Primljen / Received: 5.4.2017.
Ispravljen / Corrected: 14.7.2017.
Prihvaćen / Accepted: 22.8.2017.
Dostupno online / Available online: 10.9.2017.

Combined approach to surface water management

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Subject review

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Combined approach to surface water management

The combined approach of WFD, unified EQS and ELVs, is a key element of integral water management. The application of the Combined Approach Methodology in Croatia, the Guidelines for Mixing Zones and the Implementation of EU Forecasting Models will contribute to a combined approach with operational and investigative monitoring. The aim of the paper is to analyze and improve the practical implementation of a combined approach with examples in the Sava River Basin, with the aim of selecting an optimal recipient, achieving good water status and achieving the environmental objectives of the river basin.

Key words:
WFD, DPSIR approach, combined approach, point sources of pollution, surface waters, effluent, mixing zone, water quality models

Pregledni rad

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Upravljanje površinskim vodama primjenom kombiniranog pristupa

Kombinirani pristup ODV-a, objedinjeni EQS-a i ELVs-a, ključni je element je integralnog upravljanja vodama. Primjena Metodologije primjene kombiniranog pristupa u u Hrvatskoj, smjernica zona miješanja i primjena prognostičkih modela EU-a doprinijet će primjeni kombiniranog pristupa uz operativni i istraživački monitoring. Cilj rada je kritička analiza i unaprjeđenje praktične provedbe kombiniranog pristupa primjerima u slivu rijeke Save, sa svrhom odabira optimalnog prijamnika, postizanja dobrog stanja voda i postizanja okolišnih ciljeva riječnog sliva.

Ključne riječi:
ODV, DPSIR pristup, kombinirani pristup, točkasti izvori onečišćenja, površinske vode, efluent, zona miješanja, modeli kakvoće voda

Übersichtsarbeit

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Bewirtschaftung von Oberflächengewässern anhand des kombinierten Ansatzes

Der kombinierte Ansatz der Europäischen Wasserrahmenrichtlinie stellt die grundlegende Komponente der integralen Bewirtschaftung von Gewässern dar; da sich aber seine Anwendung in der Praxis nicht durchgesetzt hat, wurde in Kroatien das Handbuch Methodologie des kombinierten Ansatzes veröffentlicht. Die Richtlinien für die Durchmischungsbereiche und die prognostischen EU-Modelle tragen zur Anwendung des kombinierten Ansatzes bei einem gleichzeitigen Monitoring der Anwendung und der Forschungsmaßnahmen bei. Das Problem der praktischen Anwendung wurde am Beispiel der aufnehmenden Gewässer der Abwasserkläranlage im Einzugsgebiet des Sava Flusses dargestellt. Das Ziel der Arbeit besteht in einer kritischen Analyse und einem Beitrag zur praktischen Anwendung des kombinierten Ansatzes.

Schlüsselwörter:
Wasserrahmenrichtlinie, DPSIR Ansatz, kombinierter Ansatz, Verunreinigung aus Punktquellen, Oberflächengewässer, Abwasser, Durchmischungsgebiet, Wasserqualitätsmodelle

1. Introduction

The Water Framework Directive EU 2000/60/EC, referred to in this paper as the WFD [1], was adopted by the European Union as a significant and ambitious legislative project focusing on the European water policy in the scope of environmental protection activities. This document offers a real once-in-a-generation opportunity for advancement and improvement of European waters, and it has also become a basis for establishment of legislative acts in the field of environmental protection.

However, fifteen years after adoption of the WFD document it can be stated that a considerable number of problems have been encountered in its implementation. Thus, according to official EU information [2] only 53 % of surface water bodies have obtained a good water quality status, and it is quite uncertain when the objective set in this document, i.e. achievement of good status for all surface waters, will in fact be realized. Even when putting aside the discouraging technical and organisational problems encountered during its implementation, it can still be stated that great expectations that came with the WFD have not been fully met. An absence of integrated systems on which the WFD was founded has been noted, and one of the main problems lies in implementation of combined approach [3]. The WFD requested a move forward from traditional "end-of-pipe" solutions that have proven to be quite insufficient for realization of ambitions goals aiming toward sustainable management of river basins. Such approach requires deep understanding of each river basin and management that ensures harmony between humans and nature, aimed at an overall improvement of the system, with proper preservation of water and water-dependent ecosystems. Therefore, the WFD has adopted the European Environment Agency's approach **Drivers – Pressures – State – Impact – Response**, which is referred to below as the DPSIR approach. The influences on water bodies and water condition are assessed in the scope of the Programme of Measures (PoMs), and in order to reduce impact of significant pressures. Anthropogenic pressures are thus managed for the purpose of improving ecosystem health [3]. The WFD requires from the member states an integrated and properly-defined river basin management, with an emphasis on requirements that should be "tailored made" for each river basin. Numerous financial possibilities involving use of European funds, such as those enabling reduction of point sources of pollution through construction of municipal infrastructure, have been opened for Croatia through incorporation of the WFD and the European water policy into Croatian water and environmental legislation, and especially through accession to the EU. At the same time, standards and obligations have increased as to fulfilment of environmental objectives involving preservation of river basins and achievement of goods status of waters, which calls for significant financial investments, good organisation, and systematic work. The use of combined approach constitutes a special challenge with regard to monitoring and controlling wastewater discharge through point sources of pollution, the aim being to achieve good status of water in water bodies into which wastewater is discharged.

An overview of European and Croatian legislations related to the use of combined approach will be presented in this paper. Methodology of the Combined Approach Application (referred to below as the Methodology), which has been applied in Croatia since 2015, will also be presented [17]. Approaches to solving this problem will be illustrated through examples of infrastructural projects in the Sava River basin. In addition to defining the area of the project, designing the sewerage system, selecting the wastewater treatment level and technology (as related to the size of the urban area and the receiving water body), there is also a special challenge of achieving a good water status in the water body into which waste water is to be discharged. The use of the Methodology as related to discharge from point sources of pollution into surface waters will be analysed, and necessary preconditions for its implementation will be presented. A systematic use of combined approach to an integral water management in Croatia started after publication of this Methodology and it has resulted in significant positive advances, despite the fact that the methodology has been simplified in accordance with the combined approach requirements. Based on analysis of the combined approach and Methodology requirements, appropriate recommendations will be given for improving implementation of the combined approach.

2. Water legislation as related to the use of combined approach

2.1. European water legislation

Various changes in environmental protection policies, and in an integrated management of waters, are a consequence of creation of the European Union, but also of economic advancement and high standards that have been achieved with regard to the environmental protection policy. The European water policy has gone through a thorough process of restructuring and the WFD, adopted in 2000, has become a sort of an operational tool for achieving future water protection objectives. Previous European activities aimed at creating regulations on water were initiated by adopting standards for abstraction of surface water for drinking as adopted in 1975, while regulatory activities culminated in 1980 when binding objectives for the quality of drinking water were set. This included legislation related to the quality of water for fish and shellfish, for bathing, and for the preservation of ground water. The main emission control activities were undertaken in accordance with the Dangerous Substances Directive. The second stage of water legislation development was initiated in 1991 by adoption of the Urban Waste Water Treatment Directive, which assumed the use of the secondary wastewater treatment, including even stricter levels if necessary, and by adoption of the Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources. Other legislative documents are the Drinking Water Directive from 1998, and the Integrated Pollution Prevention and Control Directive (referred to below as the IPPC) from 1996 for pollution generated by large industrial plants.

