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MONITORING AND PROTECTION OF SURFACE WATER QUALITY IN THE SLOVAK REPUBLIC

MONITORING I OCHRONA JAKOŚCI WÓD POWIERZCHNIOWYCH W REPUBLIKA SŁOWACJI

The role of the society is to make efficient, reasonable and sustainable use of water. Comprehensive water protection aims at aquatic and water-dependent ecosystems, conservation or improvement of water status, river basin management as well as improvement of the quality of environment and all environmental components. In addition, it includes the flood protection aimed at minimization of flood event impacts on the landscape and human society by using available technical and technological means and measures to reduce the adverse effects of drought and the maintenance of the function of streams and hydraulic structures. Water management and water resources protection is of growing strategic importance, particularly because water availability is becoming one of the global problems.

1. Introduction

Several governmental, public and non-governmental bodies and organizations led by the Ministry of Environment of the Slovak Republic play initiation, coordination and standardization role in managing the development and quality of procedures used in water management and integrated river basin management.

2. Basic description of river basin districts

2.1. Development on watercourses and hydraulic structures administrated by water management sector in Slovakia

The watercourses in Slovakia are administrated by several entities (SVP – Slovak Water Management Enterprise, municipalities, etc.). The major rivers in the catchments of Danube, Morava, Váh, Hron, Hornád and Dunajec (figure 1) are managed by the public organization "Slovenský vodohospodársky podnik" (Slovak Water Management Enterprise). An overview of the development of watercourses administrated by the SVP is shown in the table 1.

2.2. Climate Conditions

Average annual precipitation totals in Slovakia are 760 mm. Rainfall totals in 2012 reached 711 mm, representing 85 percent of the average. The year 2012 is considered normal regarding precipitation.

Tab. 1 An overview of the development on watercourses administrated by the SVP in 2008 - 2012 [5]

Parameter	Unit	Year				
		2008	2009	2010	2011	2012
Length of watercourses	km	38 217	38 217	38 215.7	38 215.7	38 215.7
Significant water management and water supply watercourses	km	11 850	11 850	11 850	11 850	11 850
Water reservoirs	number	277	277	277	278	278
thereof: water supply reservoirs	number	8	8	8	8	8
Total capacity of water reservoirs	mil. m ³	1908	1908	1908	1908	1908

2.3. Hydrological Conditions

Slovakia is located geographically on a watershed divide of the Black Sea and Baltic Sea (figure 1). Water from 96 % of the Slovak territory flows through the Danube and Tisa into the Black Sea, while the remaining 4 % flows through the Vistula River tributaries into the Baltic Sea. The streams rising in our territory are rather unstable. High discharges occur regularly in spring from March to April (on the Danube, Poprad and Dunajec rivers approximately 2 months later). Low discharges are observed during the summer and autumn periods. An average density of the river system in Slovakia is 1.1 km.km⁻².



Fig. 1. River basin districts at national level [6]

2.4. Water resources

The long-term average annual runoff from the Slovak territory is 217.1 mm. In 2012, the runoff was in the range from 19 % (Danube sub-basins) to 89 % of the average (Poprad and Dunajec sub-basins). The average runoff was 59 % of the long-term average. The use of water resources is at a low level in Slovakia, representing about 9 % of the total water balance.

3. Use of water resources

3.1. Surface water

Use of surface water resources in Slovakia:

- service water supply,
- drinking water supply,
- hydropower potential,
- irrigation systems,
- waterways,
- fisheries.

3.1.1. Service water supply

The total surface water abstraction amounted to 305 815 thousand m³ in 2012. The most significant consumers of surface water are industrial companies such as EVO Vojany, Slovnaft Bratislava, U. S. Steel Košice, etc. Surface water supply in 1995- 2012 is shown in the table 2.

Tab. 2 Surface water supply in Slovakia [million m³]

	1995	2000	2005	2009	2010	2011	2012
Surface water supply (total):	781,1	711,0	508,8	261,9	237,8	242,6	305,8
public water supply	65,0	66,3	51,7	48,2	45,7	46,2	46,7
industry, agriculture and others	771,5	722,2	457,1	213,7	192,1	196,4	259,1

Gradual decrease in water consumption by population and implementation of various rationalization measures aimed at water consumption in industry and agriculture are the main reasons for reducing surface water supply in the Slovak Republic.

