

Agriculture and water sources protection zones

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Abstract

The question of contamination and protection of water source is a theme of great importance. Most drinking water is obtained from surface and ground water resources in the Czech Republic. For drinking water quality and quantity protection, it is necessary to establish protection zones.

The area of interest is located in the South Moravia Region at the confluence of Jihlava, Oslava and Rokytná rivers. Ivančice spring area comprises a series of hydrologic boreholes - it is the main water source for water supply of Ivančice and Rosice cities and provides water for 30 000 inhabitants. The risk analysis was created on the basis of water quality monitoring, hydrogeological assessment and terrain exploration and revision of protection zones was proposed. The spring area is situated in nitrate vulnerable zones and recently nitrate concentrations have been decreasing. Water quality evaluation results: high concentration of manganese and iron, sometimes higher concentration of ammonium and COD. This area is intensively used for agriculture and it was necessary to make a compromise solution during protection zones proposal. The regime in protection zones can't affect manganese and iron concentration (their origin is in the natural geological environment). Therefore, water treatment plant is in operation and its modernization is proposed. Further the paper deals with spring area intensification – construction of new hydrologic borehole and managed and unmanaged infiltration of surface water. The proposal of protection zones revision consists of reduction to 2nd level protection zone.

Key words: water quality, ground water source of drinking water, good agricultural practice, nitrate vulnerable zones, Czech Republic

1. Introduction

1.1. European and Czech legislation

There have been numerous changes regarding legislative framework for water during the last years. One of the reasons for these changes was the Czech Republic entering the European Union in 2004. The most important European Directives transposed to the national legislation are: Directive 2000/60/EC and Directive 91/676/EC.

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). By this Water Framework Directive, the European Union organizes management of surface water, continental water, transitional waters, coastal waters and groundwater in order to prevent and reduce its pollution, promote sustainable water use, protect and enhance the status of aquatic ecosystems and reduce the effects of floods and droughts (<http://www.directivamarco.es/>). Its fundamental principles are:

- hydrographic basin as the management unit which corresponds to the unit with natural hydrological cycle.
- cost recovery in the price of water that includes externalities.
- achievement of good eco-biological, hydromorphological and physical-chemical status.
- water and aquatic ecosystems recovery as a best guarantee of water quantity and quality – ecological aspect for sustainable water use.

- reduction of groundwater pollution and elimination of dangerous substances at source;

According to this Directive, all bodies of water used for the abstraction of water intended for human consumption providing more than 10 m³ a day as an average or serving more than 50 person (<http://www.directivamarco.es/>) must be identified.

The principles of the Water Framework Directive were adopted into Czech legislation by amending the Water Law 20/2004 Sb. (which came into force on January 23, 2004) and into the Drainage, sewers and public water supply law 274/2001 Sb.

Another very important European legislation is the Directive 91/676/EC – referring to protection of waters against pollution by nitrate from agricultural sources. Its principles were adopted into Czech legislation in the Regulation 103/2003 Sb. and its amendment. According to this Directive, nitrate vulnerable zones are areas where surface waters or ground waters have nitrate concentrations of more than 50 mg.l⁻¹ or are thought to be at risk of nitrate contamination. The purpose of this Directive is to protect water quality by preventing high nitrate concentrations polluting ground and surface waters and especially by reducing polluting effects of the intensive cultivation and reducing the use of chemical fertilizers. It also includes regulations for waste water treatment and good agricultural practice, such as nitrogen fertilizer use and storage, and livestock effluents. Action programmes should be implemented by farmers within the nitrate vulnerable zones in order to prevent and reduce pollution due to nitrates from agricultural sources and should be revised every 4 years.

Water protection in the Czech Republic is divided into general, particular and special. The general protection is based on various legislative laws relating to the protection of individual environment components. It is obligatory for all and without any compensation. The particular protection includes CHOPAV, sensitive areas and nitrate vulnerable zones and for compliance with farming aren't also compensation. The special protection includes protection zones of water resources.

Protection zones have been defined in order to protect quality and quantity of drinking water sources (Water Law 254/2001 Sb.). Three water protection zones were established by previous legislation (level 1 protection zone; level 2 protection zone divided into outer protection zone and inner protection zone; and level 3 protection zone defined in surface water sources.). In the actual water legislation, only 2 levels of protection zone are defined: level 1 protection zone where more severe measures regime exists and level 2 protection zones. The actual tendency in water protection consists in determination of protection areas more defined, in result of which the water source area and the vulnerable area are not totally included in the established protection zone. It is also possible to establish more level 2 protection zones. It is of great importance, especially for agricultures, to know and observe the regulation, especially with respect to the reduction of mineral and organic fertilizers use, as well as herbicides and pesticides use. Very often it is also necessary to elaborate special programmes for stock breeding prohibiting new constructions, establishment of new sewers and the use of chemicals for winter road maintaining within these zones (Oppeltová, Novák, 2007).

