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**REPORT ON AGRICULTURAL POLLUTION
FROM INDUSTRIAL HOG RISING FARMS
IN POLAND**

Dr. Andrzej Lysko
Robert Cyglicki

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Summary

Polish agriculture is strictly connected with the state of the Baltic Sea. It constitutes 42% of the drainage basin of the Baltic Sea and 51% of the agriculture of the Member States of the Baltic Agenda 21¹. Therefore during the last few years we are concerned about the rapid growth of the number of industrial animal farms unable to fulfill the environmental standards of the Polish law, mostly due to the methods and range of farming. Good exemplification of the problem is Smithfield Foods' activity in three Polish voivodeships (Zachodniopomorskie, Wielkopolskie and Warminsko-Mazurskie). The company invested 100 million dollars, officially developing 24 farms, each of annual capacity of 6000 to 25000 pigs/hogs.

At the behest of Polish government, Polish Inspectorate for Environment protection decided to investigate 14 out of 24 Smithfield's farms in Poland. Environmental inspection admitted that farm management had not applied for proper permits. At present, the farms are collecting necessary permits for their actions without ceasing their activity. However, the problems of over-manuring of soil and pouring liquid manure in direct neighbourhood of water bodies remain unsolved. Both the lack of permanent monitoring of the soil quality and shifting the responsibility for manure management onto the subjects not disposing enough land, will cause a gradual increase the pollution from such agricultural/industrial activities to the Baltic Sea. It is worth emphasizing that the highest degree of industrial farming occurs exactly in the Baltic drainage basin (Zachodniopomorskie and Kujawsko-Pomorskie voivodeships).

Examples of the farm impact

Studies for the West Pomeranian voivodeship

Production of liquid manure

According to the official data, in Zachodniopomorskie region 40 industrial farms grow from 2000 to 25000 pigs each (average stock 7971), which amounts in total to 318 843 pigs or 95 653 (LCU) Large Conversion Unit. Assuming that 1 LCU gives about 20 m³ (according to some sources even 21 m³) of liquid manure, we may easily establish that the number of pigs quoted above produce 1 913 060 m³ of liquid manure per year.

Soil requisition

Having calculated (the calculation methodology – page 10), to utilize the produced liquid manure in a harmless way for people and the environment, 60 000 ha is needed. Pursuant to the Act on fertilizers, safely means without exceeding a dose of 170 kg pure component N per 1 ha per year and reasonable meeting the plants' need for nitrogen. Meanwhile, according to the non-official estimation (official data does not exist), liquid manure is utilized on the half of land surface required, thus agricultural pollutants degrade the soil and infiltrate and drain to the water bodies.

Emission of odour

In Poland the scope of odour effect is not subject to legal specification. Odour as a gas mixture is characterized by small ability to mix with the air, which enables them to move over long distances. Furthermore, not only do ammonia and sulphur hydrogen give off unpleasant smell, but also they are sources of airborne contamination.

The majority of gases emitted to atmosphere by agriculture:

- **Methane-** intestine gases, animal excrement

The emission of methane from porker in West Pomeranian amounts to 930 t per year

- **Ammonia-** animal excrement

The emission of ammonia from porker in West Pomeranian amounts to 3440 t per year

- **Dinitrogen monoxide N₂O-** from agricultural soil and processing of bio-wastes

The emission of N₂O from porker in Zachodniopomorskie amounts to 205 t per year

¹ Jan Brzozowski PhD, proposal on separating smaller units in the frame of polish agricultural hot-spots of the Baltic Programme, Helsinki Convention Office in Gdansk 2001.

