CHALLENGES IN AGRICULTURAL AND RURAL DEVELOPMENT IN CENTRAL AND EASTERN EUROPE
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SOME ASPECTS OF WATER POLLUTION CONTROL IN SUSTAINABLE RURAL DEVELOPMENT IN POLAND

1. Introduction

Of all the countries in the Baltic region, Poland still has quantitatively the biggest impact on the environment. There are several reasons for this. Almost the whole of Poland falls within the Baltic drainage basin. In addition, half of the population and 40% of the arable land of the basin as a whole are to be found within the country's borders. Of the nutrients discharged by the Vistula, 70% of nitrogen and 30% of the phosphorus come from the agricultural sector.

According to the new structural policy for rural development until 2006, over 69% of farms will be connected to the central water supply system and 16% to waste water treatment plants (WWTPs). Under this policy 180,000 on-site systems for farms, 800 conventional WWTPs and 600 landfills should be established in rural areas.

Due to the underdevelopment of other elements of rural infrastructure, such as water supply, roads or telecommunications and the population's low awareness and mental impoverishment over recent years, this policy is still often put off to "some time in the future". There is still a need to increase the awareness of the rural population and to create new possibilities for funding projects when present grants run out, in order to continue successful development. Therefore, advisory and financial organisations need to be strengthened to include environmental awareness at an early stage in the modernisation process of Polish agriculture. Special efforts are needed to prevent the continuation of inappropriate storage of farm waste and agricultural practices.

In rural areas water quality is very low in 70% of domestic wells and 16% of common water supply systems. Thus, nitrate compounds and bacteria in the water supply adversely affect the health of 50% of the rural population. Rural areas are inhabited by about 16 million people, who produce over 1000 million m^3 of waste per year, of which only 12.4% are treated in 2031 common sewage treatment plants and 35 900 on-site systems. The rest of rural wastewater is discharged into the soil, ponds and rivers, into ditches and unused wells in a raw, *i.e.* untreated condition. Overall, an estimated 50% of Polish surface waters are considered unfit for municipal or even for industrial use. It is assessed that degradation of surface waters in Poland is so high, that without eco-technological solutions it is not possible to improve water quality. There is no explicit answer to the question of whether to develop central village sewage systems, *i.e.* collect sewage effluent from houses and farms, or decentralise it, by neutralisation of effluent at the place of origin?

There are some new regulations and standards for farm waste storage. It is evident that some investments in storage systems and spreading technologies are necessary to enable better use of manure and environmental farming on almost all farms. But there is an urgent need for a financial strategy at national level to solve the problem of how these projects should be funded. At the moment, there are a few demonstration projects with the aim of educating selected farmers.

2. How can we reduce point source pollution?

In the total mass of matter discharged to the sea, which is mainly at the mouths of the Vistula, Oder and other rivers, nutrients such as nitrogen and phosphorus are of specific importance. Their origin is related to point and non-point sources of pollution. Sewage originating from small towns, rural areas and holiday resorts constitutes about 15% of the total volume of liquid waste produced in Poland. Due to the concentration of nutrients, this presents a substantial threat to the environment. The impact of rural domestic sewage has been growing recently in connection with the construction of rural water supply systems. The number of rural households equipped with running water facilities has doubled over the past ten years, but these sewage management systems are seldom satisfactory.

Environmental technology or eco-technology is defined as the use of technological means for ecosystem management based on the deep understanding of the principles on which natural ecological systems are built and on the transfer of such principles into ecosystem management in such a way as to minimize the costs of the measures and their harm to the global environment [Mitsch, 1993; Straskraba, 1993]. Eco-technological methods must be extensively applied in Eastern European countries, in order to quickly counteract environmental problems such as land degradation caused by heavy metal pollution, eutrophication of lakes and rivers and ground water pollution. There are many good reasons for adopting the principles of eco-technology in these countries. First the knowledge of using such technology is not unfamiliar to people working in landscape management. Second, the costs for introducing low technology are realistic in the light of the present economic situation. However, treatment systems based on eco-technology will be most beneficial in small villages and towns in rural areas. Third, we cannot allow the utilisation of fossil energy to cause further environmental deterioration. Hence, the treatment of pollution should use a low amount of energy, *i.e.* use eco-technology. The supply of energy will be critical in many areas and the introduction of, for instance, energy dependent conventional wastewater treatment plants will be problematic. There is a considerable amount of interest in ecological purification methods in Poland, a situation caused by insufficient sewage treatment or lack of treatment.

