Contemporary Problems of Management and Environmental Protection
Vol. 5, 2010. Influence of the Pesticide Dump on the Environment: 55-65

Chapter 5

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Characterization of the Pesticide Dump Area in Warlity Wielkie, Poland

Location, geological and geomorphological conditions of the Iława Lakeland

From an administrative point of view the village of Warlity Wielkie (Fig. 1) belongs to the Ostróda Commune in the Warmia and Mazury Province. As regards the physiographic system, the object under examination is situated in the mesoregion of the Iława Lakeland, which is characterized by a hilly topographic profile. Elevation differences in this area range from 5 to10 m and slope inclination is 4°. Such a form of landscape, rich in morainal features, results from the activity of the glacier and its meltwater in the Pomeranian phase of the Vistula glaciation. Glacier meltwater, which escaped outside, flowed away along postglacial channels, the depth of which reached 40 m, building a vast outwash field, known as Ostróda *outwash*. Bottoms of postglacial channels are currently occupied by lakes occurring in this area in great numbers, such as e.g. Szeląg Wielki Lake, located in the vicinity of the area under analysis. Hilly areas of the *outwash* are built of layered sands occurring on gravels.

The outwash plains of the Mazurian Lakeland are in places strongly covered with dunes, which are frequently made up of morainic sands and sorted sands of water-glacial accumulation. Among the water-glacial deposits, loose and slightly loamy sands are prevalent. Due to their granulometric composition and poor mineralogical composition, they are among the poorest soil parent rocks.

The area of the Mazurian Lakes is characterized by a large variety of landforms. A diversified relief, represented by the ground moraine and end moraine landscape, is typical for the Mazurian Lakeland. It features numerous bulges and hollows, in which a great number of small swamps were created.

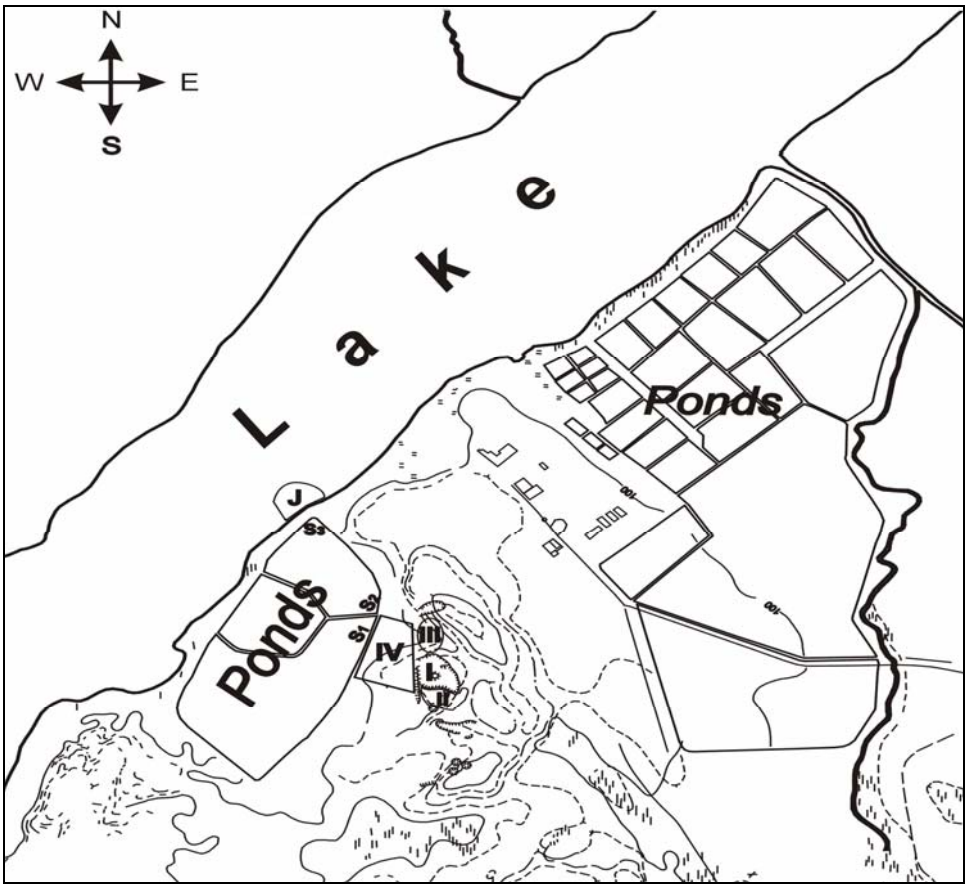

Figure 1. Location of ponds and the pesticide dump within the boundaries of the Ostróda-Warlity fish farm. The sections of the area near the pesticide dump are marked with Roman numerals.

