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ASSESSING THE PHYSICAL QUALITY OF THE COȘUȘTEA RIVER USING THE QUALPHY METHOD

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Abstract. – Assessing the physical quality of the Coșuștea river using the Qualphy method. In the context of Water Framework Directive requirements, stressing the importance of the hydro-morphology in river quality assessment and restoration, this paper aims to evaluate the physical quality of Coșuștea River (located in southwestern Romania) by using the Qualphy method (developed by the Rhin - Meuse Water Management Agency, France, 1992). The quality specific indices for the Qualphy method were calculated for three sections (Nadanova, Şişeşti, and Corcova). The information resulted from the field measurements and observations was processed with the Qualphy software, revealing, for each of the selected sections, the hydrological, geomorphological and ecological status for the three specific Qualphy sub-indices (corresponding to the riverbed, riverbanks and floodplain) and finally, the Global Qualphy Index (GQI) was calculated for each section. The GQI for the three analyzed sectors (60 % at Corcova, 70% at Şişeşti and 74% at Nadanova) showed that the physical quality of the Coșuștea River belongs to fairly good quality class, excepting Corcova section, where the GQI indicates a moderate to good quality state. The Qualphy index for the riverbed, at Corcova and Șișești, showed fairly good quality, while at Nadanova, the quality is moderate to good. For the riverbanks, the Qualphy index indicated a moderate to good quality at all the analyzed sections. Regarding the Qualphy index for the floodplain, its values showed a moderate to good quality at Corcova and a very good quality at Șișești and Nadanova.

Key words: Coșuștea River, floodplain, Qualphy method, riverbank, riverbed, river physical quality.

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1. INTRODUCTION

Assessing the physical quality of rivers is increasingly important nowadays, in the context of river restoration projects (Rhin-Meuse Water Agency, 2000) and within the Water Framework Directive requirements. Natural and anthropogenic disturbances that may arise in a river's geomorphological system frequently change its physical parameters, generating many consequences, such as: diminution or isolation of wetlands along the river, changes in the morphology and state of the active and nonactive channels (that can no longer accommodate fish populations), re-adjustments in the shape of riverbeds and their capacity for dissipating water during floods (Bravard & Petit, 2000; Cogels *et al*., 2004).

There are many methods for assessing the physical quality of rivers, which specifically target hydro-geomorphological and fish habitat characteristics (Raven *et al*., 1998; Degiorgi *et al*., 2002; Verniers & Peeters, 2013). For example, the River Habitat Survey (RHS), is one of the most commonly used methods for evaluating both the physical characteristics of a river and the quality of its habitats (Raven et al., 1998). It is worth noting that RHS has been developed primarily as a tool used by the Environment Agency of UK in conservation and restoration activities of wildlife habitats situated along rivers and in their floodplains. The main goal of RHS is to give those responsible with river management, the information necessary for maintaining and increasing biodiversity, by using two main tools: catchment management plans and environmental impact assessment. The RHS system relies on a wealth of data generated by a major baseline survey of rivers and streams located across the United Kingdom and on the Isle of Man ((Raven *et al*., 1998).

In France and Belgium, a methodology for rivers' physical quality assessment was developed within the Walphy LIFE environment project, whose objective was to evaluate the physical quality water bodies downstream certain rivers belonging to Rhin-Meuse hydrographical system (such as the study of Bocq River which stretches from the confluence with the Petit Bocq to the confluence with Meuse River, over a length of about 23km, or the example of Eau d'Heure upstream Silenrieux) (Van Brussel, 2005; Hecq, 2007; Peeters & Verniers, 2009; Peeters *et al*., 2012). Therefore, assessing the quality of the physical components of a river by measuring their degree of alteration compared to a reference state through the Walphy methodology can be considered as a decision tool for the choice of strategic river restoration and management plans (Peeters et al., 2012). Within the Walphy project, two main methods for evaluating the physical quality of rivers were developed: Qualphy and Teleos.

This paper aims to assess the physical quality of Coşuştea River (located in south-western part of Romnania, in Oltenia region) through the Qualphy method, applied in three representative sectors of the river. This method was developed by the Rhine-Meuse Agency for Waters and designed on the principle of comparing a watercourse's geomorphological reference state with the category where it belongs. It is based on determination of a composite index (Qualphy index) integrating many indicators and subindices. We consider that this is an innovative research, because it is the first attempt to apply the Qualphy method in Romania. Withal, up to now, the physical quality of the Coşuştea River has not been assessed. Relevant for the general physical-geographical knowledge of the Coşuştea watershed are the contributions of several authors, whose studies concerned the northwestern part of Oltenia Region, where this catchment is located: Şchiopoiu (1982), Tomescu (2004), and Ionuș (2011). Important information on the morphometrical and hydrological features within the Coşuştea River basin, as a stand-alone entity or as part of larger watersheds of Motru and Jiu rivers including it, can be found in studies published by Ionuș (2011) and Savin (2006).

