Implementation of EC Nitrate Directive in the Czech Republic

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1 Introduction

The European Community Council found that nitrate concentrations in waters of some areas are rising and reaching values that are disproportionate to the requirements for drinking water quality, and that this trend is not consistent with the interests of protecting the natural environment. The EC Council has adopted Directive 91/676/EEC on the protection of waters against pollution caused by nitrates from agricultural sources (Nitrates Directive, EC 1991). The Directive has only one main objective - to reduce water pollution caused by nitrates from agricultural sources and to prevent such pollution. The Directive deals generally with all groundwater and surface waters polluted by nitrates or endangered by nitrates pollution with respect to nutrient input into surface waters as well as marine and coastal waters where the nitrogen-rich runoff from the land may facilitate eutrophication. The Nitrates Directive requests the identification of water pollution by nitrates from agricultural sources and to determine vulnerable zones. It is necessary to implement measures reducing leakage of nitrates from agricultural sources into such vulnerable zones, as requested by so called 'action programs'. In addition to action programs, whose measures are mandatory in defined vulnerable zones, binding good agricultural practices must be compiled as preventative measures.

The requirements of the Directive have been incorporated into the Czech Water Rights in §33 of Act No. 254/2001 Coll.

The first phase of implementation of the Nitrates Directive in the Czech Republic was completed in 2003 when Government Decree No. 103/2003 Coll. (GR 2003) was adopted on the designation of vulnerable zones and on the use and storage of fertilizers and livestock manure, crop rotation and implementation of erosion control measures in these areas. In March 2003, initial designation of vulnerable zones was announced under Article 3 Appendix I to the Directive and on January 1, 2004, the first action program was started. The vulnerable zones were revised at the end of the first phase of implementation of the Nitrates Directive in 2007. The revised designation was declared by Government Decree No. 219/2007 Coll. (GR 2007), amending Decree No.103/2003 Coll. The Action Program was revised at the end of 2007 and in April 2008 the changes were announced by the Government Decree No. 108/2008 Coll. (GR 2008), modifying Decree No. 103/2003 Coll.

The second revision of vulnerable zones will be announced in March 2011 as part of the regular four-year cycle of revisions.

The period between the two revisions (2007 - 2010) is used for finding new opportunities for improving accuracy of input data and better identification of water pollution from agricultural sources. The monitoring of surface waters for the Nitrates Directive has been optimized and the National Groundwater Monitoring Network has been reconstructed.

To assess the impact of fertilizers on agricultural land, we tested the possibility of using an eco-hydrological mathematical model SWIM (Soil and Water Integrated Model, Krysanova et al. 1998). The SWIM model is used in the national project Labe (Elbe River) to evaluate the impact of the changes in land use and potential climate change on the dynamics of nutrients in the Jizera River (Martínková et al. 2010, Fig.1).

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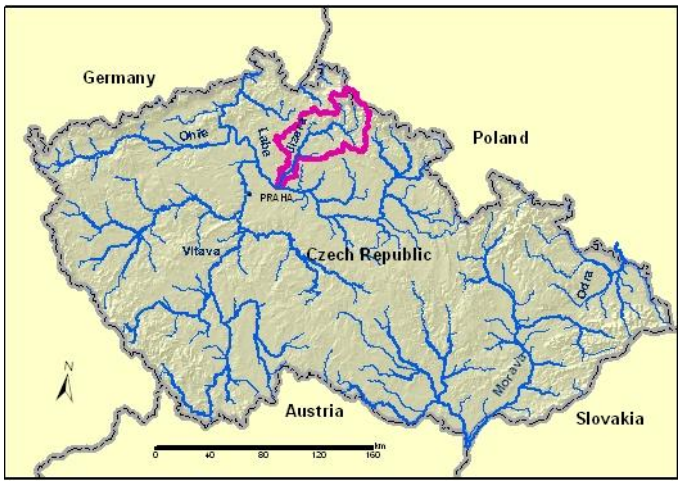

Figure 1. *Map of the Czech Republic with the outline of Jizera River test basin.*

2 Hydrography and land use

Czech Republic (CR) with an area of 78 866 km^2 and 10.2 million inhabitants is a land-locked country with mild climate. Three European continental divides of the North Sea, Baltic and Black Sea meet at Kralický Sněžník Mt. reaching an altitude of 1432 m above sea level. The main water-courses in Bohemia are Labe River (370 km long) and Vltava River (433 km), in Moravia Morava River (245 km) and Dyje River (306 km), in Northern Moravia and Silesia Region Odra River (135 km) and Opava River (131 km). Long-term average rainfall is 672 mm, the average rainfall ranges between 400 and 700 mm. Of the total area of the CR, 54% is agricultural land and 33% forests. More than 70% of agricultural land is arable land. The main crops grown on arable land are cereals (winter wheat, barley and fodder corn), potatoes, sugar beet and oilseed rape. The nitrate concentration in surface and groundwater is strongly depended on the typical land use of the watershed and on degree of dilution by infiltrated water. The concentration is also negatively affected by high percentage of sub-surface drainage all over agricultural regions. In addition, nitrate leaching is enhanced by large fields without balks and buffer strips.

