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Cross compliance of the Water Framework and Nitrate directives in Slovenia

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ABSTRACT

We describe the first characterisation of the Slovene waters and show cross compliance of the Nitrate and Water Framework Directives in Slovenia. Point and disperse sources of pollution are identified, hydrological and morphological pressures to surface water bodies evaluated and impact of all pressure to water bodies analysed. Agricultural activities in Slovenia are described and results of calculation of nitrogen and phosphorus balance in the catchment areas of the water bodies presented. The analyses show that hydro-morphological and chemical pressures from point pressures and diffused pollution from agriculture are the main reasons for the non-attainment of environmental objectives. Though consumption of mineral fertilisers and plant nutrients in Slovenia has reached more or less steady state in the last years, the quantities are still too high to reduce the risk to water environment. Therefore, the measures for reasonable fertiliser applications should be developed into more details as to give more directions for a farm level management. Miscellaneous instruments should also be developed to initiate overall sustainable use of fertilisers and plant nutrients in agriculture.

Key words: Water framework directive, nitrate directive, water environment, water pollution

IZVLEČEK

NAVZKRIŽNA SKLADNOST OKVIRNE VODNE IN NITRATNE DIREKTIVE V SLOVENIJI

Prispevek podaja opis značilnosti slovenskih voda in skladnost varstva voda, ki ga uvajata nitratna in vodna direktiva v Sloveniji. Identificirano je točkovno in disperzno onesnaževanje, ocenjene so hidrološke in morfološke obremenitve površinskih vodnih teles in analiziran vpliv vseh obremenitev na vodna telesa. Opisane so kmetijske dejavnosti v Sloveniji in podani rezultati računa dušikove in fosforjeve bilance za prispevne površine vodnih teles. Analiza je pokazala, da so hidro-morfološke in kemične obremenitve iz točkovnih in razpršenih virov onesnaževanja glavni razlog za nedoseganje okoljskih ciljev. Čeprav je raba mineralnih gnojil in rastlinskih hranil v zadnjih letih v Sloveniji dosegla več ali manj stabilno stanje, so količine še vedno prevelike za zmanjševanje tveganj za vodno okolje. Zato je treba natančneje opredeliti rabo gnojil na nivoju kmetijskih gospodarstev. Razviti moramo tudi druge instrumente, ki bodo vzpostavili trajnostno rabo gnojil in rastlinskih hranil v kmetijstvu.

Ključne besede: Okvirna vodna direktiva, Nitratna direktiva, vodno okolje, onesnaževanje voda

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1 INTRODUCTION

The Water Framework Directive (WFD) demands the impacts of anthropogenic activities on the status of water bodies of surface waters and groundwater to be assessed. As soon as data collection is accomplished and the relevant data are evaluated, it is to be stipulated whether the environmental objectives of the WFD will be achieved without any additional measures. These objectives are defined as »good chemical« and »good ecological« status for water bodies of surface waters and »good chemical« and »good quantitative« status for groundwater bodies. The process of the pressure and impact analyses, and water status assessment is termed, in short, as »first characterisation» of water bodies. The first characterisation of Slovene waters has been accomplished in 2005. This cognition of this research already serves as a basis for the elaboration of monitoring programmes, programmes of measures and catchment (water) management plans. In accordance to WFD programmes of measures have to be developed by 2009. In WFD programmes existing measures for water protection directed by other EU directives such are Nitrate, Urban Waste Water, Dangerous Substances and IPPC will be further developed and new added. The expected efficiency of all measures will be economically and environmentaly evaluated. In the paper, we describe the first characterisation of the Slovene waters and show cross compliance of the Nitrate and Water Framework Directives in Slovenia.

2 SURFACE WATER BODIES MANAGEMENT UNITS

In the territory of Slovenia we have two water districts: the Adriatic Sea water district and the Danube water district. The latter covers 81% of the national surface area, whereas a little les than a fifth of it belongs to the Adriatic Sea water district. These are also the actual water management districts. In the determination of surface water bodies, various factors are taken into consideration, such as transition of one category of water body to another (river, lake, transitional water, sea), changes in water type, or characteristic change in the environmental status of a water body.