2. STUDY AREA

The study area corresponds to the Coşuştea River watershed (extended on 449 km^2), located in southwestern Romania (Fig. 1). Coşuştea River (77 km in length) is a first order tributary of the Motru River (Fig. 1) and a second order tributary of the Jiu River, the most important tributary of the Danube River in southwestern Romania. The multiannual average discharge of the Coşuştea River is about 2.6 m^3/s (at Corcova gauging station).

From a hydro-geographical point of view, the Coşuştea River watershed can be divided into two sectors, an upper karstic sector and a lower, much larger one, belonging to the Getic Piedmont. The choice of the study section for river quality assessment can be a delicate operation, as it must be representative and also homogeneous for the river basin (Guyon et al., 2005; Van Brussel, 2005; Hecq, 2007). By homogeneity, Peeters & Verniers (2009) understand the framing of that sector or segment in one class typology in terms of hydrological regime, morphology of the riverbed and slopes, land use, types of soil and rocks encountered, as well as the functioning of the watercourse.

Following the Qualphy preliminary procedure in the study area, three homogenous sections (sectors), located in the upper, middle and lower course of the Coşuştea River were selected for applying the method, respectively: Nadanova (270 m length, at about 21.6 km distance from Șișești village), Şişeşti (210 m length, at approx. 17.5 km distance from Corcova village) and Corcova (170 m length, at 2 km distance from the confluence with Motru River). They were selected primarily on the basis of their location in close proximity to the hydrometric stations Corcova and Şişeşti and the water quality monitoring station (Nadanova section). Two types of morphological sectors were identified in the three selected sections, generally corresponding with the geomorphological characteristics of the area: types T3 (corresponding to piedmont rivers), in the sections Corcova and Şişeşti, and type T5 (corresponding to meandering rivers of the karst plateaus) at Nadanova section (according to Peeters et al., 2013).

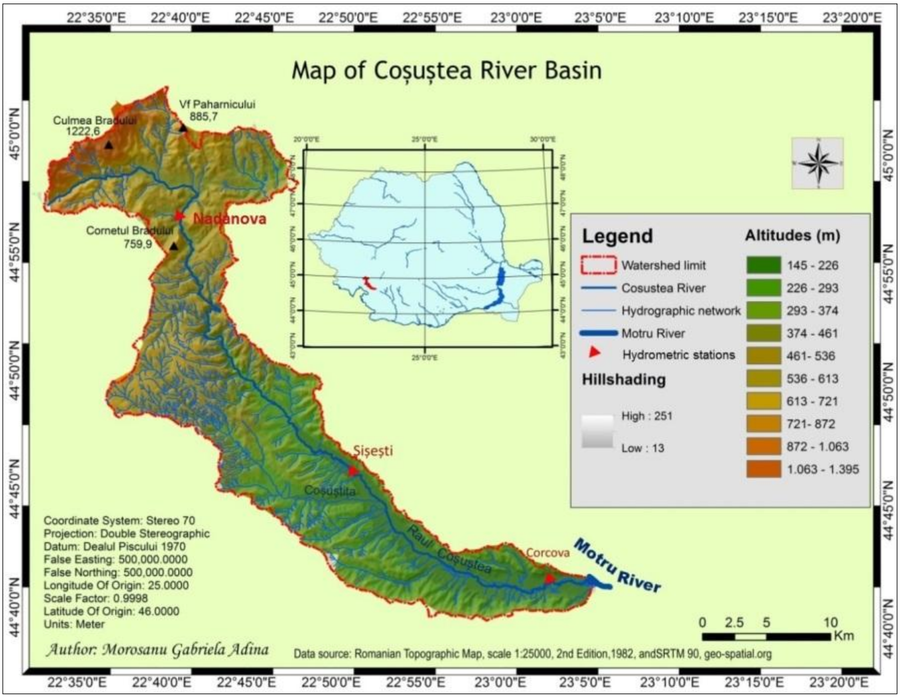

Fig. 1. Coşuştea River watershed and the location of the analyzed sections: Nadanova, Şişeşti and Corcova

