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Problems Asocciated with not Properly Conducted WFD Based Monitoring During Preparation of River Basin Management Plans – Bregalnica River Case Study

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Abstract

Preparation of the River Basin Management Plans (RBMP) requires postulation and implementation of at least a one year surveillance monitoring of the selected water bodies in the catchment. The monitoring should be as comprehensive as possible, focused on detection of reference conditions and should reveal the water bodies' ecological status and the crucial deviations from the natural conditions on which the measures in the plan are to be developed. In countries like Macedonia, where the regular monitoring activities (past and present) are very limited and not based on the Water Framework Directive (WFD) principles, the process of management plan preparation is the principal opportunity to achieving the baseline data. Nevertheless, since the funds for these types of activities are usually obtained from interna tional donors, the profit driven environment distorts the monitoring fundamentals and produces doubtful monitoring results which are quite difficult to correct in subsequent updates of water management plans. This work is based on the case study of the Bregalnica River (Macedonia), where only two full sampling campaigns of full scale WFD monitoring were conducted on the physico-chemical parameters, hydromorphological and biological quality elements. The aim of this study is to present and to comment on the obtained results. The results clearly point to the lack of a sufficient amount of data for the catchment characterization, identification of reference conditions and assessment of ecological status as required by the WFD.

Keywords: WFD, River Basin Management Plan, monitoring, problems, Bregalnica River (Macedonia).

Introduction

As a candidate country for the European Union (EU), Macedonia has to harmonize national legislation with the EU legal requirements. Consequently, the environment and water related regulative, like the Water Framework Directive (WFD, 2000), have been approximated for more than 95% into the domestic legislation. One of the basic principles of the WFD is to achieve good status for all water bodies through preparation and implementation of the River Basin Management Plans (RBMP), which are a basic tool for developing a set of measures directed to preserve and improve the water status in the catchments. There are only two RBMPs developed so far in Macedonia, the Prespa Lake (2011) and the Bregalnica River (2015), while for River Strumica (2015) there is only a preliminary one. Over the course of preparation of different RBMPs, the implementing international bodies (companies) have been focusing on the profits rather than the scientifically documented facts obtained from surveillance and investigative monitoring systems. The usual practice of budget restrictions in monitoring, but also several others misconducted approaches either by the international bodies or domestic institutions enacted to conduct and monitor the RBMPs, have created multiple problems and erroneous monitoring results. Also, based on experience gained through the preparation of the first update of a RBMP (2016), these problems will be elaborated using the example of monitoring and the results obtained during the preparation of the Bregalnica River RBMP. This paper has an ultimate intention to point out the gained knowledge on improper surface water monitoring design and implementation in order to ensure more effective preparation of the RBMPs.

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Materials and Methods

In order to achieve the principal goal of developing the River Basin Management plan for the Bregalnica River, the project has postulated ecological surveillance monitoring activities within one calendar year. A total of four sampling campaigns for river ecosystems and artificial channels have been planed – two campaigns which consisted of a full range of physico-chemical and biological field and laboratory analyses (July and October 2013) and two campaigns which were conducted in order to collect only the basic physico-chemical data for selected water bodies (August 2013 and February 2014). Regarding the six selected reservoirs in the catchment, only two sampling campaigns were planed (July and October 2013) for the basic physico-chemical and biological parameters; the priority substances were to be measured only once – October 2013. Physico-chemical analyses were conducted according to standard methods (APHA, 2009), while biological analyses followed multiple ISO or CEN standards for sampling algae from rivers and lakes (CEN, 2004), macrophytes (CEN, 2006), macroinvertebrates (CEN, 2014) and fish (CEN, 2015), as well as the guidance for monitoring under WFD (CIS, 2003).

Results and Discussion

The project management (team of experts) had originally pre-selected a total of 32 river water bodies and two artificial channels as objects for the ecological surveillance monitoring. If the whole catchment of the Bregalnica River is taken into consideration (Figure 2), it is obvious that many more water bodies would have to be delineated in order to obtain a realistic ecological situation.