2.1.1. Identification of drivers and pressures, status assessment, and response

A thorough review of the EU water policies was initiated in 1995 with the request for an integrated approach to water management. The EU Water Framework Directive (WFD) has set an ambitious goal of achieving a good water status for rivers, lakes and coastal areas, and for transition and ground waters, for the period until 2015. As a legal framework for preserving European waters and for assuring their long-term sustainability, the WFD is based on the following key objectives: wider scope of protection of all waters, achievement of good status for all waters in river basins, combined approach to setting limit emission values and water quality standards, establishment of water pricing, greater participation of general public, and simplification of legislation [4]. In accordance with the precautionary principle and the principle of reducing pollution at the place where it is generated, the DPSIR approach is applied for water management, and **drivers** and significant **pressures** are defined, while the water **status** is estimated based on the existing monitoring activities. The quality of this estimation is directly dependent on water impact assessments that are made using prognostic models, and on estimations of risk that the good status might not be achieved. The results of the analyses as well as prognostic modelling results are used for planning measures aimed at reducing environmental **impacts**. The efficiency of these measures is checked by monitoring water bodies and by estimating achievement of environmental objectives as related to river basins [5]. Water management plans based on the DPSIR approach are used for setting the program of basic and additional measures that are the foundation for achieving a good water status. The wide extent and demanding nature of this work is described in great detail by Voulvoulis et al. [3]. In fact, river systems differ as to socio-political aspects and natural conditions, which generates a variety of problems in the definition of **pressures** and water **status**, and in planning the **response** considering the relation between the society and the measures. The implementation of measures is often oriented toward realization of basic measures only, without contribution of the WFD objectives, as can be seen in Figure 1.

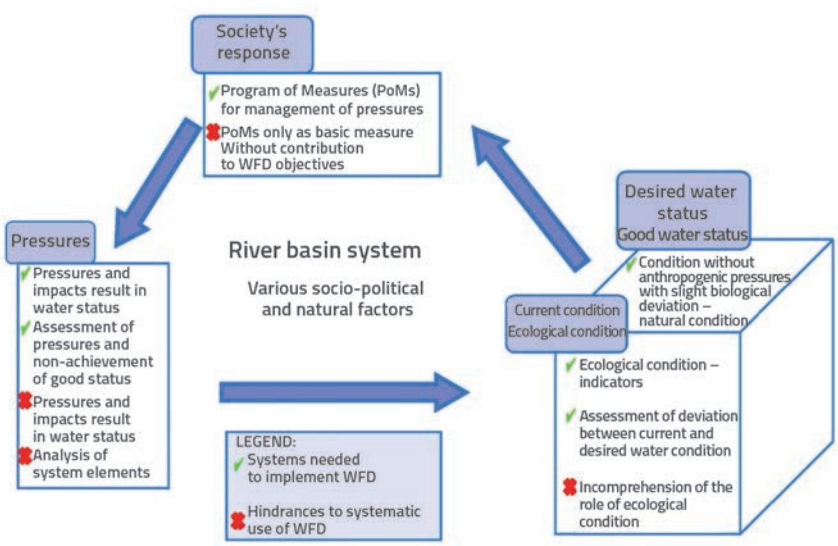

Figure 1. Problems in using DPSIR approach in WFD implementation [3]

The analysis of the **pressure – impact** relationship and establishment of the **surveillance** monitoring, is critical steps in the process of planning [5, 6], a thorough and comprehensive understanding of the river basins and, in addition to achieving individual objectives, these activities must also be oriented toward reaching general goals of the WFD. This is especially significant for the water bodies where there is a risk that a good water status might not be achieved, which is checked through operative monitoring for the selected quality elements typical for the most significant pressures affecting water bodies [6]. The WFD defines a good ecological status of the system without any anthropogenic pressures or with slight biological deviations from what could be expected according to undisturbed / reference conditions („no, or only very minor anthropogenic alterations") [7]. Consequently, the WFD uses the concept of reference conditions for describing biological elements for a very good status of water [8] in order to check deviations of biological communities from the desired good status. The request for defining specific reference conditions according to typology [9] is yet another innovation brought by the WFD. The process of estimating ecological status is based on several elements that point to the deviation of the system from its state under undisturbed / reference conditions, but this does not provide an absolute value of ecosystem quality [6]. Three groups of "quality elements" are indicated in Annex V of the WFD. These groups are: biological, and two supporting ones – hydromorphological and physicochemical. They are used for classification of ecological status of water. The WFD established an innovative approach to water management based on river basins, while also setting ambitious environmental objectives for river basins within water ecosystems.

2.1.2. Directives related to combined approach

The WFD controls realisation of environmental goals from previous legislative solutions, while also offering achievement of good status for all waters through realization of a combined approach involving emission control and attainment of an appropriatewater quality standard. For all EU member countries these new rules constitute a significant shift from the former water quality management practices. In fact, water pollution had until then been controlled using one of the two control mechanisms but, in most cases, not by the combined use of these procedures. The combined approach advocated by the WFD makes use of the advantages of both water quality control mechanisms, for the receiving water body standard and the effluent standard, while mostly avoiding their deficiencies. The principle of combined approach implies reduction of pollution of water from point sources and non-point sources of pollution, with gradual elimination of especially harmful matters, the objective being to achieve a good water status. A crucial part of implementation of the combined approach is the harmonisation with the Environmental Quality Standard (EQS) and the Emission Limit Values Standard (ELVS). Member states must ensure that all discharges into surface waters are controlled according to the combined approach that is presented in greater detail in Article 10 of the WFD, which is related to several other directives listed in Annex VI, Part A of the WFD. Significant EU directives, related to the WFD combined approach, are: the Bathing Water Directive (76/160/EEC – replaced with 2006/7/EC), the Drinking Water Directive (80/778/EEZ, as amended by 2006/7/EC), the Urban Wastewater Treatment Directive (91/271/EEZ), the Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources - the Nitrate Directive (91/676/EEC), the Industrial Emissions Directive (2010/75/EU, this is the modified IPPC directive 6/61/EZ, codified as 2008/1/EC), and the Sewage Sludge Directive (86/278/EEZ, 91/692/EEZ). The WFD supports implementation of these directives as a minimum requirement. Measures for their implementation include control of point and non-point sources of pollution in the scope of river basin management activities (Article 11.3 (a)). Joint implementation of all of the above mentioned directives is considered to be of crucial significance. This especially concerns the Urban Wastewater Treatment Directive and the Nitrate Directive in order to reduce eutrophication problems, and to solve health problems relating to microbiological pollution of bathing water and nitrate content in drinking water. The requirement for achieving good chemical condition of water is given through the WFD provision on inclusion of priority substances, depending on the hazard these substances constitute for the health of humans and environment [10]. Member countries are required to contribute to the achievement of the WFD goals through implementation of the best possible techniques or by applying water quality standards, as shown in Figure 2 [10, 11].

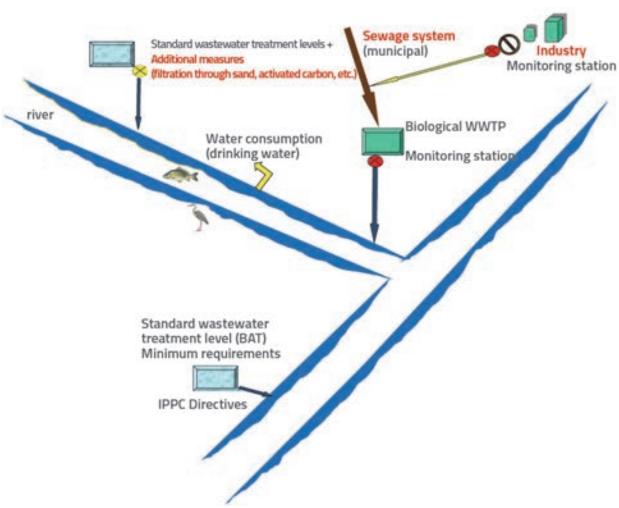

Figure 2. Implementation of the system for integrated pollution prevention and control and use of the combined WFD approach [10, 11]

Table 1. Joint measures taken for use of EU directives related to water protection [2]

Measures \ Directives	Bathing water directive	Drinking water directive	Nitrate directive	Urban wastewater treatment directive	Water framework directive
Water quality standard	■	■			■
Identification of water bodies at risk of not achieving good condition	■		■	■	■
Classification of water bodies	■				■
Water management plan	■		■		■
Emission limit values				■	
Public information	■	■			■
Participation of general public	■				■
Monitoring	■	■	■	■	■

To achieve a significant level of control, competent authorities have to have appropriate legal powers and funding so that they can: identify and monitor all kinds of wastewater and other influences on water bodies, regulate an array of activities having a real or potential influence on water based on river basin management plans, analyse and modify effluent discharge permits and take preventive actions to combat pollution (e.g. by implementing adequate measures in water protection zones or by controlling actual activities that could have a negative impact on water condition). In addition to all these activities, some joint measures aimed at water preservation need to be taken in the application of EU directives, as shown in Table 1.

