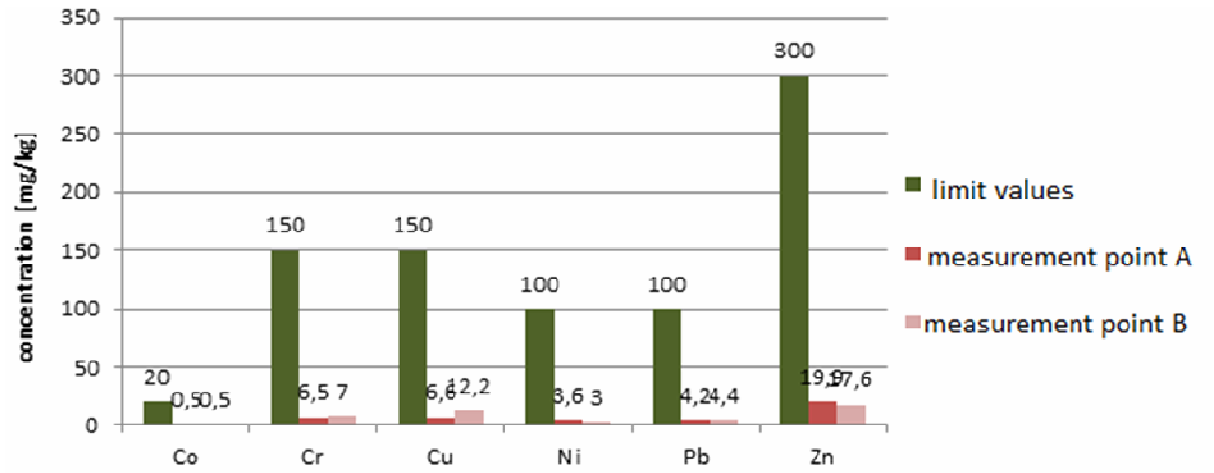

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Figure 3. The content of heavy metals in measurement points A and B in relation to the quality standards of agricultural grounds

Rys. 3. Zawartość metali ciężkich w stanowiskach A i B w odniesieniu do standardów jakości gruntów rolnych

Polish legislation does not exclude the possibility of sediments use in environmental purposes, provided that the sediments meet requirements of soil quality standards (according to Regulation of the Minister of Environment of 9 September, 2002 on standards for soil quality and ground quality standards, [16]). Figure 3 summarizes the amounts of metals in the Malta Lake sediments in relation to the quality standards of arable land in Poland.

Obtained results indicate that limit values acceptable in sediments have not been exceeded, and thus there is a possibility of their agricultural use in accordance with the principles of sustainable development.

Although heavy metal contamination constituted the most probable limiting factor, it is necessary to carry out periodic control testss also on other priority substances included in the Regulation of Minister of the Environment of 9 September, 2002 [16] on standards for soil quality and ground quality standards [16].

5. Conclusions

- Generally, the Malta Lake sediments contamination by heavy metals is low.
- Using a various assessment methods allowed obtaining consistent conclusions. The sediments collected from the measurement point A may be characterized by a slight increase in the level of chromium in relation to geochemical background, while sediments from the measurement point B indicate a moderate contamination with copper and chromium. These results are characteristic of anthropogenic catchment.
- Comparative analysis of the bottom sediments and the requirements of Polish law establish that the content of heavy metals in sediments does not exceed the set standards. Therefore, there is a potential for their use in agricultural areas poor in biogenic elements and organic matter.
- The authors highlight the need for further research of Malta Lake sediments, particularly with regard to the priority substances and composition of biogenic elements for the purposes of its use as an organic fertilizer.

6. References

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