During the last decade, man-made wetlands have been put into operation as a low-technology option for domestic wastewater treatment in many places in Europe. In general there is great public demand in Europe to improve the conditions of small rivers used as sewage receivers, and the emissions from small sewage producers are considered to be of great importance regarding water quality. The treatment capacity of man-made wetlands (subsurface horizontal flow systems) in terms of nutrient removal, however, removes only ~30% of nitrogen and phosphorus, as opposed to the promises of efficiencies greater than 90%. The lack of man-made systems fulfilling these expectations has resulted in the technique now being regarded as inadequate. System design should carefully consider demands on the purity of effluent water. When only the removal of suspended solids and BOD is required and land is readily available and inexpensive, surface flow systems and one-unit subsurface flow systems can be used. In sites with more stringent demands, including demands for the removal of nitrogen and phosphorus, combined systems consisting of vertical flow beds with intermittant loading followed by horizontal subsurface flow beds should be selected. The medium in the beds should be selected on the basis of requirements on hydraulic conductivity and binding capacity for phosphorus. The problem regarding hydraulic conductivity can be avoided by using a coarse medium like gravel instead of soil. However, as gravel has very low binding capacity for phosphorus, such systems are not expected to remove a significant amount of phosphorus. Data from Germany show, however, that a medium consisting of iron-rich sand will be able to provide the necessary hydraulic conductivity and, at the same time, have the capacity to bind phosphorus [Brix, 1994].

The phosphorus uptake in man-made wetlands of different types of infiltration beds, used for wastewater treatment, can be increased by the addition of a reactive medium. In this medium phosphorus is removed from wastewater not only by adsorption, but also by chemical precipitation. These precipitation reactions enhance the efficiency of the soil medium. The results from different investigations show that aluminium, iron and calcium compounds, pure or imbedded in the soil medium, will increase phosphorous removal.

Man-made wetlands may prove useful in many countries. Eastern European countries have severe environmental problems, because of the discharge of untreated industrial and municipal wastewater. Many small villages in rural areas have no or very poor sewage systems and because of financial shortfalls it is not possible to install high-technology wastewater treatment plants that require comparably large investments. Labour is, however, inexpensive, and man-made wetlands therefore seem to be an appropriate solution for small villages in these countries. Hopefully, these countries will benefit from the experience obtained so far with man-made wetlands in other countries and will not make similar mistakes [Brix, 1994].

In Poland several systems based on eco-technological solutions have been constructed. Non-government organisations are attempting to promote eco-technological solutions among villages and farms. Small systems (man-made wetlands) for one house, one farm or groups of farms are very popular. Most of these systems are composed of vegetation filters with common reed, cat-tail and willow. There are several systems using natural wetlands. At present, about 20 000 onsite wastewater systems designed for individual farms based on eco-technology concepts are in operation. Over 150 man-made wetlands composed of vegetation filters with common reed or willow (average inflow from 5 to 200 m^3/d) and over 50 pond systems based on Lemna (duckweed) have been installed.

3. How to reduce leakage of nutrients from agricultural areas in Poland?

Compared to the abatement of point source pollution, where visible progress has been achieved, pollution from non-point sources is a much more complicated issue to handle as it implies significant legislative and infrastructural changes at the national level prior to implementation. The difficulties associated with non-point agricultural pollution result from the dispersion of the pollutants. Migration of these pollutants occurs as the result of stochastic factors *e.g.* rain, thaws, while the quality of emittants from the basin flowing to surface waters is the result of a great number of factors, among which the most important are phisiography, farm implements used in the basin and the predominant water conditions in the basin. Methods of evaluating the role of agriculture in water pollution, together with forecasting and control of agricultural pollution, should therefore refer to the character of the basin from which this pollution flows to surface waters in the hydrological cycle, as well as to the reaction of the basin to changeable meteorological or hydrologic conditions.

Soil permeability and the slope of agricultural areas have a large impact on the emission of nitrogen and phosphorus from these areas into surface waters. Data obtained from the Vistula basin confirm that nutrient outflow from the upper part of the basin (10.6 kg N per ha per year) was higher than in the middle or lower parts (4.85 kg N per ha per year), which is associated with the greater level of water erosion in mountainous and hilly areas and soil of low permeability [Michna, 1995]

It is generally known that modern agricultural practices contribute significantly to losses of nitrogen from the soil. Agriculture's share of the emission of nitrogen to surface waters of several countries in Europe ranges from 28 to 82%.

Polish agriculture makes use of chemical fertilisers, pesticides and other chemical substances, which help to increase crop yields. The sandy nature of the majority of Polish soil means that it is very permeable. It is difficult to reduce the leaching of mineral fertilisers from arable lands into surface and ground waters. For each 100 kg of pure nitrate carried in various forms to the soil, approximately 70 kg is absorbed by plants and 30 kg washed into deeper layers of the soil and then to under ground water, drainage channels and rivers [Łabętowicz and Stępień, 2000; *Kodeks*...2002].