Recommendations for Poland:

- In accordance with the Ministry of Environment resolution and the directive IPPC 96/61EC, Polish Government must execute an obligation of possessing integrated permit for farms rising 2000 pigs and more. After the transition period finish (30th April 2004), farms that did not obtain integrated permit should be implicitly closed down.
- Lack of precise regulations as to manure disposing enables farm owners to avoid taking responsibility for environment contamination². Therefore it is necessary to include in the new amended Polish law on fertilizers regulations as to the necessity of revealing data concerning the surface, the property and the plot numbers of the area on which the liquid manure is to be utilized. The most important regulation is however not to allow for use of liquid natural manure outside the farm, where it was produced, to keep the closed circulation of the nutrients and organic matter within the farm and to protect the environment
- To avoid threats of the activity of industrial farms on ecologically fragile areas the Polish government has to amend the Polish Act on farm by introducing legal requirements, that localisation of big farms cannot be decided on without an agreement with the local municipal government. Such requirements would give the local governments a possibility to refuse localisation of big industrial farms that can be harmful for the environment.

Recommendations for HELCOM:

- It is advisable for all Baltic Sea region countries to execute inspection of all industrial farms rising more than 2000 pigs/hogs, especially to view land areas used for utilizing manure. Attention should be paid both to physiographical features of the grounds designed to fertilizing as well as to setting permissible doses of manure based on the type of soil, hydrological conditions and plant coverage.

² There exist however records of pouring liquid manure close to surface waters.

- The Helsinki Commission should examine in detail the environmental problems connected with big industrial animal farms and develop requirements and a new Recommendation for environmentally friendly management of big animal farms. HELCOM LAND should be given the task to elaborate a new HELCOM recommendation. To meet this aim it is advisable to appoint a working group, which should prepare detailed recommendations for Contracting Parties to prevent pollution of the Baltic Sea environment from big animal farms.

Introduction to the problem

Animal farming is undoubtedly necessary for meeting nutritional needs and demand for animal semi-products. However, it causes also some dangers, which directly (emission of pollution from stock buildings) or indirectly (through, among others, excrements) influence on environmental condition. This influence varies depending on forms of production and its size. The least negative impact on the environment is caused by small farms of several animals, the most by the big ones (several thousand animals), which is quite logical, considering the amount of production and wastes coming from such farms.

There are two methods of breeding used in farming: with bedding and without it, that, besides technology, differ in type and amount of produced wastes. In farms with bedding, considered as more environmentally friendly, the result is so-called dung, characteristically including large amounts of dry mass (20-30%). It is mainly an organic substance, 60% of which is so-called active humus. However, it is difficult to implement farming with bedding in farms focused on industrial production of animals, among others, because of its high costs and problems with hygiene maintenance. It resulted in establishment of form of farming without bedding, most often used in swine production. However it leads to serious environmental danger, because, besides direct impact (gathering of enormous number of animals in small space), it results in production of liquid manure much more dangerous for environment, because of its high level of mineralization, and microbiological pollution. This kind of farming was very popular in the 1980s and commonly used all over the world. In Poland it was common especially in State Farms (PGR), but after giving up the form of collective state farming in the early 1990s, some of the PGR farms were closed down.

In the times of hyper-production and focus on environment protection, this method has been gradually reduced in number also in the Western Europe, where is anyway limited by numerous regulations minimising its negative impact on environment. Departure from industrial production of animals is caused not only by problems with utilisation of liquid manure, but also with general departure from artificial production, considered to be “unnatural”.

Basic dangers related with industrial production of animals and with liquid manure

The basic problem of industrial swine farms is utilisation of enormous amounts of liquid manure produced during the farming. This problem places this type of production among one of most harmful for environment and human health and of potentially very negative impact on environment (Dz.U.98.93.589 of July 23rd, 1998). The basic form of utilisation of liquid manure is its agricultural usage and an organic fertiliser (other forms of utilisation, such as, for example, cleaning, are too expensive to be used of mass scale). Quality and quantity of liquid manure from farms depend on kind and age of animals, methods of farming, zoo-hygienic conditions and amounts of water used (Gajda at al. 1977; Bieszczad, Sobota 1996). It causes that chemical composition of liquid manure differs enormously from farm to farm, that demands detailed research every time before its agricultural implementation. It is especially important for defining appropriate management of this fertiliser.