Another critical problem with the pre-selection of water bodies to be monitored was detected when several of the rivers were found without water in the riverbed throughout most of the surveillance monitoring period (Fig. 3); water in the Zelevica (SR_13), Kozjacka (SR_21), Otinja (SR_22) and Orelska/Mavrovica (SR_26) rivers, was only detected during the winter sampling campaign in February 2014. The left, artificial channel (AC_02) was also found without water.

Figure 1: Empty riverbeds of the Orelska/Mavrovica and Kozjacka rivers (October 2013).

Two of the selected water bodies, the Sveti Nikolska River (SR_25_02) and Kriva Lakavica River (SR_24_01) were found to be heavily polluted (Figure 4) and sampling and analyses were performed in accordance with special protocols and safety precautions. The Sveti Nikolska River was found in the same ecological state throughout its entire course to the confluence with the Bregalnica River, thus having a detrimental effect on the ecological conditions of the recipient waters. The upstream flow of the Kriva Lakavica is highly unstable and not suitable for continued operational monitoring.

Pre-selected reference sites have been proven as a specific problem too. Out of the total of 7 pre-selected reference sites only the upper part of the River Zrnovska (SR_16_01) has been approved to be in reference status, based on the results of monitoring of physico-chemical and biological quality elements. The rest of the pre-selected reference sites were found to be under different type and level of anthropogenic pressure that was reflected either by the deterioration of several physico-chemical parameters (usually BOD, COD, Total P, Phosphates or Sulfates) or on biota composition and abundance. Consequently, it was necessary to select new reference sites. Thus, sources of the Bregalnica River (SR_01_01), the Brbusnica River (SR_15_01_01) and the Kocanska River upstream of the Gradce Reservoir (SR_18), as well as the Zrnovska (SR_16_01) and Ratevska (SR_11_01) were finally selected as reference or "near natural" sites for the Bregalnica River catchment.

In order to determine the reference conditions and threshold values for different parameters of ecological status, the overall variety of water body

types in the catchment had to be delineated with the highest possible precision. Using WFD's System A, the project management pre-selected (postulated) a total of 6 (and even 7) water body types in the Bregalnica River catchment. According to the results obtained during the surveillance monitoring (typology System B proposed by the WFD used) it appears that in this catchment there are only 3 water body types for rivers: 1) high mountain (above 1100 m latitude) source water bodies with reference conditions, 2) water bodies that occupy the middle stretches of rivers (not below 500 m), and 3) lowland river stretches prior to their confluence with the recipients (below 500 m). Having in mind that silica is the dominant geological substrate in the catchment, in addition to the observed chemical and biological features of the examined water bodies, this water body type delineation seems to be the most reliable one. There is a definite necessity for further research to corroborate this proposal, but if such delineation is accepted the postulation of operational monitoring and implementation of the management plan would be much easier to achieve and monitor.

Finally, one of the most demanding results, posted as an outcome of the performed surveillance monitoring activities, is the definition of reference values and type specific assessment system. Throughout the course of only two full campaigns (biological and chemical analyses) and two additional campaigns for physico-chemical analyses, with limited analyses of priority substances and heavy metals were performed, there is obvious need for increasing the reliability of the final conclusions. For example, there were two documented events of fish killings (Figure 5) during the course of the monitoring for which the underlying causes have not been detected by the monitoring activities.