3. METHODOLOGY

The study is based on the application of the Qualphy method, designed in France (in 1992), by the Rhine-Meuse Water Management Agency, for assessing the physical quality of rivers. It succeeds in optimally integrating the components of the river physical environment, and is remarkable due to its structure and operating mode (Verniers & Peeters, 2013). Because of the interest it enjoys, Qualphy has become a reference point in the creation of systems aimed at evaluating the physical quality of water (Hecq, 2007; Peeters *et al*., 2012). The Qualphy method is based on comparing a reference type with an observed situation (Peeters *et al*., 2009). The physical quality of the environment used as a reference is that of a watercourse that exhibits a form and a state that are entirely natural, with no man-made interventions. This tool considers the functioning and the natural dynamics of a watercourse by integrating its three main components – the floodplain, the riverbanks and the riverbed (river channel) (Cogels *et al*., 2004). Briefly, Qualphy method is defined by four fundamental principles (Peeters *et al*., 2012):

- classifying watercourses according to a physical typology that allows the assessment of the natural state of several variables and the weight of each one in the specific watercourse type;
- the division of the watercourse into homogenous sectors;
- the description of resulting sectors through a chart where qualitative variables are recorded.

The functioning of the Qualphy method requires to respect a general workflow (Fig. 2) with some specific features for this scientific approach.

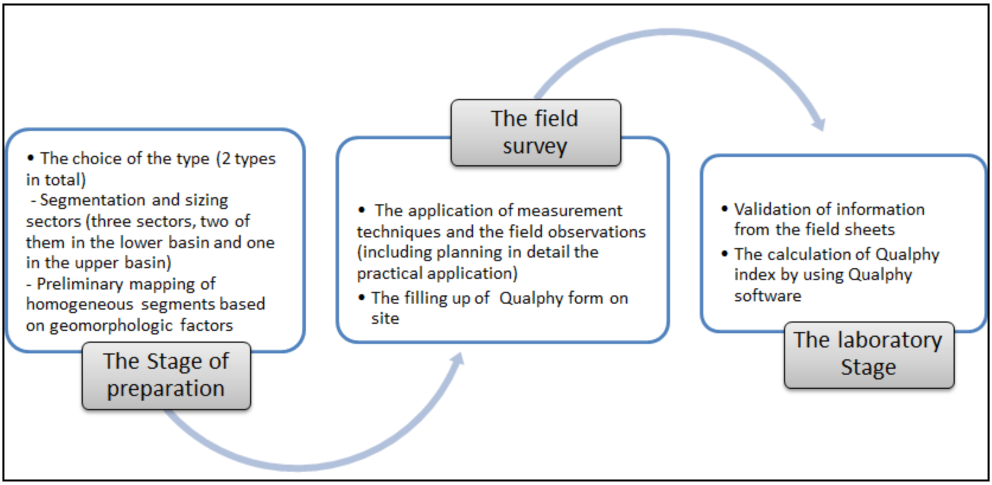

Fig. 2. The general workflow of the Qualphy method

In this study, the first step consisted in the segmentation and sizing of the three above mentioned sections (sectors), followed by a preliminary mapping of homogeneous segments based on geomorphologic factors. After obtaining homogenous sectors, they could be evaluated in terms of their internal properties by means of a field form that includes around thirty variables, mostly quantitative, which describe the state of the floodplain, the riverbanks and the riverbed. Variables targeting the floodplain have both morphological and hydrological nature, those concerning the riverbanks are mostly hydrological, and also target bank structure and vegetation, while those related to the riverbed follow three types of criteria: hydrology, longitudinal continuity and riverbed morphology.

From the total of about 40 sets of observations, most of them were established on the field, while few others were discussed and indirectly interpreted according to the field observations and measurements. They were integrated in 8 sub-indicators which led to the estimation of the Qualphy indices for each of the three compartments of the river valley, the floodplain, the riverbanks and the riverbed (Fig. 3). Finally, the Global Qualphy Index was calculated, as a weighted average of the typological variables' values calculated for the three compartments of the river valley. Values are ranked and take the form of a tree structure that allows a simple handling of data in the software. Coded data, of a quantitative nature, can be turned by the computer into qualitative values, such as percentages, where lower values reflect detrimental situations. The calculations are made by using the Qualphy.DAM software.

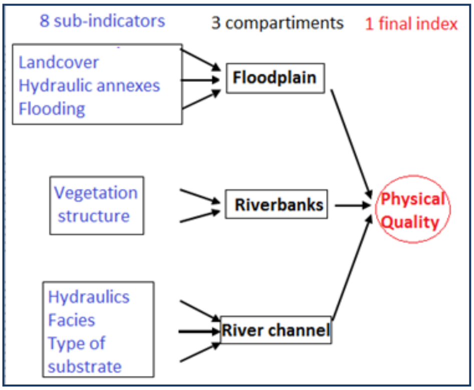

Fig. 3. Calculation scheme of the Qualphy Index

4.RESULTS AND DISCUSSION

4.1. General data on the analyzed sectors

Although not integrated in the calculation algorithm, the Qualphy software requires some information on the studied sections, as the location of the sites, the slope, the width of the riverbed and the length of the sites, etc. (Table 1), as well as the time/date when the measures and observation were performed (on 6 - 7 May 2015, in this case).