3 Vulnerable zones designation

National environmental goals with respect to nitrate leaching and designation of vulnerable zones are similar as the Nitrate Directive requirements – 50 mg.l^{-1}. The CR has accepted the principle which identifies specific vulnerable zones and adopted stricter measures for those areas in the form of an action program. An extensive study of water pollution, part of the general pollution study of the Ministry of Environment, the project ran from 1998 - 2002 (Rosendorf 2003), formed the basis for the initial designation of vulnerable zones. Detailed maps of susceptibility of soil and rock substrate to allow nitrates penetration into water were prepared; at the same time the development of agriculture and its contribution to water pollution in different areas of the CR were evaluated. Vulnerable zones of surface water and groundwater were first evaluated by concentration of nitrates. The next step was to evaluate the danger of eutrophication of inland and marine waters. The resulting vulnerable zones were created by combining individual areas, by river basins of the 3rd order, in the case of deep hydrogeological structures also according to the knowledge of natural conditions. The use of soil was also considered as predominantly agricultural land. Vulnerable zones also include areas with insufficient data base but susceptible to pollution. The resulting vulnerable zones were then transferred to cadastral maps as required by the Government (Hrabánková et al., 2002).

The first several revisions in 2007 were based on the same procedure as in 2003, but special emphasis was given to the assessment of nitrates concentrations observed in surface and groundwater monitoring stations, and to establishing concentration trends (Hrabánková et al., 2007). For detailed evaluation of water pollution by nitrates, the entire territory of the CR was divided into two types of areas on the basis of predominant groundwater circulation. Areas with shallow groundwater circulation (in Paleogene and Cretaceous sediments of the Carpatian system, in Permo-Carboniferous deposits, in Proterozoic and Paleozoic crystalline rocks and in Zones of the top layer in Upper Cenozoic sediments) were evaluated together with

surface waters and areas with deeper or more complex groundwater circulation (in Tertiary and Cretaceous basin sediments and in Upper Cretaceous sediments) were evaluated separately. In this case absence of surface waters pollution does not automatically exclude pollution of groundwaters.

National environmental goals with respect to eutrophication are not determined exactly. The level of eutrophication is most frequently evaluated in various studies on the basis of phosphorus concentration or according to the P:N-ratio. The assessment method is being developed by the T.G.Masaryk Water Research Institute (Rosendorf et al. 2008); it is related to concentration of total phosphorus and chlorophyll-a in flowing waters. The evaluation of eutrophication was also based on the contribution of point and diffuse sources of pollution. The contributions of the individual sources were differentiated on the basis of the ratio of nitrate nitrogen to total inorganic nitrogen in the monitored sites.

Monitoring of surface water in the CR is secured partly by the state monitoring network (operated by the Czech Hydrometeorological Institute, CHMI). Here, sites on large rivers evenly distributed over the whole country are monitored - a total of 325 such sites, monitored once a month, are used for the Nitrates Directive. The other important source of information on concentrations of nitrates in surface waters is a monitoring system set up specifically for the Nitrates Directive (EC 2003). This monitoring system is working with a network of major, operational and investigative sites. The main sites monitor significant water-courses in both vulnerable and invulnerable zones with sampling once a month. They are located in areas representative of the monitoring of water bodies under the EU Water Framework Directive (WFD) with emphasis on water bodies with the highest proportion of agricultural land (EC 2000). Operational sites monitor the major tributaries of water bodies or parts of the river basins in the vulnerable and invulnerable zones. They are monitored regularly every four years and focus on areas with agricultural activities. Investigative sites are especially useful for determining the effectiveness of measures implemented within the action programs. They monitor the most critical period with regard to nitrates leaching out of the soil into water during winter period October-March. Altogether 624 measuring sites were used for revisions in 2007.

Groundwater is monitored in the state monitoring network that is used as data source for the purposes of the WFD and the Nitrates Directive. This monitoring is to be performed at measuring sites that are representative for groundwater aquifers. The monitored sites are wells and springs, 408 sites have been evaluated for these purposes so far; their number will increase significantly after a complete reconstruction of the monitoring network in 2010. Groundwater is sampled each year in spring and autumn.