On river network in Slovenia, 134 river water bodies have been defined in 2005, 109 (81.5%) of which fall within the Danube water district and the remaining 25 (18.5%) to the Adriatic Sea water district. There are 15 water bodies of lakes, three natural lakes (Bled, Bohinj and Cerknica) larger than 50 ha, one artificial lake and 11 reservoirs on certain watercourses that are classified as candidates of heavily modified water bodies. In the discharge areas of the Rižana and Dragonja rivers, the sections with the characteristics of brackish water are in both cases shorter than 5 km and therefore do not meet the additional criterion to be classified as transitional water bodies. Škocjanski zatok, classified as lentic brackish water of costal damming is defined as a heavily modified water body of the sea. There are also five other sea water bodies defined in Slovenia.

3 GROUND WATER BODIES MANAGEMENT UNITS

Groundwater water bodies were defined on the basis of a) boundaries of water bodies in view of the characteristics of aquifers and aquifer systems, b) an assessment of

various anthropogenic pressures, which could have an impact on groundwater water bodies (pressures from dispersed and point sources of pollution, pressures due to water abstraction for water supply, and pressures exerted on the water regime), c) description of general characteristics of the upper geological layers, via which a groundwater water body is being supplied, and d) checking of direct dependence of surface water bodies or land ecosystems on groundwater.

In the territory of Slovenia, 165 aquifer systems assembled in 21 water bodies of groundwater have been defined. In the Danube water district, 18 water bodies of groundwater (85%) have been established. Water bodies of groundwater differ a great deal in view of their size, considering that their surface areas range from 97 km² to 3,355 km². The average surface area of a water body of groundwater of the Danube water district is 965 km², whereas the surface areas of water bodies of groundwater of the Adriatic Sea are slightly larger.

4 IDENTIFICATION OF PRESSURES

The key element of the first characterisation process is, apart from definition of water bodies, identification of significant pressures of water bodies and assessment of their actual impacts. The WFD's major objective is the highest possible protection of waters from the input of dangerous matters and plant nutrients. Their quality is also influenced by other pressures, such as water abstraction, regulation of watercourses and morphological changes. These are usually condensed in a single indicator called "hydro-morphological pressures".

4.1 Point sources of pollution

In Slovenia, 611 direct industrial discharges into watercourses have been recorded, 91 of which (15% of all discharges) exceed the EPER threshold (the exceeding values are reported to the European Parliament Emission Register). A comparison between the two water districts show that direct industrial discharges in the Danube water district comprise 87% (532 outflows) of all industrial discharges into Slovene watercourses and no less than 99% (90) of all point pressures due to direct outflows of industrial wastewater into watercourses stipulated as significant. In Slovenia, there are also 53 cases of point sources of pollution from waste water treatment plants and 54 cases of pressures from agglomerations with unsuitable communal wastewater collection and treatment systems (48 of them located in the Danube water district (89%)). Also significant, as point source pressures are concerned, are industrial plants or appliances with thermal pressures exerted on the national watercourses. There are 12 such industrial plants or appliances in the Danube water district, while in the Adriatic Sea water district no such pressures have been recorded.

4.2 Hydrological and morphological pressures

In the territory of Slovenia, altogether 31 larger dams have been documented. Abstraction of water for various needs has been recorded on 86 water bodies. Much more water is abstracted for the needs of small-scale hydroelectric power stations (almost 296) and breeding of water organisms (with 110 recorded fish farms). In the

Adriatic Sea water district, water is abstracted for the preparation of drinking water, in the Danube water district for the irrigation of arable land, preparation of drinking water and for the needs of various technological processes. On the basis of expert judgement it has been estimated that in view of the documented water abstractions and storages, hydrological pressures that have an impact on the status of surface water are present on 76 water bodies. Small and less demanding water facilities and appliances, which individually do not exert significant pressures on the water regime, are not dealt with separately but within the framework of the arrangement of watercourses in seven classes in view of the state of the watercourses' morphological elements, which reflect the extent of hydro morphological pressures.

As morphological pressures exerted on lakes, anthropogenic pressures on the lakes' shores and particularly shores built up to more than 30% of their length were stipulated in the preparation of the first survey of morphological pressures. As far as natural lakes are concerned, only Lake Bled is defined as such, with 30 to 45% built up shore, and six lakes of anthropogenic origin with more than 45% built up shores.