Air pollution

Liquid manure possesses some qualities of especially negative impact on environment. The processes of non-oxygen fermentation (rotting) taking place in it causes polluting air with such gases as ammoniac, sulfuretted hydrogen, carbonyl compounds, amines, mercaptan etc., causing troublesome smells. In Poland the range if their impact in not normalised by legal regulations. Smells as mixtures of gases are characterised by limited ability to mix with air, thus they can be transported in long distances. Moreover, such gases as ammoniac and sulfuretted hydrogen, besides their unpleasant smell, are a source of air pollution, and their acceptable amount in the air is regulated by the Environment Ministry Regulation of June 6th, 2002 on acceptable levels of some substances in the air, alarm levels of some substances on the air and tolerance margins of acceptable levels if some substances (Dz.U. 2002.87.796). As Bieszczad & Sobota (1996) state: a farm of 25 thousand pigs produces every hour approximately 10 kg of ammoniac, that causes increase in its concentration within the area up to **600 km²**.

Amonnia:

- ∞ Considered to be one of the major factors causing soil acidifying, by washing out the magnesium, ferrum, aluminium, and calcium ions. In the provisions of the Helsinki Commission it is postulated to technologically limit its oxygenation;
- ∞ It causes water eutrophisation as amonias of nitrogen penetrate to the water as a result of fertilizing with liquid manure, and later on they change into other compounds;
- ∞ In people it causes apart from negative effect on air-stream mechanism transformation of hemaglobine into hematine, which is the cause of anoxia and may even lead to death of lesion of central nervous system (mainly the brain)

Dinitrogen monoxide:

- ∞ Damages ozone laser causing heating effect

Micro-biological pollution

Liquid manure is a source of microbiological pollution that many go to ground waters and surface waters or, in a form of aerosol move with the atmospheric air. Among the bacteria that can be transmitted into environment in result of industrial swine farming there are: staphylococci, E. coli, fecal streptococci, rubella bacilli, tubercle bacilli, various illnesses-causing staphylococci and streptococci, foot-and-mouth disease viruses, various fungi and parasites (like solitaires). Many of those micro-organisms may be harmful for humans (Tarczynski 1977; Szejniuk, Kluczek 1996; Bieszczad, Sobota 1998). Sanitary danger related with using liquid manure in agriculture is much higher than in case of dung, among others, because of its low temperature (below 20°C). Low temperature limits the processes of thermal disinfecting that take place in dung (high temperature in dung prisms has disinfecting values). Such a situation results in higher survival rate of harmful micro-organisms (tab. 1).

Tab. 1

Survival rate of some micro-organisms in liquid manure (acc. Wolkow 1977)

Type	Survival rate [days]	
	spring and summer	autumn and winter
rubella bacilli	92	157
typhoid bacilli	85	158

	Survival rate [days]	
brucellosis bacilli	108	174
foot-and-mouth disease viruses	42	192
tubercle bacilli	457	

So-called seasoning of liquid manure is one of methods to eliminate this danger. It is also possible to use substances disinfecting liquid manure, such as iodine/phosphor mixes and synthetic phenols (for example, *Tagonin*, *Zephyrol*, *Diaparen*, *Omnisen*, *Bioval*, *Sterinol*). However, using them is not neutral to environment after agricultural treatment of liquid manure.

Water pollution

Main danger related with agricultural usage of liquid manure is its negative impact in condition of ground waters and surface waters. Washing out nutrition elements from liquid manure is closely related with mechanical composition of soil and fertilisers dose. Thus while fixing the level of liquid manure doses one must consider:

- composition of fertilising elements in liquid manure;
- terms of usage of liquid manure;
- soil (type, kind, amount of nutrition elements, etc.)
- current demands and regulations concerning environment protection.