4 SWIM modeling

The Jizera River was used in simulating the impact of fertilization on nitrates concentrations in surface waters, applying the eco-hydrological model SWIM. This model simulates water and nutrient fluxes in soil and vegetation, as well as transport of water and nutrients to and within the river network (Krysanova at al., 1998). The Jizera Basin is situated in NW Bohemia, CR (Fig. 1). Drainage area of the Jizera Basin is 2180 km^2. The River Jizera is 185 km long and drains into the River Elbe. The altitude of the basin is between 168 and 1434 m above sea level. Point and diffusive nitrogen sources were included in the model. Calibration was carried out for winter wheat as a crop. Details on calibration and modeling of nitrogen dynamics are presented in Martinkova et al. 2010.

5 Results and discussion

Compared to the first designation in 2003, the area of vulnerable zones in 2007 increased by 3.2 % to 31 358 km^2, which represents 39.8 % of the area of the CR (Fig.2). Most zones designated as vulnerable in 2003 remained so, and some even deteriorated. Some vulnerable zones where nitrate concentrations in the groundwater decreased below 25 mg/l were excluded in 2007. On the other hand, new areas with much arable land and high amounts of livestock manure became vulnerable, as nitrate concentrations increased to 25-50 mg/l.

Table 1 shows a summary of measuring sites in surface and groundwater in the CR, together with the distribution of average concentrations of nitrates according to the categories prescribed by the European Commission.

Table 1. *Number of sites in each category according to the average concentrations of nitrates in groundwater locations and surface waters for the period 2004 - 2006.*

Nitrate concentration [mg/l]	Groundwaters		Surface waters	
	Number of sites	%	Number of sites	%
0-24.99	303	74.3	772	81.4
25-39.99	33	8.1	157	16.5
40-49.99	14	3.4	14	1.5
≥50	58	14.2	6	0.6
Total	408	100.0	949	100.0

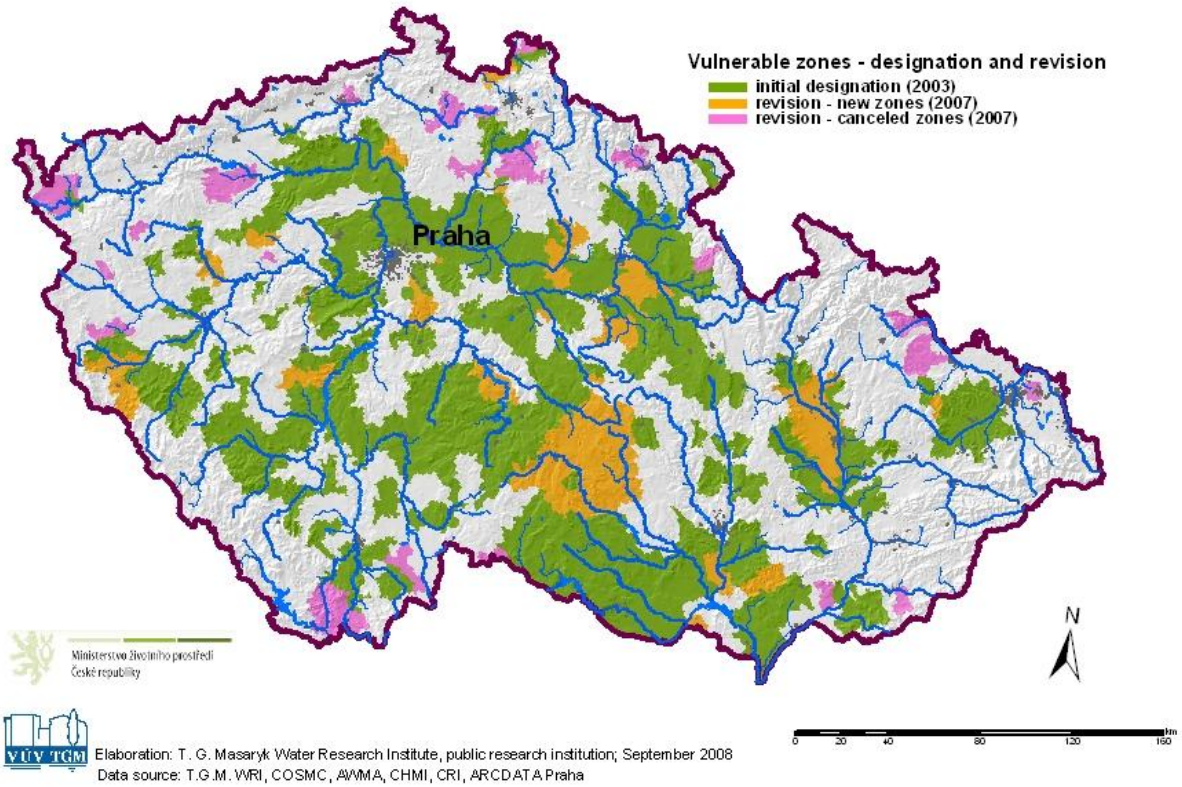

Figure 2. *Designation of vulnerable zones in the CR in 2003 and after revisions in 2007.*

