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Best management practices in Poland to keep good quality of surface waters in rural areas

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Introduction

The quality of surface water is influenced mainly by nutrient and pesticide loads. These substances sprayed in the air can fall directly into the water (atmospheric deposition) or can be transported with soil particles in surface runoff. Water moving down the soil profile, subsurface flow and tile drainage are other paths by which surface water becomes enriched with biogenic elements and pesticide residues. In order to protect water against unwanted contamination it is necessary to avoid spraying chemical substances into the air, to reduce soil erosion and to limit the concentration of water-soluble nutrients in the soil during the period of intensive water drainage. There are two main sources of contamination in rural areas: agricultural production and rural habitation. The latter is not actually an agricultural source and depends on sanitation systems in rural areas. Actual sources of agricultural contamination are land under agriculture (dispersed sources) and animal manure storage (point sources).

Avoiding pollution from point sources

Improperly stored manure is a major source of nitrogen diffused to environment. Mitigation of nitrogen losses from livestock manure has a financial and environmental consequence. The most important aspect of manure storage is a correctly constructed and built tank for liquid manure and a pit for solid manure. These facilities should have leak-proof bottoms (Figure 11.1) and tanks for liquid manure should have waterproof walls as well (Figure 11.2). Liquid manure should be covered with

FIGURE 11.1. Manure pit with leak-proof ground

FIGURE 11.2. Cement slurry container

a floating plate or with a tight roof that is provided with ventilating holes and an entrance. The capacity of the tank or pit should be appropriate to the quantity of manure production in the farm. Calculation of storage capacity should consider that manure can be applied onto fields twice a year, so on average it has to be stored for 6 months. The quantity of manure produced by different types of animals is shown in Table 11.1. The values calculated for cattle should be reduced in proportion to the duration of grazing period.

TABLE 11.1. Annual manure production

Animal category	Solid manure (t)	Dense slurry (m^3)	Liquid and water manure (m^3)
Dairy cow	12,0	23,2	5,5
Calves (0–6 months)	2,6	–	0,44
Young cattle (6–12 months)	2,9	7,0	1,7
Young cattle (12–24 months)	4,8	12,1	3,2
Fattening bulls	5,8	12,2	1,9
Stud-bulls	6,4		3,7
Nursing sows	4,0	8,3	2,8
Fattening pigs (20–110 kg, fattening –128 days)	0,4	0,8	0,28
Horse	2,8	–	0,39
Poultry, hens	0,11	–	–
Poultry, broilers (2 kg)	0,008	–	–

The capacity of a manure tank and pit should equal half of the total quantity of manure produced by all animals on the farm. The amount of slurry produced within a farm should be reduced by decreasing water usage for sanitary purposes and for watering animals. Any other liquids, such as household waste water, should not be added to the tank. The size of manure pit has to be calculated depending on the height of pile, as shown in Table 11.2. All outflows should be collected and stored in the tank or be diverted back to the pile.

The storage of FYM (farmyard manure) in the field directly on the soil is not allowed because this may greatly increase the concentration of nitrogen in the soil profile and cause contamination of ground water as a result of N leaching.

TABLE 11.2. Amount of FYM stored on the unit of pit area

Height of manure pile (m)	Amount of FYM (t/m^2 of the pit)
1,0	0,90
1,5	1,35
2,0	1,80

Source: Polish Code of Good Agricultural Practice (IUNG 1999).

Mineral fertilizers must be stored in their original containers inside storehouses or under a roof. Fertilizers sold separately must be stored in storehouses or in heaps formed on hardened and sealed ground. They must be prevented from being dispersed into environment.

Agricultural equipment, such as sprayers and spreaders for fertilizers and pesticides, must be washed on special washing stands from which waste water cannot penetrate into ground water. If there is no washing stand in a farm, sprayers and spreaders should be filled with water and unloaded when moving on the field.

Careful preparation and storage of silage plays a very important role in water protection. This can be prepared in special devices. All leakage from silage must be carefully collected.

Another point source of water contamination could be domestic waste water. Sewage from farm houses not connected to the public sewage system should be neutralized on the farm with special treatment plants. It is not allowed to discharge waste water directly on the soil or into a water course.

