10.2478/v10067-008-0023-0
ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LXIII, 2 SECTIO C 2008

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The impact of the phosphogips heap on meiobenthos assemblages (Pomerania, Poland)

Wpływ hałdy fosfogipsów na zgrupowanie meiobentosu (Pomorze, Polska)

SUMMARY

The aim of research was to evaluate the influence of the phosphogips heap, production waste of fertilizer of Gdańsk Fertilizer Phosphorous Factory (GZNF) in Wiślinka, on the surrounding water environment, while the examination was carried out on three levels: the influence of the heap on basic water physical and chemical parameters, on bio-diversity of meiobenthos, as well as on Copepoda-Cyclopoida species content. Physical and chemical parameters of water samples (conductivity, salinity, TDS, NO3, PO4) have a relatively high value near a heap. As a result of analysis carried out, an essential dependence is confirmed between the density of homing meiobenthos, taxonomic differentiation of meiobenthos and the distance from the dumping ground of phosphogips. Cyclopoida analysis allowed confirming the occurrence of 18 species in the whole material. The poorest species content was stated for the region of the influence of phosphogips heap.

STRESZCZENIE

Celem badań była ocena wpływu hałdy fosfogipsów, odpadów z produkcji nawozów fosforowych (Gdańskie Zakłady Nawozów Fosoforowych, Wiślinka) na otaczające środowisko wodne, przy czym badanie zostało przeprowadzone na trzech poziomach: wpływ hałdy na podstawowe parametry fizyczno-chemiczne wody, na bioróżnorodność meiobentosu oraz skład gatunkowy Copepoda-Cyclopoida. Przeprowadzone analizy fizyczno-chemiczne wody wskazują na wysokie wartości przewodnictwa elektrolitycznego, zasolenia, TDS, NO3, PO4 w sąsiedztwie hałdy. W wyniku przeprowadzonych analiz stwierdzono istotną zależność pomiędzy gęstością zasiedlenia, zróżnicowaniem taksonomicznym meiobentosu a odległością od składowiska fosfogipsów. Analiza Cyclopoida pozwoliła na stwierdzenie występowania 18 gatunków w całym materiale. Najuboższy skład gatunkowy stwierdzono dla stanowisk w rejonie oddziaływania hałdy fosfogipsów.

Key words: meiobenthos, Copepoda-Cyclopoida, anthropopression, phosphogips, Wiślinka

INTRODUCTION

Degradation and deficit of inland fresh waters connected with anthropopression constitute a serious problem concerning greater and greater areas of Poland (Dobosiewicz, Olszewski 1994). Chemical interference in eco-systems results mostly in decreasing quality of waters as well as in emasculation of content and structure of biocoenosis (Trojan 1977).

On the bank of Martwa Wisła (Death Vistula), Wiślinka village is located in the neighbourhood, in which for over 35 years on the site of Gdańsk Fertilizer Phosphorous Factory (GZNF) there is a dumping ground of wastes from production of phosphorous fertilizers, commonly known as phosphogips heap. The heap with the approximate dimensions (height – 41 m, width – 400 m) consists of about 16 millions of tonnes of phosphogips. In the examined surface waters in the vicinity of the heap, the allowable standards stated by the European Union concerning such hydrological parameters as: electrolytic conductivity and concentrations of nitrates and phosphates were exceeded (Directive 86/280/EU 1986, Dojlido 1995). The evaluation carried out by Gdańsk University of Technology explicitly indicates a lack of negative influence of the heap on the environment beyond the borders of the 300-metre zone being the property of GZNF (Hupka et al. 2006).

The borders of the hydrological protection zone are about 150 m distant from the dumping ground rampart. While beyond the border, being at the same time the border of contamination from the heap moved by air and surface waters spreading, there is an uninhabited buffer zone, distant from the heap for 300 m (PU "OIKOS" 2003). Because of the lack of suitable protection, toxic substances e.g. phosphorus, nitrates, phosphates and heavy metals – arsenic, cadmium, nickel and zinc (PIG 2007) from the heap get to drainage ditches as well as into the Death Vistula, which is distant for 50 m from the heap (PU "OIKOS" 2003, Hupka et al. 2006, http://fosfi.hostingrails.pl; http://www.greenpeace.org/poland/).