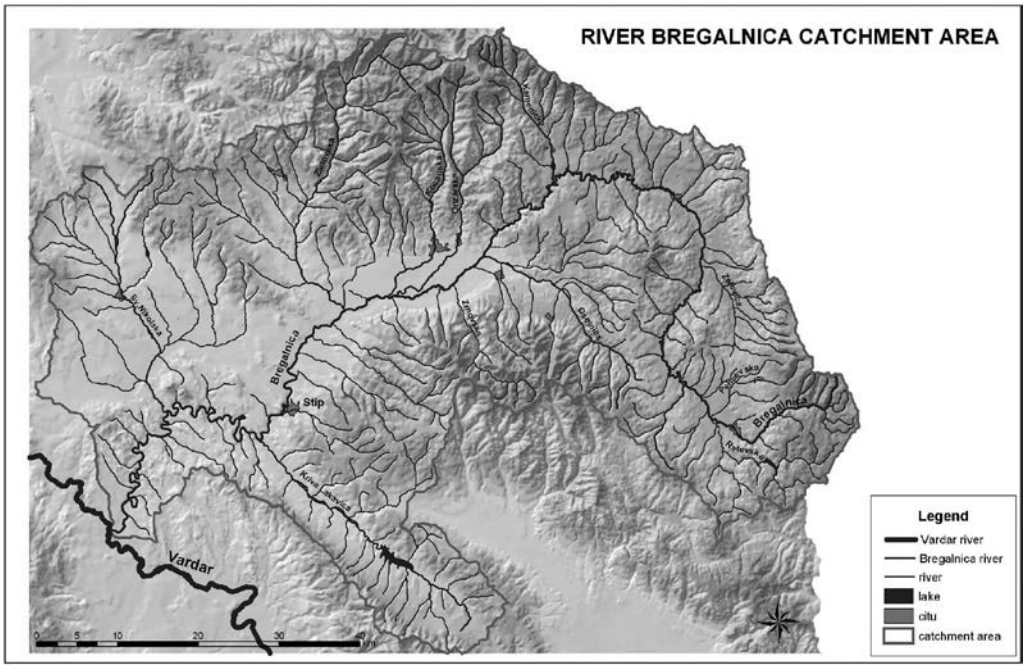

Figure 2: The full range of the Bregalnica River catchment area.

Figure 3: The Kriva Lakavica and Sveti Nikolska rivers – heavily polluted waters.

Figure 4: Newly selected reference water bodies – Ramna Reka River (Bregalnica sources) and Barbusnica River.

Figure 5: Fish kill in the Bregalnica River after Delchevo, November 2013.

A bit different line of arguments for utilization of not reliable biotic indices (specifically for macroinvertebrates and diatoms) can be underlined in regard to obtaining very unreliable reference values and limits (Krstic et al., 1998, 2007). Namely, biotic indices like IPS and IBMWP have been developed in different countries and tested in variety of ecological conditions. Due to specificity of taxa composition and different indicative values of species in investigated area, there is a need to develop indices adapted for particular region.

Comments on Reference Conditions, Types of Water Bodies and Limiting Values for Parameters

In order to determine the real ecological state and water quality status of the examined water bodies, detecting the constant and reliable reference conditions for many important parameters is of crucial significance. Furthermore, the reference conditions are to be postulated for every water body type in the catchment, and treshold values for different boundaries among classes need to be defined in order to detect the overall status of the particular water body for which there is a need of activities in the management plan or not. The results obtained in the frame of this project do not permit confident conclusions on these important issues due to several reasons:

1. Lack of data – traditionally there is a huge lack of monitoring data in Macedonia, and consequently also in the Bregalnica River catchment. Especially unknown are the background natural values for all parameters which are particularly important in areas where significant concentrations of natural minerals, ores and metals are detected and exploited.
2. Low sampling frequency and narrow area of investigations – in the course of this project the predicted sampling frequencies for the biological investigations are very modest and do not allow any significant field and laboratory work. The same can be stated for the area covered by the monitoring activities. In order to determine the real natural conditions, these remote areas should be monitored at least 6 times per year (including one sampling in winter months) and be in the focus of the investigative monitoring for several years.
3. Initially determined water body types – as stated before, the initial categorization of water body types according to the WFD System A, have proven to be erroneous as a

result of both data obtained through research and the data obtained from various historical references. Namely, the geology of the Bregalnica River catchment is almost entirely composed of various siliceous substrates and the rivers have a generally similar chemical and physical environment. Small or even medium differences in the catchment areas are not an important factor for proclaiming different water body types. What remains is only the altitude of the flow, in which regard there are only 3 water body types in the catchment - 1) high mountain (above 1100 m latitude) source water bodies with reference conditions, 2) water bodies that occupy the middle stretches of rivers (not below 500 m), and 3) lowland river stretches prior to their confluence with the recipients (below 500 m). Having in mind that silica is the dominant geological substrate in the catchment, in addition to the observed chemical and biological features of the examined water bodies, this water body type delineation seems to be the most reliable one. There is a definite necessity for further research to corroborate this proposal, but if such delineation is accepted the postulation of operational monitoring and implementation of the management plan would be much easier to achieve and monitor. Consequently, the reservoirs should also be divided into 3 types, according to the type of river that is used for their creation.