The owners whose land is within the protection zone receive subsidy to reduce disadvantages caused due to limitation they are subjected to. In view of the large initial area of protection zones and in view of the fact that the users of water sources did not want to pay high price for the subsidy paid to affected owners, new and more reduced protection zones have been gradually delimited (Oppeltová, Novák, 2007).

1.2. Spring area Ivančice

The area of interest is located in the South Moravia Region at the confluence of Jihlava, Oslava and Rokytná rivers. Ivančice spring area comprises a series of nine hydrologic boreholes - it is the main water source for water supply of Ivančice and Rosice cities and provides water for 30 000 inhabitants.

In 1985 and 1986 hygienic protection zones were established. Level 1 hygienic protection zone is common for all nine hydrologic boreholes (13,5 ha) and level 2 hygienic protection zone divided into outer protection zone (827 ha) and inner protection zone (57,8 ha). The whole Level 1 hygienic protection zone is fenced and there are permanent grasslands. The area of level 2 hygienic protection zone is agricultural and forestry used and there are municipalities although. The spring area is situated in nitrate vulnerable zones.

2. Material and Methods

The data on water quality and the reservoir flow values have been obtained from VODÁRENSKÁ AKCIOVÁ SPOLEČNOST, a.s., which operates the water supply.

The following parameters were evaluated: iron, manganese, sulphates, chloride, nitrates, ammonia, DQO – permanganate, pH, cuprum, lead, cadmium, clostridium perfringens, thermotolerant bacteria, Enterococcus bacterias and Escherichia coli,

The risk analysis was created on the basis of water quality monitoring, hydrogeological assessment and terrain exploration and revision of protection zones was proposed.

3. Results

3.1. Water quality evaluation

Raw water complies with requirements for drinking water quality in most chemical, physical, microbiological, biological and radiological indicators. Between problematic indicators belongs manganese (the limit for drinking water is 0,05 mg.l⁻¹, but if the manganese concentration in groundwater has the origin in the natural geological environment, the limit is 0,2 mg.l⁻¹) and iron (the limit for drinking water is 0,2 mg.l⁻¹, but if the iron concentration in groundwater has the origin in the natural geological environment, the limit is 0,5 mg.l⁻¹). The concentration limit of manganese and iron was exceeded in most boreholes at each analysis. Hydrogeological assessments confirm the natural origin of manganese and iron pollution.

The regime in protections zones can't affect high concentration of manganese (up to 2 mg.l⁻¹) and iron (2 – 7 mg.l⁻¹) because their origin is in the natural geological environment. The manganese and iron concentration is reduced in water treatment plant and after the treatment the values already comply Regulation No. 252/2004 Coll. for drinking water, as amended. Similarly with microbiological indicators - water disinfection is taking place in water treatment plant and in treated drinking water there aren't free microorganisms. In three boreholes (marked HV 1, HV 2, HV 4) a high concentration of ammonium - up to 1 mg.l⁻¹ - was regularly detected. For the future, it is recommended not to use these boreholes and to eliminate them gradually.

In 2006 temporarily increased chloride, sulphate and COD concentrations. This could be the floods consequence that had been there in March 2006 and it was the exceptional condition.

The agriculture in arable land surround the spring area could be an important source of the diffuse pollution. The processed results of drinking water samples show that in the last five years the maximum nitrate limit has not been exceeded. At present, agricultural management relies on the Nitrates Directive and it is necessary to respect the Action Programme principles of this Directive.

Ground water in the spring area is subsidised by infiltration from the alluvial plain of Jihlava river and depends on precipitation distribution in the upper parts of the catchment. The spring area is located in the meadow and its surrounding is agricultural and forestry used. The nearest built-up area is located approximately 500 m from the spring area and the houses are connected to the waste water treatment plant.

The old cow house is situated in the area of origin hygienic protection zone - level 2 - but currently is not operating. This object is used by small companies that don't affect the water quality or quantity in the spring area.