Freshwater invertebrates quickly react to contamination in the form of a mixture of different chemical compounds, introduced into the aquatic environment, which lead to disadvantageous changes of eco-systems. The proper functioning of a water eco-system is possible due to ecological integrity, which includes e.g. water physical and chemical properties as well as biological life of water reservoirs (e.g. De Pauw, Vanhooren 1983, Clarke et al. 2003, Batty et al. 2005, Czerniawska-Kusza 2005, Czerniawska-Kusza, Szoszkiewicz 2007, Beauger, Lair 2008). Meiobenthic invertebrates: 0.042–1.0 mm (Pfannkuche, Thiel 1988), are sensitive indicators of changes appearing in the environment. The examination of meiobenthos organisms enables quick evaluation of the environment condition (Särkkä 1992, Nałęcz-Jawecki 2003, Dye 2005, Reis, Schmid-Araya 2008).

The purpose of examination was to evaluate the influence of the phosphogips heap on the surrounding water environment, while the examination was carried out on three levels: the influence of the heap on basic water physical and chemical parameters, on bio-diversity of meiobenthos, as well as on Copepoda-Cyclopoida species content.

DESCRIPTION OF THE AREA

The area covered by the examination aiming at stating the influence of the heap on surface waters and bio-diversity of meiobenthos was located on 36 hectares of the depression area of Żuławy Wiślane, where in the former clay working there is a dumping ground of wastes from the production of phosphorus fertilizers (Hupka et al. 2006, http://fosfi.hostingrails.pl; http://www.greenpeace.org/poland/). On the areas in the direct vicinity of the heap, water in ditches and in the canal was covered with white foam of an unpleasant smell. In a distance of 50 m to the north of the heap, there is the riverbed of the Death Vistula. The material for examination on the influence of collected wastes of phosphogips on meiobenthos was collected from two drainage ditches and from the canal, which is located between the embankment separating the heap from the Death Vistula and the heap.

The comparative material was collected from the points distant from Wiślinka, that is: two fresh water reservoirs in Sobieszewo (north of Wiślinka, Sobieszewo Island is an area of protected landscape), a drainage ditch in Przejazdowo and a fresh water reservoir in Gdańsk–Morena. Data concerning location of the given points are presented in Table 1 and on the map (Fig.1).

Tab.1. Location of sample collecting stations

No. of station	Location	Max depth [m]
1	Wiślinka – a drainage ditch, 150 m away from the heap	1
2	Wiślinka – a drainage ditch by a house, 600 m away from the heap	1
3	Wiślinka – a canal, 3 km away from the heap	3
4	Sobieszewo – a small reservoir, 4.5 km away from the heap	4
5	Sobieszewo – a small reservoir, 5 km away from the heap	2
6	Przejazdowo – a drainage ditch, 13 km away from the heap	1.5
7	Gdańsk – a small reservoir, 25 km away from the heap	4