Regarding the limiting values for physico-chemical and biological parameters that define the various ecological and water quality classes and boundaries, the performed analyses are the least supportive and informative. The results obtained from the monitoring activities are far too insufficient for obtaining a reliable database capable of generating a sufficient amount of physico-chemical dynamics and biota composition structures information at the various water bodies over time. In addition, limited information pertaining to reference conditions may have made this part of the monitoring report highly erroneous. Consequently, the final reported categorization of the water quality status might also be erroneous and have an important impact on the management plan itself.

Nevertheless, the obtained results from the monitoring are real data, and they are used to determine the exact values for monitored parameters to the highest possible level. Secondly, the obtained data are compared to pre-determined water quality class data charts which are stated in domestic legislation (this is an old legislation and needs to be improved), but also to other protocols developed for this area and Europe. There are many approaches in this respect, the classifying values are usually different for different countries and the ranges between classes may differ substantially. On the other hand, there are well documented and thoroughly confirmed values for parameters such as nutrients, like phosphorus and nitrogen compounds, for which different reactions of biological communities are observed. Knowledge on adverse effects of heavy metals and different toxins is much more elaborate. Therefore, even if the physico-chemical results do not reflect the real ecological situation (what is frequently recorded in lotic environments), the biological parameters usually do. In that sense, even if the postulated values for physico-chemical parameters are significantly erroneous, the biological analyses are generally correct.

In the case of the Bregalnica River catchment, the obtained results are devastating. But, the problems are not due to the excessively strict limiting values and class boundaries, but rather, due to the limited amount of available data, research and knowledge. Biological components of the water ecosystems are indicators of intensive human impacts within the entire catchment, except of course the fish and macrophytes which are governed by other principles (fishing, repopulating, migrations, channelization, introduction of alien species, etc.) so that the changes in postulated class boundaries will not have effect on the final conclusions for the water quality status. This can only be achieved by continuous monitoring and research for the basic reference conditions, especially in regards to biota, but also for detecting the natural physico-chemical capacity in the catchment. Only in this way will the management plan have its clear goals and milestones.

In conclusion, the obtained results in the course of the performed surveillance monitoring in the Bregalnica River catchment, can only be regarded as preliminary information on the actual ecological state of the analyzed lotic and lentic water bodies. Monitoring should be much more refined, the number of water bodies increased, their typology and delineation changed, reference conditions properly checked and confirmed, limiting values checked and refined, biological communities clearly defined for the various water body types, forced biota changes due to human impacts recorded and defined, if the proper and reliable operational monitoring system is to be achieved. Moreover, if the management plan is to be properly developed and its application monitored, these changes and the relevant information have to be introduced as soon as possible.

Final Categorization of Surface Water Bodies in the Catchment

Table 1: River water bodies.

Water body	ID	Algae	IBMWP	Fish	QBR	IHF	Biological Status	Ph-Ch Status	Ecological Status	Chemical Status	WB Status
Rivers											
Bregalnica 01	SR_01	M	G	H	G	M	M	P	P	Gc	Fgs
Bregalnica 02	SR_02	P	P	G	M	M	P	B	B	F	Fgs
Bregalnica 03	SR_03	P	M	G	M	M	P	B	B	F	Fgs
Bregalnica 04	SR_04	P	P	G	P	P	P	B	B	F	Fgs
Bregalnica 05	SR_05	P	P	G	M	M	P	B	B	F	Fgs
Bregalnica 06	SR_06	P	P	G	B	M	B	B	B	F	Fgs
Bregalnica 07	SR_07	P	P	G	P	P	P	B	B	Gc	Fgs
Bregalnica 08	SR_08	P	M	G	P	M	P	B	B	F	Fgs
Bregalnica 09	SR_09	P	P	G	P	M	P	B	B	F	Fgs
Bregalnica 10	SR_10	P	M	G	G	M	P	B	B	F	Fgs
Ratevska 01	SR_11	M	H	B	G	M	B	P	B	Gc	Fgs
Ratevska 02	SR_12	P	M	G	M	M	P	B	B	Gc	Fgs
Zelevica	SR_13	P	M	G	P	M	P	M	P	F	Fgs
Kamenica	SR_14	P	P	B	M	M	B	B	B	F	Fgs
Osijnica	SR_15_01	M	H	G	M	M	M	P	P	Gc	Fgs
Osijnica	SR_15	P	P	G	B	B	B	P	B	F	Fgs
Zrnovska	SR_16_02	P	B	B	B	P	B	B	B	F	Fgs
Orizarska	SR_17_02	P	P	G	P	P	P	B	B	F	Fgs
Kocanska 01	SR_18	P	H	G	G	M	P	P	P	F	Fgs
Kocanska 02	SR_19	P	B	M	P	P	B	B	B	F	Fgs
Zletovska	SR_20	P	P	G	P	M	P	B	B	Gc	Fgs
Kozjacka	SR_21	N/A	B	B	P	P	B	P	P	F	Fgs
Otinja	SR_22	P	P	B	M	B	P	B	B	F	Fgs
Kriva Lakavica 01	SR_23_02	P	M	B	G	M	B	M	B	F	Fgs
Kriva Lakavica 02	SR_24_01	B	B	B	P	P	B	B	B	F	Fgs
Madenska	SR_24_02	B	B	B	M	M	B	B	B	F	Fgs
Svetinikolska 01	SR_25_02	B	B	B	P	M	B	B	B	F	Fgs
Nemanjica	SR_26	P	P	B	B	P	P	B	B	F	Fgs