2.1.3. Use of combined approach and mixing zones

In order to preserve European water resources, EU published in November 2012 a Blueprint to Safeguard Europe's Water Resources. As an addition to the WFD, the 2008/105/EZ Directive sets out environmental quality standards for 33 priority substances (Annex X of the WFD) and for eight other pollutants that have already been regulated at the EU level through Directive 76/464/EEC. The document was prepared to enable uniform implementation of the WFD by all experts that are directly or indirectly concerned by its issue. Thus a framework for sustainable water management was established and this through preparation of water area management plans and programs of measures (PoMs) forming part of such plans. These documents were prepared so as to prevent deterioration of water environment and to achieve a good condition of all water bodies by 2015. According to the WFD, the PoMs consist of basic and supplementary measures.

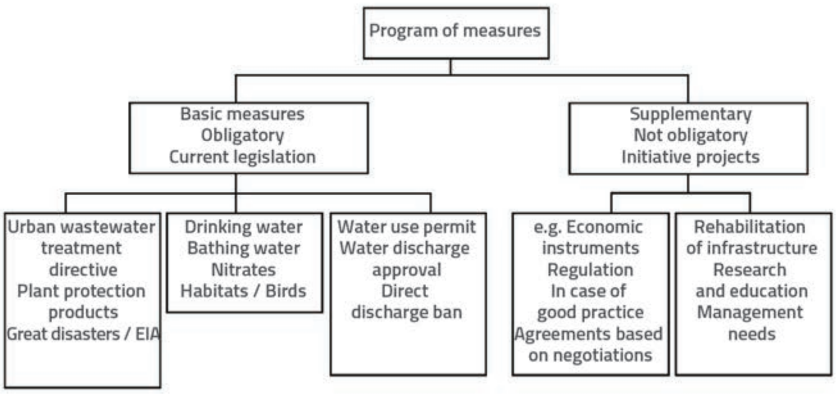

Figure 3. Structure of a programme of measures [11]

analysis of pressures and impacts in fifteen member countries are presented in the fourth report on implementation of the WFD as a significant problem in the use of this combined approach. Relationships between pressures and PoMs were not clear in 21 out of 27 member countries, and so in 23 out of 27 member countries, the analysis of the gap between the existing and desired water status is conducted, with regard to achievement of environmental objectives for river basins, using a traditional approach only, i.e. by applying cost efficient basic measures [13]. Member countries often decide by themselves how much the existing measures will contribute to achievement of environmental protection objectives as set out in the WFD [13, 14], which explains extensive use of exceptions, albeit without sufficient justification, as shown in Figure 4.

Basic measures are minimum requirements that will be included in PoMs (treatment of wastewater in accordance with best available techniques, obtaining water-rights permits and environmental permits, etc.). They consist of measures related to application of other EU regulations for water protection (Article 11 [10] and Annex VI of the WFD), as well as of measures for harmonisation with objectives set in the Nitrate Directive, Urban Wastewater Treatment Directive, and other directives related to abatement of pollution and preservation of water environment. Supplementary measures are needed it these cases (Article 11 [11]). The WFD does not specify the type of supplementary measures (as an addition to basic measures), and so member countries can select measures as relevant to specific situations. Supplementary measures are specified in an appropriate annex as an incomplete list of potential initiatives aimed at improving the status of waters. The structure of a programme of measures is presented in Figure 3.

According to the corresponding WFD amendment, the concept of mixing zones is introduced in Article 4 of Directive 2008/105. These mixing zones are areas adjoining discharge points where concentration of one or more substances may exceed environmental quality standards if they are not detrimental to the good status of water in the remainder of the water body. It should be noted that member countries are not required to define mixing zones, although technical guidelines have been put in place for identification of such mixing zones. Technical guidelines will be applied in the second cycle of the river basin management plan, and then the principle of caution will become the governing rule. Mixing zones are defined by competent authorities for a part of a surface water body situated next to a discharge point where concentration (of one or more polluting substances) may exceed the EQS, provided that the rest of the water body is compliant with the EQS. When the guidelines and mixing zones are applied, it is necessary to estimate the size of such mixing zones based on quality standards relating to an annual average (AA) and / or maximum allowable concentration (MAC) [12].

In case a member country has defined mixing zones, as well as the approach and methodology to be applied for defining such mixing, and measures to be taken to reduce the extent of such zones in the future, such member country must be included in river basin management plans. Problems encountered during

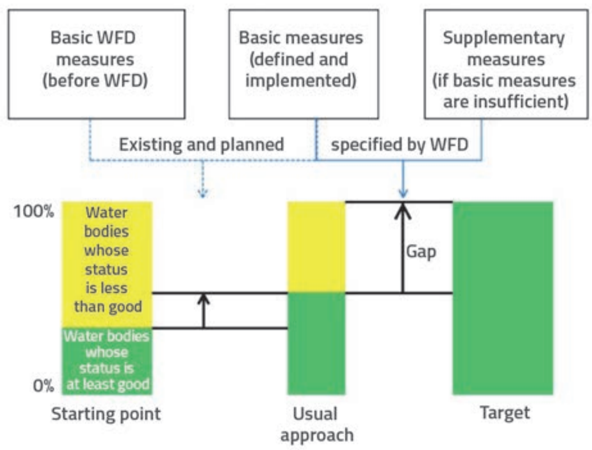

Figure 4. Simplified view of the procedure for determning and overcoming the gap between the usual approach and objectives of achieving good water status for 2015 [13]

Problems with implementation of the WFD come to light when member countries continue with their traditional water management practices, with an emphasis on regulating specific pollutants. In this way, they partly neglect the complexity of interactions taking place within river basins. According to the European Commission's estimate, many countries have planned their measures based on the principle of dealing with the "existing or planned" or "realisable" situations, not placing a sufficient emphasis on pressures and existing condition of those water bodies for which it has been established through management plans that they prevent achievement of a good water status [13, 15]. In 2014, the Commission requested submittal of implementation programs, and it is expected that they will closely monitor fulfilment of such programs. Relating to the analysis of the mentioned gap, recommendations were given as to what needs to be done: determine the most effective combination of measures needed to overcome current situation and reach good water status, re-examine and harmonize existing water-rights permits in line with the WFD objectives, strengthen basic measures for solving non-point sources of agriculture-based pollution and make basic measures mandatory, consider in more detail the relationship between the quantity and quality when estimating pressures on water ecosystems, and establish measures for water intake and flow regulation. Although a third of all water bodies in the EU have been hydromorphologically modified, current programs of measures do not contain any measures to tackle this issue. Ecologically acceptable flows should be applied in case basic measures prove insufficient [15]. Following analyses of the water bodies that fail to achieve a good water status, planned basic and supplementary measures should be fulfilled, and the efficiency and economic justification must be confirmed through enhanced operative monitoring of waters so as to bridge the gap. All this, in combination with the control of implementation of the European water policy, also represents a control mechanism for using European funds from the Cohesion Fund in the realisation of infrastructure projects which are, at the same, the key basic measure of the WFD.

2.2. Croatian water legislation

The accession of Croatia to the European Union was conditioned acceptance of all rights and obligations on which this unique union of European states is based, i.e. upon acceptance of the EU acquis. In this respect, during pre-accession negotiations, the Republic of Croatia requested a transition period for the implementation of municipal water directives (Directive on the quality of water intended for human consumption (98/83/EZ) and the Urban Wastewater Treatment Directive (91/271/EEZ)). The plan for implementation of the municipal water directives has served as the basic planning and investment document in the sphere of water management. This plan sets out the framework program for investment in public water supply and public drainage for the period from 2010 to 2023, until adoption of the multi-year programme for construction of municipal water facilities 2016-2021 (Official Gazette 66/16).

