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# COST EFFECTIVENESS OF SOME ENVIRONMENTAL PROJECTS IN AGRICULTURE IN POLAND AND THE EU COUNTRIES

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ABSTRACT
INTRODUCTION
REDUCTION OF EMISSIONS IN THE EPRA PROJECT
COST EFFECTIVENESS OF THE EPRA PROJECT
COST EFFECTIVENESS OF THE NSAS PROJECT
COST EFFECTIVENESS OF THE SRRP PROJECT
COST EFFECTIVENESS OF THE NVZ PROJECTS IN SCOTLAND
CLOSING REMARKS
REFERENCES

## ABSTRACT

The cost effectiveness of the Polish ‘Environmental Protection in Rural Areas’ (EPRA) project financed from both Polish and international sources is compared to the effectiveness of several projects in the EU countries. The main objective of the compared projects was to reduce nitrogen compounds emissions to the environment, in particular to surface and ground waters. Effectiveness in the Polish project, if measured by the reduction of emissions to the ground was close to the effectiveness in three British projects (Nitrate Sensitive Areas Scheme, Nitrate Vulnerable Zone in the river Ythan catchment and in the whole of Scotland), though much smaller than in the Danish Skjern River Restoration Project. The main reason for differences was not the country of implementation, but the difference in the technological measures applied for attaining the goals. The effectiveness in various projects and project options measured by reduction in emissions varied between 2.4 and 40 kgN/100 PLN, in Polish złoty of 2001. Within this wide range the effectiveness closer to the lower value can be expected in most cases.

**Key words:** nitrogen emissions, cost effectiveness, environmental protection

## INTRODUCTION

Nitrates in surface waters cause their eutrophication, the growth of the poisonous blue-green algae results, among others, in a decrease in the fish population. Ammonia evaporating to the atmosphere causes acid rains damaging forests and fish. Nitrates in drinking water may be associated with the oxygen starvation of bottle-fed infants and stomach cancer of adults. The European Economic Community directive [4] set up, although biologically disputable, the standard of a maximum of 50 mg/l of nitrate ($NO_3$) concentration in drinking water in the contemporary EEC countries.

Another directive [3] required the EEC governments to identify by the end of 1993 the nitrate vulnerable zones where the nitrates from agricultural sources were polluting or might be polluting water. By the end of 1995 the plans for action aimed at reaching the standard concentration level must have been elaborated, then the action taken so that by the end of 1999 the standard was achieved.

Reduction in nitrogen emissions to water environment has also become one of the aims of the water management policy in Poland [15].

Contemporary agriculture acts as a major contributor of nitrogen compounds into the water and atmosphere. Justus Liebig, by introducing in the nineteenth century the theory and practice of mineral fertilisation initialised an anthropogeneous process of striking out of balance the chemical equilibrium in the natural environment which had been maintained since the origins of agriculture on earth [19].

Growing concern about the agricultural pressure on the environment has given rise to a publicly supported movement of so called ecological or organic farming. With regard to the nitrogen compounds it seems however to increase instead of decrease the emissions because of an excessive share of papilionaceae, assimilating nitrogen from the air, in the cropping patterns [11]. The same effect of increased nitrate leaching into the ground waters would have had the planned general agri – environmental programme for Poland [20]. Agriculture in many cases can nevertheless be used as means of recycling the waste products of other sectors of economy [1]

In years 1999 through 2002 a pilot agri-environmental project managed by the National Fund of Environmental Protection and Water Resources Management (NFEPWRM) was operating in Poland under the name of ‘Environmental Protection in Rural Areas’ (EPRA) [17]. It consisted mainly of an extension service and financial aid programme in a chosen group of big farms specialising in animal production. The financial aid was concentrated on subsidising (in ca 70 %) the construction of animal excreta storing facilities like concrete manure pits accompanied by covered liquid manure tanks for effluent from manure stacks and covered watertight slurry tanks. About 400 farms were chosen from among those which volunteered for the project in three pilot areas: Elbląg (Elbing), Toruń (Thorn) and Łomża – Ostrołęka (Lomza – Ostrolenka).

The main objective of the project was the reduction of the nitrogen compounds emissions to the surface and ground waters and in consequence the reduction of their emissions to the Baltic sea waters. For that reason the project acquired wide international support. Table 1 shows the participation of various sources in financing the project (The percentages can be treated only as a rough estimate, because various procurements were denominated in various currencies (dollar, euro and Polish złoty) whose exchange rates somewhat fluctuated in time).