In general loses of nitrogen it is important to define: how big amount of it can get into deeper levels of soil profile and be washed out to ground waters. As the Mazur's researches (1996) proved, mineral fertilisation and using liquid manure of pigs plus mineral fertilisation (with fixing the same dose of NPK for both types of fertilisation), causes dramatic increase in amount of nutrition elements in water (with exception for potassium). Eutrophisation of water with nitrogen and phosphorus is also worth highlighting. This kind of fertiliser caused also 1,4 time increase in amount of calcium and 2,5 time increase of magnesium in water, compared with mineral-only fertilisation. It should be mentioned that having at disposal appropriate amount of agricultural lands, one must define the level of liquid manure fertilisation of 50% of plants demands on nitrogen, while the other 50% should be supplemented my means of mineral fertilisers. In some cases it is acceptable to use pure nitrogen in 75%. It is caused mainly by imbalanced proportion between NPK in liquid manure and possibility of washing out nutrition elements into the profile, that negatively influences biological balance of soils and causes environment pollution (Krzywy, Woloszyk 1985; Mazur 1996; Krzywy 1999).

Among the washed out elements nitrogen substances are most important, because coming through various chemical transformations in soil they can evolve into some very toxic substances, causing health hazard or even dangerous to human life. Nitrates are the basic danger for the can concentrate on cultivated plants and, via nutrition chain, they can get into animal organisms. Nitrates, as a basic nitrogen compound in soil, if too concentrated are reduced to nitrites, and than to toxic and carcinogenic nitro-amines. Over-fertilisation of soils with nitrogen (especially in case of organic fertilisation) is a basic cause of creating of such compounds, that leads to concentration of nitrites or ammonium nitrate (Mazur 1991).

Methodology of the calculations

Calculation of manure doses and surface necessary to liquid manure utilization for Zachodniopomorskie voivodship.

Pursuant to the register in Zachodniopomorskie Voivodship there are 40 large-scale farms rising from 2000 to 25000 pigs each (average stock 7971), which amounts in total to 318843 pigs. It makes about 95653 LCU.

Assuming that one LCU gives about 15 to 20 m³ (according to some sources even 21 m³) depending on the type of the animals, it may be estimated that the abovementioned number of pigs produces from 1 434 795 to 1 913 060 m³ of liquid manure. As a basis we assume the maximum number, as pigs produce the biggest amounts of excrements, the most toxic, containing the highest number of NPK and the pure nitrogen component.

Example:

Cattle NPK 230, pigs 210-260 NPK (depending on the nourishment)

Pure nitrogen component cattle 90 kg; pigs 130 kg per LCU/year

For the calculation needs we assumed utilization of liquid manure on the 50% level of the plants' need for nitrogen. In some cases a maximum dose is 75% use of nitrogen.

The Table 2 below presents so called manure equivalents meaning the maximum amount of the component taken from mineral manure, which is estimated as 100%. An exemplary equivalent amounting to 60 for liquid manure of pigs means that only 60% of the nitrogen from the liquid manure can be taken by plants and the remaining 40% is subject to a loose, meaning that it is washed into the deeper layers of the soil.

Tab. 2

Manure equivalents N, P₂O₅ i K₂O of the liquid manure depending on the agronomical category of the soil and the period of its utilization (ed. Mazur 1978).

<i>Soil</i>	Period of utilization of liquid manure		
	August-September	October-November	Spring

<i>Soil</i>	Period of utilization of liquid manure								
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
Light	30	100	60	40	100	80	70	100	100
Medium	40	100	80	55	100	100	70	100	100
Rich	60	100	100	70	100	100	70	100	100

Calculation pattern

$$D = \frac{P * b}{Cx * Wn}$$

D – dose of liquid manure per year [m³ * ha⁻¹]

P – need for manure of the given class of plant per year [kg * ha⁻¹]

b – planned degree of fulfilling the need for nitrogen in the pure liquid manure component (50%-70%)

Cx – manure component concentration in liquid manure

Wn – manure component (see table 1)

Table 3 contains calculations for manure doses for three plants: grains, grass, Papilionaceae (difference of need for pure nitrogen). For the needs of West Pomeranian voivodeship I chose the equivalent 0,6 (60%) – an average for the vegetation period and need covered in 50%, which gives an average manure dose for cereals of 33 m³. The component of pure nitrogen in the liquid manure is considered to be 0,4% - this is an average dose for pigs. I have chosen such a dose (33 m³) because in West Pomeranian the majority of soils are light soils (especially in the area of farming) – thus the manure equivalent is very low and the mostly cultivated plants are grains.