Characteristics of soils of the Warlity Wielkie pesticide dump area

Founded with the beginning of 1970's pesticide dump was situated 800 m away from Szeląg Wielki Lake and ca. 750 m away from a drinking water intake and a few hundred meters away from fishing ponds belonging to a fish farm (Figure 1). The total quantity of hazardous materials deposited at the area has been determined during its liquidation in 2004 and accounted to 53.59 tons. The wastes have been transported to an incinerating plant (LOBBE in Dąbrowa Górnicza) for utilization.

Table 1 presents soil units occurring in the vicinity of the Warlity Wielkie dump area (Fig. 2). Proper podzol soils, belonging to the autogenic soil division, the order of podzol soils and type of podzol soils occurring in Warlity Wielkie in section I (in the vicinity of pesticide dump silos, in sections IIIa and IIIb (the area of the ravine) and in section V (the coastal area of Szeląg Wielki Lake) are presented. Podzol soils in these areas were formed from loose sands which are poor in nutrients.

The humus horizon (mummified organic matter), which is dark grey in colour, is characterized in these soils by low thickness. Beneath this, the eluvial horizon of iron and aluminium, light grey to white grey in colour, clearly stands out. Under the eluvial horizon, the illuvial horizon of humus and iron compounds (spodic) occurs, grey-brown and yellow-brown. This level shows a low degree of consolidation. The yellow parent rock is composed of loose sands, which are poor in nutrients and mainly made up of quartz. The granulometric composition of the soil under examination is presented in Table 2. A characteristic feature of these soils is very low or even zero content of silty materials. No washable parts were established in the content of soil samples collected from all layers.

Table 1

Classification and occurrence of soils of the dump area

Division	Order	Type	Subtype	Location
II. Autogenic soils	C. Podzol soils	Podzol soils	Proper podzol soils	Section I – dump area Section IIIa, IIIb – ravine area Section V – coastal area of Szeląg Wielki Lake
II. Autogenic soils	B. Brown forest soils	Brown soils	Brown leached soils	Section II – old gravel pit area Section IIIc – ravine area Section IV – mixed forest area
IV. Hydrogenic soils	B. Post-bog soils	Muck soils	Peat bog soils	Section VI - fish pond area

Table 2

Granulometric composition of proper podzol soil of the Warlity Wielkie dump

Sample No.	Sample collection depth (cm)	% content of soil fractions (mm)				Granulometric group
		>1.0	1.0-0.1	0.1-0.02	<0.02	
1	0-30	-	81-97	3-19	0	loose sand
2	30-50	-	81-97	3-19	0	loose sand
3	50-100	-	84-95	5-16	0	loose sand

Figure 2. The area of the pesticide dump in Ostróda-Warlity (*on the right* – a warning sign)
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The soil under examination is acidic (in 0-30 cm layers – pH_{H2O} = 5.5, in layers below 50 cm – pH_{H20} = 5.0), with low buffer properties and very low adsorbing capacity. The absence of colloidal parts and unfavourable physical and chemical characteristics prevents the podzol soils from being able to adsorb significant amounts of nutrients, metal elements or other compounds. In these soils, significant migration of these elements is observed and they most frequently are washed to underground waters to be carried away to water reservoirs. Podzol soils are poor soils, belonging to quality class V of arable lands and weak rye complex (6). These soils are very often intended for forestation or are occasionally used as pond areas or left as barren land.