**Table 1. Capital structure of the EPRA project, %**

| Capital source | Participation |
|---|---|
| National Fund of Environmental Protection and Water Resources Management | 23.6 |
| - in the above a loan from the World Bank | (15.4) |
| Grant from the Global Environmental Facility | 15.0 |
| Grant from the Nordic Environmental Finance Corporation | 6.8 |
| Grant from PHARE Large Scale Infrastructure Facilities | 22.0 |
| Farmers’ own capital | 27.4 |
| Polish government and local authorities grants | 5.2 |
| Total | 100.0 |

The authors were engaged in a major consulting work [17] with a task of calculating the cost effectiveness of the EPRA project and comparing it with the analogous effectiveness of some similar projects in the EU countries.

## REDUCTION OF EMISSIONS IN THE EPRA PROJECT

As a result of the construction of the animal excreta storing facilities a reduction of the immission to the environment will presumably occur because of two reasons:

- liquidation of the point emissions from the inadequate storing facilities,
- as a result of the more agronomically appropriate time of the organic fertilisers application (which is rendered possible thanks to the greater capacity of the slurry tanks and therefore possibly longer time of storage before transportation to the fields).

The reduction of the nitrate load leached to the ground waters has been determined by taking advantage of two interrelated computing programmes SEEP/W and CTRAN/W [22]. In each of the project areas several typical hydro-geological cross-sections have been discerned and a model of contaminant's migration has been constructed for each section following the requirements of the programmes.

The reduction of the nitrogen emissions to the environment as a result of the project's implementation has been estimated by means of constructing reduced simplified models of a series of typical farms participating in the project. The total reduction has been calculated by multiplying the reduction attained in the separate model farms by the number of farms participating in the project and corresponding to the particular models. Models have been specified for different farm situations (the pilot area, highland or river valley, distance from the nearest watercourse), production type (cattle, pigs or both), production size intervals (represented by number of animal heads) and type of storing facilities determined by the production technology (watertight manure pit with effluent tank or slurry tank).

Environmental effects of the project if defined as a reduction of the amount of nitrogen compounds reaching the particular components of the natural environment have a character of a dynamic process. Especially migration of nitrogen pollutants in the ground before they reach the ground water table or the surface watercourse usually takes a long time. Consequently the reductions in the pollutant flow reaching various components of the environment are also observed with a certain delay to the reduction at the source of pollution. They also grow from year to year until they stabilise at a certain level. This is exemplified in the figure 1 which shows the projected reductions over the next 22 years in one of the farm models.

The average yearly reduction during the investigated 22 years does not equal the final steady state annual reduction caused by the project. This stabilised reduction can be approximated by the reduction occurring in the final 22nd year of calculation which, if the nowadays constructed facilities are in the future replaced with the new ones, will continue and soon reach the steady state level of reduction. The estimated reduction of nitrate emission caused by the project in the 22nd year after its completion is 1.856 times higher than the average. Hypothetical extension of the project's measures on the whole of farms in Poland would give a 1.069 % reduction of the general Polish nitrogen emission to the Baltic sea and 3.34 % of the agricultural emission.

## COST EFFECTIVENESS OF THE EPRA PROJECT

Unit costs of the reduction of emission in the particular areas comprised in the project were calculated by dividing the total average annual costs in the area by the estimated average annual reduction of emission of the nitrogen in the area.

The total costs were calculated by summing up projected annual costs in model farms multiplied by the number of farms corresponding to particular models and adding the indirect (overhead) costs connected with the implementation of the project at the local (pilot area) and the national level. The overhead project costs as occurring only in the three first years of the project were amortised over the total life span of the storing facilities constructed within the project in order to spread them over the period of time they concerned. This period was estimated as 22 years which is a standard depreciation period for the appropriate type of fixed assets.

Cost effectiveness of the project (unit costs) has been determined from the macroeconomic (socio-economic) viewpoint using three alternative values of the rate of interest used for calculation of capital costs.

- 8 % rate recommended by the official, although partially obsolete, book of instructions for the cost – benefit analysis of water management projects [13]. This rate was based on the interest rate on foreign loans taken by the People's Republic of Poland, but in view of growing Polish foreign debt it can still be considered as the cost of capital in the public funds.