Nitrogen and phosphorus are considered as pollutants only after having exceeded a specified level of concentration, above which they lower the quality and usefulness of water. The problem of „threshold outflows" that characterise the natural, in a sense, concentration of these elements in the "hydrochemical background" cannot be decisively determined. This background level can be characterised to some extent by limit values accepted in water purity classification. The composition of water balances and of chemical compounds and, in consequence, non-point sources of nutrients and active effluents depends on local physical and geographical conditions, lithological and pedological conditions, intensity of production in rural areas, the level of development of civilisation in local communities, as well as on the technical, production and social infrastructure. It should be mentioned here that the above factors have a dynamic character and their influence changes together with the process of agricultural and food economy restructuring.

Today the Vistula river transports about 47 tonnes of ions per year as a non-point source of pollution per km^2 of its catchment area to the Baltic Sea. Natural outflow consists of approximately 24 tonnes. About 1000 years ago the outflow from the Vistula catchment area was on average 15–18 tonnes, but outflow to the Baltic Sea was only 12 tonnes (25–30% of ions were stored or accumulated by natural wetlands). This means that about 1000 years ago natural losses of substances important from an agricultural point of view were 30% less than now [Maruszak, 1988].

There are two general possibilities for reducing leakage of nutrients from rural areas and agricultural land in Poland. The first is by reducing natural outflow by raising the water level and restoring natural wetlands or establishing man-made wetlands. The second is by reducing outflow of nutrients using good agricultural practices or the reducing outflow of pollutants from point sources in rural areas.

In many countries, applying man-made wetlands is focused on treating eutrophied surface water systems. Agricultural runoff and drainage water treatment from man-made wetlands has been studied in many European countries and in the United States.

Wetlands may act as efficient purification systems for water with high nitrogen and phosphorus concentrations. Nitrogen and phosphorus can be removed by a variety of biological, physical and chemical processes, including plant uptake, bacterial transformation, sedimentation, adsorption and precipitation.

Removal of nutrients is most efficient during the growing season. In wintertime, the natural processes removing nitrogen and phosphorus are considerably less active. Although man-made wetlands can be applied to reduce nutrient concentration, they cannot alter the macro-ionic composition significantly.

During the next 10–15 years it will be necessary to remove 1–1.5 million ha of land in Poland from agricultural use. Some of this will come from the construction of natural or semi-natural meadows. Meadows have a rather high potential for reducing the concentration of nitrogen. Nitrogen retention and transformation in flooded meadows have been investigated in Sweden [Bengtsson, 1994; Leonardson, 1993]. A comparison was made between two experimental meadows. The hydraulic load were 40–50 mm/d and 100–150 mm/d, respectively. The de-nitrification rate for the top 10 cm of the soil was measured. Almost all water left the meadows as sub-surface flow. In the case of the high hydraulic load, there was no net retention of nitrogen observed, except in summer. A large proportion of, but not all, nitrate-nitrogen was removed. However, ammonium appeared in the water leaving the meadows. Still, the level of de-nitrification was measured to be 40 kg/ha/month. The residence time for most of the water was less than a few days. In the case of the meadows in which the hydraulic load was about 50 mm/d, all the nitrate-nitrogen was removed or transformed to ammonium-nitrogen. The annual level of retention was about 100 kg/ha. For flooded meadows to be effective in removing nitrogen at the scale of the basin, it requires that about 10% of the basin should be flooded and that river water is regulated to appropriately redistribute the runoff water.

It is very important for Poland to restore natural wetlands and establish new water storage systems in its agricultural landscape. Poland has problems with its water balance compared with other European countries. The capacity of water reservoirs is very low. Only 5% of outflow from Poland is stored in reservoirs. Given the climatic and geographical conditions in Poland, approximately 15% of outflow should be stored in reservoirs. It would be possible to increase this percentage and simultaneously improve the rural landscape by constructing small water storage systems for drainage waters, for example, small ponds or special ponds for fish breeding, or increasing the water level in ponds and small lakes.

The construction of new wetlands and restoration of natural wetlands is a very popular idea in Poland. Wetlands may act as an efficient purification system for water with a high concentration of nitrogen and phosphorus. In some areas many goals could be achieved by such a strategy.

There are also several systems using natural wetlands under operation. The utilisation of sewage effluents in willow and poplar plantations has a long tradition in Poland. Articles on some practical examples of the purification of drainage waters from agricultural lands (drainage waters recycling) and non-point pollution control by biological and geochemical barriers wave appeared.