General objectives for water protection in Croatia have been adopted from the WFD. Basic measures are conducted in the scope of their implementation (treatment of wastewater according to best available techniques, etc.) as minimum requirements to be met so as to fulfil requirements from the EU directives relating to pollution abatement. When basic measures are not sufficient, supplementary measures are specified and implemented. According to Croatian water legislation, all polluters of a water body have to implement basic measures set out in the EU regulations: Urban Wastewater Treatment Directive, Integrated Pollution Prevention and Control Directive (IPPC Directive), Industrial Emission Directive (IED), Nitrate Directive (ND), and Regulations on placing on the market of plant protection products. As basic measures were not implemented by most polluters, these measures were defined in the River Basin Management Plan 2013 – 2015 (Official Gazette 82/13) and they have to be implemented until the agreed transition periods, as a first step in the achievement of a good status of waters [16]. Supplementary measures were not considered in the planning cycle defined in the River Basin Management Plan 2013 – 2015, i.e. this issue was postponed for the next plan periods. When defining supplementary measures, it is important to note that the polluter who has implemented or intends to implement basic measures must not be placed in the position that is less favourable compared to other polluters who have not implemented basic measures as needed to maintain a water body in a good condition [16].

2.3. Application of combined approach in Croatia

The combined approach principle is defined in Article 58 of the Water Law (Official Gazette, issues 153/09, 63/11, 130/11, 56/13 and 14/14). The Methodology was defined based on the *Byelaw on wastewater emission limit values* (Official Gazette, issues 80/13 and 43/14) and Article 2, Paragraph 3, of the *Byelaw on wastewater emission limit values* (Official Gazette 27/15) [17], taking also into account the *Ordinance on water quality standard* (Official Gazette, issues 89/10, 73/13, and 151/14), *River basin management plan* (Official Gazette 82/13), *Plan for implementation of urban water directives* (2010), and the framework set out in the WFD. The need to adopt a combined approach has been present in Croatia for the last two decades, and was felt even before the WFD was adopted, i.e. at the time when water-rights permits were introduced for legal entities – polluters. In this respect, Malus and Telišman [18] explain the combined approach concept and analyse relevant European and American experience in an attempt to improve the existing approach to water management and thus to contribute to the implementation of combined approach in Croatia. The authors caution that water monitoring activities should be stepped up (both quality and quantity wise), that prognostic model data should be collected more systematically, and that the models used in this respect should range from rudimentary ones to complex mixing zone models. The existing monitoring was insufficient as to the availability of date, and quality and quantity harmonisation, which all proved detrimental to the use of data for modelling processes in water bodies. The above deficiencies with regard to availability of data for use in prognostic models are still present.

The newly-adopted Methodology is used in the following procedures: assessment of the environmental impact of projects and analysis of the need to assess environmental impact of projects, ecological network impact assessment, issuance of water-rights terms, issuance of water-rights certificates and detailed-design certificates, issuance of water-rights permits for the discharge of wastewater, and when providing opinions and assessments in the environmental permit delivery procedure. The combined approach principle must be incorporated in the documentation for the control of point sources of pollution [17], and it is mandatory for all surface water bodies and groundwater bodies. Depending on new information, available data and documents, and changes of regulations and water planning documents, and also during every approval of river basin management plans [19], the Methodology will be re-examined and, if necessary, extended, amended, and improved, and contribution of this paper could also prove beneficial in this respect.

Water bodies at risk are defined for the application of the combined approach in the scope of the River Basin Management Plan 2016-2021 (Official Gazette 66/16). These are the water bodies that do not meet required water quality standards and that were not expected to meet such standards by the end of 2015, which was actually the first deadline for realization of environmental objectives. That is why appropriate measures for the resolution of the remaining issues must be implemented in the plan period from 2016 to 2021. Risk assessment is related to the expected condition of water bodies at a planned future moment, which means that the process of determining water bodies at risk must include current and expected mass concentration, which is derived from development plans and programs prepared in various significant sectors of economy [19]. The possibility of estimating influence of pollution introduced in the water from point or non-point sources of pollution depends on the availability of data on the emission of pollutants at the sources of pollution, but also on the availability of data on the presence and concentration of pollutants in water. The establishment of proper relationship between elements of the conceptual model from the DPSIR approach is decisive for the preparation of a high-quality and viable program of measures at those water bodies where good condition was not attained by 2012, i.e. for which it was established that the good water condition or status would not be achieved by 2015, and at those water bodies where good water status will not be achieved by the end of 2021 despite conduct of measures belonging to the second planning cycle (implementation scenarios and exceptions).

When determining the DPSIR relationship, a balance model is used for those water condition indicators for which the data about mass concentrations and concentration of pollutants in water are available [16]. A three-dimensional computation model developed in *Hrvatske vode* (Croatian Water) is used for this balancing. The change in mass concentration along the section is compared for every design section (which is defined by the position of gauging stations where water quality is monitored) and for every pollutant, all this based on input from point sources in the direct catchment area of the section. The initial (naturally present) pollution, estimated based on reference concentrations of individual pollutants, is taken as the known pollution. The total difference in mass concentration is attributed to indirect inflow from non-point sources of pollution and is generally divided between sources of pollution according to their proportion in the total emission of pollutants in the direct catchment area of the section. This is a simplified model that simulates complex processes and relationships described in recommendations given in Technical Guidance [20]. The spatial distribution of potential points of discharge of pollutants is taken into account when defining the surveillance monitoring program [19]. If it is determined that at least moderate or good water status can not be achieved by applying basic or supplementary protection measures, and if the polluter establishes that the achievement of more stringent limit emission values would be excessively costly, the polluter may redirect its treated wastewater directly to another appropriate water body that is in good condition. Exceptionally, if the discharge of treated wastewater into another appropriate water body in good condition (as mentioned in the previous paragraphs) is technically unfeasible and/or excessively costly, the polluter may be allowed to discharge such treated wastewater indirectly into ground water (Byelaw on wastewater emission limit values – Official Gazette 80/13, 43/14 and 27/15).

A well-developed biological and hydromorphological monitoring, that was not fully in place in 2012, has to be established to check hydromorphological changes in water bodies, as these changes are considered to be a highly important obstacle to the achievement of a good water status. The purpose of this monitoring is to determine: changes in habitat due to changes in hydrological regime and morphological changes, and disturbances to longitudinal continuity. Hydromorphological changes to water bodies caused by human activities are estimated indirectly, through expert analysis of cumulative influence of various morphological changes in water bodies [21]. Water and environmental permits are delivered based on the data about point sources of pollution as contained in the water management documents kept by Croatian Waters on the approvals granted for the discharge of wastewater as required according to the *Byelaw on wastewater emission limit values* (Official Gazette, issues 80/13 and 43/14). The approvals are delivered in the form of water-rights permits for the discharge of wastewater, or in the form of decisions on granting environmental permits for facilities regulated by the Industrial Emissions Directive (IED), which is a modification of the IPPC.

3. Examples of the use of combined approach in the Sava River Basin

The experience gained in the use of combined approach based on the Methodology is presented on the basis of approved projects for the construction of drainage systems and wastewater treatment plants [17]. This experience is related to practical application of the combined approach for water quality management as related to the discharge from point sources of pollution into surface waters of urban communities Ivanić Grad and Novska. The aim of these projects was to fulfil obligations arising from the planning documents of the Republic of Croatia, namely: Water Management Strategy (Official Gazette 91/08) [22], River Basin Management Plan [23], Plan for implementation of urban water directives [24], and EU directives. The analysed examples are the result of prepared and approved projects of the company Hidroprojekt-Consult Ltd. from Zagreb, and the procedure of application of each combined approach ended with the statement of the body competent for water management for the planned system of drainage and treatment of wastewater. In this statement it is indicated that the project will not worsen the quality of the water bodies nor will it prevent achievement of the good condition/potential of water bodies in the area covered by the project, and that – after the wastewater treatment plant is put in operation – water status will improve and a good ecological and chemical situation will be achieved at relevant discharge rates, and that there will be no significant hydromorphological changes in the surface water body.