Brown leached soils belonging to the autogenic soil division, order of brown forest soils and type of proper brown soils, occur in Warlity Wielkie in section II – old gravel pit, in section IIIc – ravine area and in section IV in the mixed forest area (Tab. 1). These soils are characterized by a humus horizon with a thickness up to 30 cm. In the lower part of this horizon, there is a poorly developed initial eluvial horizon of certain mineral components. Below, there occurs a browning horizon, with a diagnostic cambic level. Brown leached soils in section II are made up of slightly loamy sands occurring on loose sand, and in sections IIIc and IV – of light loamy sands occuring at the depth of about 50 cm on heavy loamy sand (Tab. 3). The content of sand fraction in brown leached soil occurring in section II in all layers of the soil profile amounts to more than 90%, with a dust fraction in the surface layer making up 3% , in the 30-50 cm layer – 2%, and in the layer of 50-100 cm – 4%. The highest content of washable parts (7%) is found in the humus layer. In brown leached soil occuring in section IIIc and IV, the content of the sand fraction is lower and ranges from 74% to 81%, while the content of the dust fraction ranges

from 8% in the 0-30 cm layer to 10% in the 50-100 cm layer. In sections IIc and IV of the Warlity Wielkie dump, brown leached soils are characterized by a higher content of washable parts, ranging from 11% to 16%. The reaction of the soil under examination varies from slightly acid (pH_{H2O}=6.1-6.5 in soils of section II) to neutral (pH_{H2O}=7.2–7.3 in soils of sections IIIc and IV). Brown leached soils, created from light loamy sands and loose sands, are poor soils of quality class VI (the poorest arable lands) and complex 7 (very weak rye complex). These are soils which do not show any significant ability to adsorb elements and retain water. For these reasons, soils of this type most frequently reveal a neutral content of heavy metals. However, a significant part of these elements can be washed out, even up to the underground water level, and carried away to water reservoirs.

Table 3

Granulometric composition of brown leached soil of sections II, IIIc and IV of the area of the Warlity Wielkie dump

Sample No.	Sample collection depth (cm)	% content of soil fraction (mm)				Granulometric group
		>1.0	1.0-0.1	0.1-0.02	<0.02	
Section II (gravel pit)						
1	0-30	-	90	3).	7	slightly loamy sand (sls)
2	30-50	-	97	2	1	loose sand (ls)
3	50-100	-	95	4	1	loose sand (ls)
Section IIIc (ravine), **IV** (mixed forest)						
1	0-30	-	81	8	11	light loamy sand (lls)
2	30-50	-	82	7	11	light loamy sand (lls)
3	50-100	-	74	10	16	heavy loamy sand (hls)

Peat-muck soils, belonging to the hydrogenic soil division, occur in section VI of the area under examination, i.e. in the area of fish ponds, alternatively used for agricultural purposes (Fig. 3). These soils, created under conditions of permanent anaerobiosis, are characterized by organic matter content ranging from 21.1% to 24.4 %, and by its profile thickness exceeding 30 cm under natural conditions. Periodic boggy conditions favour the growth of hydrophilic plants.

Lowering of the underground water level results in the dewatering of boggy soils, interrupting the process of organic substance accumulation in the site and initiates the process of organic matter mineralization. This phenomenon is known as subsidence and results in physical, chemical and biological changes in the soil, manifesting themselves in morphological features of the upper layers of the soil profile.

In the examined soils, poorly decomposed remains of plant fibre can be observed in the muck level of granular structure. The parent formation, made of peat of

fibrous or amorphous structure, occurs directly under the muck level. Organic soils, including peat muck soils, show the ability to adsorb a significant amount of both metallic and non-metallic trace elements.

The Ostróda-Warlity Fish Farm

A lowland pond centre of the Fish Farm in Ostróda - Warlity Wielkie was constructed in 1978-1982, and until 1994 belonged to the State Fish Farm in Olsztyn. In 1994, as a result of the reorganization of the farm, division of ponds and establishing a lease, a new, independent company was created under the name of Gospodarstwo Rybackie Ostróda-Warlity, sp z o.o. (Ostróda-Warlity Fish Farm) and is still currently in operation.