4. Identification of significant pollution effects

Surface water is affected by anthropogenic pressures. These pressures have an effect on surface water bodies of every river basin district in Slovakia. The pollution types are categorized as follows:

- organic pollution,
- nutrient pollution,
- relevant and priority substances pollution,
- hydro-morphological changes.

4.1. Organic pollution of surface water

Organic pollution of waters occurs due to water contamination by organic substances from natural and anthropogenic sources. Organic substances naturally present in water come mainly from soil erosion and degradation processes of dead organic matter. This pollution is relatively insoluble and slowly degradable. Organic compounds resulting from various human activities are among the most commonly occurring pollutants discharged into the surface water.

Organic pollution of surface water is characterized by oxygen regime parameters: dissolved oxygen (O₂), oxygen saturation, biochemical oxygen demand (BOD₅), chemical oxygen demand by potassium dichromate and potassium permanganate (COD_{Cr} and COD_{Mn}). The main sources of organic pollution of water bodies are:

- agglomerations
- industry,
- agriculture (particularly diffuse sources of pollution) .

The current conditions of wastewater collection and treatment in municipalities are still not satisfactory. According to available data, 3,359,000 inhabitants are connected to public sewerage systems, representing 62.4 % of Slovakia's population.

4.2. Nutrient pollution of surface water

Emissions of nutrients (total nitrogen, total phosphorus) get into the surface water in different ways: from point sources (agglomerations, industry, agriculture) and from diffuse sources (erosion, surface runoff, groundwater and atmospheric deposition). Diffuse sources are partly of natural and partly of anthropogenic origin (mainly from agriculture). The most significant impact of high nutrient load is eutrophication of water. Major polluters of surface water by nutrients are the same as for organic pollution.

The state of surface water is poor at present, since there are identified 66 plants discharging wastewater with priority substances in Slovakia.

Other sources of pollution (priority substances, hydromorphological changes) do not play such an important role in water pollution in Slovakia.

5. Monitoring and information system

5.1. Monitoring system

Monitoring of surface water and groundwater is carried out comprehensively in river basins and sub-basins. The monitoring system is specified under the Decree of the Ministry of Environment 418/2010 on implementing certain provisions of the Water Act. In 2012, the monitoring was carried out within the following monitoring sub-systems:

1. Quantitative surface water parameters
2. Quantitative groundwater parameters
3. Surface water quality
4. Groundwater quality
5. Thermal and mineral water
6. Irrigation water
7. Bathing water

The subsystems 1 up to 4 are managed by the Ministry of Environment. The subsystems 5 and 7 are managed by the Ministry of Health, and the subsystem 6 is controlled by the Ministry of Agriculture.

5.2. Surface water quantity parameters

The scope of the monitoring within the subsystem is described in the 2012 monitoring programme. In 2012 the monitoring of surface water quantity parameters was conducted in 418 monitoring sites, including 2333 measurements carried out. Joint measurements on transboundary rivers included 115 measurements on 38 common river

profiles. These measurements are performed pursuant to the bilateral agreements between neighbouring countries.

The goal of the monitoring of surface water quantity parameters is to monitor systematically quantitative elements and physical properties of water (water levels - H, discharge - Q, water temperature - T, ice phenomena and suspended load) to obtain information on the status and development, as well as the temporal and spatial variability of surface water resources. The monitoring aims mainly at examination, measurement and evaluation of water level and flow regime of surface water using technological line in the network of surface water gauging stations, with regard to transboundary rivers [3].

At present, the water status monitoring programme in Slovakia includes the identification and assessment of the status of surface water and groundwater in protected areas, their monitoring, as well as keeping records on water bodies and water balance, i.e. monitoring of surface water and groundwater quantity.

The monitoring network comprises the surveillance and operational monitoring of surface water.

Water status monitoring programme is established for a relevant year and can be developed in several alternatives. The proposal envisages that the water quality monitoring will be conducted at the sampling sites of surveillance and operational monitoring network. Additional sampling sites can be included in the monitoring network in order to establish reference conditions (reference sites).