Former black dump consisted of building debris and excavated soil could be the potential source of drinking water contamination. There may be indefinite amounts of unknown harmful substances. Currently, the dump is covered and the old grass covers its surface. For

now, the influence of the dump on the water quality in the spring area has not been found. Due to ignorance of the exact dump composition, in order to protect the water sources it is necessary to include the dump in to the proposed protection zone of second level. In the future, it is possible to build several monitoring boreholes in the direction of groundwater flow.

3.2. Protection zones propose

The risk analysis was created on the basis of water quality monitoring, hydrogeological assessment and terrain exploration and revision of protection zones was proposed. Original hygienic protection zones were cancelled and new protection zones were established (Fig.1).

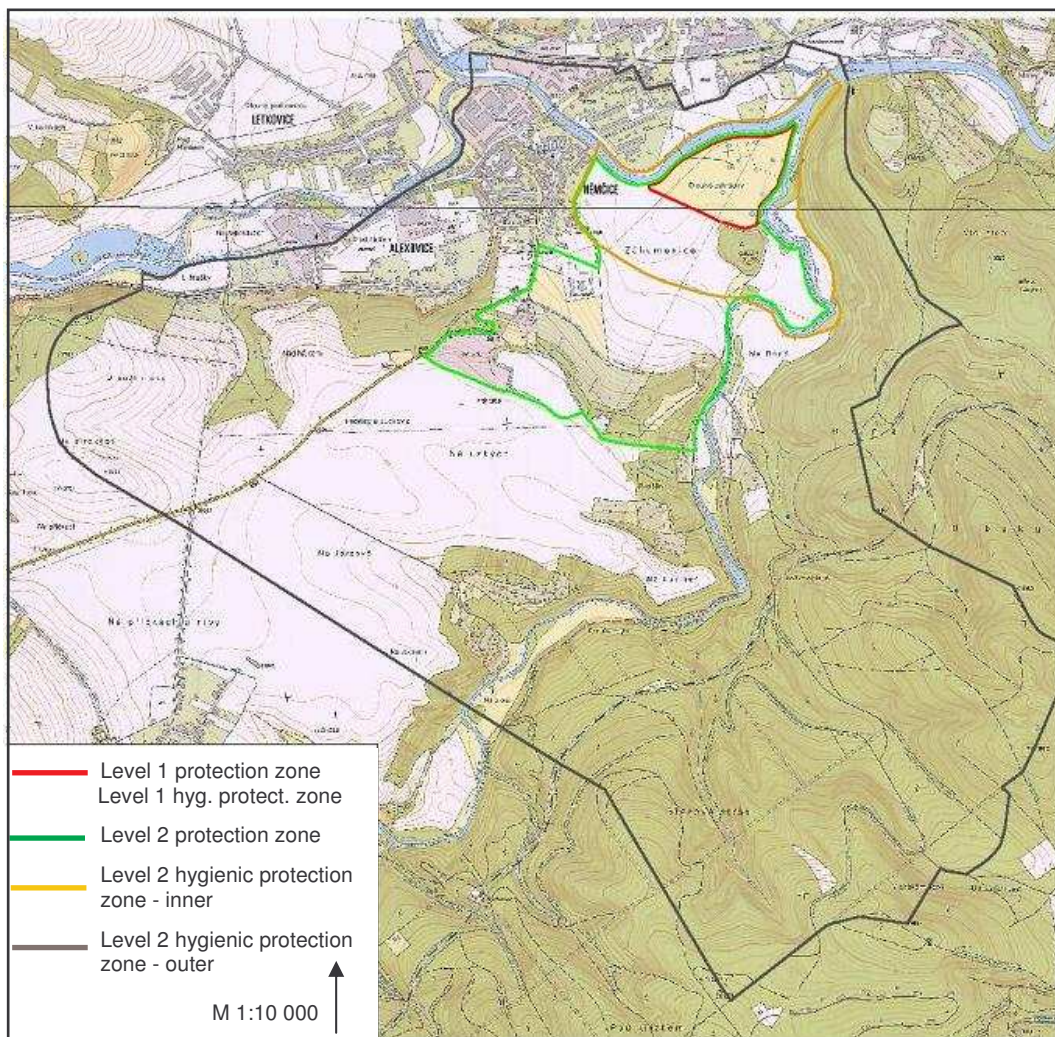


FIGURE 1: New protection zone and original hygienic protection zone

Level 1 protection zone extension is the same like original level 1 hygienic protection zone (13,5 ha) and forms the immediate surroundings of collecting boreholes (Fig. 1). There are eight hydrologic boreholes (marked HV 1, HV 2, HV 4, HV 3, HV 7, St 1, S VII, HV 101), one collection well and water treatment plant in the level 1 protection zone. The entrance to the level 1 protection zone is restricted by fencing and protected against entry of foreign persons, and marked with warning boards. In three boreholes (marked HV 1, HV 2, HV 4) high concentrations of ammonium - up to 1 mg.l^{-1} - were regularly detected. It is recommended in the regime in protected zones not to use these boreholes and to eliminate them gradually. Water supply operator must regularly monitor the physico-chemical and microbiological parameters in all boreholes. In level 1 protection zone it is prohibited to carry out any activities not related to captation, transport, treatment and accumulation of ground water and not related to the maintenance of the surface and vegetation or technical support of the