- 5 % rate recommended by the draft guidelines for economic analyses of projects applying for grants from the EU funds [7].
- 3.73 % rate specific to the EPRA project, calculated as the cost of the loan from the World Bank. This rate was established by combining the Libor and Euribor rates applying to the dollar and euro parts of the loan, adjusting for inflation, including the bank's commission and the readiness fee.

Costs (denominated in Polish złoty, PLN) have been associated with the environmental effects defined in various ways. Cost effectiveness was compiled as the inverse of unit costs (see tables 2 and 3).

**Table 2. Average cost effectiveness (during the expected economic life of the facilities constructed in the project) as represented by reduction of the nitrates emission to the ground, 2001 price level, kgN/100PLN**

| Area | Rate of interest, % | | |
|---|---|---|---|
| | 8 | 5 | 3.73 |
| Łomża - Ostrołęka | 4.484 | 5.435 | 5.988 |
| Toruń | 1.567 | 1.898 | 2.083 |
| Elbląg | 8.130 | 9.900 | 10.989 |
| Average 3 areas | 4.405 | 5.348 | 5.882 |

**Table 3. Average cost effectiveness (during the expected economic life of the facilities constructed in the project) as represented by reduction of the nitrates emission to the environment, 2001 price level, kgN/100PLN**

| Area | Rate of interest, % | | |
|---|---|---|---|
| | 8 | 5 | 3.73 |
| Łomża - Ostrołęka | 6.211 | 7.513 | 8.264 |
| Toruń | 8.929 | 10.870 | 11.905 |
| Elbląg | 10.638 | 12.987 | 14.286 |
| Average 3 areas | 8.130 | 9.901 | 10.870 |

The variation of unit costs of reducing the emission to the ground between the areas can be first of all attributed to the differences in the hydro-geological characteristics of the areas. For example the compact heavy soils and subsoil strata in the Toruń area make it more difficult for the effluents to penetrate into the deeper strata of the ground, therefore the reduction of emission to the ground is relatively smaller and that to the air larger. The emissions and consequently the cost effectiveness are also connected with the different depths of the ground water tables, with the various situation of the farms with respect to the ground water layers, with the different composition of the farm populations in various areas with regard to the size and type of production as well as production technologies.

If the cost effectiveness with regard to the whole environment is considered (table 2), the differences between the regions are less prominent, since the variations in the topographic conditions are levelled out.

## COST EFFECTIVENESS OF THE NSAS PROJECT

The British Ministry of Agriculture, Food and Fisheries (MAFF) set forth in 1990 the Pilot Nitrate Sensitive Areas Scheme (NSAS) in the areas where the drinking water sources exceeded or were at risk to exceed the EEC nitrate content limit [10]. The need for further action and the success of the original scheme induced MAFF to extend it to a much larger area in 1994. The pilot scheme comprised five options for the participating farmers, one basic and four premium ones. In the basic option the farmer was required to:

- adhere to the economic fertilisation recommendations (including full allowance for nitrogen from manure and previous crops),
- reduce nitrogen fertilisation below the economic optimum by 25 kg/ha for winter cereals and 50 kg/ha for winter oilseed rape,
- introduce cover crops on land which would otherwise be bare over winter,

- apply no more than 175 kg/ha of nitrogen in organic matter per year,
- not to apply poultry manure nor slurry from July to October inclusive (September to October on grassland).

In the premium options the farmer was obliged to convert the participating arable land to grassland and, additionally, in option:

- A: not to apply fertiliser nor manure and not to graze animals,
- B: not to apply fertiliser nor manure but could graze animals,
- C: not to apply more than 150 kg N/ha but could graze animals
- D: manage the land as in a afforestation project called Farm Woodland Scheme, in short not to fertilise and to plant some trees.

The participating farmers were compensated for the potential losses in value of the agricultural output by payments from MAFF. The unit payment (per hectare) was varied according to the option chosen by the farmer and land productivity in various locations.

