Carpathian Journal of Earth and Environmental Sciences, February 2017, Vol. 12, No. 1, p. 161 - 169

HYDRO-MORPHOLOGICAL ASSESSMENT OF ATYPICAL LOWLAND RIVERS – ROMANIAN LITORAL BASIN CASE STUDY

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Abstract: This paper aims to discuss the applicability of the updated version of the *Methodology for hydromorphological assessment of Romanian rivers* developed in line with the Water Framework Directive in a special case (lowland rivers with small catchments and special characteristics due to the location close to Back Sea). The 11th hydro-morphological indicators that describe the deviation from the natural conditions of the hydrological regime, river continuity and morphological conditions have been calculated for five atypical lowland water bodies, based on the data sets generated by the Romanian National Hydrological and Hydrogeological Database. Subsequently, the values (scores) of uni-criteria indicators were used to calculate multi-criteria indicators in order to establish the final status of some elements (e.g. hydrological regime element). Most of the hydro-morphological indicators classify the analyzed water bodies mainly in quality classes I and II except some indicators in class III and IV (moderate and poor status) for example the riparian zone indicator. We used the "one out, all out" principle (the worst status of the elements used in the assessment) to classify the final hydro-morphological status (in case of four out of five waterbodies the riparian zone indicator gave the final hydro-morphological status). The correct classification is important for taking measures to improve water quality. The results stress the necessity for an in-depth analysis of the link between hydro-morphological, physico-chemical and biological status as well as to further refine the hydro-morphological classification schemes at least for some river types. The final classification should be consistent across all 3 assessments required by Water Framework Directive (using hydro-morphological, physico-chemical and biological elements).

Keywords: hydromorphological assessment, hydrological regime, river continuity, morphological conditions, indicator

1. INTRODUCTION

As a consequence of the Water Framework Directive (WFD), the management of hydro-morphological pressures that takes into consideration the changes in the structure and functions of aquatic ecosystems (the links between biology and hydro-morphology) is the main challenge. As hydromorphological alteration is considered one of the most important pressures on river ecosystems in Europe (EEA, 2012) and represents a major threat to water quality (EEA, 2012), the new approach places the physical rivers characteristics and processes at the centre of river management and restoration (Newson & Large, 2006; Vaughan et al., 2009).

In this context, the assessment of river hydro-morphology and the development of classification schemes has become a priority for the international scientific community.

Within Europe, some hydromorphological assessment methods (e.g. Raven et al., 1997, 1998; Herring et al., 2003) were developed with the aim to implement of EU Water Framework Directive. The existing methods with notable differences in their aims, spatial scales, collected data and applicability, are increasingly applied in order to support river management (Belletti et al., 2015). Nevertheless, for the most E.U. Member States, the consideration of the hydromorphological elements still remains the main gap in the ecological status assessment of rivers water bodies and an integrated approach of all quality elements is limited, but increasing (Rinaldi et. al., 2013).

Although the WFD requires the assessment of river hydro-morphology, the consideration of human impact to flow regime, rivers continuity and morphological conditions, the main gap identified in most methods is the insufficient consideration of physical processes in the assessment of hydromorphological conditions (Rinaldi et al., 2013).

Many methods analyze the hydrological and morphological elements at a certain moment through field investigation and only a few methods assess the alterations of hydrological regime, water depth and width, bed substrate due to human activities. Regarding the riparian zone assessment, most EU methods focus on identifying artificial features (water works) and the land use.

On the other hand, numerous researchers emphasize that the hydromorphological assessment should go beyond the physical habitat assessment by including "pressures" and "response" variables (hydromorphological and biological indicators) in order to emphasis the river dynamics and processes (Fryirs et al., 2008; Rinaldi et al., 2013).

However, an integrated approach merging the full range of disciplines (hydrology, geomorphology, water quality, biology, ecology) in the assessment of river conditions still remains a challenge (Belletti et al., 2015).

