# THE ASSESSMENT OF HYDROMORPHOLOGICAL STATUS OF ROMANIAN RIVERS

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**ABSTRACT. The Assessment of Hydromorphological Status of Romanian Rivers.** The quality protection and improvement of the aquatic ecosystems and achievement of "good status" for all water bodies until 2015, involved integration of key ecosystem principles into water policies and a series of new management elements. Thus, the "health" status of aquatic ecosystems is a new objective for European water policy which is reflected in the structure and functioning of aquatic ecosystems, being defined by the biological, morphological and physico-chemical quality components as well as the presence of specific pollutants (synthetic and non-synthetic). In order to achieve good ecological status / good ecological potential for all water bodies (rivers) of Romania, the paper presents an innovative approach regarding monitoring of hydromorphological quality component and its integration in the assessment of ecological status of water bodies. In this approach the river system is seen in the context of stream corridor as a complex of ecosystems which includes not only the river, but also the riparian zone with the species of plants and animals that inhabit this space. The river corridor is responsible for shaping the river bad, retaining the water and sediments, and also constitutes the support for creating a variety of habitats / microhabitats for communities of aquatic organisms underlying the assessment of ecological status of rivers. In this context, the paper presents hydromorphological indicators set identified in accordance with the requirements of the WFD and a hydromorphological classification system of rivers in five quality classes which should represent a scientific basis for the water monitoring and evaluation system and assists in a judicious way the decision makers to improve water quality in Romania.

**Keywords**: ecological status, ecological potential, hydromorphological indicators

## 1. INTRODUCTION

The "water quality" concept has performed in Europe for the last 20 years, starting with the assessment of the chemical water quality (organic pollution), and reaching to assess both chemically and biologically water quality. The Water Framework Directive (WFD/60/EC) has strengthened the need to broaden the perspective of the "quality" of water by its requirements relating to the assessment of "ecological status" and by using hydromorphological quality elements which together with the physico-chemical elements represent the main elements supporting the biological communities.

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In order to assess of rivers hydromorphological condition in the last few years have been developed several methods based on the WFD requirements (McGinnity et al., 2005), have been identified and used different hydromorphological indicators which accurately reflect the status of water bodies and enable the hydromorphological classification.

The paper highlights the need for a methodology for determining the hydromorphological indicators in order to assess the hydromorphological status of water bodies (rivers), which subsequently be integrated with biological, chemical (specific pollutants) and physico-chemical (temperature, oxygen, salinity, etc.) indicators, having the final goal the assessment of the ecological status as required by the WFD, being aware that the removal from the natural flow regime, urges the damage of aquatic ecosystems. At the same time, the paper presents the shortcomings of the current water quality monitoring system in Romania in terms of insufficient integration of biological, physico-chemical and hydromorphological components as well as the development of tools (indicators set) able to determine with highest confidence the water quality status. Also, in order to implement the WFD in Romania, the paper presents a set of indicators for assessing the hydromorphological status of water bodies (rivers) and a classification system in five quality classes. This method is intended to be a tool that can efficiently assist the policy makers on water management in Romania.

## 2. MATERIAL AND METHODS

In this approach the river system is seen in the context of stream corridor, as a complex of ecosystems which includes not only the river, but also the riparian zone with the species of plants and animals that inhabit this space. The river corridor is responsable for shaping the river bad, retaining the water and sediments, and also constitute the support for creating a variety of habitats / microhabitats for communities of aquatic organisms underlying the assessment of ecological status of rivers.

The rivers belonging to fluvial geomorphologic system has a morphological component and a "flowing" component. The first component express the relationship between shapes and variables, and the second component expresses the mass flow (sediment and water) and energy. The geomorphological processes rise to the creation of habitats, habitats that are occupied by living aquatic communities underlying the biological assessment of rivers. Considering the hydromorphological characteristics (called physical by some authors) can be done having regard to the four major interrelated themes: liquid flow - solid flow - morphology - connectivity, all leading to habitats.