**Table 4. Costs effectiveness in the NSAS project as represented by reduction of the nitrates leaching from the soil, 2001 price level**

| Project option | Reduction of nitrogen load leached, kgN/100PLN | | Reduction of nitrate concentration, mg$NO_3$/100PLN | |
|---|---|---|---|---|
| | at currencies purchasing power parity | at currencies exchange rate | at currencies purchasing power parity | at currencies exchange rate |
| basic option | 12.048 | 6.711 | 21.277 | 11.905 |
| premium option A | 5.102 | 2.849 | 9.009 | 5.025 |
| premium option B | 5.376 | 3.003 | 9.524 | 5.319 |
| premium option C | 6.711 | 3.745 | 11.905 | 6.623 |
| premium option D | 5.525 | 3.086 | 9.804 | 5.464 |

Cost effectiveness in the NSAS project for the comparative purposes has been calculated in two versions: by converting the pound sterling (GDP), after updating costs to their 2001 values, to PLN at the prevailing exchange rate in 2001 or by a rate multiplied by the purchasing power of foreign currencies factor in Poland as compared to this power in Great Britain. This factor has been estimated as 1.7918 [14]. The first cost effectiveness estimate represents an international viewpoint (for example that of an international donor), the second the inner Polish viewpoint, reflecting the opportunity cost of the foreign currency.

The basic option, though seemingly most cost effective, could not have been ranked as the best because it did not satisfy the imposed quality standard in the leachate, namely the concentration of less than 50 mgN/l.

## COST EFFECTIVENESS OF THE SRRP PROJECT

Danish Skjern River Restoration Project involved renaturalisation of the estuary of river Skjern and the neighbouring land, including a conversion of 1550 hectares of arable land into an extensively grazed wet grassland. This resulted in reduction of the nitrogen emission into the water environment by 350 kgN/hectare/year [6].

Transformation measures cost ca 10 thousand Danish crowns (DKK) per hectare and loss in agricultural net margin amounted to ca 1500 DKK/hectare/year. These numbers translate into cost effectiveness of reduction in nitrogen emission to the water environment (in that case almost directly into sea waters) of about 40 kgN/100 PLN at the average exchange rate in 2001 or 71.4 kgN/100 PLN if the purchasing power of currency is taken notice of.

According to the Danish Institute of Agricultural and Fisheries Economics the renaturalisation of agricultural land into the state of grazed wetlands is one of the cheapest ways of reduction of the nitrogen compounds emissions to the environment. Therefore the cost effectiveness of the SRRP project compares very favourably with that in the Polish project.

## COST EFFECTIVENESS OF THE NVZ PROJECTS IN SCOTLAND

The area adjacent to the lower stretch of river Ythan in north-east Scotland was designated in 2000 as a Nitrate Vulnerable Zone in light of article 3 of the EEC nitrate directive [3]. According to the rules of that directive an agri-environmental project NVZ was introduced, affecting some 600 farmers in the area [21].

In option 1 the project required the farmer not to apply slurry on sandy and sandy – loamy soils between September 1st and December 1st on grasslands and between October 1st and December 1st on other lands. A ban on mineral fertilisation was imposed between September 15th and February 20th on grasslands and between September 1st and February 20th on other lands. Option 2A additionally required farmers to put fences along watercourses, to avoid ploughing the permanent pastures, to avoid soil compacting by heavy machines, to locate manure stacks no closer than 10 meters from the watercourse, to avoid repairs on the drainage systems, to create buffer strips along the watercourses and to sow the winter cereals only in the row drill system. Option 2B additionally above the requirements of option 2A assumed leaving part of the land in stubble over winter and introducing spring barley or spring rape into the crop rotation.

**Table 5. Costs effectiveness in the NVZ project in the river Ythan catchment as represented by reduction of the nitrates leaching into ground, 2001 price level**

| Project option | Cost effectiveness, kgN/100 PLN | | | |
|---|---|---|---|---|
| | From | | to | |
| | at currencies purchasing power parity | At currencies exchange rate | at currencies purchasing power parity t | at currencies exchange rate |
| Option 1 | 22.727 | 12.658 | 31.250 | 17.543 |
| Option 2A | 4.274 | 2.387 | 5.780 | 3.217 |
| Option 2B | 6.329 | 3.534 | 11.494 | 6.410 |

**Table 6. Costs effectiveness in the NVZ project extended over whole Scotland, as represented by reduction of the nitrates leaching into ground, 2001 price level (only direct costs)**

| Project option | Cost effectiveness, kgN/100 PLN | | | |
|---|---|---|---|---|
| | From | | to | |
| | at currencies purchasing power parity | at currencies exchange rate | at currencies purchasing power parity | at currencies exchange rate |
| Option 1 | 10.753 | 5.988 | 14.925 | 8.333 |
| Option 2A | 2.793 | 1.560 | 4.237 | 2.364 |
| Option 2B | 4.878 | 2.725 | 8.403 | 4.695 |

Extension of the NVZ project in the Ythan catchment over the whole of Scotland was considered [24]. The forecasted cost effectiveness of the venture, excluding the indirect costs of projects management, is presented in table 6.