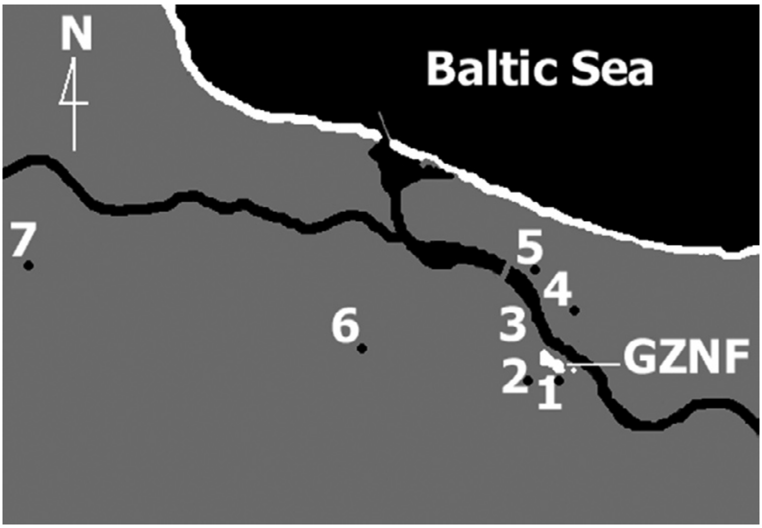

Fig.1. Research area

MATERIAL AND METHODS

Quantitative assessments (collected by means of a pipe with a diameter of 2.5 cm from the surface layer of bottom sediment to the depth of 10 cm) and qualitative assessments (with a volume of about 0.5 l collected by means of a manual scoop with a trawl with mesh of 42 µm) were made in the years 2007–2008. Together with the sampling, physical and chemical properties of water were examined: electrolytic conductivity, pH, salinity, TDS, for a series of samples from spring 2008 nitrates and phosphates (Tab. 2).

Tab. 2. Physical and chemical properties on the sampling stations

Station		pH	Conductivity [µS/cm]	TDS	Salinity [psu]	NO_3 [mg/l]	PO_4 [mg/l]
1	A	8.49	4750	apart from range	2.5		
	W	8.72	5800	apart from range	3.1		
	S	5.14	5300	apart from range	3.2	10.0	> 10.0
	Su	4.92	3030	1420	1.5		
2	A	8.51	1742	820	0.7		
	W	8.54	1305	613	0.4		
	S	7.86	1892	960	0.5	10.0	1.0
	Su	7.81	695	324	0.1		
3	A	8.59	883	414	0.2		
	W	8.39	979	587	0.4		
	S	8.05	1568	745	0.6	5.0-10.0	10.0
	Su	8.78	2030	956	0.9		
4	A	8.38	1567	735	0.6		
	W	8.25	1501	774	0.8		
	S	8.18	1485	859	1.5	1.0	< 0.5
	Su	7.81	1329	625	0.5		
5	A	8.48	1942	915	0.8		
	W	8.56	1819	854	0.7		
6	A	8.06	553	258	0.1		
	W	8.02	615	323	0.1		
	S	7.91	902	424	0.2	5.0	<0.5
	Su	7.82	257	1206	1.2		
7	A	8.22	446	210	0		
	W	8.14	563	249	0		
	S	8.02	607	285	0	2.0	1.0
	Su	8.27	784	360	0		

On the basis of quantitative tests, the density of meiobenthos N_{10} (amount of specimens / 10 cm^2) was evaluated. Because of the small meiobenthic density of some points, sub-samples with a volume of 50 ml from qualitative tests were used for bio-diversity evaluation. In the analyzed material, characteristic taxa of the group were assayed, however of different systematic positions. Zoocenological analyses were carried out, these were: frequency was calculated (Fr), commonness of occurrence expressed as $Fr = N_i/N$, where N_i – a number of points in which a given species was found, N – amount of all the points; relative number (Dm) expressed as a percentage share of the amount of specimens of the taxon in relation to the amount of all the specimens on the given point or in the material from a series of tests; domination indicator, while the following division in terms of percentage share in the group was accepted: dominants [D > 50 %], sub-dominants [25 % < sD ≤ 50 %], influents [10 % < I ≤ 25 %], sub-influents [3 % < sI ≤ 10 %], recedents [1 % < R ≤ 3 %], sub-recedents [sR ≤ 1 %] (Wojtasik 2007). The correlation between N10 with conductivity was calculated.

Mature females were used for the evaluation of Copepoda-Cyclopoida taxonomic content, the determination of which was carried out according to the following works: Rylov (1948), Dussart (1969) as well as Rybak and Błędzki (2005). Nomenclature was given in accordance with the work of Rybak and Błędzki (2005).