The combined approach was used to determine environmental protection measures aimed at achieving protection objectives for the Sava River basin, in the scope of evaluation of the need to estimate environmental impact of individual projects, based on relevant conceptual design and preliminary design for the sewage system and wastewater treatment of the agglomerations [25-28]. In the scope of this evaluation of the need to estimate environmental impact, based on the conceptual design for the system of water supply, sewage system and wastewater treatment in the agglomerations of Ivanić Grad and Novska, the combined approach was used to define environmental protection measures aimed at achieving objectives related to environmental protection of the river basin. This estimate is based on the Ordinance on assessment of environmental impacts (Official Gazette 61/14), Annex II, Paragraph 10, Subparagraph 10.4 [29]. It is important to note that environmental impact assessment ends with delivery of the location permit that is usually based on the insufficiently detailed design documentation. Environmental protection measures defined during the assessment are entered into this location permit, and the same measures are subsequently entered in the building permit. According to European legislation, environmental impact assessment is conducted continuously until delivery of the building permit, which enables more appropriate implementation of environmental protection measures.

As these projects demonstrate fulfilment of obligations assumed by the Republic of Croatia according to planning documents, activities are now under way to improve the water management infrastructure and related services, through investment in the construction or rehabilitation of plants and facilities, and through preparation of various projects. During implementation of basic measures that include use of best available techniques, possible impact on water bodies in which treated wastewater is to be discharged was considered based on combined approach, all in accordance with the River basin management plan for point sources of pollution (sewerage system and WWTP) [17]. It is estimated that, during implementation of basic measures, it will be necessary to start with realisation of those parts of possible projects that are related to implementation of supplementary measures based on combined approach principles, and achievement of more stringent limit values using advanced wastewater treatment technologies. This activity is proposed when there is a risk that good water status would not be achieved, or when such activity is mandatory according to the corresponding River basin management plan.

The preparation of alternative solutions also involves analysis of the impact of pollutants on the first downstream water body. The estimate of relevant water flows is based on balancing river sub-basin at gauging stations with daily flow data measurements, while calculation is based on the assumed homogeneity of hydrological characteristics (runoff) of river sub-basins at gauging stations. As no data exist for full calculation of hydrological parameters at check sections at entrance and exits of rivers in the area under study, the estimates were made under assumption that river sub-basin between gauging stations and check sections are similar, from the point of view of runoff, to immediate upstream and downstream drainage areas for which balancing can be made. If no measurements have been made at a watercourse, it is assumed that specific runoff from the river basin is equal to specific runoff in the neighbouring river basin. The reference flow rate of the final place of discharge Qp corresponds to the 90 % flow rate at the point of measurement (Q90). As the data provided by the existing monitoring are insufficient (which was also the problem in the cases under study), a document called Monitoring Harmonisation Program 2014-2018 was formed. This Program is fully harmonised with the WFD requirements and with national legislation.

The implementation of this Program, establishing the planned monitoring cycles with the surveillance and operational components, started in January 2015. The Program is an integral part of the River Basin Management Plan 2016-2021. The use of combined approach, aimed at optimising the urban areas, sewerage systems, technological solutions, and WWTP sites, as well as points of discharge of effluents into natural surface water bodies, will be presented on the example of agglomerations Ivanić-Grad and Novska.

The tertiary treatment of wastewater is planned for these agglomerations, as they are situated in an environmentally sensitive area. In addition to the load generated by local population through wastewater discharge into water bodies via the sewerage system and the WWTPs, the load of legal entities and the load of non-point sources of pollution in the corresponding river basin, were estimated based on water-rights permits issued by the authorities. All loads are presented as annual figures. The transport of load was modelled conservatively, i.e. the auto-purification of watercourses was not taken into account. In fact, the use of combined approach called for utilisation of an iterative procedure by which initial solution is checked with regard to environmental protection, as this is done in relation to the technical-technological solutions, cost-benefit analysis and water availability analysis. This approach results in optimum solutions with regard to all three key sustainable development factors: environmental, economic, and sociological.

3.1. Ivanić-Grad agglomeration

According to current plans, the agglomeration of Ivanić-Grad is to benefit from rehabilitation and extension of its sewage system, including construction of a wastewater treatment plant for the tertiary wastewater treatment, with the capacity of 21,400 PE. The Lonja River has a small river basin and features small flow rates. The flow of the Lonja River has been intercepted by construction of the external channel Lonja – Zelina – Glogovnica, and so more than 400 l/s of water now flows into the river Lonja from the right-side of the external channel via this constructed external channel. The Lonja flows into and joins the external channel Lonja – Strug. The map of the river basin is shown in Figure 5, and the planned discharge scheme is shown in Figure 6. The combined approach principle is used to consider the quality of water discharge and the influence of such discharge on the status of water in the discharge zone. Depending on condition in water body, allowable emission limits are set and the wastewater pollutant load is determined and, hence, a good status of water is obtained.

As neither continuous nor periodical water level and flow measurements are conducted for the Lonja River water body, the reference flow was defined on the basis of the river bed geometry and water levels in riverbed as observed in this zone. The reference flow of the receiving water body Q corresponds to the

Table 2. Properties of water body DSRN165027 (Lonja) according to the River Basin Management Plan (RBMP) for 2013-2015 (Official Gazette 82/13)

PROPERTIES OF WATER BODY DSRN165027	
Water body code	**DSRN165027**
River basin	**Danube River Basin**
Sub-e basin	**Sava sub-basin**
Ecotype	**T03A**
National / international water body	**HR**
Reporting obligations	**National**
Immediate river basin (design basin for RBMP)	**96,1 km²**
Total river basin (design area for RBMP)	**96,1 km²**
Length of water body (watercourse with drainage area exceeding 10 km²)	**26,8 km**
Length of associated watercourses with the drainage basin of less than 10 km²	**113 m**
Name of the most significant watercourse in the water body	**Lonja**

Table 3. Water status assessment of the water body DSRN165027 (Lonja) according to the River Basin Management Plan, 2013-2015 (Official Gazette 82/13)

Water status		Indicators	Status assessment	Limit concentrations for *					
				estimated status	very good status	good status	moderate status	poor status	very poor status
Ecol. status	Chemical and physicochemical quality elements that support biological quality elements	BPK$_5$ (mg O$_2$/l)	very good	**< 2,0**	< 2,0	2,0 – 4,0	4,1 – 5,0	5,1 – 6,0	> 6,0
		KPK-Mn (mg O$_2$/l)	very good	**< 6,0**	< 6,0	6,0 – 8,0	8,1 – 10,0	10,1 – 12,0	> 12,0
		Total nitrogen (mgN/l)	very good	**<1,5**	< 1,5	1,5 – 2,5	2,6 – 3,5	3,5 – 4,5	> 4,5
		Total phosphorus (mgP/l)	moderate	**0,26 – 0,4**	< 0,2	0,2 – 0,25	0,26 – 0,4	0,41 – 0,5	> 0,5
	Hydromorphological condition		good	**0,5 – 20 %**	< 0,5	0,5 – 20 %	20 – 40 %	40 – 60 %	> 60 %
	Total condition according to chemical and physicochemical and hydromorphological elements		moderate						
Chemical condition			good						

* According to Ordinance on Water Quality Standard (Official Gazette 89/2010)

90 % durability at the measurement point (Q90) and amounts to 2.6 m³/s. The inflow from the upper reaches of the Lonja amounts to 0.4 m³/s, and the inflow from the Lonja River river basin is 2.2 m³/s. The inflow from the corresponding water body river basin and the concentrated inflow from the upstream water body were estimated. All loads concern pollution generated by local population, economic operators and agriculture, as calculated and estimated according to the inflow from the water body drainage area (according to Figure 7). Concentrations registered to the upstream and downstream of the planned discharge, and the corresponding flow rates, were also determined. The concentration of pollutants in the receiving water body to the downstream of the effluent discharge zone (C_d was calculated using the following mixing formula:

$$Cd = \frac{Cu \times Qu + Cgve + Cgve \times Qef\,max\,dn}{Qd} \tag{1}$$

Qd – flow in the receiving water body to the downstream of the effluent discharge zone, as obtained by adding Quzv and Qef max dn

Cu – mean annual concentration of pollutants in the receiving water body to the upstream of the effluent discharge zone, based on the surface water condition monitoring over the past 5 years

Qu – flow in the receiving water body to the upstream of the discharge zone, expressed in m³/day

Cgve – concentration of pollutants, mg/l

Qef max dn – maximum daily flow of effluents, m³/day.