In response to the requirements of Water Framework Directive, the *Methodology for hydromorphological assessment of rivers* developed by the Romanian National Institute of Hydrology and Water Management relies on the existing datasets and information such as CORINE land cover, water works. A first version of the Methodology was presented and published in the proceeding of the Conference of the Danubian Countries (Galie et. al., 2014). An updated version as a result of testing activity for more than 100 rivers water bodies was published in the proceeding of the SGEM Conference (Moldoveanu et. al., 2015).

In this paper, the updated version of the Methodology, which will be the official one for the implementation of the WFD in Romania, were used to investigate the hydromorphological condition of some natural river water bodies. The 5 waterbodies were chosen because the catchments are small, the characteristics are special due to the location close to Back Sea and the river biology is atypical all over Romania (e.g. no fish fauna).

Whilst intended as a demonstration of the application of the methodology to some atypical lowland river typologies, the outcomes of this assessment could be used for a variety of purposes, for example to identify significant pressures in the catchment as well as to support and interpret biological and physico-chemical status.

2. METHODS

2.1. Study area

The Litoral basin is located in the southeast part of the country and is scarce in surface waters, having an average density of rivers around 0.072 km/km^2 and small catchment areas (Cadastral Water Atlas of Romania, 1992).

The registered flow rates are very low, frequently they are drying up and therefore there are no water uses within the basin. Also, most of the water bodies within the Litoral basin have very large floodplains (riparian zones) where there is no specific vegetation. Regarding the land cover, the natural wooded areas are very small compared with the rest of the country.

According to the first WFD assessment cycle no river water body within the Litoral basin has been designated as heavily-modified water body. This is a consequence of the fact that many water works (e.g. dikes) are made by local materials (earth, rocks, etc.) with minimum impact on biology.

The paper focuses on five rivers water bodies (Table 1) located within the Litoral basin.

Catchment areas are small (Table 1) and the multiannual average flow (computated for the period 1955 - 2005) are very low (0.068 - 0.632 m^3/s).

Regarding the rivers' typology (Table 1), the analyzed water bodies were classified as special lowland typologies: RO06* and RO08*, that are distinct from the other lowland typologies across the country (RO06 and RO08).

In Romania, the characterization of surface water body types was done using System B (obligatory factors: ecoregion, altitude, geology, size of catchment; optional factors: e.g. lithological structure of river bed, multiannual average specific flow, multiannual average precipitation). According to the National River Basin Management Plan (2015), the Romanian type RO06 corresponds to European broad type 5 and RO08 corresponds to European broad type 4; for Romanian types RO06* and RO08* no European broad type was identified. The particularities of these types (RO06* and RO08*) refer to the structure of biological communities - the fish fauna is lacking in natural conditions.

Table 1. The analyzed water bodies, their typology and the hydrometric stations related to them

River name	Water body name	Water body length (km)	Typology	Hydrometric station name	Hydrometric station code	Area corresponding to hydrometric station (km^2)	Multiannual average flow (m^3/s)
Telita	Telita	48	RO06*	Posta	A	58	0.068
Taita	Taita 3	31	RO08*	Satul Nou	B	565	0.434
Slava	Slava 2	18	RO08*	Ceamurlia	C	350	0.160
Hamangia	Hamangia	33	RO06*	Baia	D	218	0.208
Casimcea	Casimcea 2	48	RO08*	Cheia	E	500	0.632