RESULTS AND DISCUSSION

As a result of analysis carried out, an essential dependence is confirmed between the density of meiobenthos, taxonomic differentiation of meiobenthos, as well as Cyclopoida species content and the distance from the dumping ground of phosphogips. The smallest amount of specimens falling on 10 cm² of the surface of bottom sediment was stated on the point located the closest to the heap (Table 3). Additionally, examinations carried out show that the greatest taxonomic abundance was observed at points distant from the heap (Table 3, 4). The recognition of basic chemical properties carried out and bio-diversity of points examined show that this is the hydrochemical differentiation, which is essentially linked to the level of their contamination by toxic compounds of phosphogips heaps in Wiślinka (http://fosfi.hostingrails.pl; http://www.greenpeace.org/poland/; Hupka

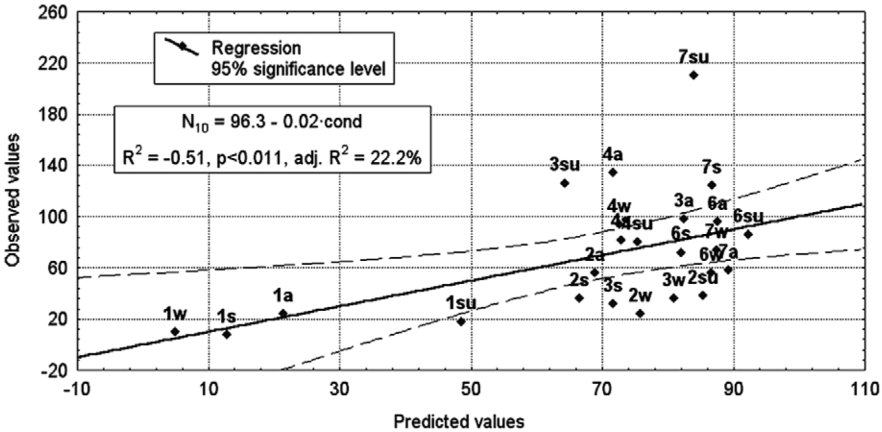

Fig. 2. The correlation between N_{10} with conductivity (a – autumn, w – winter, s – spring, su – summer, 1, 2... 7 – number of the sampling station)

Tab. 3. Relative abundance (Dm) and frequency of occurrence (Fr) of taxa found in the samples analysed, Dm(t) – relative abundance in all samples (A – autumn, W – winter, S – spring, Su – summer, T – total)