The fish farm in Ostróda-Warlity uses 5,774,000 ha of lakes of various types in terms of fish and limnology and one carp pond facility. This pond is located in Warlity Wielkie, a village situated about 6 km north of Ostróda and the express road E-7 Warszawa-Ostróda-Gdańsk and about 45 km west of Olsztyn. The farm is situated on a finger lake, Szeląg Wielki (area – 599 ha, h_{max} - 35.5 m, fishing type: *whitefish*), from where, with the use of a pumping station and covered ditches, all ponds of the centre, fish keeping areas and a hatchery are supplied with water (Fig. 4).

A fry-stocking centre in Ostróda-Warlity has at its disposal 35 ponds with a total area of 90 ha, of which ponds No. 30-35 are winter-fish ponds, of a total area of 1.8 ha. The main complex of the farm is made up of 33 ponds, and three remaining ponds are situated 2 km from the farm, covering the total area of 18.5 ha (Tab. 4). All ponds are situated in four main complexes, of which the largest one (65.00 ha) is situated on the right side of the Ostróda-Warlity road and through a ditch from Szeląg Lake to Drwęckie Lake, while three other complexes are situated on the left side of the same road. The bottoms of carp ponds are poorly covered with water and marsh plants, characteristic for ponds of a short period of use (since 1978). A detailed characteristic of the pond flora is presented in Chapter 6.

Table 4

Total area of ponds of specific categories in Ostróda-Warlity

Complex No.	Registered area	Production area	Pond category	Share of total area (%)
I.	**3.43**	**2.74**	Spawning ponds	**3.77**
II.	**13.50**	**9.80**	Fingerling ponds I	**14.86**
III.	**68.66**	**56.02**	Fingerling ponds II	**75.56**
IV.	**1.60**	**1.50**	Winter-fish ponds (K_1)	**1.76**
V.	*3.68*	*2.94*	*unused*	*4.05*
T o t a l	**90.87**	**73.00** ***(80.3%)***	***T o t a l***	***100.00***

Figure 3. A panorama view of the ponds of the Ostróda-Warlity farm, (*in the background, on the right, at the edge of the forest* – the area of the pesticide dump)

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Figure 4. A panorama view of carp ponds in Warlity (*in the bottom* - Szeląg W. Lake, *on the right* – a pumping station, a hatchery, offices, fish keeping areas)

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Figure 5. Mechanized fishing in nursery ponds in the Ostróda-Warlity Fish Farm

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The bottom fauna of nursery ponds in Warlity Wielkie is represented mainly by water insect larvae (*Diptera varia*), with a strong prevalence of *Chironomus plumosus*. Additionally, the bottom is inhabited by chrysalides: *Culicidae, Limnofilus vittatus,* larvae *Ephemeroptera, Trichoptera* and *Stratiomyia, Sphaeromias sp.* as well as other chironomids (*Chironomidae sp*.). Oligochaete (*Olichochaeta sp.*), an important component of the benthos of carp ponds, occur on the bottom of nursery ponds relatively rarely (unfavourable peat medium), including *Tubificidae*, or they are completely absent (sand with clay).

The level of benthos in individual ponds of the Warlity Wielkie centre is quite low and slightly diversified, mainly due to the above mentioned character of the ground (bottom) in individual ponds. The seasonal (months VI-IX) average population size and biomass of benthos in the main complex A (sand), and B (clay) were similar, and amounted to, respectively, 1002 and 1517 pcs/m^2, and 2.81 and 2.76 g/m^2 of the bottom. On the other hand, in ponds on the peat-sand ground (complexes C and D), the average population size of benthos amounted to 903 pcs/^{2} and 13.40 g/m^2 of the bottom, i.e. it was four times higher. Such high biomass mainly resulted from the high biomass of Mollusca (mainly *Lymnea stagnalis),* the share of which at the beginning of summer amounted to 19.50 g/m^2, i.e. 25.5 % of total mass of the summer benthos. However, it should be assumed that after a 30-year period of using the ponds for fishery purposes, applying organic

fertilizers, feeding fish and carrying out annual tillage and cultivation works, the fertility of those ponds measured by the abundance of the bottom fauna, is currently much higher and at present amounts to 125-170 kg/ha.