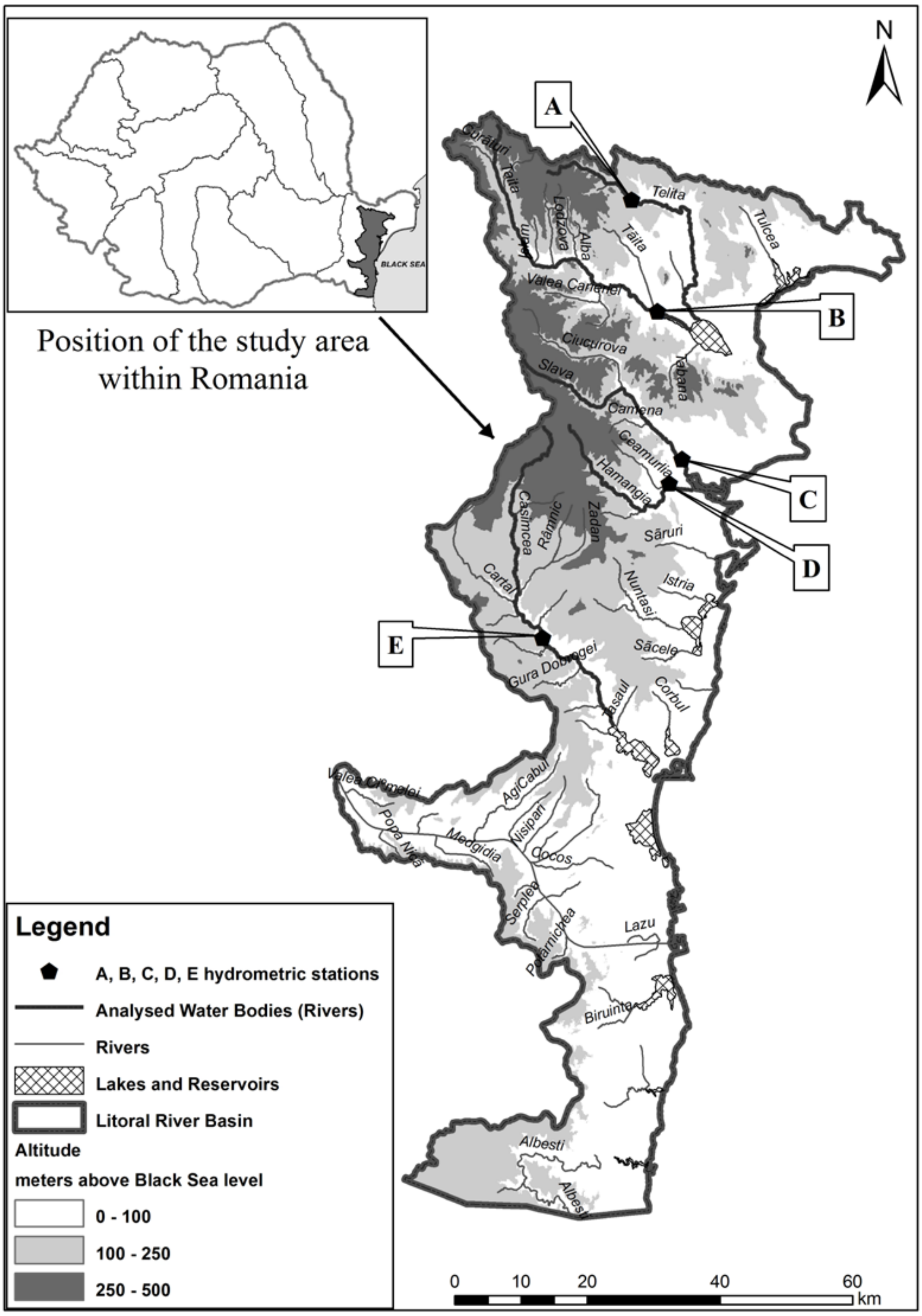

Figure 1. Study area: The Litoral basin and the location of the hydrometric stations. (A - Posta; B - Satu Nou; C - Ceamurlia; D - Baia; E - Cheia)

2.2. Assessment of the hydromorphological status

The hydromorphological assessment was done by applying the *Methodology for hydromorphological assessment of Romanian rivers* (Moldoveanu et al., 2015) based on 11 indicators (listed in Table 2) belonging to the three groups of elements required by WFD as follows: *hydrological regime* (quantity and dynamics of water flow, connection to groundwater bodies), *river continuity* (longitudinal and lateral continuity / connectivity) and *morphological condition* (river depth and width variation, structure and substrate of the riverbed and the riparian zone).