A necessary information is the *river typology*. It concerns the shape of the riverbed, which can be symmetric or asymmetric on the one hand, or flat-bottomed, V-shaped or U-shaped on the other. Accordingly, the major functional types of alluvial beds were grouped by the fluvial eco-regions established by Wasson *et al.*, 1996, quoted by Heidemann (1997). In our case, the shape of the river bed was determined visually and cartographically, by taking into accounts both the riverbed and its connectivity with the riverbanks, the floodplain and the slopes, which allow us to assess the valley's influence over the water levels during flash floods, and also the phenomenon of divagation.

Table 1. Morphometric data of the three analyzed sectors on Coşuştea River

Parameters	Corcova	Șișești	Nadanova
Average altitude (m)	154	204,2	401
Length (m)	170	210	270
Width of the riverbed during average waters (m)	19,2	12,4	6,6
Width of the riverbed during high waters(m)	25,3	25	10,7
Slope (‰)	0,5	0,7	0, 2
Slope class	Very low	Very low	Very low

The Corcova sector was classified as an asymmetrical valley type, with a flat bottom, because the floodplain is more developed on the right side and narrower on the left, towards the row of houses located at the foot of the hill. At Șișești, the ratio between the width of the flood channel on the left side and on the right side is almost equal to 1 (symmetry), whereas the bottom of the riverbed is also flat. At last, at Nadanova, the riverbed is again asymmetrical: more developed on the right this time, with a narrower left side, and the valley bottom is flat.

The three studied sectors belong to different typologies, depending on whether they are located in the lower part of the basin, in a plateau region, or in the upper area, developed on limestone relief. Thus, the Corcova and Șișești sectors, in accordance with their geomorphologic and geological features, belong to the plateau and glacis watercourses, and the Nadanova sector fits into the category of rivers flowing at the base of limestone and marl-limestone plateaus. The specificity of the typology assigned to each sector will be essential for calculating the final weights of the parameters defining the Qualphy Index.With regards to the path of the river channel, and the presence or absence of natural hydraulic annexes, canals, islands, or dead arms, the results of our evaluation (expressed in percentages) were synthesized in Table 2.

Table 2. Data (in %) on theCoşuştea riverbed at the analyzed sections

Data	**Corcova**	**Șișești**	**Nadanova**
Straight or almost straight	0	100	95
Sinuous or curved	100	0	5
Very sinuous	0	0	0
Islands and arms	-	30	-
Accumulation of materials transported by the river	40	50	10
Losses and resurgences	No	No	No

4.2. Assessing the floodplain

For floodplain evaluation, we have analyzed four aspects reflecting the way in which the floodplain was modified or influenced by human intervention: land use, communication routes, hydraulic annexes and flooding potential.

Land use (quantified for both banks as a whole) distinguishes between natural categories (wetlands, abandoned land colonized by spontaneous vegetation, forests, bushes or grasslands) and human influenced categories (farmland, orchards, gardens, parks and other types of green spaces, artificial canals, urbanised areas, sand and gravel exploitations, dykes and man-made structures built in order to protect against water etc.). The field observations are synthesized in Table 3.

Table 3. Land use on both banks of the Coşuştea River at the analyzed sections

Land use	Corcova		Șișești		Nadanova	
	Dominant	**Present**	**Dominant**	**Present**	**Dominant**	**Present**
Natural	Pastures	Bushes	Pastures	Bush	Pastures	Forests
Artificial	Farmland	Sand and gravel exploitation, flood protection works	Farmland and urbanized areas	Farmland and gardens	-	Urbanized areas

The inventory of *communication infrastructure* and their locations is justified if we take into account the disturbances they can cause when such structures cross the floodplain and the river channel. The field observation on the communication infrastructures is synthesized in Table 7 and showed in Fig. 4.

Table 4. Information on the communication infrastructure which can influence the natural water flow during floods on Coşuştea River at the analyzed sections

Corcova	Șișești	Nadanova
Parallel to the floodplain at its extremity Crosses the riverbed without an embankment (there is a small bridge) - *DJ 671E and DJ 61* Along the low flood plain or tangent to it, built on a parallel embankment for almost the entire length of the sector	Parallel to the floodplain, at its extremity (*DJ 671A*) Crosses the riverbed, without an embankment (there is a small bridge) There are structures, represented by a transversal embankment (road, bridge, railway line) The chosen sector is bordered by two bridges, upstream there is a concrete road bridge and downstream there is a wooden bridge, used for hydrometric measurements and observations.	Parallel to the floodplain, at its extremity, there is a road along the base of the slope.