spring area. It is also prohibited to build dumps, apply fertilizers and pesticides, pursue the pasture and drive with motor vehicles. It is necessary to cut the grass regularly and to remove it from protection zone.

The extension of level 2 protection zone will be significantly reduced compared with the original level 2 hygienic protection zone (Fig. 1). The area of interest is located in nitrate vulnerable zones and the farmers must comply the regime according to the Nitrates Directive and good agricultural practice:

- comply periods when the land application of fertilizer is inappropriate;
- the land application of fertilizer to steeply sloping ground;
- the land application of fertilizer to water-saturated, flooded, frozen or snow-covered ground;
- the conditions for land application of fertilizer near water courses;
- the capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the groundwater and surface water of liquids containing livestock manures and effluents from stored plant materials such as silage;
- procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, that will maintain nutrient losses to water at an acceptable level.

(<http://ec.europa.eu/environment/water/water-nitrates/directiv.html>)

In the case of observe all conditions in nitrate vulnerable zones it isn't necessary to include such a large territory to the level 2 protection zones and propose other special regime. Also the processed results of drinking water samples shows that in the last five years the maximum nitrate limit has not been exceeded. On the contrary, the black dump is included to the level 2 protection zone and this area must be regularly monitored. In level 2 protection zone is prohibited:

- carry out large grading without previous hydrogeologists permission;
- permit other collection objects for commercial purposes;
- construct a waste dump, industrial and agricultural buildings and use the chemical road salting.

It is possible to determine other level 2 protection zones in the case of water quality deterioration. Compliance with the Nitrates Directive conditions is required by law and there is no possibility to pay any compensation. The proposed conditions in protected zone aren't although subject to refunds.

3.3. Spring area intenzifikacion

In the future, the development and construction of residences is expected in the area of interest. At present, this trend is limited by the deficiency of water sources. The permitted ground water intake from the spring area is $30,9 \text{ l.s}^{-1}$. Another proposed project which deals with the intensification of spring area Ivančice is proposed. The owner and the operator of the water supply deal with this project. The aim is to obtain a subsidies from European funds for the realization. The project substance is continue to use perspective intake objects (HV 3, HV 7, St 1, S VII, HV 101) and their yield increase by managed and unmanaged infiltration of surface water.

The proposal of unmanaged infiltration: the movable weir is constructed in Jihlava river near the spring area, and it is possible to manipulate the water level in the river and subsequently groundwater level in the surrounding. The collection drain will be constructed around the spring area to the depth of groundwater level (affected by the weir in the river).

The proposal of managed infiltration: two lagoons will be constructed near the spring area and the water from the river will be pumping there. The water in the lagoons will gradually infiltrate and enrich the ground water. In case of high contamination of surface water in the

river, the surface water will be pumped to the pre-treatment plant, which will be constructed during treatment plant modernization.

Spring area intensification is also related to the water treatment plant intensification - a capacity increase about 30 l.s⁻¹. Existing technology - single-stage filtration and ozone oxidation, will be preserved.

Conclusions

Agriculture and water supply belongs to the important landscape functions and during protection zones revision it was necessary to work closely together and create a compromise solution.

The farmers have to comply with the Nitrates Directive conditions and no other measures in protection zones were necessary to propose. The cooperation between water managers, farmers and government control authorities is the current tendency when the protection zones are proposing.

New level 2 protection zone is smaller than the original level 2 hygienic protection zone. Water supply operator must regularly monitor the physico-chemical and microbiological parameters in all boreholes.

It is possible to determine other level 2 protection zones or more restrictive regime in the case of water quality deterioration. Currently, in the spring area we can find all types of water protection measures - preventive, technical and technological measures. Protection zones represent the preventive measures. Selection of perspective intake objects and the infiltration represent the technical measures and water treatment plant modernization and pre-treatment processes of surface water given up to infiltration represent the technological measures.

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