4.3 Diffuse sources of pollution

Diffuse sources of pollution play an important part as point sources from the aspect of input of plant nutrients, pesticides and other forms of pollution on entire catchment areas. Within the framework of the first review of pressures exerted waters from diffuse pollution sources, a survey of pressures with nitrogen and phosphorus in agriculture was prepared. The survey is based on the overall analysis of the agricultural activities in Slovenia, on which evaluation of the nitrogen and phosphorus balance for fields, vineyards, grasslands; orchards and heterogeneous agriculture land have been calculated. The next step in a process of WFD implementation in Slovenia will be to model the fate of calculated surpluses of pollutants that is how much of nitrogen and phosphorus surpluses reach surface and ground waters.

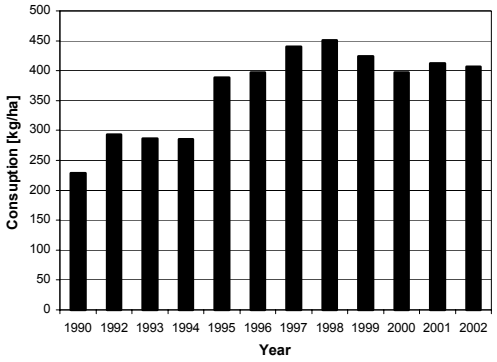

Figure 1: Consumption of mineral fertilisers in Slovenia (1990-2002) (SURS, 2004)

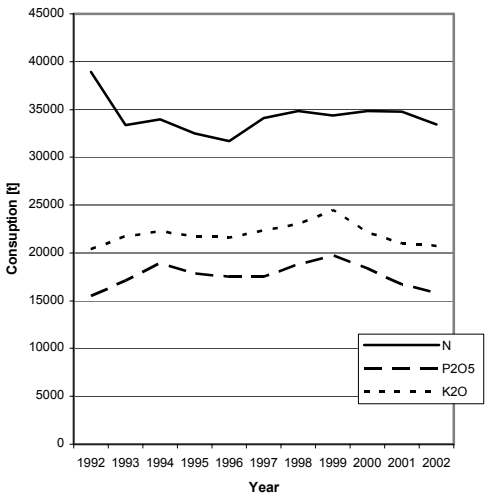

Figure 2: Consumption of plant nutrients in Slovenia (1990-2002) (SURS, 2004)

4.3.1 Agricultural activities in Slovenia

Approximately one third of Slovene surface area, which measures 20,250 km^2 belongs to the agricultural area, what covers app. 618,000 ha. Arable land (34.8 %) and extensive meadows (30.6 %) prevail among different use of agricultural land. Meadows together with pastures represent grassland and cover 50 % of agricultural land in Slovenia. Animal breading is the main farm production in Slovenia and cattle breading is prevailed with the share of 70 %. The animal density per hectare in Slovenia is only slightly above the average animal density in EU, what is 0.92 and 0.90 LSU/ha respectively. LSU is "livestock size unit" what corresponds 500 kg of weight of an animal. Animal density over 1.5 LSU per ha of agricultural land could be observed in the central north and in some areas toward to the east part of Slovenia. The lowest animal density is on the east, west and south part of Slovenia. National statistical data show that fertiliser and nitrogen consumption has slightly decreased since the year 1998 (Figure 1). Decrease of nitrogen consumption is somehow smaller that decrease of phosphate and potassium consumption (Figure 2).

4.3.2 Calculation of nitrogen and phosphorus balance

Nitrogen balance for field, vineyard, grassland, orchard and heterogeneous agriculture land has been calculated based input and output parameters. Input parameters: a) consumption of N mineral fertilizers in kg/ha/a and b) livestock manure from number of pigs, chicken and cattle (kg/ha/a) on field and grassland) have been taken from statistical data from 2000. Other input parameters, c) nitrogen from precipitation (kg/ha/a), d) humus mineralization (kg/ha/a) and c) biological fixation from *Fabaceae* for grassland (kg/ha/a) have been predefined. Outputs calculated are nitrogen crop uptake (kg/ha/a) and denitrification (kg/ha/a). Land use data have been gethered from Corine land Cover 2000 (CLC, 2000).