Tab. 3

Exemplary calculations of the manure doses and the area necessary for farm implementation of liquid manure for different indexes of coverage of need for nitrogen and manure equivalents

<i>Plant</i>	<i>Need for nitrogen [kg* ha⁻¹]</i>	<i>Need coverage 50% and equivalent 0,7</i>	<i>Need coverage 50% and equivalent 0,6</i>	<i>Need coverage 70% and equivalent 0,6</i>	<i>Need coverage 70% and equivalent 0,5</i>	<i>Need coverage 100% and equivalent 0,7</i>
		<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>grains</i>	160	28	33	46	55	56
<i>grasses</i>	180	31	37	51	61	63

<i>Papilionaceae</i>	40	7	8	11	14	14
<i>Average dose of liquid manure [m³*ha⁻¹]</i>		22	26	36	43	44
<i>Given dose of pure nitrogen per year</i>		91	107	148	177	181

Assumed dose of nitrogen in liquid manure 4,1 kg/m³ - about 0,4%

Surface needed for utilization of the dose of liquid manure given above (1 913 060 m³) - below.

Surface for manuring was calculated on the basis of the following pattern:

$$Ao = \frac{Q}{D}$$

Ao = the surface required

Q – total amount of liquid manure produced annually

D – dose of liquid manure per year [m³ * ha⁻¹]

We obtain the result of 57 971 ha necessary for safe utilization of the liquid manure, meaning, in accordance with the Act on manuring, without exceeding a dose of 170 kg pure component N per 1 ha per year, as well as common sense in meeting the plants' need for nitrogen and fertilizing periods.

To sum it up, safe utilization of liquid manure requires at least 60 000 ha (the surface should be provided by the farms). Areas excluded from fertilizing should be added to this result; the Act is appended (Off. J. 2001.60.616 (R) Detailed description of usage of fertilizers and instruction on their usage)

Amount of gases given off in Zachodniopomorskie out of 40 farms officially registered

Tab.4

Emission of ammonia NH₃ to the atmosphere

<i>Animal</i>	<i>Emission index as at one locality [kg/year]</i>			Total amount of pigs (318843 pigs in West Pomerania) [kg]
	W chlewni	Stocking of liquid manure	Using as a fertilizer	
Piglet	2,89	0,85	5,57	2968428,3
Porker	3,5	1,3	6	3443504,4

Attention: Official data as to the structure of rising in individual farms has not been found

Emission from porkers in West Pomeranian amounts to 3440 t/year

Tab. 5

Emission of methane(CH₄)- to the atmosphere

<i>Animal</i>	<i>Emission index</i>		
	From intestine gases [kg per head]	From excrements [kg per head]	total (318843 pigs in West Pomeranian) [kg]
Piglet	0,6	0,96	497395,08
Porker	1,5	1,43	934209,99

Emission of methane for porkers in West Pomeranian amounts to 930 t/year

Tab 6.

The approached emission of N₂O in kg per ha of surface fertilized with liquid manure

<i>Source of liquid manure</i>	<i>Surface fertilized</i>	<i>Emission index of N₂O [kg/ha* r⁻¹]</i>	<i>Emission [kg*year⁻¹]</i>
Piglets	60000	3,42	205200
Porkers	60000	3,42	205200

Emission of N₂O from porkers in West Pomeranian amounts to about 205 t/year