In order to assess the hydromorphological status of rivers the Water Quality Standard (SR EN 15843/2010) recommends taking into account the following elements: riverbed geometry (shape in plan and cross section); substrate (volume of allochthonous material, mixture of substrate); riverbed vegetation and organic deposits; erosion; impact of artificial structures; modification of the river banks; adjacent land use; the degree of lateral connectivity; the degree of lateral change of river bed. In order to assess the hydromorphological status of water bodies all the elements listed above, and other parameters were analyzed and have been proposed their quantification as hydromorphological indicators.

The assessment of hydromorphological state of water bodies starts from the idea that they are in the natural status in terms of hydrological, morphological and minor river bed configuration, transversal and longitudinal processes of the channel, the continuity bed or banks and lateral mobility, riparian zone and lateral connectivity. As a result of human activities the naturalness of the river is affected, especially several parameters that characterize the natural status and the magnitude of the changes are severe.

In order to characterize the hydromorphological status of water bodies has prepared this assessment expressed by the indicators which were given scores as numbers, with positive values for the natural status and penalties for any anthropogenic intervention. Penalty values are the higher since the degree of damage of parameters is higher. Also, to provide these scores were taken into account the place and the role which the affected parameter has in the development of the river to a state of dynamic equilibrium. Thus, the higher penalties were given to flow modification, the riverbed morphology and longitudinal continuity.

In granting scores were taken into account the following considerations:

- Under natural conditions streams have the tendency to provide a relatively stable combination between the different variables which are specific to them. There are two types of variables: independent or control variables and the dependent or response variable. As independent variables, two are fundamental and determines the natural fluvial dynamics: liquid flow and solid flow. As dependent variables which shaping the riverbed morphology to be proper for optimal transit of liquid and solid flows are considered to be the riverbed geometry, velocity, sinuosity, and the average diameter of the particles of riverbed.
- An overwhelming role in the development of the river hidrogeomorphology plays the liquid and solid flow including the relationship between river channel and floodplain (floodplain) that influence the maximum flow.

## 3. RESULTS AND DISCUSSIONS

The assessment is based on consideration of three groups of parameters for which were given conventionally the following scores: ***hydrological regime*** - 90; ***channel morphology and platform naturalness*** - 60; ***riparian corridor characterization*** - 60. The classification system into five classes is based on the percentage of the maximum score attributable to each class as can be seen in Table 1.

Considering those mentioned above results the following classification of hydromorphological status of rivers can be made (Table 1).

*Table 1. Total and partial scores for each section of the index and hydrogeomorphological quality classes*

| Class | | Percentage (%) | Characterization of hydrological regime | Characterization of minor the riverbed and of the river banks | Riparian corridor characterization | Hydromorphological status |
|---|---|---|---|---|---|---|
| class I | Very good | 81 - 100 | 73 - 90 | 47 - 60 | 47 - 60 | 170 - 210 |
| class II | Good | 61 - 80 | 55 - 72 | 37 - 46 | 37 - 46 | 128 - 169 |
| class III | Moderate | 41 - 60 | 37 - 54 | 25 - 36 | 25 - 36 | 86 - 127 |
| class IV | Poor | 21 - 40 | 19 - 36 | 13 - 24 | 13 - 24 | 44 - 85 |
| class V | Bad | 0 - 20 | 0 - 18 | 0-12 | 0 - 12 | 0 - 43 |

We are mentioning that the hydromorphological assessment of rivers will be done at water body level. In special cases, when the water body is too large, it will be split into several sectors after hydromorphological criteria, respectively river slope, elevation, flow, form and the limits of the valley, bed morphology, the size of the floodplain, the continuity of the riverbed, the banks material, riparian corridor continuity, etc.

In the following will be present brief explanations on determining hydromorphological indicators.