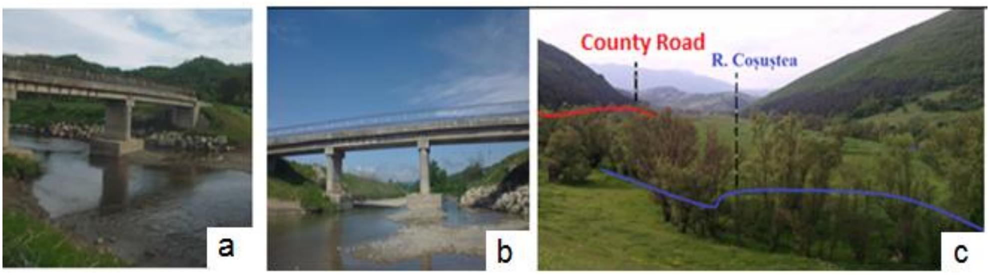

Fig. 4. Communication infrastructure (bridges and roads) at Corcova (*a*), Șișești *b*) and Nadanova (*c*)

The third set of observations was represented by the choice of connexion and influence (positive or negative) between the *hydraulic annexes* and the riverbed. By ”hydraulic annexes”, one should understand any fluvial micro-relief form, temporary, permanent or absent (canals, dead arms, secondary arms etc) with which the river can communicate and have hydraulic exchanges (Peeters *et al*., 2012).

According to field observations and older aerial maps (2005, 2013), we have identified an entirely natural situation in the Șișești and Corcova sectors, determined by the absence of any hydraulic annex. In Nadanova sector, a non-disturbed and natural situation, characterized by the presence of old river arms, silted and covered by vegetation, but still capable of activation during strong floods, was found.

The last parameter characterizing the floodplain was the *flooding potential*, analysed from the perspective of flood protection works. Thus, for the Corcova sector, we have estimated a 50% lower flood potential (in terms of frequency and affected area), due to the presence of dykes and embankments. At the same time, the percentage of the sector's length that is covered by flood protection works is estimated to be around 100%, and, in terms, or area occupied, 5% (the surface occupied by dykes and embankments). In the two other sectors (Șișești and Nadanova), we have found a normal situation, represented by a state of the river that has not been modified or is naturally flooded.

4.3. Evaluating the riverbanks

In a morphological river system, the banks play a relevant role because of the connection they establish between the floodplain and the riverbed through their specific vegetation, and also because they are subject to the permanent dynamic induced by the erosion and accumulation processes. At the same time, the river's freedom space is limited by its banks, which gain a function in the river's dynamic (Schumm *et. al.*, 1987). Qualphy method consider as features for river quality assessment, the riverbank height, slope, nature, dynamics and vegetation. In Table 5 the data on riverbanks height and slope are included.

Table 5. Height and slope of riverbanks in analyzed sectors on Coşuştea River (Dom = dominant; Sec = secondary)

Parameter	**Corcova**				**Șișești**				**Nadanova**			
Height (m)	1-2				2-3				1-2			
Slope (°)	MS		MD		MS		MD		MS		MD	
	Dom.	Sec.	Dom.	Sec.	Dom.	Sec.	Dom.	Sec.	Dom.	Sec.	Dom.	Sec.
	30-70	5-30	30-70	5-30	30-70	>70	30-70	>70	>70	30-70	>70	30-70

The nature of the riverbanks was assessed through the size of the composing gravel and rocks, whereas for the types of banks, the natural and man-made forms were accounted (Table 6). Some examples of the riverbanks natures from Șișești and Nadanova sectors are illustrated in Fig. 5:

Table 6. Nature of the riverbanks in analyzed sectors on Coşuştea River

	Corcova		Șișești		Nadanova	
	Dominant	**Secondary**	**Dominant**	**Secondary**	**Dominant**	**Secondary**
Right Bank	Sand	Clay and vegetation	Vegetation	Stone blocks (Fig. 5.a.), gravel, soil	Clay	Clay and vegetation
Left Bank	Sand	Clay and vegetation	Clay	Vegetation and wood bundles (Fig. 5.b.)	Roots (Fig. 5.c.)	Clay and vegetation

Fig. 5. Nature of the riverbanks: a. Stone blocs on the left bank of the Șișești sector; b. Wood bundles used to consolidate the banks at Șișești; c. Tree roots on the left bank of the Nadanova.

With regards to the riverbank dynamics, we have approximated the length of eroded banks and of accumulation banks (Table 7).