Table 2: Artificial channels.

Artificial Water Body	ID	Ph-Ch WB Status	Chemical Status	Water Body Status
Irrigation Channel				
Right Channel 1	AC_02	P	Gc	F

Table 3: Reference water bodies for rivers.

Water body	ID	ALGAE	INVERTEBRATES	FISH	MACROPHYTES	BASIC Ph-Ch	CHEMICAL STATUS	FINAL STATUS
Reference sites – rivers								
Bregalnica Springs	SR_01_01	M	G	B	H	M	Gc	M
Zelevica 01	SR_13_01	M	M	M	M	G	Gc	M
Kamenica 01	SR_14_01	P	P	B	G	P	Gc	P
Brbusnica	SR_15_01_01	G	H	P	G	G	Gc	G
Zrnovska 01	SR_16_01	G	G	H	H	G	Gc	G
Orizarska 01	SR_17_01	G	G	G	G	M	Gc	M
Kriva Lakavica 01	SR_23_01	P	M	G	M	M	Gc	P
Svetinikolska 01	SR_25_01	B	B	B	M	B	Gc	B

Table 4: Reservoirs.

Water body	ID	ALGAE	INVERTEBRATES	FISH	BASIC Ph-Ch	CHEMICAL STATUS	FINAL STATUS
Ratevska Reka	AL_01	P	P	G	B	F	B
Kalimanci	AL_02	P	B	M	B	F	B
Gradce	AL_03	P	B	M	P	F	B
Knezevo	AL_04	M	G	G	G	F	M
Mantovo	AL_05	P	B	P	M	F	B
Mavrovica	AL_06	B	B	M	B	F	B

Conclusions

After a full range of surveillance monitoring was performed throughout the course of this project on the selected lotic and lentic water bodies in the Bregalnica River catchment, which included four physico-chemical samplings, two biological surveys and one additional sampling on 10 monitoring sites which were found either without water or had controversial results, the following assessments of the ecological (water quality) status have been developed.

The most striking fact is that all examined lotic water bodies were found to be in a bad or poor ecological state, the bad (or the worst) ecological state being dominant in the catchment (24 WB out of 29, or almost 83%). This situation is highly critical and has to be addressed with outmost sincerity in the process of development of the management plan.

The principal underlying cause of this intensive impact is the untreated waste waters such as communal waste waters that introduce nutrients (P and N compounds) and many other pollutants (like phthalates) in vast quantities, while industrial waste waters have a devastating effect through various toxins and organic and/or inorganic pollutants, like oil from the refinery in Stip or strong solvents from the dairy works. These impacts severely change the natural conditions of the water environment and encourage the development of specific and highly resistant microflora and invertebrate communities, the biological elements that respond closely to changes in water quality status. Macrophytes and especially fish do not reveal the actual ecological state of the water quality as precisely as expected. It is more likely that species composition and community structure of fish and macrophytes, but especially their indices, reflect other human impacts rather than the water quality. It might be more feasible to use them as *biomonitors* than bioindicators in order to reveal the levels of different toxins accumulation in their tissues and corresponding damages to organs or reproductive stages.