4. Possibilities of water pollution control at farm level

The National Fund for Environmental Protection and Water Management in Poland introduced a pilot project called "The Rural Environmental Protection Project". The main goal of the project was the introduction of a package creating favourable conditions for environmental protection in selected farms specialised in meat and milk production [*Ochrona Środowiska...*, 2003].

The main idea of the Rural Environmental Protection Project was that the main source of pollution coming from rural areas was farms themselves (sewage, animal excrement and outflow from waste fodder – 80% overall), and the remainder (around 20%) was connected with agricultural production. The main aim of the project was to present rational, modern ways of solving the problem of pollution from animal breeding.

The actions aimed at the completion of the project are financially supported by the World Bank, the government of Poland, GEF, NEFCO, as well as the European Union. The actions carried out in the project are connected directly with completing the comprehensive program for the protection of the Baltic Sea (HELCOM) and implementation of Baltic Agenda 21 in the agricultural sector [*Agricultural pollution*..., 2002].

Environmental and economic aspects of this project, as well as possible ways of disseminating the experience gained will be discussed. There is an urgent need for a financial strategy at the national level to solve the problem of how these projects should be supported.

The following facts regarding the realisation of future projects in the areas of the Baltic Sea Region and other countries should be noted:

1. Problems concerning the environment are not major problems in the agricultural sector in countries like Poland. The main problems are economic and social. As pro-ecological investments in farms give results only after a very long time, the farming sector can expect support from the national authorities.

2. The countries in the Baltic Sea basin, as well as in the Black Sea basin are good examples of countries introducing regional programs of sustainable development. To assess such projects, universal indicators of eco-development should be defined and utilised. Such indicators were formulated based on the documents connected with completing Agenda 21 in the catchment area of the Baltic Sea – Baltic Agenda 21 for agriculture [*Agriculture. Baltic 21*..., 1998].

3. The necessity of taking environmental aspects in farming into consideration comes from the following constraints and internal incentives:

– the losses incurred by the national economy resulting from environmental pollution (including the agricultural sector) cause the need for investments in protective infrastructure in rural areas (in Poland the percentage of the overall loss caused by pollution in the agricultural sector is 24% of the overall environmental loss, which is equal to 10% GDP);

– the costs of protective infrastructure are considerable at the scale of a farm, and their low profits they bring the farm creates the need for public funds. Obviously, awakening social consciousness that this function should be carried out by society as a whole, not only farmers, is the main problem here The extent and the sources of support to farms (mainly to those specialising in milk and meat production) is an open issue;

– an important precondition for pro-ecological action in rural areas is the necessity of meeting the requirements of the relevant legal acts (such as in Poland – the Water Law Act, the Fertiliser and Fertilising Act, in the European Union – the Water Framework Directive, the Nitrate Directive, etc.);

– an important incentive in favour of environmental protection in rural areas is given by external regulations, mainly: satisfying the decisions of the Helsinki Convention dealing with protection of the Baltic Sea, active participation of Poland (as a co-ordinator) in introductory projects included in Baltic Agenda 21 for agriculture and the actions aimed at introducing EU Directives (especially the Water Framework Directive and the Nitrate Directive);

– a necessary precondition for the introduction of pro-ecological action in rural areas is the raising of ecological consciousness of farmers and inhabitants of such areas. The consciousness of these inhabitants should not be shaped by orders and punishments, but mainly by education. Until farmers do not feel the positive effects coming from protecting the environment, they will not be interested in keeping the environment clean. Still, the problem of costs is going to appear at a certain stage. These additional costs will increase the cost of production. Hence, financial grants will be necessary. In the European Union such incentives have been used successfully for a long time.

4. The actions should take social and economic aspects into account. The rule that the actions connected with investments should create new jobs should be accepted. This is especially important as in the rural areas of the catchment areas of the Baltic and Black Sea there is a high rate of unemployment. Hence, investments aimed at protecting the natural environment should be treated as an incentive for professional activation of local societies and a form of public sector work.

5. The assessment of the effects of investments at the level of a small scale farm only become noticeable after long time (a noticeable improvement of water purity, a reduction of the nitrate levels in the waters). Having that in mind, monitoring the situation should take place before the beginning of investments, as the pollution process begins much earlier than when it reaches its maximum level. The situation gets worse over a long period of time. Similarly, the process of returning to the natural state is also time-consuming. It is estimated that the Baltic Sea will return to the state it was in before 1950 after 50 years (almost as long as the duration of degradation). According to experts, a noticeable change

of the situation in the Baltic Sea will be observable 20 years from the implementation of protective actions [Kindler & Lintner, 1993].

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