Nitrogen balance for each agriculture land use has been calculated as a difference between inputs and outputs (kg/ha/a). The balance has been calculated as a weighted average for second level hydro-geographical areas in Slovenia. The highest surplus (more that 120 kg N/ha per year) appears toward the east of Slovenia, meanwhile the lowest surplus of nitrogen (less than 80 kg N/ha per year) appears toward the west part of Slovenia (Figure 3).

Phosphorus balance for field, vineyard, grassland, orchard and heterogeneous agriculture land use has been calculated based on the inputs and output parameters. The input parameters are: a) consumption of P_2O_5 mineral fertilizers (kg/ha/a) (from statistical data for the year 2000), b) livestock manure from number of pigs, chicken and cattle (kg/ha/a) on field and grassland (from statistical data for the year 2000) and c) phosphorus from precipitation (predefined values). The output parameter is phosphorus crop uptake (kg/ha/a). The procedure for phosphorus balance calculation has been the same as for the nitrogen. The Figure 4 shows the weighted average of phosphorus balance (kg of P/ha/a) for contributory area of each surface water body.

The pattern of surpluses is almost the same for both pollutants. The highest surplus (more that 10 kg of phosphorus/ha per year) appears more toward the east of Slovenia, meanwhile the lowest surplus appears toward the west part of Slovenia

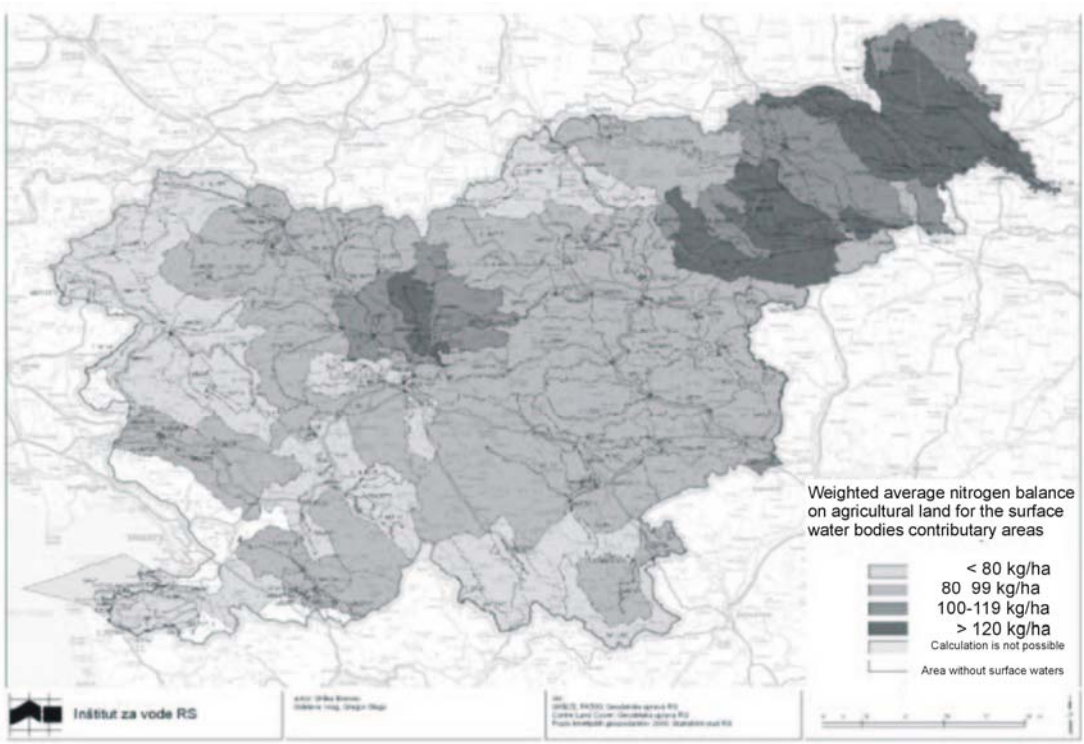

Figure 3: Weighted average nitrogen balance (kg of N/ha/a) for the surface water bodies contributary areas.