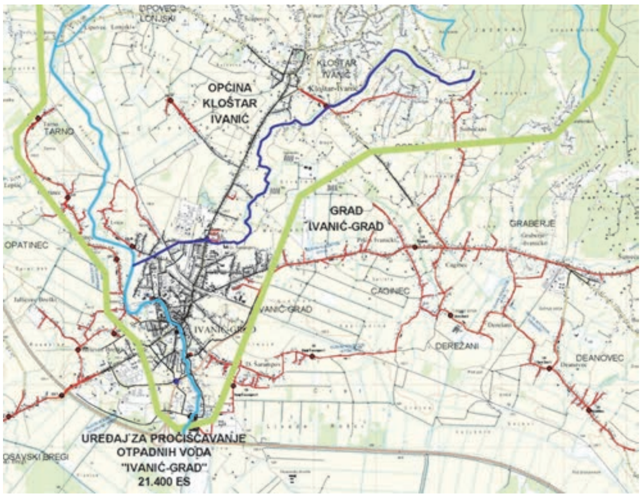

Figure 5. Lonja River river basin (84.694 km^2 or 8469.4 ha in area) [27]

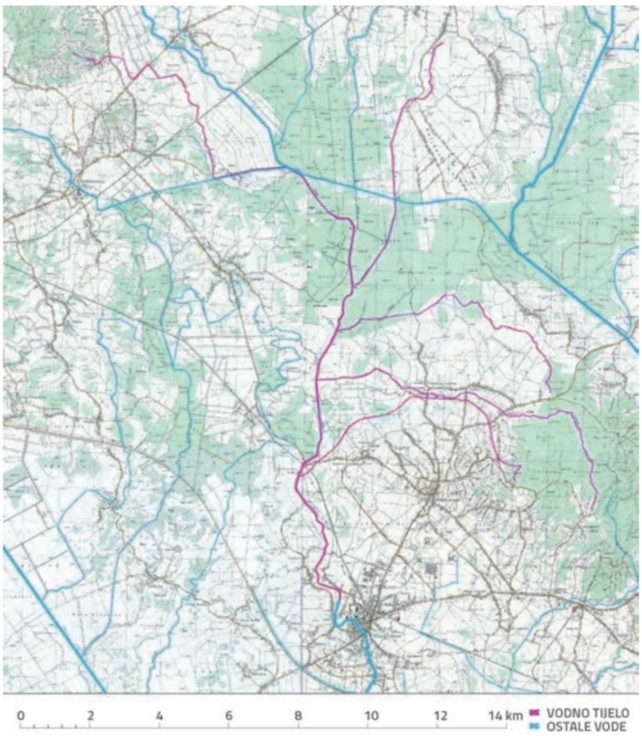

Figure 6. Water body DSRN 165027 into which wastewater from the WWTP is to be discharged [27]

The concentration calculations and verifications related to limit values were conducted for the following indicators: BOD_5, COD, Tot. N and Tot. P. The reduction in total phosphorus concentration will be achieved by construction of the third level WWTP, and so the quality condition would pass from moderate to good at the flow rate of the receiving water body corresponding to the 90 % durability at the point of measurement (Q90). It can therefore be concluded that at least good ecological and chemical condition of the water body DSRN 165027 Lonja will be achieved after construction of the Ivanić Grad WWTP with the tertiary treatment. This is in compliance with General Objectives for preservation of water environment in the Republic of Croatia, as well as with the objectives set in the WFD.

3.2. Novska agglomeration

The location permit was issued for the previously planned wastewater treatment plan for the Novska agglomeration. The capacity of the wastewater treatment plant was reduced from former 15,000 PE to 11,700 PE. The same site was approved using the combined approach methodology and calculation based on equation (1), and the decision was made that the receiving water body will be the Novska Channel, situated to the downstream of the initially planned receiving water body (Novska River). The runoff regimen that can serve for regulating the flow in the Novska River and Novska Channel would be established by construction of the water storage to the upstream of the town of Novska.

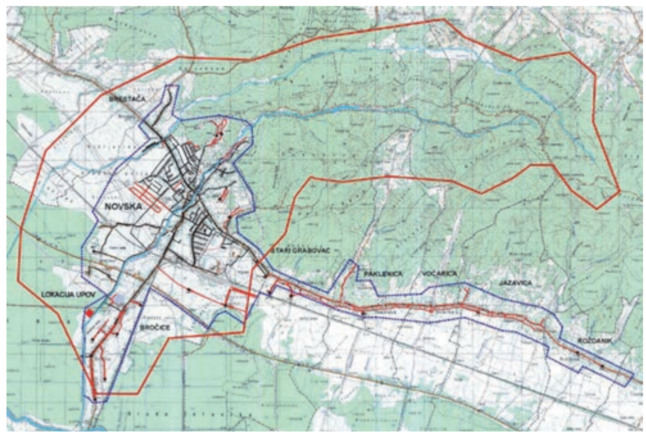

Figure 7. River basin area: A = 15,36 km^2 [28]

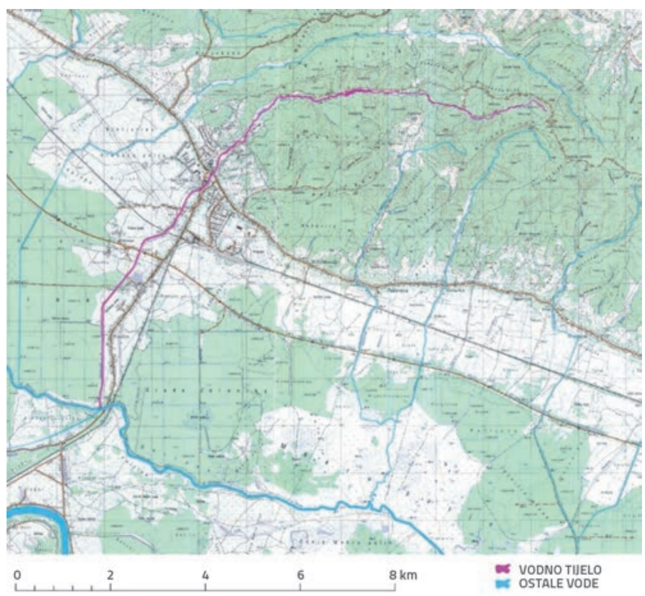

Figure 8. Water body DSRN925034 in which wastewater from the WWTP will be discharged [28]

Table 4. Properties of water body DSRN925034 (Novska) according to the River Basin Management Plan, 2013 – 2015 (Official Gazette 82/13)

PROPERTIES OF WATER BODY DSRN925034	
Water body code	**DSRN925034**
River basin	**Danube river basin**
Sub-e basin	**Sava River sub- basin**
Ecotype	**T03A**
National / international water body	**HR**
Reporting obligations	**National**
Immediate river basin (design basin for RBMP)	**(16,7) 37,36 km²**
Total river basin (design area for RBMP)	**(16,7) 37,36 km²**
Length of water body (watercourse with drainage area exceeding 10 km²)	**(4,15) 13,536 km**
Length of associated watercourses with the drainage basin of less than 10 km²	**15,4 m**
Name of the most significant watercourse in the water body	**Novska**

Table 5. Water status assessment of the water body DSRN925034 (Novska) according to the River Basin Management Plan, 2013 – 2015 (Official Gazette 82/13)

Water status		Indicators	Status assessment	Limit concentrations for *					
				estimated status	very good status	good status	moderate status	poor status	very poor status
Ecol. status	Chemical and physicochemical quality elements that support biological quality elements	BPK$_5$ (mg O$_2$/l)	very bad	**> 6,0**	< 2,0	2,0 – 4,0	4,1 – 5,0	5,1 – 6,0	> 6,0
		KPK-Mn (mg O$_2$/l)	very bad	**> 12,0**	< 6,0	6,0 – 8,0	8,1 – 10,0	10,1 – 12,0	> 12,0
		Total nitrogen (mgN/l)	moderate	**2,5 – 3,5**	< 1,5	1,5 – 2,5	2,6 – 3,5	3,5 – 4,5	> 4,5
		Total phosphorus (mgP/l)	bad	**0,4 – 0,5**	< 0,2	0,2 – 0,25	0,26 – 0,4	0,41 – 0,5	> 0,5
	Hydromorphological condition		good	**0,5 – 20 %**	< 0,5	0,5 – 20 %	20 – 40 %	40 – 60 %	> 60 %
	Total condition according to chemical and physicochemical and hydromorphological elements		very bad						
Chemical condition			good						

* According to Ordinance on Water Quality Standard (Official Gazette 89/2010)

The Novska River joins the Veliki Strug River at approximately 2500 m to the south of the planned WWTP site (Figures 7 and 8). The quality of the discharged wastewater and its influence on water in the receiving water body is analysed using the combined approach principle. Based on chemical, physicochemical and morphological elements, it was established that the condition of water is very poor (red colour). Taking into account the condition of water in the water body, allowable limit emissions and allowable pollutant content in wastewater were established, in order to achieve a good water status, as shown in Tables 4 and 5.