Table 7. Data on riverbank dynamics in analyzed sectors on Coşuştea River

Aspects	**Corcova**	**Șișești**	**Nadanova**
Dynamics	This is mostly an accumulation bank, with vertical instability in patches because of erosion.	Vertical erosion and alternating accumulation banks (Fig. 6.a.) Occasionally, the evolution of the riverbanks is blocked (banks are stabilised and isolated from the riverbed with sandbags– *Fig. 6.b.)*	Naturally stable banks
Importance of the erosion	Localised erosion of average importance	Generalised erosion (*Fig. 6.a.*) of great significance in the river's dynamics, creating a functional border for the riverbed.	Weak
Origin of perturbations	Progressive erosion combined with the impact of animal herds	Progressive erosion	Very weak erosion

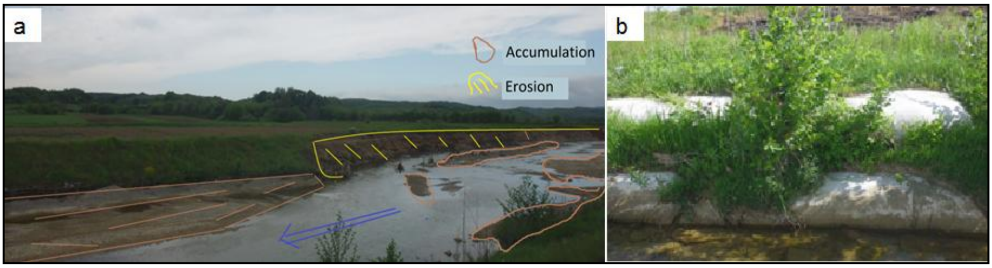

Fig. 6. Riverbank dynamics at Șișești: a. Alternating eroded and accumulation banks; b. Sand bags used for stabilizing the banks (left bank).

With regards to the extent of the erosion, significant part of the right bank was separated after the floods that occurred in the summer of 2014, which widened the riverbed by more than two meters and created a stronger current.

Due to the fact that the vegetation that covers the banks influences river processes and limits erosion, it is considered to form a buffer-zone with a specific plant composition, different from that of adjacent areas (Dackcombe & Gardiner, 1983; Guyon *et al*., 2005). The role of vegetation is thus to create and maintain a buffer-zone between the river's ecosystem and the areas affected by human interventions located in the flood channel and on the river terraces (Van Brussel, 2007). Also, plants moderate the effects of floods, by storing excess humidity (Peeters *et. al*., 2009).

In addition to specific plant types found on riverbanks, the Qualphy field form requires the assessment of the importance of trees and forests located on the river's banks in terms of the shadow they offer for the riverbed. According to Peeters *et. al*. (2013), approximating the degree of shadow must be done at noon, when the Sun is at its zenith and theoretically, in the absence of clouds and shadow provided by plants, it is capable of lighting the entire water surface. In Table 8, we have synthesized the data on vegetation and its role for the riverbanks and the aquatic environment.

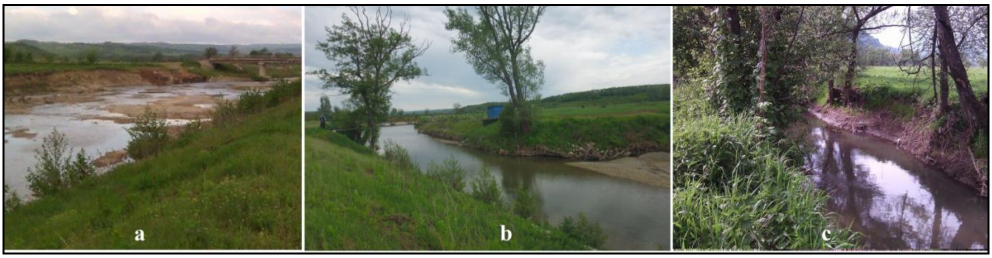

Fig. 7. Vegetation on the riverbanks of the Coşuştea River. *a*. Corcova; b. Șișești and c. Nadanova sectors.