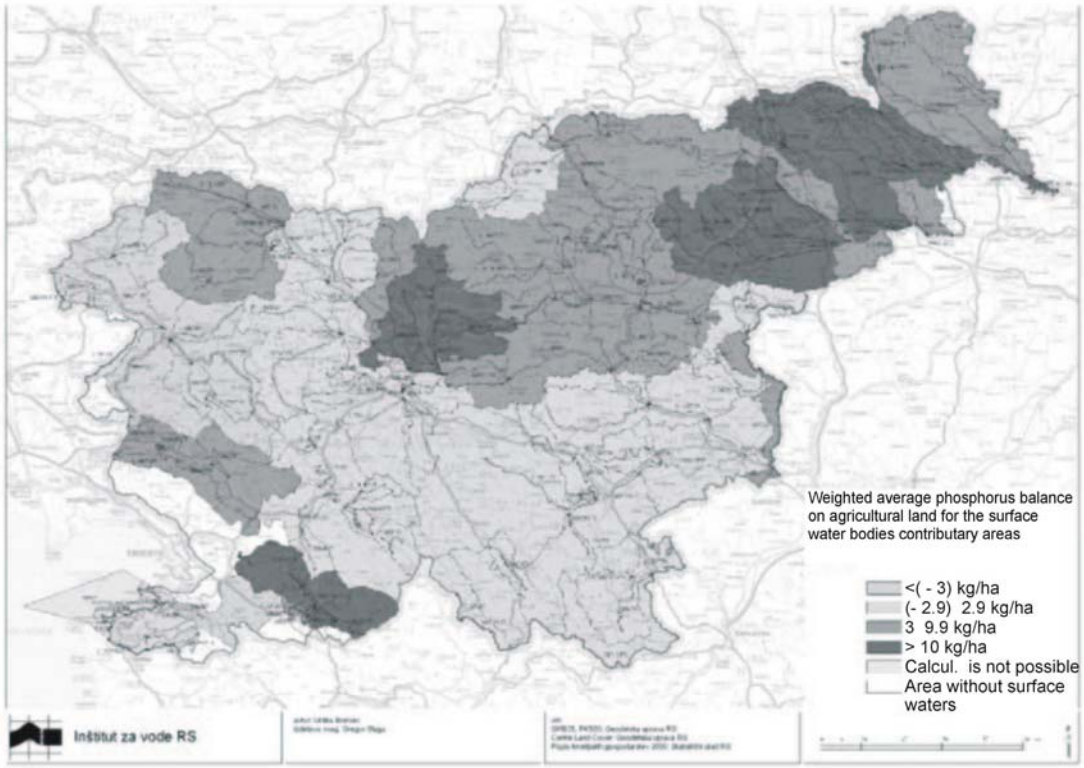

Figure 4: Weighted average phosphorus balance (kg of P/ha/a) for the surface water bodies contributary areas.

5 ASSESSMENT OF THE PRESSURES IMPACT ON THE WATER BODIES STATUS

The status of waters in Slovenia is assessed in view of the environmental objectives stipulated by the Water Framework Directive. These objectives are defined as "good chemical" and "good ecological" status for the water bodies of surface waters and "good chemical" and "good quantitative" status for the water bodies of groundwater. I order to establish whether separate water bodies are going to reach the environmental objectives, a scale of four descriptive marks in view of the probability of achieving these objectives has been made:
- environmental objectives will be achieved (1),
- environmental objectives may be achieved (2),
- environmental objectives may not be achieved (3),
- environmental objectives will not be achieved (4).

The first and fourth marks are used when suitable and reliable data on the status of water bodies are at hand or when it can be claimed with certainty that there is a very small or very big impact of pressures on a water body. In the opposite cases, the second and third descriptive marks are used.

5.1 Surface water

The assessment whether separate surface water bodies will attain certain environmental objectives as stipulated for them is initially made separately in view of hydrological, morphological, chemical and biological elements as well as with regard to pressures exerted in direct contributory areas of separate water bodies. Final assessment for the bodies where measurements do exist is the worst among status assessments. Owing to the lack of suitable monitoring network for more than half of water bodies, there are no actual data on their chemical and biological status. This is the reason why assessment of environmental objectives for such water bodies is given only on the basis of hydro-morphological elements and significant pressures (point and diffused chemical, hydrological) in direct water body's contributory area. The results are shown in the Figure 5.