## 4. CHARACTERIZATION OF HYDROLOGICAL REGIME

### 4.1. Liquid flow naturalness (deviations from the natural state)

In order to characterize the liquid flow naturalness is necessary to know the following data: liquid flow hydrograph under natural regime, expressed in average monthly flows; seasonal monthly average flows used by hydroelectric plants; active storage of reservoirs, inactive storage, flood storage and total storage; average flows catch from the river; average multiannual liquid stock in dam location or water intake discharge; average multiannual river discharge in the dam location or water intake discharge.

Once these data are known, the correct scores expressing the deviation from the natural dynamic liquid flow is very simple to give.

In the case of reservoirs with high volumes with use exclusively or mainly hydropower, equipped with large installed hydroelectric flow and operating according to the rules required by the National Power Dispatch can be a reversal of the seasonal hydrological regime.

### 4.2. Sediment supply and mobility

This indicator expresses the influence of hydrotechnical works on the creation and transport of sediment. It is reminded that the sediments are coming from surface soil erosion and riverbed erosion.

The main works that modify the creation and transport of sediments are soil erosion control works in forestry and agricultural heritage, fighting dams torrent from the river basin.

The main criteria to granting the scores is the percentage of surfaces with soil erosion control works from total river basin of surface (or total water body surface) in the control section located at the downstream of water body, or for dams and sill with the capacity of sediments retention in tributaries, is taking into consideration the percentage of river basin of surface in the dam section or the sill from the total river basin surface in the section from downstream of the water body.

Another anthropogenic activity that influences the creation and transport of sediments is the extraction of mineral aggregates either in organized gravel pits or dredging. The criterion for granting penalty points is the aggregate annual volume extracted, more or less than 50,000 $m^3$.

The alteration of creation and transport sediments can be caused by artificial paving of minor riverbed, recessed bottom sill, the existence of reservoir sediments retention and some works to reduce energy and water current strength (reducing the depth of water, slope, etc.).

An important part in the creation and transport of sediments are the hydrotechnical works build on tributaries that flows directly into the studied water body, works situated at a distance of up to 5 km upstream of the confluence.

### 4.3. Floodplain functionality

This indicator measures the floodplain changes as a result of human actions and therefore the floodplain can no longer fulfill its natural functions of flood prevention, of taking silt and energy dissipation current. To assess this indicator is necessary to know the length and width of the floodplain and also the existing obstacles (embankments, railway communications, dams subdivision, etc.).

It is also necessary to know land use within the floodplain and especially the presence of dams, their length, the continuity or discontinuity of them, their location from the edge of the minor river bed.

Floodplain can be frequently flooded (every 3-4 years) or occasionally (every 10-20 years).

To determine this indicator, it is considered the situation in which the floodplain is frequently flooded and in this case is determined the width and length. Frequently flooded area in its natural state is determined from the plans, orthophotos and flood hazard maps. If such documents are not available, it is acceptable that the floodplain potential width at flow with the rates of return of 3-4 years is four times the width of the minor riverbed (the minor riverbed corresponding to bankfull discharge.

A key role in the floodplain functionality modification has the dikes located on one or both side of riverbanks which can be continuous or not. It is also very important the location of dykes from the riverbank, the dykes continuity and their summed length compared to the length of the floodplain.

## 5. CHARACTERIZATION OF CHANNEL MORPHOLOGY AND RIVERBANKS

### 5.1. The naturalness of channel morphology and its configuration

This indicator aims to assess the removal of the natural state of minor riverbed due to more or less severe changes, consisting of riverbeds deviations, riverbeds closures, artificial filling of abandoned riverbeds, reducing the number of arms of braided riverbeds.

The reference element in quantifying these influences is the length of these works percentage of the total length of the water body.. For example, is measured the length of riverbeds deviations, riverbeds closures, corrections of alignment of the riverbanks, arms of braided riverbeds, classified as changes category in the table and in relation to the length of the water body is given appropriate penalty points.

### 5.2. The riverbed continuity and the naturalness longitudinal and vertical processes

This indicator estimates the degree of cross section alteration, the continuity of the riverbed, etc. due to the existence of sills, water retention dams, bridges, etc.