Non-point water pollution

Pollution of this kind comes from areas under agriculture. So-called surface pollution results from application fertilizers or pesticides at rates which are too high or by methods that are inappropriate or incorrectly timed. Rain or wind at the time of application, or shortly after it, may cause pesticide or fertilizer losses from the field into the water courses. Hence, if heavy rainfall is expected, it is not recommended to apply liquid fertilizers and pesticides. Spraying or spreading of powder fertilizers is not permissible when it is windy.

Buffer zones may be established between open water bodies and the fields on which fertilizers are applied. The width of a zone is 15–20 m and, in detail, depends on soil type, field slope and plant cover.

The rate of fertilizer application must not exceed the nutritional demand of plants, and the method and time of application should minimize losses from the field. The timing of fertilizer application should correspond with the periods of maximum nutrient uptake by plants. Animal manure may not be applied from 1st December until the end of February. The dose of manure must not exceed 170 kg N per ha per year (Fertilization Act 2007). In addition, a single application of liquid manure may not be higher than ca. 40 m^3 per ha. On fields where manure or organic fertilizers are applied, the dose of mineral fertilizers should be reduced. The amount of this reduction depends on the total content of nutrients in manure or organic fertilizer and the specific fertilizer equivalent (Table 11.3). The value of these equivalents depends on the time and

TABLE 11.3. Fertilizer equivalent of N from different sources

Type of fertilizer	Time of application	
	autumn	spring
FYM	0,30	0,30
Slurry	0,50	0,60
Liquid manure	0,50	0,80

method of application. It is very important, in this context, to incorporate manure directly into soil or cover it with soil as quickly as possible after spreading. This procedure prevents ammonium nitrogen losses to the atmosphere.

Good management practice should aim to make applications when fertilizer equivalents are at highest values, and especially in periods when losses are at their lowest and utilization by plants is at a maximum. The fertilizer equivalent shows how much N in mineral fertilizer substitutes 1 kg N in manure. The quantity of active nitrogen in manures is calculated by multiplying the total amount of N in manure by the fertilizer equivalent. The dose of mineral nitrogen fertilizers should be reduced, taking into account the amount of active nitrogen in manure, if it was applied.

Overestimation of fertilizer dose is one of the most important factors influencing nutrient losses from agricultural ecosystems. Nitrogen does not tend to accumulate in the soil so any excess not used by plants is very easily translocated to ground water. That is why nitrogen rates should be precisely fitted to plant demands.

The demand for nitrogen can be calculated on the basis of available yield of crops and nitrogen uptake for production of one unit of yield (Table 11.4). Other sources of nitrogen available for plants in the soil should be also considered. These can include by-products of previous crops left on the field and incorporated into the soil or after-harvest residues of legumes.

The recommendations regarding application of fertilizers were elaborated (booklet and computer programs) and disseminated to help farmers in developing a fertilization plan (Fotyma et al. 2001; Jadczyszyn and Pietruch 2003; Jadczyszyn 2009).

The calculated dose of nitrogen fertilizer should be applied shortly before the time of intensive nutrients uptake by plants. If it is possible, the total dose of fertilizer should be applied in 2 or 3 smaller portions, which encouragesgreater utilization by plants and reduces the risk of losses in the case of unfavorable weather conditions. On permanent grasslands, nitrogen fertilizers may be applied until the beginning of September. Late application of nitrogen fertilizer is risky and may cause accumulation of mineral forms in soil after harvest and their subsequent leaching to ground waters.

All types of fertilizer must be spread uniformly across the whole field area (Figure 11.3). It is also necessary to avoid application of mineral fertilizers during long period of drought.

TABLE 11.4. Nitrogen uptake by different crops (kg/t)

Plant species	Main product	By-product	Total
Winter wheat	18,9	5,2	23,7
Spring wheat	21,0	5,5	25,1
Winter barley	17,4	5,0	22,3
Spring barley	16,3	5,5	21,0
Rye	15,7	5,5	21,6
Triticale	17,9	5,9	24,1
Oat	16,1	5,9	22,2
Corn	15,5	10,9	28,4
Cereal mixtures for grain	16,5	6,1	22,0
Buckwheat	20,5	10,6	41,7
Bean *	39,8	13,4	54,2
Pea *	34,3	16,8	48,6
Lupine **	55,0	12,0	67,0
Soybean **	54,0	10,0	68,0
Cereal-legume mixtures for grain**	25,4	11,4	35,3
Oilseed Rape	33,6	6,9	44,5
Linseed	33,6	5,3	40,3
Mustard	50,0	7,0	60,5
Early potatoes	3,0	2,1	3,3
Potatoes	3,1	2,6	3,9
Sugar beet	1,7	3,6	4,0
Fodder beet	1,8	3,3	3,3
Other root crops	1,8	3,5	3,2
Maize for silage		6,5	3,7

* – 85%, ** – 100%, *** – 50% biologically fixed. Source: Fotyma et al. 2001.