Table 8. Information on bank vegetation in analyzed sectors on Coşuştea River

	Corcova	Şişeşti	Nadanova
Distinctive riverine vegetation	No	Yes, on the left bank No, on the right bank	Yes, well defined (Figure 7.c.)
Location of the vegetation band	-	Left bank– at the front of the bank and beneath it Right bank – only beneath the bank	On the bank's front and beneath it
Significance of the shadow provided by vegetation	10 %	On the left bank – 50% On the right bank – 10%	80 %
State of trees along the river	Suspended (unreachable for plants)	Wooded river vegetation, well maintained or without need for maintenance	Well maintained trees along the river or vegetation that does not require maintenance
Composition of the vegetation	Grassland (Fig. 7.a.)	Bushes on the left bank and no vegetation, or farmland, on the right one (Fig. 7.b.	Vegetation with three layers (trees and bushes) and, occasionally, grass.
Percentage of illumination of the water's surface	More than 75%	More than 75%	5 – 25%
Elements offering shade for the water	The valley and also the vegetation belt of the river	The river's vegetation belt	The river's vegetation belt

4.5. Evaluating the riverbed

In Qualphy methodology, the evaluation of the riverbed is based on aspects concerning the hydraulic characteristics of the river channel and its vegetation, which, if available and abundant, can provide a habitat for hydrophilic plants and animals.

The first analysed parameter was the *sinuosity coefficient*, defined as a ratio between the length of a river or river sector taken as a sinuous line, which includes meanders and curved sections, and its length in a straight line (Thorne, 1998; Bravard & Petit, 2000; Peeters *et al*., 2009; Ioana – Toroimac, 2009). Furthermore, the sinuosity coefficient is used to group the three sectors in classes based on their sinuosity index (Table 9). According to Cohen (2001), quoted by Peeters *et al*. (2009), $IS < 1.05$ is for a straight course, $1.05 < IS < 1.25$, corresponds to a sinuous course, $1.25 < IS < 1.5$, a very sinuous course and $1.5 <= IS$ corresponds to a meandering course.

Table 9. Sinuosity of studied sectors on Coşuştea River in analyzed sectors

	Corcova	Şişeşti	Nadanova
Sinuosity class	Sinuous (1.24)	Straight (1.02)	Straight (1.0008)

It is worth mentioning the connection between the sinuosity class and the analysis of possible sources of flow disturbance, caused by human intervention (changes in the hydrological cycle caused by micro-hydro power stations or localised small-scale alterations). In our case, we were able to determine normal flows in all three sectors, and no apparent disturbances. Nevertheless, from a general perspective on the sectors chosen at the beginning, (measuring 1-2 km), only Nadanova has a more or less straight course, because upstream (Șișești and Corcova) the river has strong meanders.

The next items concerned *the existence of artificial barrages* that could prevent the flow of water or the migration of fish. All three sectors have received the value “0”, as the river's cross-profile is not modified.

The following parameters have analyzed the conditions under which a sector or part of a sector can be fitted in a *facies*, defined as a homogeneous hydraulic sequence concerning the depth and the speed of the water and the width of the flow channel (Peeters & Verniers, 2009; Peeters *et al.*, 2012). Forwards, the proportion of each facies was calculated depending on the measured length of the portion exhibiting a certain facies, compared to the total length of a sector (Table 10).

The *nature of the riverbed* is established depending on the limits between the granulometric classes (Schmitt *et al.*, 2000; Peeters *et al.*, 2009). On field, we estimated the nature of the riverbed based on direct observation, and the results are presented in Table 11. For more accurate results it is recommended to use appropriate tools, as an aquascope or to proceed to granulometric measures (Peeters *et al.*, 2013).

Regarding to deposits on the riverbed, they were evaluated from the point of view of the manifestation and extent of silting, which is defined as a phenomenon involving the depositing fine materials carried by a running water, which leads to a gradual raising of the bottom of a basin or portion of a riverbed (Dackombe & Gardiner, 1983). The field evaluation has shown that, for the Corcova sector, localised silting deposits are a specific occurrence (0-25% of all silting), in Șișești there are localised non-silting deposits (0-25% of all silting), and in Nadanova there are generalised non-silting deposits (0-25% of all silting).

Table 10. Evaluation of the facies in analyzed sectors on Coşuştea River

	Corcova	**Nadanova**	**Șișești**
Depth	Less varied, flat bottom and localized deposits	Constant	Constant (aspect) and/ or less variable, or laminar flow
Flow variation	Constant (aspect) and/ or less variable, or laminar flow	Wavy (in surface) and/or taking the form of parallel or convergent streamlines	Varying (alternating short and long facies on a less than 100 m distance)
Facies weight	Chenal Lentique 0-10% Chenal Lotique - > 50%	Radier >50% Chenal Lotique 10 -50 %	Radier 10 -50% Chenal lotique > 50%
Width	Regular with acumulations and/ or with helophytes	Totally regular	Variable with accumulations

Table 11. Nature of the riverbed in analyzed sectors on Coşuştea River

	Corcova	Șișești	Nadanova
Type of granulates	Dominant – sand Secondary – gravel and clay	Dominant – gravel Secondary – boulders and sand	Dominant – sand Secondary – gravel and clay

In addition to inorganic silting (mineral), the Qualphy form also takes into account the possibility that the mineral substrata/sub-layer of the riverbed is covered with various materials, usually organic in nature (detritus, fallen trees, branches etc.). In our case, we noticed in the Corcova sector the occasional presence of such deposits, no such occurrences in the Șișești sector and in the Nadanova sector we observed floating branches from the thick belt of trees and bushes covering the banks.