The current drainage basin of the Novska Cannal also comprises the drainage basin of the Brestača River that joins the Novska River to the downstream of the planned Novska WWTP site. This fact was taken into consideration when making calculations and estimates concerning condition of this water body. In fact, neither continuous nor occasional measurements of water level and flow rate are being made, and so the reference flow rate was determined based on river bed water levels in the planned WWTP water discharge zone.

The reference flow rate of the receiving water body Q corresponds to the 90 % flow durability at the point of measurement (Q_{90}), Q_{90}= 0,166 m³/s. Concentrations of all indicators will be reduced after construction of the WWTP for the tertiary wastewater treatment level. In this way, the water status will improve from very bad (very poor) to moderate, according to typical indicators, at the 90 % flow at the point of the planned future discharge, which is situated to the downstream of the merging point of the Brestača and Novska River

(Q_{90}). In case of extremely low flow rates, the ecological minimum flow rate can be established and regulated by controlled discharge of water from Novska Lake. After establishment of continuous monitoring activities, it will be possible to conduct a more detailed analysis of all measured parameters and, based on appropriate measurements, the reference flow rate in the receiving water body (Q90) will be established. The calculation was conducted as described in the text related to the Ivanić-Grad agglomeration. Thus, a moderate ecological and chemical condition will be achieved at the Novska water body after construction of the Novska WWTP with the tertiary treatment [29-31]. This is compliant with General Objectives for preservation of water environment in the Republic of Croatia, as well as with the objectives set in the WFD. Nevertheless, the use is made of Article 11, Paragraph 4 of the *Byelaw on wastewater emission limit values* (Official Gazette, issues 80/13 and 43/14, 27/15 and 3/16) where it is stipulated that the receiving water body Novska River is temporarily exempted from the obligation of achieving good water status according to the River Basin Management Plan, 2016-2021. This temporary exemption is specified in Annex 2 (by statement of the competent body responsible for water management) in which it is indicated that, during realisation of basic measures by all polluters, additional/supplementary measures will also be introduced, depending on the condition of the receiving water body. In the meantime, the Water Basin Management Plan for 2016-2021 (Official Gazette 66/16) was passed, which has significantly improved the assessment of water condition. This implies assessment of the existing condition of water according to the Ordinance on Water Quality Standard (Official Gazette 73/13), and water condition assessment according to the analysis of pressures and impacts, which includes assessment of the current condition, prediction for 2021, prediction for the period beyond 2021, and prediction of expected achievement of environmental protection objectives.

4. Experience in the use of combined approach and overview of its implementation in Croatia

The use of the combined WFD approach seems to be quite logical as a means of improving quality of waters. However, it should be noted that the WFD text is in fact incomplete with regard to real-life implementation of combined approach. Or, more precisely, the fact that the WFD does not specify where exactly in the water body should the European water quality standard be used is arbitrarily and differently interpreted by water authorities in individual EU countries [32]. Even the interpretations in which the values given in the Environmental Quality Standard (EQS values) are applied either directly at the point of discharge, or after the full mixing, are illogical and are not fully in line with the real implementation of the combined approach. Future changes of and additions to the Directive, or the corresponding national procedures for implementation of the combined approach, must include a clearer regulation of mixing zones for all point sources of pollution, so that current deficiencies can be corrected.

The Environmental Quality Standard (EQS) defining limit values for individual pollutants or for groups of pollutants that must not be exceeded in the water body [1] is a considerable improvement of the approach, as it directly addresses hydromorphological, physical, chemical and biological properties of the water body, change in water condition due to discharge, and provides direct discharge reduction measures. However, the practice of defining the quality of water, based exclusively of quality standards, may lead to the situation in which a single discharge may fully use up capacities of a water body, up to concentrations defined in EQS. Similarly, difficulties in monitoring achievement of a good water status may arise from the issue of where and how often should such measurements be made in the water body.

EQS values must be applied outside and at the boundary of the mixing zone, i.e. in a limited area around the point source of pollution. This rule points to the physical fact that the transition from EVLS to EQS is operated through gradual mixing, for which an appropriate area is required. In the future, as an additional requirement for practical application of the combined approach, competent water authorities should make greater use of prognostic models for checking quality of water. In other words, mixing zone models should be used for the evaluation of measured indicators, and for extending the use of measured data (without spatial and time limitation) for the existing point sources of pollution, and also for the detection and regulation of all new sources. This would facilitate further implementation of the combined approach in national legislations, especially as to planning of measures, i.e. as related to WWTPs and administrative procedures for the delivery of water permit. At the same time, theuse should be made of general water quality models, namely in cases of greater mass concentrations of pollution through interaction of various sources, including additional dispersed sources [32].

Mixing zone models based on simple equations, that are in fact simplified versions of water quality models, are recommended. These models use a moderate amount of data and are simple and safe to utilise, especially if the limits of their application are supported by an expert system. The authors of the paper [32] suggest that this new controlling mechanism could play a significant role not only in the long-term management of European waters, but also in initial implementation of the WFD, i.e. in the characterisation of the existing condition (quality status) of water bodies. According to principles of caution and reduction of pollution at the source, the use is made of the DPSIR approach and the risk of non-achievement of good water status is estimated, while appropriate measures are planned based on spatial analyses (GIS technology) of *Hrvatske vode. This* work is based on the analysis of pressures and impacts on water body, and on the assessment of water status according to the current insufficient monitoring, but also no the assessment of achievement of environmental objectives in the river basin. It is important to point out that condition assessment is made based on available data, using the existing surveillance and operational monitoring and, at that, the assessment of hydromorphological elements is not fully accurate due to lack of reference conditions and a classification system. Thus, the assessment was not made with regard to: phytoplankton, macrophytes, fish, pH, potassium permanganate, ammonia, nitrates, orthophosphates, pentabromodiphenyl ethers, C10-13, chloroalkane, tributyltin compounds, trifluralins [21].

In Croatia, the use of combined approach was initiated by publication of Methodology of the Combined Approach Application [17] that is used to assess the influence of wastewater discharge on the condition of water bodies. It is applied in the procedures for estimating environmental impact of projects (environmental acceptability of projects), delivery of water-rights documents, delivery of water permits and opinions, and in appraisals for environmental permits. The authors of the Methodology, aware of its incompleteness, have indicated that the Methodology will gradually be improved [17]. It should be noted that WWTP sites specified in land-use planning documents are currently being re-examined and revised using the combined approach although in most cases the land has already been purchased, permits delivered, and wastewater discharge zone specified. Even though the Methodology has been developed in order to plan zones in which wastewater from WWTP will be discharged and for the purposes of delivery of water-rights permits, the manual did not consider the existing discharge zones and water permits. In fact, only an example of two agglomerations in the Sava river basin (Ivanić-Grad and Novska) is given in order to present in which way the combined approach may be used, and which are the difficulties that can be encountered during its application. This is why the planned WWTP sites, figuring in land-use planning documents as the "only possible" solutions, have been re-examined, but not to address property-rights issues and WWTP position with regard to new construction that has generated in the meantime, but to select a favourable water body in which the treated wastewater will be discharged, without jeopardizing achievement of good status of water in this water body.