The water body assessment, a scoring system and a classification system into five classes as the WFD requires are the milestones of the Methodology. Thus, for each indicator, the reference status / natural or a slight deviation from this is class I and the score is maximum (score 13). Class I is the most natural condition and class V has highest anthropogenic impact. For the other cases (classes II-V), the score is lower depending on the severity of anthropogenic pressures (e.g. class II score 10 for indicators 1,2,3,5,6,8,9 or scores 10-12 for indicators 4, 10, 11 listed in Table 2; class III score 7 for indicators 1,2,3,5,6,8,9 or scores 7-9 for the others, and so on). For some indicators the class boundaries have been set after the testing activity (see Moldoveanu et al., 2015) and for others still remain equidistantly.

The method aims to characterize rivers at the water body scale but in some cases the information is collected from the hydrometric stations and considered as representative for the whole waterbody. Therefore, some of the indicators are computed using measured values in hydrometric stations, while others using criteria that reflect the severity of anthropogenic pressure at water body level (e.g. length of the dikes). So, the indicators 1, 2, 7, 8 and 9 (listed in table 2) were computed using the hydrological and hydro-geological database of the Dobrogea-Litoral River Basin Authority. The datasets were collected from 5 hydrometric stations belonging to the national hydrological network. The analyzed period for the reference conditions was the year 1999 and current modified conditions was the period 2000-2013.

The *River connection to groundwater bodies* (indicator 3) is based on the average annual values of water levels measured in wells, located closest to the river, on both sides of the water body, before (reference conditions) and after the construction of dykes and dams (modified/current conditions).

The criteria used for some indicators are, for example, the length of water works (dikes) (indicator 5), and the location of these works (dikes) at a certain distance from the minor river bed (indicator 6).

An interesting approach should be highlighted for the riparian zone assessment. **The delineation of the riparian zone** (type-specific width), **is based both on valley geomorphology and water bodies' typology**, accepting that the riparian zone width under natural conditions is different, increasing from upstream to downstream. The criterion for assessing the continuity of the riparian zone is the percentage of the natural zones (according to CORINE Land Cover) out of total surface of riparian zone, corresponding to the water body.

Each indicator is assessed in five classes and for the indicators that assess similar features (e.g. indicators 5 and 6 listed in table 2), the methodology uses some multi-criteria indicators for assessing the hydro-morphological element (e.g. river lateral continuity / connectivity with the riparian zone/ floodplain). Subsequently, the multi-criteria indicators were computed and also the boundaries for the quality classes have been set equidistantly.

Table 2. The list of the hydromorphological indicators used to assess the hydro-morphological status of water bodies in the Litoral basin

Hydrological regime	**River continuity**	**Morphological conditions**
1. Average used/consumed flow	4. Longitudinal continuity / connectivity of the river bed	7. Mean depth corresponding to multiannual average flow*
2. Maximum flow abstraction	5. River lateral continuity / connectivity with the riparian zone/ floodplain (considering the length of water works)	8. Mean width corresponding to multiannual average flow*
3. River connection to groundwater bodies*	6. River lateral continuity / connectivity with the riparian zone/ floodplain (considering the reduction of the riparian zone width)	9. The sediment structure of the river bed*
		10. Minor riverbed morphology and its lateral mobility
		11. Riparian zone

**The computations have been done in the hydrometric stations and the results have been considered for the whole waterbody.*

The principle "one out, all out" (the worst status) was applied between indicator 1 and 2 and also in order to establish the final hydro-morphological status.

3. RESULTS

3.1. HYDROLOGICAL REGIME ASSESSMENT

The hydromorphological pressures (e.g. water uses, water diversions) modify the quantity and dynamics of flow (magnitude, time) throughout the analyzed water body.

$$Indicator\_1 = \frac{\sum_{i=1}^{j} Q_{mean\_used} - \sum_{i=1}^{k} Q_{mean\_return}}{Q_{natural\_multiannual\_mean/reference\_condition}} * 100$$

where j=number of water intakes, k=number of users which return flows.

$$Indicator\_2 = \frac{\underset{i=1}{\overset{j}{Max}} Q_{mean\_abstracted}}{Q_{natural\_multiannual\_mean/reference\_conditions}} * 100$$

where j=number of water intakes

Both indicators are classified in five classes (see Moldoveanu et al., 2015).