The number of sampling sites within the surveillance monitoring network ranges from 100 to 105, while the number of sampling sites within the operational monitoring is doubled depending on the conditions. In addition, about 60-70 reference sampling sites are also included.

5.3. Surface water quality

The quality requirements for surface water are specified pursuant to the Government Regulation no. 269/2010 Z.z. defining pollution parameters and their maximum acceptable value. The parameters include general parameters: physical (temperature, pH, etc.), chemical (organic and inorganic - nutrients, pesticides, chlorides, heavy metals), hydro-biological, microbiological indicators (coliform bacteria, faecal streptococci, Salmonella, etc.) and radioactivity indicators (alpha, beta, strontium, etc.). In addition, there are indicators of synthetic and non-synthetic substances. Concerning water bodies intended for the abstraction of surface water for drinking purposes, a list of some 80 parameters with recommended limit values (OH) and threshold values (MH) is developed. The values are required for categorization of water according to levels of water treatment technology to be applied (A1, A2 and A3).

In 2012, the surface water quality parameters were monitored at 314 sites of the surveillance (86) and operational (63) monitoring.

The frequency of monitoring is usually evenly distributed throughout the year, i.e. 12 times a year in accordance with the monitoring program. Some biological indicators have a lower frequency of monitoring, i.e. they are monitored seasonally (annual frequency: 2-7 times a year), radioactivity parameters (4 times a year) and relevant substances (4 times a year).

The requirements for the surface water quality established under the Government Regulation 269/2010 Z.z. were met for the following parameters at all monitoring sites in 2012:

- general indicators (Part A): magnesium , sodium , sulphates, free ammonia , fluorides, surface active agents, phenol index, chromium (VI), vanadium, chlorobenzene, dichlorobenzene
- Indicators of radioactivity (Part D): gross alpha and beta activity, tritium, strontium, caesium

As regards general parameters, the limit values were exceeded most frequently for the nitrite nitrogen in all sub-basins. As far as hydro-biological and microbiological parameters are concerned, the limit values were exceeded most frequently for coliform bacteria (in 7 sub-basins), thermotolerant coliform bacteria (6 sub-basins) and intestinal enterococci (6 sub-basins) .

The potential of surface water bodies is assessed based on parameters monitored within each category (biological, chemical and physical parameters). Water quality is assessed in accordance with the European Quality Standard (EQS) for relevant substances. The results are divided into 5 categories (high, good, moderate, poor, bad) depending on the quality of water in a stream. Assessment of the chemical status of surface water bodies in Slovakia is carried out in two ways:

1. using direct measurements at representative monitoring sites and extrapolation of the results of water bodies monitored at representative sites to water bodies aggregated in the same group but not monitored at representative sites,
2. using direct measurements at representative monitoring sites and the results of risk analysis.

The number of monitoring sites and the parameters not meeting the general requirements for surface water quality under the Government Regulation 269/2010 Z.z. but monitoring results are recorded and available to the public.

5.4. Ecological status assessment

The assessment of ecological status of surface water bodies is based on the biological quality elements, i.e. individual water communities that synergistically accept all changes in aquatic environment. Responses of organisms to environmental changes are reflected in the changes of their structure and functions expressed through the relevant metrics. Biological quality elements include benthic invertebrates (macrozoobenthos), fytoenthos and macrophytes, phytoplankton and fish. Classification schemes are ready for the biological quality elements and supporting quality elements [1]. Classification schemes for biological quality elements are type-specific and include the possible pressures (stressors). The rate of the effect is expressed in metrics for each biological quality element. Their number varies and metrics (different number for different types) are transformed to the ecological quality ratio for each limit value of the ecological status categories. Fish were not included in the assessment of ecological status of surface water bodies in 2010, since the fish were not systematically monitored until 2010.