In assessing this indicator are essential the length of water retention, the existence or not of silt washing openings, depending on which are awarded appropriate penalty points.

The reservoir length and weirs means the length at the normal water levels.

For infrastructure such as bridges over water courses, weirs, it is considered the number of these obstacles per kilometer of riverbed.

This indicator involves an assessment of the minor riverbed topography, its shape, the morfometry of riverbed materials, vegetation and the extraction of building materials is estimated as lengths and relates to the length of the water body.

### 5.3. River banks naturalness and lateral mobility

This indicator aims to outline the constraints in the natural evolution of the river banks and the dynamic of river bed, constraint generated by channeling the riverbed, banks protection, etc. All these constraints are quantified as length and are depending on the length of the water body when awarded appropriate penalty points are.

## 6. CHARACTERIZATION OF RIPARIAN CORRIDOR, THE STRUCTURE AND ITS NATURALNESS

An important role in the river ecosystem plays the riparian area (the area near the river banks). Riparian area may be part of the floodplain, but has a minor role in the hydrological dynamics instead, is a natural biofilter that protect aquatic ecosystem from diffuse pollution due to runoff, excessive alluvium or erosion. There are many definitions for this area. Of these more appropriate to the goal of this paper is the one given by U.S.D.I. Fish and Wildlife Service (1997): *"Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have one or both of the following characteristics: (1) distinctly different vegetative species than adjacent areas, and (2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland."* The width of riparian areas is not easy to be determined that is why some authors (Spackman and Hughes, 1995) believe that their potential width is estimated between 10-30 meters and even 100 meters.

Riparian vegetation is not structured coincidentally. It is arranged in three parallel groups, each containing species adapted to the specific humidity and an atmosphere region as follows:

- ***Zone 1*** **-** starts from the water's edge and populated by emergent aquatic macrophytes represented by aquatic species plant (cattail, bulrush, reeds). These plants have a deep and strong root that stabilizes river banks from erosion and is a critical element in the process of groundwater recharge. Estimated width of this zone is 5-10 m;
- ***Zone 2*** **-** is in the wet field, usually near the river bank and is populated by bushes, trees and herbs and humidity tolerant plants. The width of this zone is estimated at 15 to 25 m;
- **Zone 3 -** is a mixture of riparian plant species and terrestrial species belonging to upland area. It is placed in a dry land where riparian zone merges with riverane zone, its potential width being estimated about 6-10 m.

### 6.1. Longitudinal continuity of riparian vegetation

Characterization of riparian corridor starts from the idea that in the natural status it was continuous over the entire length of the water body, located on both sides of the minor bed according to the geomorphology of the valley, but due to anthropogenic interventions corridor became discontinuous, whole areas being affected by urbanization, infrastructure, resulting a series of discontinuities with major effects on the biological role of this corridor (EPA 1999; Gurnell, 1997; Hanson et al., 1990; Lovell and Sullivan, 2005; Merritt et al., 2000; Robertson and Rowling, 2000). The assessment criteria of naturalness riparian corridor is the riparian corridor discontinuities length of total water body length.

### 6.2. The width of riparian corridor

This indicator relates how the riparian corridor currently keeps potential natural width. When the width of the riparian corridor potential is in its natural status cannot be determined, it is acceptable that is about 30-40 m. Removal of the natural status of this indicator is estimated by the existing width ratio of riparian corridor to the potential width.

### 6.3. Structure, naturalness and cross connectivity of riparian corridor

This indicator assesses the changes of vegetation, habitats and species diversity due to human activities. The clump of riparian vegetation and riparian zone quality is assessed by the disturbance and the lack of lateral connectivity of the riparian corridor.

## 7. CONCLUSIONS

The hydromorphological indicators set and the hydromorphological classification system of water bodies are based on similar systems used in some european countries. The system is not perfect. Thus, in 2014, the indicators will be tested on 80-100 of representative water bodies for each river basin and depending on the results, the proposed method will be finalized and will be applied at the national level in order to integrated assessment of water bodies ecological status in Romania.

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