Due to the fact that there are no water uses within the analyzed water bodies the two indicators developed to describe the human impact on the quantity and dynamics of water flow, were not calculated. Therefore, in these cases, one has considered that the changes of flow are natural and these water bodies have been classified in class I (score 13) with note "(NA, EJ)" ("NA" - not applicable, "EJ" - expert judgment). The principle "one out, all out" between the two indicators (1 and 2) was applied to assess flow status.

Another element which influences the hydrological regime is the connection of the river to groundwater bodies. In order to analyze the connection between the river and groundwater aquifer the average annual values of water levels measured in wells, located closest to the river, on both sides of the water body were analyzed, before (reference conditions) and after the construction of dykes (modified/current situation).

Take into account the presence of wells, the indicator 3 was computed only for Slava 2 water body (Ceamurlia hydrometric station - C) based on water level recorded in the river and in the two closest wells. It was considered approximately the same time period (both natural and modified conditions) for the groundwater table measurements in wells and the water level measurements in the river (at the hydrometric station C).

$$Indicator\_3 = \frac{\left(\frac{mean\_water\_level\_measured\_a.s.l.}{mean\_groundwater\_tabel\_measured\_a.s.l.}\right)^{natural}}{\left(\frac{mean\_water\_level\_measured\_a.s.l.}{mean\_groundwater\_tabel\_measured\_a.s.l.}\right)^{modified}}$$

According to the instructions mentioned in the methodology (see Moldoveanu et al., 2015) which set up 5 classes for this indicator, the result (1.012/0.95 ≥ 0.9) classifies the hydrometric station Slava 2 in class I, score 13.

For the other analyzed water bodies, due to the fact that there are no wells located closest to the river, the indicator 3 was not computed and in these cases one noted "NA" - not applicable.

In order to have a **final status for the hydrological regime element** the following formula has been used:

Multi-criteria Indicator 1 = Score ("one out, all out" between Indicator 1 and Indicator 2) *0.8 + Score (Indicator 3) * 0.2

The value obtained using the above formula gives the scores of the water body status in terms of hydrological regime (Fig. 2). Kipping in mind that for class I the score is 13, the boundaries of the classes are set equidistantly as follows: class I – (10.6-13), class II – (8.2-10.6), class III – (5.8-8.2), class IV – (3.4-5.8) and class V – (3.4-1).

For example, in section C: Multi-criteria Indicator 1 =13*0.8+13*0.2=13 belongs to (10.6-13) meaning class I (high status).

3.2. River continuity assessment

Three indicators were developed for assessing river continuity within the Romanian methodology (one indicator for longitudinal continuity – indicator 4 and two indicators for lateral continuity – indicator 5 and indicator 6). **The *Longitudinal continuity* indicator** was designed to assess the impact of dams or other transversal structures on the mobility of fish species and to determine whether within the analyzed water body the continuity for fish fauna is ensured. The indicator analyses each barrier that interrupts the minor river bed continuity and the movement and migration of fish communities within the analyzed water body by quantifying the difference between upstream and downstream water level. Taking into account that the fish fauna is missing in natural conditions in the analyzed water bodies, indicator 4 (table 2) **has no relevance for the assessment** (It will be note NR - "not relevant") (Fig. 2).

Keeping in mind that, in many cases the floodplain is constrained by water works (dikes) on one or both sides which do not allow the natural functioning of it (flood prevention and sediment retention) two indicators were developed within the Methodology for analyzing **the lateral continuity of the river with the riparian zone/floodplain** (indicators 5 and 6). Indicator 5 analyses if the water works length varies in a certain percentage out of the double length of the water body (e.g. the length of the waterbody is 10 km and the length of the dikes is 5 km on one side of the river, the percentage is 5*100/(2*10)=25%). Indicator 6 analyses the percentage of reduction for the floodplain's width caused by water works (dikes).

The indicator 5 classifies 3 water bodies in class III (Telita, Taita and Slava 2) and two water bodies in class II respectively in class I (Fig. 2).