Cost effectiveness of the NVZ river Ythan project is presented in table 5. Depending on the local natural conditions the costs and consequently the cost effectiveness varied within the bounds shown in the table.

## CLOSING REMARKS

The OECD countries officially adopted the 'polluter pays principle' (PPP) as the central premise of their environmental policy in 1974. The experts on the subject see it however in practice as an 'abstract rationale for raising funds necessary for meeting ... cost of public environmental management' [16] rather than taking it at its face value. The environment being the public good, its management naturally lies in hands of the public representative, namely the government, supervised by the parliament who is setting the rules by instituting the law. Within the governmental policy it is decided what better serves its multiobjective aims; in particular whether it is charging the polluter with the environmental costs or the opposite, subsidising him in order to achieve compliance with the environmental requirements, so as to avoid an excessive damage to the other aims of the policy. The farmers and the agricultural production in the EU countries, being protected for a variety of reasons, are therefore subsidised in order to induce the farmers to disintensify their farming activities rather than make the society pay the environmental costs of agricultural production. This is at the first glance completely contrary to the PPP. However it can also be interpreted in another way. The PPP with regard to the industrial polluters actually means that the polluter's customer pays. The farmer's role in the wealthy society of the Western Europe is gradually changing from that of the food producer to that of the museum guardian (besides of the other roles, like that of insurance against the case of a sudden and prolonged food supply distortions, in the extreme a war), the museum being the very much endangered environment. In that respect the whole society is the farmer's customer and therefore pays for the environmental services and protective measures as the environment's consumer.

The agri-environmental schemes fall in the category of the economic instruments of environmental protection called the 'market creation'. In this case the market works the other way round than the classical market in marketable pollution permits [2]. It is not the polluter that buys from the society or from another polluter the right to pollute, but the society who buys from the polluter, namely the farmer, the right to pollute in order not to make use of it. The right to pollute is in this case equivalent to the right to farm, which is traditionally and legally endowed on the farmer. The society is offering to buy a part of these rights and the farmer is free not to take the bid.

The unit costs of reduction of the nitrogen emissions to the ground in Polish EPRA project and therefore also the cost effectiveness turned out to be close to the unit costs and their effectiveness in the comparable EU projects. The cost effectiveness of the projects depended not so much on the country of implementation as on the type of the technological measures adopted. If the purchasing power of the freely exchangeable currencies in various countries is taken notice of, the Polish project reveals usually lower effectiveness than the EU counterparts. If the difference in the purchasing power was neglected, which is appropriate from the viewpoint of an international donor, the EU projects cost effectiveness would become in many cases much smaller than in the Polish projects and this could have meant a Polish comparative advantage in competing for EU funding.