The supporting elements for the organisms dependent on water include physical-chemical quality elements and hydromorphological quality elements. Physical-chemical quality elements are water temperature, conductivity, pH, dissolved oxygen, BOD₅ , COD_{Cr}, acid neutralizing capacity up to pH 4.5 (ANC_{4.5} ; alkalinity), ammonia nitrogen, nitrate nitrogen, total nitrogen, phosphate phosphorus and total phosphorus. Hydro-

morphological quality elements include hydrological regime, continuity – disturbed migration of organisms and morphological conditions.

The assessment of ecological status also includes the evaluation of selected chemical quality elements - specific synthetic and non-synthetic substance relevant for Slovakia. In Slovakia, these include 26 substances that are used in significant quantities, discharged into the receiving body, toxic, accumulated in aquatic environment and are hardly degradable (aniline, arsenic, benzenesulphonamide, benzothiazole, biphenyl (phenylbenzene), bisphenol A, clopyralid, desmedipham, dibutyl phthalate, diphenylamine, ethofumesate, phenanthrene, formaldehyde, glyphosate, chromium, cyanide, copper, MCPA, 4-methyl-2,6-di-tert-butyl phenol, PCBs and its congeners, pendimethalin, 1,1,2-trichloroethane, toluene, vinyl benzene (styrene), xylene (isomers), and zinc). National environmental quality standards have been established for these substances [1]. In assessing the status of surface water bodies, background concentrations of heavy metals were also taken into account for specific non-synthetic substances relevant for Slovakia [19].

When assessing the ecological status and following the above criteria and schemes, the principle is that the worst rated quality element classifies the entire water body. Sampling site shall meet the representativeness criteria for the entire water body [14].

5.4.1. Risk analysis

Where monitoring had not been carried out, the risk analysis was applied to water bodies. Risk analysis [15, 16] was developed and updated in order to assess the risk of failing to achieve the environmental objectives (good water status) due to the relevant pressures (hydro-morphology, organic pollution, nutrients, hazardous substances). Risk estimation was carried out based on historical results of surface water quality monitoring in Slovakia, the information on pollution sources as well as available maps and other relevant data resources.

5.4.2. Extrapolation of results

Monitoring sites under the Water Framework Directive may not be designed individually for all water bodies, but in case of the same type of water body and the nature of a pressure they may represent a group of water bodies [11]. If only one or several water bodies are monitored within a group of water bodies applying the same criteria, the results can be extrapolated to water bodies not monitored within the group.

For the purpose of effective monitoring the water bodies can be grouped according to certain criteria [13]. It is thus possible to characterize the state of other water bodies forming the relevant group by using the results of assessment. Verification and update of status assessment can be done through the monitoring of other water bodies of the relevant group (rotation of monitoring within clusters of water bodies).

5.4.3. Ecological status assessment in Slovakia

In 2010, the ecological status was assessed for 1648 surface water bodies that have been identified as natural. Other water bodies in the process of testing were designated as heavily modified or artificial. The assessment of ecological status was conducted on

the basis of monitoring results only for 89 water bodies. The rest of water bodies were evaluated using the extrapolation of the results. In cases where no water body of the entire group was monitored, the updated risk analysis was used. Extrapolation of the results was done based on the monitoring of the status of surface water bodies from the previous years by transferring the category (or in case of several years, using the average of categories) of the overall ecological status of all water bodies assessed within the group for the relevant monitoring period. The lowest reliability of the assessment was determined for surface water bodies, where the extrapolation of results had been used to assess the status [12].

The results show that the ecological status for 70.45 % of the total number of water bodies was evaluated as high and good (1161 water bodies). In terms of the total length of streams, it is 61.89 %, covering the 10 458.67 km of water bodies. A relatively large number of water bodies (419) achieved moderate ecological status (25.42 % - 4 955.55 kilometres of water bodies). Poor and very bad status was achieved in 68 surface water bodies (61 and 7 respectively - 4.13 % of the total water bodies). In terms of length it is 1 485.18 km.

6. Monitoring and information system

Protected areas of Slovakia are locations designated for the protection of water resources, including areas designated to protect habitats or plant and animal species where maintaining or improving the status of water is important for their protection. Protected areas include the following:

- protected areas designated for the abstraction of drinking water (protection zones of water resources, catchments of rivers used for water supply, protected water management areas)
- protected areas intended for recreation, including bathing waters (waters intended for recreation are not specifically defined and designated in Slovakia)
- protected nutrient sensitive areas (sensitive areas and vulnerable areas),
- protected areas designated for the protection of habitats or animal and plant species, including relevant sites of Natura 2000.
- protected areas designated to protect economically significant aquatic species.