For all analyzed water bodies the water works are generaly located within the floodplain at large distance from the river banks. In this context, the uni-criteria indicator 6 classifies all water bodies, in class II.

In order to have the scores for the water body lateral connectivity the following formula was used:

Multi-criteria Indicator 2 = Score (Indicator 5) * 0.25 + Score (Indicator 6) * 0.75

The boundaries for classes I to V for the Multi-criteria Indicator 2 are established in the same way as for the hydrological regime element (Multi-criteria Indicator 1).

In all cases, the status for the river continuity was established only by assessing the *River lateral continuity / connectivity with the riparian zone.* The *Longitudinal continuity indicator* has no relevance for the assessment because there are no fish in natural conditions (the low flows cannot sustain fish life within the analyzed water bodies). All water bodies were classified in class II (Fig. 2).

3.3. MORPHOLOGICAL CONDITIONS ASSESSMENT

The river morphological conditions are assessed by the five indicators listed in Table 2.

Indicator 7 quantifies the relative error / deviation of the mean depth (h_m) of the river bed (corresponding to the multiannual average flow) in anthropogenic conditions compared to natural ones in the studied sections and ranks it in 5 classes. For section C, indicator 7 is computed below.

$$Indicator\_7 = \frac{h_{mm} - h_{mn}}{h_{mn}} \cdot 100$$

where:
h_{mm} - mean water depth corresponding to the modified multiannual mean flow (current conditions);
h_{mn} - mean water depth corresponding to the natural multiannual mean flow (reference / natural conditions).

The result for indicator 7 is (0.25-0.18)*100/0.18 = 38.9% corresponding score 7 class III.

Indicator 8 quantifies the relative error / deviation of the mean width (B_m) of the river bed (corresponding to the multiannual average flow) in anthropogenic conditions compared to natural ones in the studied sections and ranks it in 5 classes. For section C, indicator 8 is computed below.

$$Indicator\_8 = \frac{B_{mm} - B_{mn}}{B_{mn}}$$

where:
B_{mm} - mean water width corresponding to the modified multiannual mean flow (current conditions);
B_{mn} - mean water width corresponding to the natural multiannual mean flow (reference / natural conditions).

The result for indicator 8: (3-2)*100/2 = 50% is between ± 21% and ± 40% scoring 10. The values of the two indicators were used to calculate the multi-criteria indicator 3 using the following formula:

Multi-criteria Indicator 3 = Score (Indicator 7) * 0.7 + Score (Indicator 8) * 0.3

The boundaries of classes I to V for Multi-criteria Indicator 3 are established in the same way as for the hydrological regime element (Multi-criteria Indicator 1). Multi-criteria Indicator 3 for section C = 10*0.7+10*0.3=10 belonging to 8.2-10.6 indicating class II (good status) (Fig. 2).

Indicator 9 quantifies the relative error / deviation of the riverbed mean particle size fraction ($D_{50\%}$) in anthropogenic conditions compared to natural ones in the studied sections and ranks it in 5 classes. For section C, the indicator 9 is computed below.

$$Indicator\_9 = \frac{D_{50\%m} - D_{50\%n}}{D_{50\%n}} \cdot 100$$

$D_{50\%m}$ - mean particle size fraction corresponding to current conditions;
$D_{50\%n}$ - mean particle size fraction corresponding to reference / natural conditions.

The result (0.0098-0.008)*100/0.008 = 22.5%) for indicator 9 is between 21% and 50% scoring 10, class II (good status).

Minor river bed morphology, the riverbed shape and its lateral mobility have changed due to human pressures (e.g. regularization).