The combined approach is applied using the mixing formula for which the reference flow in the receiving water body Qp, corresponding to the 90 % flow durability at the measurement point (Q90), must be known. As this information is not available for many smaller watercourses, the methodology for calculating the environmentally acceptable flow (EAF) has not been defined, and the same applies to the methodology for water bodies that suffered significant change. In 2015, the European Commission issued the Guidance Document No. 31 entitled *Ecological flows in the implementation of the Water Framework Directive*. This document is considered to be an extremely important element in the preparation of river basin management plans as the EAF defined for a water body or section within a water body must correspond to reference condition adopted for that water body in the corresponding river basin management plan. The EAF is defined in order to preserve or re-establish the structure and function of water and water related ecosystems, and it contributes to the achievement of a good water status and to realization of environmental protection goals through sustainable use of water.

Croatian Waters makes reference-flow assessments for receiving water bodies (Qp) as a part of every river basin management plan, but only for bigger watercourses. At the same time, polluters can make, via an authorised legal person, continuous measurements of flow through the receiving water body, and these measurements will be taken into account during subsequent reference flow assessments. In fact, if hydrological data and data about condition of a water body are not available, the surveillance monitoring must be conducted during construction of sewerage systems and WWTPs, and during definition of the receiving water bodies, for the implementation and improvement of the combined approach. This is especially important for those water bodies for which it has been established that achievement of good water status is not to be expected. In the European Commission's report on advancements in the use of the WFD and implementation of the program of measures, it is indicated that quantitative assessments must be made to identify obstacles to be overcome using special measures in order to reach objectives set in basic measures, with an emphasis on hydromorphological pressures [33]. That is why intensive activities aimed at establishing hydromorphological monitoring of waters are currently under way in Croatia [35].

The paper does not even consider a key practical issue discussed in many papers, such as in *Environmental Quality Standards in the EC-Water Framework Directive: Consequences for Water Pollution control for Point Sources* [32]. The mentioned key issue is related to the specific points of discharge into water bodies in which European quality standards must be applied. If the values indicated in the EQS are applied after the full mixing, the physical mixing process in rivers and greater water bodies will take place gradually until "cloud emptying", and considerable areas in the water body will suffer concentrations above the ELVS values and will thus become a sort of "sacrificed regions". In this case, good chemical status will not be assured in the long run. Real dimensions of the mixing zones must be limited, and can be specified in simple guidelines, depending on the type and use of the water body or, in an "ad hoc" procedure, based on agreement between the polluter and the competent authority [35]. A compromise must obviously be reached in the form of mixing zones that are clearly defined and specified.

In the EU working document on the need to model pressures on water bodies on the European level, it is indicated that significant indicators of pressure exerted on water bodies must be redefined for each member country and that the term "naturalized flow" must be introduced and, finally, that the confirmed "in-house" models made by the European Commission's Joint Research Institute (JRC) must be used [33, 34].

5. Conclusion

In addition to the Emission Limit Value Standard (ELVS), the WFD-based combined approach also includes the environmental quality standard (EQS), and is therefore capable of contributing to the improved quality of surface waters. However, the WFD lacks specification of points/zones within water bodies in which the environmental quality standard (EQS) should be applied, which can result in different interpretations by water authorities of individual EU countries. Thus, the approach – albeit quite logical and appropriate as to its concept – lacks practical implementation activities that would finally improve the quality of water and result in a good status of all surface waters.

After analysis of legislative solutions and experience in the use of the combined approach in the EU, it was established that the WFD text relating to actual implementation of the combined approach should be clearer and more detailed. It is currently quite difficult to incorporate the combined approach into national legislations and administrative procedures (delivery of water and environmental permits), and it can therefore be expected that the declared combined approach will only partly be implemented. Possible interpretations, according to which the EQS values should be applied directly at the place of discharge, or after full mixing, are not in full harmony with the intentions of the combined approach. Future changes of and additions to the Directive, or to the corresponding national procedures for the implementation of combined approach, must contain clear specification of mixing zones for all point sources, so that current deficiencies can be corrected.

Although the EU member states are left to do so by regulating clearly defined mixing zones, they should not, however, endanger the WFD's prescribed environmental objectives of the river basin. Therefore, competent water management authorities should make a greater use of prognostic models for implementation of the combined approach. The decision on such use is closely related to the advancement of system-related monitoring activities so that good quality input data can be obtained. On the one hand, mixing zone models should be used for the evaluation and broader use of measured data (beyond spatial and time constraints) for the existing point sources while, on the other hand, these models could prove helpful in cases of significant mass concentration (load) of pollution in the interaction of various point and non-point sources of pollution.

In accordance with the objective set out in this paper, the experience gained from the practical implementation of the combined WFD approaches for water quality management has been analysed, with respect to the emissions from point sources of surface water pollution. The use of existing monitoring as a surveillance factor, the establishment of new operational monitoring in accordance with the WFD requirements for a better assessment of water status, water bodies in risk and assessment of achievement of environmental objectives - represent a great need but are also a considerable cost. In fact, the monitoring system is gradually extending and, considering that improvements in the area of water body characterisation are currently under way, the possibility of multiple use of monitoring should also be taken into account. Q90, as defined in the Methodology, is considered to be a transitional, administrative solution to be used until approval of the methodology defining the EAF according to water body types, and until approval of the methodology defining environmental potential for highly modified water bodies. In this respect, it should be noted that the environmentally acceptable flow (EAF) and environmental potential are key elements for implementation of the combined approach and for preparation of the second and third cycles of river basin management plans in the European Union. Furthermore, relevant legislation should continuously be improved based on professional and scientific analyses and research.

The Methodology shall be re-examined and if necessary extended and improved in the light of new information, available data and documents, changes of water management planning documents and regulations, and upon publication of river basin management plans. The use of the Methodology has opened many questions, but it has also tested its suitability, and contributed to the widening of its scope. This gives opportunity and advancement of the Methodology as part of the next planning cycle.. Although Methodology has started with modest requirements, it is still the first crucial step in the application of the combined approach, and it can now be estimated that it has made a significant step forward compared to the previous practice of wastewater discharge into the water body at the site designated for UPOV, according to spatial documents spatial that have been made in the last twenty years. The Methodology has revealed to the professional and scientific community a whole array of deficiencies in the existing monitoring activities, and has broadened the possibilities and responsibilities of those who plan solutions to point sources of pollution, while cautioning about the need of improving water management practices by ensuring harmonisation with EU water policy requirements, through which various guidelines are issued in an attempt to simplify, provide information, and advance professional practice in all EU countries. This concerns even those countries that have already made considerable progress in the use of combined approach, considering their high economic potential and possibility of reaching high standards in the sphere of water quality management. These countries have mostly met basic requirements for the control of point sources of pollution in the period since WFD was adopted.

Benefiting from the EU funding, Republic of Croatia now has the opportunity of controlling point sources of pollutions using the WWTPs that were planned earlier, but for which no funding was previously available. The implementation of the Methodology has opened many questions that are now being addressed so that reliable answers may soon be available. For each water body that is planned as a waste water receiver from the WWTP and for the implementation of basic measures, such as the construction of WWTP, it is necessary to establish research and improve existing operational monitoring to monitor the effects of the taken measures.

As to the procedure for the obtaining of water permits, it is important to determine which procedures need to be applied, while discharges will have to comply with limit effluent values and the corresponding EQS values. Discharges should be regulated using the prognostic models that describe physical mixing and transport, as well as physical and biochemical water-body transformation processes, to as to ensure an integrated realisation of the combined approach. At that, it is indispensable to take into account various hydrological situations and physical conditions (relevant seasons of the year, i.e. as related to stratification density). All above mentioned issues constitute new obligations for the Republic of Croatia but, considering national experience in the use of combined approach, these challenges will undoubtedly lead to gradual improvement of the Methodology and to positive effects in its implementation.

Acknowledgements

The authors extend their thanks to employees of the *Hrvatske vode* for their support and for the data and information they have provided, but also for technical discussions and explanations related to implementation of the combined approach.

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