6.1. Protected areas designated for the abstraction of drinking water

The protection aims at water supply resources, i.e. surface water bodies used for the abstraction of drinking water or available to supply more than 50 people or having a supply capacity of more than 10 m³ of raw or treated water (public water supply). There are three types of water supply resources protection in Slovakia:

- protection zones of water supply resources – intended for health protection in order to ensure protection of quantity (yield), quality and safety of water in the water resource;
- catchments of rivers used for water supply - 102 streams are designated as water supply resources intended for drinking water abstraction in Slovakia;

- protected water management areas - designated 10 protected water management areas - protected areas of natural water accumulation in the region of Žitný ostrov and some other protected areas of natural water accumulation.

In Slovakia there are 43 surface water supply resources, including 81 protection zones covering the total area of about 490,000 ha.

6.1.1. Areas designated to abstract water for human consumption

It is needed that each water body intended for drinking water abstraction be defined as a protected area. It is required to ensure necessary protection of these water bodies in order to prevent quality deterioration and reduce the level of treatment needed to produce drinking water. The protection zones of water supply resources intended for human consumption are already defined in Slovakia. The protection zones of water supply resources are legally designated by national water authority based on the assessment by public health authority. Protection zones are divided into:

- Protection zone 1 - protection of area in the immediate vicinity of water abstraction point or intake structure,
- Protection zone 2 - protection of water supply resources against risks from distant area.

National water authority may establish the protection zone 3 aimed at enhanced protection of water supply resource.

Water supply resource protection zone of the 1st degree (hereinafter referred to as "**protection zone 1**") shall be designated for all surface water supply resources. Protection zone 1 of surface water resources (direct abstraction of water from watercourse) is designated to protect the intake structure and riparian zone along a river upstream of the intake structure. As regards water supply reservoirs, the protection zone 1 is designated to protect the entire area of water surface of the reservoir, including riparian buffer zone above the maximum water level in the reservoir and to protect the area along the major tributaries of the reservoir in an appropriate width and length upstream [2].

Protection zone 2 shall be designated for surface water resources, if the area of creation and circulation of water is without other types of sufficient protection or the protection through protection zone 1 is inadequate.

Protection zone is designated to protect available quantity, quality and safety of drinking water resources in relation to natural conditions and to the impact of human activity on the relevant area. Protection zone 2 shall be established in the hydrological catchment following the designation of the protection zone 1 in order to protect water mainly from microbiological contamination and pollutants. Protection zone 2 is established when abstracting water directly from a watercourse or from a water reservoir through buffer strips along a river or using surface method.

If the protection zone 2 is designated through buffer strips, it will cover an area along a river or its tributaries in appropriate length and width [2].

Protection zone 3 of the surface water supply resources shall be established, if it relates only to water protection (especially prevention of contamination by hazardous substances), and if the infiltration area or hydrological catchment of surface water is not included fully in the protection zone 2, or if water protection is provided in line with special legal regulations [2].

When defining the boundaries of the protection zone, one should take into account the morphology of the area, hydrological watershed divides, hydrogeological boundaries, properties of the rock environment (karst-fissure, fissure and intergranular), natural boundaries of vegetation, artificial territorial boundaries, line constructions, the boundaries of land lots according to the land registry and the boundaries of urban areas [2].

6.1.2. Water protection measures in protection zones

Water protection within the protection zones is provided through the measures to prevent or limit activities posing a risk to or deteriorating water quantity, quality and safety of water supply resources and through technical measures to protect drinking water resources [2].

6.2. Protected areas intended for recreation and bathing waters

In 2012, 36 localities were designated as bathing waters, covering the area of about 90 square kilometres. These waters are monitored in line with the defined time schedule and the results are submitted to the European Commission.

6.3. Nutrient sensitive protected areas

Two types of nutrient-sensitive areas are identified in Slovakia: sensitive and vulnerable areas.