HS	Hydrological regime					River continuity				Morphological conditions								HYMO final status (one out, all out)
	1	2	one out, all out between (1,2)	3	Final status / Multi-criteria Indicator 1	4	5	6	Final status (Multi criteria Indicator 2)	7	8	Multi-criteria Indicator 3 status	9	10	Multi-criteria Indicator 4 status	11	Final status (one out, all out)	
A	I (NA,EJ)	I (NA,EJ)	I	NA	**I**	NR	III	II	**II**	II	III	II	II	III	II	II	**II**	**II**
B	I (NA,EJ)	I (NA,EJ)	I	NA	**I**	NR	III	II	**II**	II	II	II	II	III	II	IV	**IV**	**IV**
C	I (NA,EJ)	I (NA,EJ)	I	I	**I**	NR	III	II	**II**	II	III	II	II	III	II	III	**III**	**III**
D	I (NA,EJ)	I (NA,EJ)	I	NA	**I**	NR	II	II	**II**	II	IV	II	II	II	II	III	**III**	**III**
E	I (NA,EJ)	I (NA,EJ)	I	NA	**I**	NR	I	II	**I**	II	I	I	II	I	I	IV	**IV**	**IV**

Figure 2. Water hydro-morphological quality classes of each uni-criteria indicator, multi-criteria indicators and the final hydro-morphological status for the analyzed water bodies

(Abbreviations are as follows: 1-11 are the hydro-morphological indicators as listed in Table 2; A-E - the hydrometric stations listed in Table 1 and Figure 1; NA - not applicable; EJ - expert judgment; NR - not relevant).

Indicator 10 assesses (using expert judgement), for different percentage of water works' lengths out of the double length of the waterbody, if:

a) the water works are discontinuous and there are no important changes, or there are minor ones; or there are old changes and the river system partially re-naturalized them (e.g. score 12, class II; score 9, class III);

b) the water works are continuous on both sides and the changes are not significant (banks corrections, minor corrections of riverbanks alignment) (e.g. score 11, class II; score 8, class III);

c) the riverbed is channelized and modifications are significant (e.g. deviations, riverbed closures, refilling abandoned riverbeds) that affect the aquatic ecosystem structure and function (e.g. score 10, class II; score 7, class III).

In case of Slava 2 water body, the water works have a length between 30-50% out of the double length of the waterbody and the water works are continuous on both sides. Therefore, the score is 8 corresponding to class III.

All water bodies' scores, fall into water quality class II in terms of sediment structure of the river bed. The channel/minor riverbed morphology and the lateral mobility (indicator 10) fall in class III for the most waterbodies. In order to have one status for the two indicators, the following multi-criteria indicator has been computed:

Multi-criteria Indicator 4 = Score (Indicator 9) * 0.50 + Score (Indicator 10) * 0.50

The boundaries of classes I to V for Multi-criteria Indicator 4 are established in the same way as for the hydrological regime element (Multi-criteria Indicator 1).

For water body Slava 2, where is located hydrometric station C, Multi-criteria Indicator 4 = 10 * 0.50 + 8 * 0.50 = 9 belongs to 8.2-10.6 range corresponding to class II (good status) (Fig. 2).

Indicator 11 assesses the riparian zone in terms of natural, agricultural and artificial areas. Along the water body, there are certain surfaces with discontinuities of riparian zone as a result of human activities that interrupt the longitudinal continuity, reduce the width and affect structure and also alter the natural function. There is a range of values (in percentage) for each class (e.g. for class III 20-40%) of the natural zones out of total surface of riparian zone (corresponding to the analyzed water body) and the rest of the surface of riparian zone (in percentage) is characterized as follows:

a) mainly occupied by agricultural areas (e.g. score 12, class II; score 9, class III);

b) divided equally between agricultural and artificial areas,

c) mainly occupied by artificial areas (e.g. score 10, class II; score 7, class III).

In order to compute the indicator 11, a large riparian zone width (about 30 meters for RO06* respectively 60 meters for RO08*) was considered for all analyzed water bodies.

For example, in case of Slava 2 water body a 60 meters width for the riparian zone was considered. Using this value and GIS environment the following surfaces resulted:

Zone	Surfaces (m^2)	Percentage (%)
Agricultural	1191587.221	64
Artificial	271536.586	15
Natural	386343.037	21
Total	1849466.843	100

Keeping in mind that the natural areas are 21% out of total surface of riparian zone (corresponding to the analyzed water body) and the rest of the surface of riparian zone (in percentage) is mainly occupied by agricultural areas, the score is 9, corresponding to class III (moderate status).