In the Jizera River Basin, where was tested the SWIM model, vulnerable zones were designated because of increased concentrations in both ground and surface waters. Higher concentrations in surface waters (near 40 mg/l) were found in Kněžmostka River - the left tributary of the Jizera River. The SWIM model was calibrated for the outlet (monitoring station Předměřice, Fig. 3). Here, we present the results of several modeling experiments focused on fertilization: the monthly average concentrations of nitrates at the basin outlet increase no more than 20% in the ten-year period with a maximum dose of fertilizer (170 kg N per ha). Consequently, the mean nitrate concentrations would increase to a maximum of 20 mg/l.

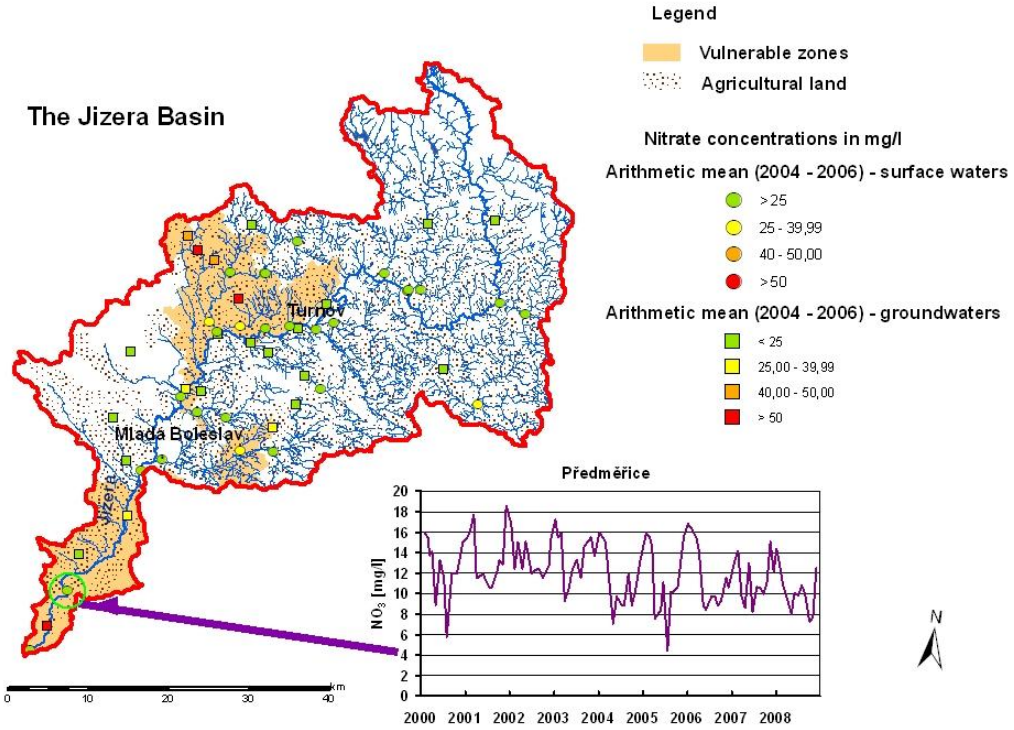

Figure 3. *Monitoring of groundwater and surface waters in the Jizera River Basin and the decreasing trend of concentrations of nitrates observed in the station* ***Předměřice****.*

6 Conclusions

Vulnerable regions in the CR are designated in cadastral maps. Their total area is 31 468 km^2, which represents 39.9% of the entire territory of the CR. The proportion of vulnerable agricultural land is 47.7 % of the total agricultural land in the CR. The results of modeling with the SWIM model proved that the influence of fertilization on nitrate concentrations in surface waters at the outlet of the Jizera Basin is not significant.

Subsequent implementation of the Nitrate Directive (by the first action programme in 2004) limited the effect of monitoring in the CR. The measures of the first action programme were applied mainly as a test. In the present period, the data from water monitoring and monitoring of farming practice are not well connected. The missing relationship is planned to be built up in 2010. A new revision of vulnerable areas is planned for March 2011. A modernized groundwater monitoring network and a monitoring system optimized for surface water Nitrates Directive will then be utilized.

Acknowledgements

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