Station		Relative abundance (Dm [%]) of major meiobenthic taxa																Total number of individuals	N_{10}
		Turbellaria	Rotifera	Nematoda	Oligochaeta	Conchostraca	Cladocera	Copepoda	Ostracoda	Collembola	Diptera larvae	Trichoptera larvae	Ephemeroptera larvae	Acarina	Tardigrata	Gastropoda	Bivalvia		
1	A	0.0	20.4	32.7	0.0	0.0	0.0	28.6	16.3	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	49	24
	W	0.0	38.5	23.1	0.0	0.0	0.0	7.8	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13	10
	S	11.1	38.9	27.8	0.0	0.0	0.0	0.0	16.7	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	18	8
	Su	7.8	28.8	13.5	0.0	0.0	0.0	1.9	3.8	21.2	15.4	0.0	0.0	7.8	0.0	0.0	0.0	52	18
2	A	0.0	8.2	13.7	0.0	0.0	0.0	58.2	4.9	0.0	1.6	0.0	0.0	0.0	0.0	13.2	0.0	182	56
	W	0.0	28.2	21.4	4.9	0.0	0.0	23.3	17.5	0.0	1.9	0.0	0.0	0.0	0.0	2.9	0.0	103	24
	S	2.2	17.0	6.5	0.4	0.0	0.0	61.3	3.0	0.0	1.7	0.0	0.0	0.0	0.0	7.8	0.0	230	36
	Su	4.1	19.4	1.8	0.5	0.0	1.8	41.0	18.0	0.0	0.0	0.0	0.0	0.5	0.0	12.0	0.9	217	38
3	A	0.0	16.7	40.3	6.3	0.0	4.9	4.2	16.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	144	98
	W	0.0	22.9	59.0	4.8	0.0	0.0	3.6	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83	36
	S	2.2	18.5	50.4	15.6	0.0	0.0	0.0	10.4	0.0	2.2	0.0	0.0	0.0	0.0	0.7	0.0	135	32
	Su	7.1	16.0	58.0	11.4	0.0	0.0	0.0	5.0	0.0	1.4	0.0	0.0	0.0	0.0	1.1	0.0	281	126
4	A	0.0	32.3	26.7	0.0	0.0	0.0	8.7	10.6	0.0	19.3	0.0	0.0	0.0	0.0	2.5	0.0	161	134
	W	7.1	41.6	2.7	1.8	0.0	0.0	14.2	7.1	0.0	20.4	0.0	0.0	0.9	3.5	0.9	0.0	113	94
	S	17.1	34.8	5.3	0.0	0.5	0.0	24.6	9.1	0.0	3.2	0.0	0.0	0.5	3.2	1.6	0.0	187	82
	Su	16.7	30.2	4.5	0.0	2.0	14.7	25.7	2.4	0.0	1.6	0.0	0.4	0.8	0.0	0.8	0.0	245	80
5	A	0.0	27.3	27.3	2.1	0.0	0.0	25.2	9.1	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	143	76
	W	0.0	31.5	35.6	0.0	0.0	0.0	20.5	6.8	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	73	30
6	A	0.0	16.5	32.3	1.3	0.0	0.0	40.2	8.7	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	127	96
	W	0.0	14.1	34.3	1.0	0.0	0.0	42.4	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99	56
	S	6.4	8.0	3.4	0.6	0.0	0.0	77.4	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	327	72
	Su	6.2	14.5	5.8	1.2	0.0	0.0	57.0	14.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	242	86
7	A	0.0	25.5	22.6	0.0	0.0	9.5	2.9	6.6	0.0	19.0	0.0	0.0	0.0	0.0	13.9	0.0	137	58
	W	0.0	30.7	30.7	0.0	0.0	0.0	2.3	13.6	0.0	14.8	0.0	0.0	0.0	0.0	8.0	0.0	88	74
	S	23.4	12.5	7.4	0.6	0.0	0.0	8.0	3.7	0.0	10.3	0.6	0.0	0.0	32.5	1.1	0.0	351	124
	Su	16.2	28.7	17.2	0.7	0.0	0.9	5.4	1.3	0.0	8.2	0.9	0.0	0.2	17.7	2.4	0.0	536	210
Fr	A	0.0	1.0	1.0	0.43	0.0	0.29	1.0	1.0	0.0	0.71	0.14	0.0	0.0	0.0	0.57	0.0		
	W	0.14	1.0	1.0	0.43	0.0	0.0	1.0	1.0	0.0	0.57	0.0	0.0	0.14	0.14	0.43	0.0		
	S	1.0	1.0	1.0	0.67	0.17	0.0	0.83	1.0	0.0	0.83	0.14	0.0	0.17	0.33	0.67	0.0		
	Su	1.0	1.0	1.0	0.67	0.17	0.50	0.83	1.0	0.17	0.83	0.14	0.17	0.67	0.17	0.67	0.33		
	T	0.50	1.0	1.0	0.58	0.08	0.19	0.92	1.0	0.04	0.73	0.12	0.04	0.23	0.15	0.58	0.08		
Dm	A	0.0	20.8	26.9	1.5	0.0	2.1	24.5	9.5	0.0	7.8	0.1	0.0	0.0	0.0	6.8	0.0		
	W	1.4	28.7	28.7	2.1	0.0	0.0	18.0	11.0	0.0	7.3	0.0	0.0	0.2	0.7	1.9	0.0		
	S	11.6	16.5	10.8	2.1	0.1	0.0	37.5	5.4	0.0	4.0	0.2	0.0	0.1	9.6	2.1	0.0		
	Su	11.2	23.3	18.6	2.5	0.3	2.9	20.3	6.5	0.7	3.8	0.3	0.1	0.5	6.0	2.8	0.2		
	T	7.6	21.5	19.4	2.1	0.1	1.5	25.9	7.5	0.3	5.2	0.2	0.1	0.2	5.0	3.3	0.1		

et al. 2006; PU „OIKOS", 2003). Biodiversity increases together with the distance of points examined from the heap, while physical and chemical parameters do not exceed the permitted limits (Tab. 2, 3, 4). The correlation between N10 with conductivity shows Fig. 2.