One specific problem that occurred during the performed surveillance monitoring in the Bregalnica River catchment was the detected status of the pre-selected reference water bodies for rivers. As presented in Table 3, only two sampled water bodies, the Brbusnica and Zrnovska, can be regarded as sites with reference conditions,, although the fish results for Brbusnica were found in poor conditions. There are many reasons for this situation, but the principal one is that the performed monitoring activities are not enough to reveal the real situation or natural conditions. Since the reference conditions are crucial for detecting the level of deterioration in the catchment and are the target for developing limiting parameter values, as well as management activities. The reference water bodies remain to be an object of investigative monitoring in the next period.

As expected, the only artificial channel for irrigation that was working during the monitoring period had revealed the water body status (Table 2) in the line with the status of the ecosystem it is constructed from. Namely, the poor water quality remains in a channel which fails to achieve good status.

Finally, as a consequence of all the detected influences on rivers, the water quality of the monitored reservoirs is also very bad (Table 4). As the polluting chemicals are accumulating in the reservoirs, their overall ecological state is continually deteriorating over the time. This process is termed *eutrophication*, a process that can change the ecological state of an ecosystem permanently, thus rendering it unusable and unsafe for any human activity. Additionally, the accumulated chemicals in the bottom sediments act as an inside pool which generates nutrients in excess, even without the external input of pollutants. In this case micro flora and fauna are exposed to increased environmental pressures on which they react by changing their species composition and abundance towards the most resistant species. In the case of algae these are usually blue-green cyanobacteria which tend to dominate the ecosystem and present yet another source of toxicity,such as excess of biomass (algal blooms) and release of toxic compounds – *the cyanotoxins.*

Except for the Knezevo reservoir, all the other five ecosystems were found in a deep stage of eutrophication. Performing two full sampling campaigns was insufficient for proper detection of all changes in the monitored reservoirs, but the obtained

results were clearly documented and conclusive. Developing and implementing an efficient reservoir management plan represents a real challenge. Their monitoring should be expanded and extended in the following plan since even the Knezevo Reservoir shows natural or human pressures, while the others may be regarded as highly unsafe for any utilization other than energy production. Their real threat remains yet to be resolved and understood, while the Mavrovica Reservoir is already a dangerous ecosystem in every respect.

Performed investigations could not answer the questions of the diffuse agricultural pollution or aero deposition of pollutants coming from transport and burning of fossil fuels, pollution sources that might have an important impact on water resources in the Bregalnica River catchment.

Future prospects

- Monitoring represents a starting and an ending point of every activity. In regards to the environment, this means that the monitoring should reveal the state of the systems at present, but also explain the past changes and predict future trends. A proper monitoring system will also be able to follow the implementation of any activity and detect any positive or negative effects. It is therefore essential to postulate, perform and enable a reliable and comprehensive monitoring plan and activities based on expertise of highly educated and confirmed experts. Monitoring cannot be modified according to the project budget – in that case the results will be erroneous.
- As a fundamental focus of WFD, biological parameters of the monitoring should be treated with a special appreciation. Namely, biological organisms are adaptable and changeable, they usually cannot be easily compared among each other – that is one of the principal driving forces for the vast biodiversity on our planet. Hydrobiota are particularly difficult to compare since water is a much more rapid environment with sharp and intensive oscillations in short time periods. In every particular moment multiple parameters influence living organisms to which they need to adjust otherwise they will become extinct. These impacts are unique for every particular ecosystem. Therefore, a universal pattern cannot be elucidated, while the common indices are obsolete. Every ecosystem should be regarded as a separate entity with a unique biology, and the changes followed through the changes within the communities rather than changes in numbers which are erroneous. Evolution and history imply that there is no number which can be applied to living organisms, from bacteria to humans; such mathematics have not been invented yet. Application of biological indices developed in different regions end ecosystems is erroneous too; that is the principle obstacle the WFD inter-calibration process is facing today.

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