The indicator 11 classifies the analyzed water bodies into quality classes III and IV (moderate and poor status).

In order to establish the final morphological status, the "one-out, all-out" principle was applied between status established by Multi-criteria Indicator 3, Multi-criteria Indicator 4 and riparian zone Indicator (Indicator 11).

For example, in case of Slava 2 water body the final morphological status is class III (moderate status).

The final hydromorphological status of each water body was established applying the "one-out, all-out" principle (the worst status of the elements used in the assessment) between the hydrological regime status (status of Multi-criteria Indicator 1), river continuity status (status of Multi-criteria Indicator 2) and morphological status (the "one-out, all-out" principle among Multi-criteria Indicator 3, Multi-criteria Indicator 4 and Indicator 11) (Figure 2). Applying "one-out, all-out" for the Slava 2 water body, between Multi-criteria Indicator 3 (class II), Multi-criteria Indicator 4 (class II) and Indicator 11 (class III), the final hydromorphological status was class III (moderate status).

4. DISSCUSIONS

The hydromorphological pressures as water flow regulations, embankments, significant water intakes and water users which return flows, were considered for the hydromorphological asssessment.

Within this paper, the 11 hydromorphological indicators assess the deviation from natural conditions in terms of hydrological regime, river continuity and morphological conditions for the five water bodies in the Litoral basin. The quality classes and the scores depend on the severity of hydromorphological pressures. In most cases, the hydromorphological indicators classify the water bodies in the I^{st} and II^{nd} quality classes, except some indicators including the riparian zone indicator (indicator 11): 2 waterbodies – class III and 2 waterbodies – class IV. It should be mentioned that indicator 7 is the only one classifying in class IV. This fact might be explained by the large agricultural areas about 46 - 70% out of the total surface of the riparian zone.

Taking into account the role of riparian land use in catchment management (Feld, 2013), our findings are likely due to the diffuse pollution from agricultural activities and rural areas located in river catchments.

The European Environment Agency report (2012) highlights that the sources of diffuse pollution (including land use) and hydro-morphological alterations are the significant anthropogenic pressures for river water bodies in Romania.

Recent research on the existing hydro-morphological methods has highlighted the importance of improving our understanding of the relationship between organisms and hydromorphological pressures (Rinaldi et al., 2013). It is important to corroborate the physico-chemical and biological elements with hydromorphological one in order to provide an integrated approach to the ecological status assessment and to explain some changes within the biotic communities.

5. CONCLUSIONS

The development of the *Methodology for hydromorphological assessment of rivers* is an important step for the WFD implementation and for an integrated rivers ecological status assessment, in Romania.

The hydromorphological assessment of the five river water bodies within Litoral basin highlights the applicability of the updated version of the *Romanian Methodology* to atypical lowland typologies.

The paper has identified some discrepancies in hydro morphological quality classes as follows: Indicator 11 (riparian zone Indicator) classified in class III and IV (four waterbodies out of five) and most of the other indicators in class II and I. The power to show the hydro-morphological alterations (due to human activities) of indicator 11 and to establish the final hydro-morphological status is being questioned suggesting that more research is needed.

The results of this paper show that the integration of the hydromorphological assessment within the biological and physico-chemical assessment is needed for better understanding of interrelations within the river ecosystem. This paper might also be used to further elaborate the 5-classification system of hydromorphological indicators at least for some river types.

The hydro-morphological status and physico-chemical status should be consistent with biological status, keeping in mind that the hydro-morphological and physico-chemical elements are supporting elements for biota.

The robustness of the classification schemes is important to guide in a judicious way the aquatic ecosystems management and also to take appropriate measures to improve water quality.

Acknowledgments

The authors wish to acknowledge the contribution of the experts from the National Administration *"Apele Romane"* (Romanian Water Authority) and the River Basin Authorities to the updated version of *the Methodology for hydromorphological assessment of Romanian rivers.*

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Received at: 31. 01. 2016
Revised at: 06. 09. 2016
Accepted for publication at: 25. 10. 2016
Published online at: 31. 10. 2016