## REFERENCES


1. Berger J., Böss A., Fehrenbach H., Knappe F., Vogt R., 2003. Die Beurteilung landwirschaftlicher Produktion aus Sicht der Abfallwirtschaft. Berichte über Landwirtschaft vol.81 (2).
2. Coase R., 1960. The problem of social cost. Journal of Law and Economics no 3, pp.1-44.
3. Council Directive of 12 December 1991 Concerning the Protection of Waters Against Pollution Caused by Nitrates from Agricultural Sources, 1991. 91/676/EEC. Official Journal of the European Communities no L 375/1, 31.12.1991.
4. Council Directive of 15 July 1980 Relating to the Quality of Water Intended for Human Consumption, 1980. 80/778/EEC. Official Journal of the European Communities no L 229, 30.8.1980.
5. Dewes Th., 1993. Wie gefährlich sind Mistplätze? Landpost. 17 April 1993.
6. Dubgaard A., Kallesoe H., Petersen M. L., Ladenburg J., 2002. Cost - benefit Analysis of the Skjern River Restoration Project. Papers from Department of Economics and Natural Resources. Social Science Series. 10/2002. Royal Veterinary and Agricultural University. Kopenhagen.
7. Guide to Cost Benefit Analysis of Major Projects in the Context of EC Regional Policy, 1997. 1997 Edition. Draft. European Commission. Directorate General for Regional Policy and Cohesion.
8. Humer J., Galler J., 1994. So lagern Sie Stallmist am Feld richtig! Der fortschrittliche Landwirt no 20.
9. Kleczkowski A.S., 1984. Ochrona wód podziemnych [Groundwater protection]. Wyd. Geologiczne. Warsaw [in Polish].
10. Manteuffel Szoege H., 1999. Ekonomiczne oddziaływania w celu ochrony wód podziemnych przed obszarowymi odrolniczymi zanieczyszczeniami azotem (na przykładzie Wlk. Brytanii). [In:] Ochrona zasobów i jakości wód powierzchniowych [Economic measures for protection of groundwater against non-point nitrate pollution from agricultural sources (Great Britain case study). [In:] Protection of surface water resources and quality]. D. Wawrentowicz ed. Wyd. Ekonomia i Środowisko. Augustów [in Polish].
11. Manteuffel Szoege H., Sobolewska A., 2001. Ecological agriculture in Poland and its impact on the environment. [In:] Ecologically Improved Agriculture - Strategy for Sustainability. Tidskrift Kungl. Skogs – och Lantbruksakademiens no 6.
12. Manteuffel Szoege H., Sobolewska A., 2002. Ocena ekonomicznych skutków działań projektowych na szczeblu krajowym i globalnym. [In:] Raport drugiego etapu w kontrakcie R68/2002. Program oceny ekonomicznej i strategii powielania [Evaluation of the economic effects of project actions on the national and global level. [In:] The second stage report, contract R68/2002. The programme of the economic evaluation and the multiplication strategy]. Working paper for AGRO-CONSULT. Warsaw [in Polish].
13. Metodyka określania ekonomicznej efektywności inwestycji wodnych, melioracyjnych i zaopatrzenia wsi w wodę [Manual for determination of the economic effectiveness of investments in water resources development, land amelioration and water supplies in the rural areas]. Instrukcja branżowa, 1976. Ministerstwo Rolnictwa & IMUZ. Warsaw [in Polish].
14. Międzynarodowe stosunki gospodarcze na przełomie wieków [International economic relations between the centuries]. 2001. M. Piklikiewicz ed. Difin. Warsaw [in Polish].

15. Miłaszewski R., 2002. Polityka gospodarki wodnej. [In:] Teraźniejszość i przyszłość ekorozwoju w Polsce [Water management policy. [In:] Present and future eco-development in Poland]. G. Dobrzański ed. Wyd. Politechniki Białostockiej. Białystok [in Polish].
16. Opschoor J.B., Vos H.B., 1989. Economic Instruments for Environmental Protection. OECD. Paris.
17. Roszkowski H., 2002. Prezentacja Programu Ocena Ekonomiczna i Strategia powielania [Presentation of the Programme: Economic Evaluation and Strategy of Multiplication]. Regionalne Centrum Doradztwa, Rozwoju Rolnictwa i Obszarów Wiejskich. Przysiek [in Polish].
18. Sapek A., Sapek B., Pietrzak S., 2002. Obieg i bilans azotu w rolnictwie polskim. Nawozy i nawożenie no 1 [The circulation and balance of nitrogen in Polish Agriculture. No 1] [in Polish].
19. Schweigert P., Zimmermann P., 2003. Der $N_{min}$ Gehalt von Ackerböden als Agrar-Umweltindikator für Gewässerbelastungen durch Nitrat. Berichte über Landwirtschaft vol.81 (2).
20. Sobolewska A., 2002. Ekonomiczne efekty zastosowania wybranych instrumentów polityki ochrony środowiska przed zanieczyszczeniami pochodzenia rolniczego [The economical effects of selected instruments of environmental protection policy against pollution from agricultural sources]. Doctoral thesis in Agricultural Economics Faculty WAU. Warsaw [in Polish].
21. The Action Programme for Nitrate Vulnerable Zones (Scotland) Regulations 2001. 2001. Draft. Regulatory and Environmental Impact Assessment.
22. Tremblay M. (1996): Modelling of Groundwater Conditions in Silts and Fine Sands. A study of groundwater changes based on laboratory and full-scale field tests. Swedish Geotechnical Institute. Report no 50. Linköping.
23. Ustawa o nawozach i nawożeniu z dnia 26 lipca 2000 r. [The fertilizers and fertilization act.] 2000. Dziennik Ustaw R. P. no 89, item 991 [in Polish].
24. Water Quality Action Programmes for Scottish Nitrate Vulnerable Zones. Annex II, 2001. Draft Regulatory and Environmental Impact Assessment.

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