A fourth of water bodies of Slovene watercourses (34) will not attain their environmental objectives, whereas for only a good eighth of them (18) it is estimated that good status will be attained. For more than half of the water bodies of watercourses it has been estimated that they will (probably) not reach the Directive's environmental objectives. A comparison between the Adriatic and Danube water districts indicates that in the Adriatic water district a little less than half of the water bodies of watercourses will attain the environmental objectives, while in the Danube water course only a little less than a tenth will succeed in doing so and that more than a fourth of all water bodies of watercourses in the Danube water district will are not going to achieve the stipulated environmental goals.

The conditions are clearly most critical in the **north-eastern part of Slovenia**, where water bodies that will (probably) not attain the environmental objectives prevail, while in the western and southern parts of the country the environmental status is estimated, with few exceptions, as a great deal more favourable.

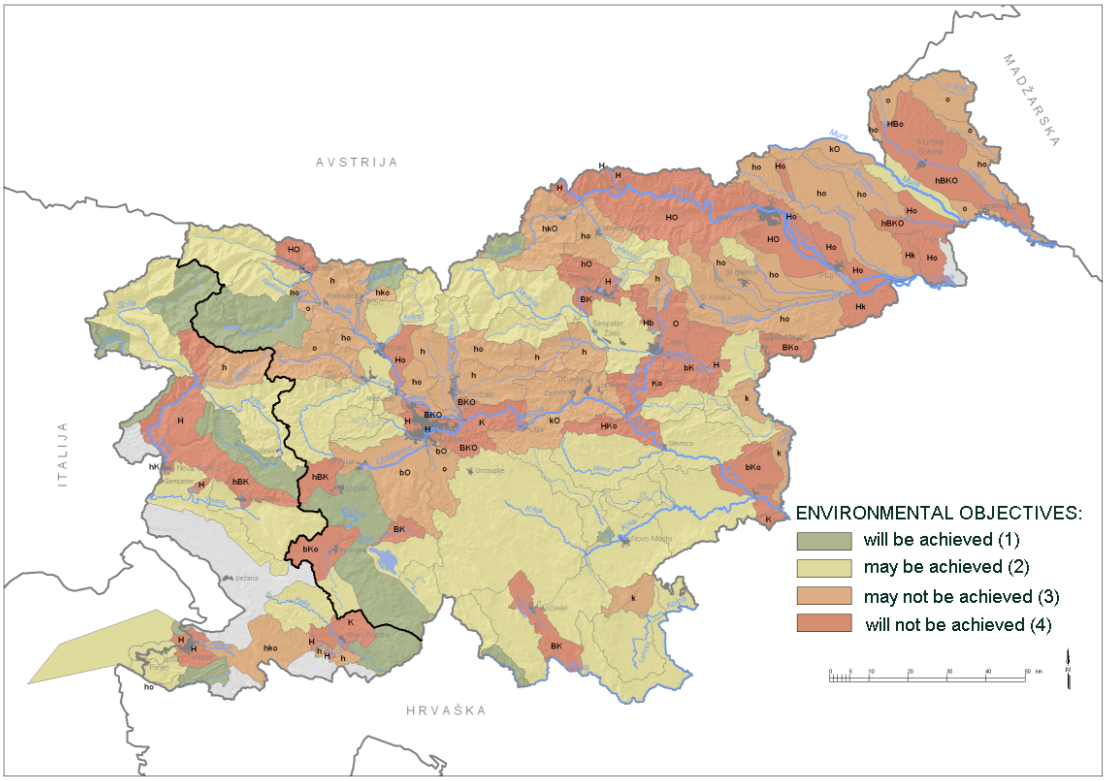

Figure 5: The probability of achieving environmental objectives, shown for direct contributory areas of the surface water bodies. Red and orange indicate that environmental objectives will not or may not be achieved.

5.2 Groundwater bodies

In all water bodies of the Slovene groundwater, a balance between the abstracted and disposable quantities of groundwater has been restored, which means that the impacts of major pressures on their quantitative status are under control. This is the reason why all water bodies of the Slovene groundwater are assessed as being able to attain the objectives stipulated by the Water Framework Directive. Somewhat more worrying is the assessment as to the chemical status of our groundwater, considering that the data at hand indicate excessive pollution of three groundwater water bodies (**the "Drava", "Savinja" and "Mura" basins**). Groundwater pollution is primarily the result of pressures originating from dispersed sources (agriculture and urbanisation), which is particularly explicit in the very northeastern part of Slovenia (the "Pannonian basin"). The most critical pollutants, which quite characteristically contribute to the pollution, are desetilatrasin, nitrates and atrasin. While the trends of atrasin and desetilatrasin contents are mostly falling and clearly showing the effects of their banning, the trends of nitrate contents are more worrying considering that in places they are still rising.