We also assessed the aquatic vegetation, which plays a major role in the efforts to recreate aquatic habitats in France and Belgium, according to the standards established by the EU Framework Directive on Water (EU, 2000). Thus, for the Corcova and Șișești sectors, it was found that aquatic vegetation is very poorly represented or even non-existent, with no plant proliferation, and in the Nadanova sector, we could only find underwater roots and helophytes.

4.6.Calculating and interpreting the Qualphy index

The information presented in the previous chapters was introduced into the calculation algorithm of the Qualphy.DAM software, which determines the quality index for each sector and for all three compartments (floodplain, riverbanks, and riverbed) – the Global Qualphy Index. The data are introduced in the form of a tree structure which allows to eliminate a parameter if it does not have a purpose or to expand the tree with new branches, depending on the complexity of our input data.

The classification of water courses into typologies allows to evaluate the relative importance of each of the three main compartments and to have a global view on the physical quality of a river. For example, for the two typologies that correspond to the analysed sectors, the weights for the three compartments are presented in Table 12. It is noteworthy that, for each typology, the importance of the three compartments differs and this issue must be taken into account in the final calculation of the quality index.

Table 12. Relative importance (%) of the three main compartments of a watercourse (according to the typology proposed by Hecq, 2007)

Compartment	T3	T5
Riverbed	33,3	40
Riverbanks	33,3	20
Floodplain	33,3	40

The resulted indices showing the physical quality of Coşuştea River in the analyzed sections can be presented in a colour coded form, proposed by the methodology (Table 13).

Table 13. Values of the Qualphy Index (QI, in %) in analyzed sectors on Coşuştea River

Qualphy Indices	Corcova	Șișești	Nadanova
GLOBAL INDEX	60	70	74
Floodplain Index	60	86	93
Riverbed Index	62	64	50
Riverbanks Index	58	59	50

Yellow= moderate to good quality (QI = 41 – 60%); Green= fairly good quality (QI =61 - 80%);
Blue = very good quality (QI = 81 – 100%) (according to Peeters & Verniers, 2013)

The Global Qualphy Index (GQI) indicates generally fairly good quality of the analyzed sectors (GQI = 70% at Şişeşti and GQI = 74% at Nadanova), while at Corcova section, the GQI = 60%, showing a moderate to good quality state. Considering the compartments, there are some differences concerning the physical quality (Table 13). The floodplain Index highlights a moderate to good quality for Corcova and a very good quality for the upstream sectors, at Șișești and Nadanova.

The rivedbed is, nevertheless, quite poor for a river without major man-made works and hydraulic uses. At Corcova and Șișești, the results show fairly good quality (Riverbed Index = 62 – 64%), while at Nadanova, the quality is moderate to good (Riverbed Index = 50%).

As respects the Riverbanks Index, his values for the analyzed sectors range between 50% and 59%, indicating a moderate to good quality.

CONCLUSIONS

This paper aimed to assess the physical quality of Coșuștea River, based on the Qualphy methodology, developed by the Rhin - Meuse Water Management Agency (France, 1992). It was applied on three sectors of the Coșuștea River (Nadanova, Şişeşti, and Corcova) located in the upper, middle and respectively lower part of the river. The Qualphy methodology revealed the hydrological, geomorphological and ecological status for three specific Qualphy sub-indices, corresponding to the riverbed, riverbank and floodplain:

- the *iverbed Index* showed a slight variation, from fairly good quality state (at Corcova and Şişeşti), to moderate quality (at Corcova);
- the *Riverbanks Index* corresponds for all the analyzed sections to the same quality class (moderate to good);
- the *Floodplain Index* illustrated a very good quality at Şişeşti and Nadanova, and moderate to good quality at Corcova.

According to the overall score (Global Qualphy Index), Corcova sector fits the moderate to good quality class, while the sections Şişeşti and Nadanova fit the fairly good quality class.

Despite the subjectivity of handling the Qualphy software, limited to fewer details than the items on the field worksheet (form), the river quality assessment through Qualphy method proved to be enough suitable for characterizing the Coșuștea river from an ecological, hydraulic and hydro-morphological standpoint. Therefore, adapted and applied on a larger scale, the Qualphy method could be further used in the management plans of the Coşuştea River catchment and others watersheds in Romania.

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