Furthermore, fertilizers should not be applied to:
- soil flooded or saturated with water,
- soil frozen or covered by snow,
- bare soils located on slopes if there is no possibility of mixing them with soil immediately.

The problems of fertilizer application are regulated by legal act (Directive 2008). Residual nitrogen, not utilized by plants, must be protected from leaching after harvest. The best way of doing this is by sowing a catch crop ("green fields"), which is left for winter and ploughed down only in spring time. "Green fields" also have a role to play as winter and perennial crops. At least 60–65% of arable land on areas of low slope should be left under cover in autumn and winter time. Incorporation of straw

FIGURE 11.3. FYM spreading

has very similar effect. Each tonne of straw may fix about 10 kg of mineral nitrogen from the soil, because of an effect of uptake by rapidly reproducing soil microorganisms. So, the "green fields" may be replaced by ploughing-in cereals, rape or corn straw. It may be assumed that the effect of 1 ha of "green field" is equivalent to the effect of 1,6 ha ploughed straw. Up to 20% of the area that should be covered with plants during autumn and winter may be replaced by ploughing-in the straw.

The migration of nitrogen, phosphorus and pesticides to open water can occur in hilly regions through water erosion. Surface run-off can be substantially limited if the fields in hilly regions are cultivated across the slope (Figure 11.4). Fields should be covered by plants or mulch

FIGURE 11.4. Surface run-off

during winter time. The proportion of "green fields" on areas threatened with erosion should not be less than 75–80%. It is recommended to reduce the intensity of soil cultivation on arable fields. This should be done by not turning the soil. The most effective approach is via a no-till cultivation system.

Protection against N migration from pastures

During the grazing season, different parts of pastures should be grazed rotationally. It is not advisable to graze cattle on soils which are too moist or later than in the second half of October, as nutrients from excrement are likely to leach to ground water. Natural storages or water courses should not be regarded as watering places. Water troughs should be moved from place to place, as there is a danger of a point concentration of excrement being produced where animals are drinking.

Permanent grassland of degraded sward or sod should be restored. The number of agricultural treatments aimed at restoring the sward completely should be limited, and sowing must be completed so that the soil is completely covered with plants before the end of September.

Grassland can be converted into arable land only in exceptional cases. It must be considered that the conversion causes intensive mineralization of organic matter and emission of very large amounts of mineral nitrogen.

Application of pesticides

Use of pesticides may occasionally contribute to water contamination if the pesticides are stored or spread inappropriately, or if they are blown away during application.

The issue of pesticides application is regulated by Plant Protection Act (2003) and only officially registered pesticides may be used. The dose, method and timing of pesticide application must strictly follow the recommendation of the producer. Each sprayer used for crop protection must have a certificate of efficiency, issued by the authorized service station. Pesticides may be applied only by specially trained operatives or by the qualified workers of specialized services. After finishing the work, the sprayer must be washed with water, which may be spread on the treated field.

Empty containers must be collected by the distributor or producer of the pesticide. Pesticides should be stored in original properly marked and labeled containers, and in a specially closed, roofed and floored room.

Application of sewage and sludge

The use of sewage and sludge in agriculture is regulated by legislation (Water Act 2001; Directive 2004 and 2010).

Each farmer wanting to use sewage is obliged to obtain a waste-disposal license. Sewage and sludge for agricultural purpose must meet special sanitary requirements and threshold values for heavy metal content.

The sewage and sludge dose must be determined according to the agrochemical status of the soil. The annual dose of sewage sludge used on arable land must not exceed 3 t per ha of dry matter. Application of waste must be proceeded by soil analysis for pH, and heavy metal and phosphorus content.

Sewage cannot be used on slopes and on grasslands inclined at more than 10% and 20% respectively. It is not allowed to be applied on arable fields and grasslands if the level of ground water is not deeper than 1,2 m and 1 m respectively.

After spreading sludge and sewage onto the field, it must be mixed with the soil immediately.

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