Sensitive areas - sensitive area is a surface water body where the potential risk of increasing nutrient concentrations is present. The entire territory of Slovakia is categorized as a sensitive area.

Vulnerable areas include agricultural land within administrative boundaries of municipalities, where the nitrate concentration in water exceeds 50 mg.l⁻¹.

6.4. Protected areas designated for the protection of habitats or animal and plant species (Natura 2000)

This group comprises protected bird areas and the sites of Community importance aimed at the protection of other rare and endangered animal and plant species and their habitats. There are 38 protected bird areas in Slovakia, covering a total area of about 1.2 million ha.

Sites of Community Importance

Protection of habitats and species is defined under the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, which is transposed in the legislation of the Slovak Republic through the Act 543/2002 on nature and landscape protection. The main objective of this Directive is to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora on the territory of a Member State.

The Slovak National List of the proposed Sites of Community Importance contains 382 sites with a total area of 559,163 ha. The list comprises, among others, the Pannonian biogeographical region and the Alpine biogeographical region, as well as other 381 areas on the Slovak territory.

6.5. Areas designated to protect economically significant aquatic species

This type of protected areas was not established under the Water Act in Slovakia. However, the areas for the protection of fish species defined as surface waters suitable for life and reproduction of native fish species were designated. The aim is to protect or improve the quality of running or standing fresh water.

In Slovakia there are 43 streams with a total length of 2856.4 km designated (thereof: 26 streams suitable for salmonids and 17 for carp species).

7. Inspection activities in the field of water protection and dealing with emergency water quality deterioration

In 2012, the activities of the department of water protection inspection and the sections of water protection inspection of the Slovak Environmental Inspection aimed mainly at the control and approval of the plans of prevention measures to prevent uncontrollable release of hazardous substances and priority hazardous substances into the environment and at the development of emergency plan in case of accidents.

Out of the total number of 1 098 inspections carried out in 2012, the violation of law was recorded in 218 cases (19.85%). It is a lower percentage as compared to 2011 (25.33 %). In the period from 2005 to 2012 the major pollutants include mainly oil products (about 65 times a year), caustic substances (twice a year), pesticides (once a year), agricultural fertilizers (12 times a year), wastewater (16 times a year), dispersive substances (3 times a year), other substances (6 times a year) and unidentified substances (12 times a year). The main causes of pollution are usually transport (30 times a year) and human factor (20 times a year)[4].

The Environmental Inspectorate recorded 117 cases of emergency water quality deterioration in surface and ground water bodies in 2012. It represents the average of deterioration compared to previous years.

In 2012, the Principal International Alert Centre - Slovakia (PIAC 04) was activated 2 times within the Accident Emergency Warning System (AEWS) in the Danube Basin [4].

8. Environmental objectives

Environmental objectives should aim at long-term sustainable water management based on a high level of protection of the aquatic environment by 2015 for the surface water and groundwater bodies as well as protected areas dependent on water.

Environmental objectives for surface water bodies

Environmental objectives for surface water bodies focus on the implementation of the following measures:

- a) prevent deterioration of the status of surface water bodies;
- b) protect, improve and restore surface water bodies in order to achieve good status of water;
- c) protect and improve artificial and heavily modified surface water bodies in order to achieve good ecological potential and good chemical status;
- d) progressively reduce pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous.

The general objective of the WFD is to achieve good status for all surface waters by 2015. Good status means both good ecological status and good chemical status. The following is important for achieving the objectives by 2015:

- transform normative definitions of the directive into the numerical limits of good status categories base on scientific knowledge;
- know the current status and an estimate of the efficiency of measures proposed by 2015;
- take into account the socio-economic consequences of achieving the objectives.

9. Conclusion

Surface water quantity and quality monitoring has a long tradition in Slovakia. The legal conditions supported also by the EU legislation exist in Slovakia at present. Surface water quantity and quality parameters show that the water status slowly improves, although several water resources still fail to achieve the quality required for drinking water in Slovakia. It is important to believe that environmental objectives established within the measures will have the effect on improving the quality of surface waters in Slovakia.

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