Tab. 4. Occurrence (+) and frequency of occurrence (Fr) of Cyclopoida species found in the samples analysed

Species of Cyclopoida	Station							Fr
	1	2	3	4	5	6	7	
Acanthocyclops kieferi (Chappuis, 1925)						+	+	0.29
Acanthocyclops robustus (Sars, 1863)		+						0.14
Acanthocyclops sensitivus (Greater et Chappuis, 1914)							+	0.14
Acanthocyclops venustus (Norman et Scott, 1906)				+		+		0.29
Acanthocyclops vernalis (Fischer, 1853)		+	+	+		+	+	0.71
Cyclops insignis (Claus, 1857)					+			0.14
Cyclops vicinus (Uljanin, 1875)				+				0.14
Diacyclops abyssicola (Lilljeborg, 1901)						+	+	0.14
Diacyclops bicuspidatus (Claus, 1857)	+	+		+		+		0.57
Diacyclops bisetosus (Rehberg, 1880)	+						+	0.29
Diacyclops crassicaudis (Sars, 1863)	+			+				0.29
Diacyclops languidoides (Lillijeborg, 1901)					+			0.14
Diacyclops languidus (Sars, 1863)							+	0.14
Diacyclops nanus (Sars, 1863)						+		0.14
Eucyclops macruroides (Lillijeborg, 1901)					+			0.14
Eucyclops serrulatus (Fischer, 1851)					+		+	0.29
Microcyclops varicans (Sars, 1863)						+		0.14
Paracyclops affinis (Sars, 1863)							+	0.14

Meiofauna of examined points was represented by 16 major systematic groups characteristic of the assemblages, while essential differentiation of meiofauna was noted for the given points (Tab. 3). The most numerous in assemblages were Rotifera and Nematoda, a significant role was confirmed also for Copepoda and Ostracoda. Other taxa belonged mostly to sub-influents and recedents. Also the seasonal changeability of determined systematic groups was confirmed.

In the samples collected from the points located close to the heap (150–600 m), the smallest taxonomic diversity was observed while meiofauna was represented mostly by ubiquitous invertebrates such as Nematoda.

Cyclopoida analysis allowed confirming the occurrence of 18 species in the whole material (Tab. 4). The poorest species content was stated for points 1, 2 and 3, that is the region of the influence of phosphogips heap. It has to be underlined that the species found at the mentioned points show essential resistance to increased salinity. In the case of *D. bisetosus* and *D. crassicaudis*, their resistance to the increased salinity was confirmed even earlier (Rybak, Błędzki 2005, Wiśniewska-Wojtasik, Walczak 2005).

Because of the content of mineral substances, the points examined (1–6) were eutrophic. The concentration of mineral components changed in different seasons of the year, which is connected with their usage during the time of plants development. Artificial excessive eutrophization caused by industrial contamination, in the form of dumped phosphogips contributes to disorders in circulation of mineral substances, which in turn prevents the ecosystem from functioning. The direct effect of the increase of waters abundant in mineral substances is the rich development of plankton algae. Cyclopoida as well as other invertebrates from point No 1 were coated with algae.

The processes of progressive artificial eutrophization are the result of significant amounts of nitrogen and phosphorous compounds emitted from the heap to surface waters. It also should be noted that phosphogips are acidic, so decreased pH in the points in the neighbourhood of the heap confirm its influence on surface waters (Hupka et al. 2006).

It was observed through the worsening of physical and chemical conditions of waters, as well as the decrease of meiofauna bio-diversity in the examined water ecosystems.

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