The main breeding species in Warlity Wielkie is carp (*Cyprinus carpio* L.) and this farm specialises in the production of stocking material of this species (July and one-year-old fry and, only to a limited extent, fish in the second year of life – K_2 and commercial carp). Additionally, this centre also produces other species: pike, common whitefish, vendace and pike-perch (other fish are bred occasionally). The fish centre in Warlity Wielkie is not focused on the production of commercial (table-size) carp, although every year 2.3 tonnes of commercial fish are produced to satisfy its own needs. Some fish are left as selected specimens and spawners (150-200 fish on average) are used for spawning under artificial conditions in the hatchery.

For more than ten years, the Warlity Farm has been producing heavy carp fry (100-120 g/pc, max. over 220 g/pcs) and, to some extent, fish in the second year of life (K_2). After obtaining carp hatch (K_0) from artificial spawning, nursery ponds – the so-called fingerling ponds I (June), and fingerling ponds II (July-October) are stocked with fish. Depending on the thermal characteristics of the season and successful rearing, some (excess) of the obtained July fry is sold outside, and the fingerling ponds II owned by the farm are stocked with the rest.

Carps in ponds were fed every day only with artificial feed with high protein content (pellets). The feed usually applied consisted of extruded pellets intended for fry, produced by a well-known feed company Aller-Aqua Master, with high protein – 35% and fat content – 9%. The pellets were poured to semi-automatic feeders (on average one per 2-3 ha of the pond), situated on the pond water from which fish took the feed on their own.

In all ponds of the Ostróda-Warlity Fish Farm, as in other fish farms of northern Poland, fish are caught in October, i.e. in a safe period before the first frosts and pond icing (fig. 5). The obtained growth performance of fry, the amount and the costs of the feed consumed, as well as the feed conversion ratio (FCR) for the warm season of 2006 are presented in Table 5.

Table 5

Fish density and growth performance, consumption and cost of feed in nursery ponds of the Ostróda-Warlity Fish Farm in the season of 2006 (*Materials: Fish Farm Ostróda-Warlity*)

Stocking variant (pcs/ha)	Ponds – fingerling ponds II		Growth, *FCR*** and feed costs		
	n*	Area of individual ponds (ha)	Total growth (kg)	*FCR*	Feed cost (PLN/kg)
A. LOW *(up to 20,000)*	3	1.42 - 8.72	**6,770**	*1.48*	**3.85**
B. MEDIUM *(up to 30,000)*	3).	0.85 - 2.00	**1,780**	*1.67*	**4.34**
C. HIGH *(up to 45,000)*	4	0.92 - 5.40	**3,260**	*1.51*	**3.93**

** n - number of nursery ponds analysed*

*** FCR – feed conversion ration (amount of feed: fish growth performance = in kg)*

The occurrence of high water temperature in summer, and particularly at the end of September 2006, was a decisive factor influencing the intensity of feeding and growth performance of carp. Consequently, this resulted in a high final production of carp fry (1,010-2,066 kg/ha). Global amounts of produced fry, fish in their second year and commercial (table-size) carp and other fish produced in 2006-2008 are illustrated in Table 6.

Table 6

Fish production in the Ostróda -Warlity Fish Farm in 2006-2008
(*Materials of Ostróda-Warlity Farm Fish*)

Year	**Fish production** (kg)					
	Summer fry K_w ('000 pcs)	One-year-old fry (K_1)	Fish in the second year of life (K_2)	Commercial fish (K_2+K_3)	**Total carp - kg** *(kg/ha)*	***Other fish*** *('000 pcs)*
2006	*1 051*	78,700	1,000	1,850	**81 550** *(896)*	*Pike - hatch - 4 696* *Pike-perch - fry- 837* *Vendace - hatch - 11 000* *Vendace - fry - 2 400*
2007	*730*	56,574	840	1,771	**59 185** *(650)*	*Pike-hatch - 3 918* *Pike-perch - hatch - 1 500* *Vendace - hatch - 7 900* *Vendace - fry - 1200 400* *Koi - fry - 32*
2008	*587*	45,000	53,000	11,970	**109 970** *(1,208)*	*Pike-hatch - 4 877* *Pike-perch - fry- 465* *Vendace - hatch - 12,900* *Vendace - fry - 2 400*
average	***790***	**60,100**	**18,380**	**5,200**	**83 600** *(918)*	*Hatch + fry* *5 species of fish*

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