6 NITRATE DIRECTIVE

According to the Nitrate directive (Directive of European council 91/676/EEC) the whole territory of Slovenia has been designated as a vulnerable zone with the amendment of the Regulation on In the programme are included three groups of

measures applied to the whole territory: Input of the Dangerous Substances and Plant Nutrients into the Soil (Official Journal RS 35/2001). The Nitrate directive has been transposed into the national regulative.

The action programme for protection of waters against nitrate pollution from agricultural sources for the period 2004–2008 has been prepared based on the Environment Protection Law (Official Journal RS 32/93; 1/96) and National programme of the environment protection.

- Measures for fertilizer application according to the principles of good agricultural practices and for taking account of limit values for annual applications.
- Measures to ensure appropriate storage capacities for livestock manure.
- Measures for adopting livestock operations to environmental standards (There are 25 bigger livestock operation in Slovenia that cause substantial environmental problems).

Measures for reasonable fertilizer application are as follows:

- Threshold value for annual input of nitrogen in livestock manure is 170 kg/ha per year.
- Periods of prohibited liquid manure application: from 15th of Nov. till 15th of Feb.
- Restricted use of manure on steep slopes, water-saturated ground, and on frozen or snow-covered ground, on aquatic and coastal land and in flood zones. Some special measures are prescribed in water protection zones
- Prohibition of use of any kind of manure or fertiliser on water areas, which are represented by strips along watercourses in a width of 15 m at rivers of the 1st order and of 5 m of the other
- Plans for fertilisation on a farm level taking into account the status of fertiliser in a soil profile.
- Storage capacities for livestock manure should be adequate for the period of storage, when application of manure is not permitted and additionally for periods when the weather conditions do not permit fertilizer application

7 CONCLUSIONS

The first pressure and impact analyses and water status assessment of Slovenian water show that hydro-morphological and chemical pressures (point pressures exerted on water bodies by industry) are the main reasons for the non-attainment of environmental objectives, quite often in connection with diffuse pollution from agriculture and various urban agglomerations. This is particularly characteristic of **the north-eastern part of Slovenia,** the entire course of **the Drava river** and **the Sava river's** water bodies in its middle and lower parts**.**

Not favourable environmental status of the water in the **north-eastern part of Slovenia** corresponds with results of nitrogen and phosphorus balance in Slovenia. It has been calculated that the highest nitrogen surplus (more that 120 kg N/ha per year) and the highest phosphorus surplus (more that 10 kg of phosphorus/ha per year) appears toward the east of Slovenia.

For **the Drava river** it has been estimated that its water bodies will not attain the stipulated environmental objectives. The major reason for such state of affairs is to be looked for in the river's regulations, since all Drava's water bodies are defined as heavily modified water bodies. An additional difficulty lies in the great pressures from various point sources (waste water treatment plants and agglomerations, industrial plants) and dispersed sources from agriculture (nitrogen).

It is also estimated that good status will likewise not be attained by the greater part of **the Sava river's** water bodies in its middle and lower parts. This, however, is to be contributed primarily to the agricultural pressures exerted on the water bodies, and only partially to the hydrological and morphological elements.

Though consumption of mineral fertilisers and plant nutrients in Slovenia have decreased from 1990 on and reached more or less steady state in the last years, an assessment of water environment status showed, that the amount of the fertilisers are still too high to reduce the risk to water environment. The measures for reasonable fertiliser applications being implemented in Slovenia on the basis of Nitrate Directive are quite strict, but still too general to be efficiently introduced into practice. On the other hand there is hardly any efficient control mechanisms developed. Therefore, the measures for reasonable fertiliser applications should be developed into more details as to give more directions for a farm level management. Miscellaneous instruments should also be developed to initiate overall sustainable use of fertilisers and plant nutrients in agriculture to reduce risk to water environment such are financial incentives, awareness and knowledge rising actions, educations etc.

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