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CHARACTERIZATION OF THE AQUATIC BIOTOPES OF THE SIRET RIVER AND PRUT RIVER IN THE CONFLUENCE AREA WITH THE DANUBE RIVER

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Abstract

Often, in the studies for the evaluation of fish stocks, the abiotic and biotic habitat characteristics of the environment are very briefly described, but a good knowledge of this environment is indispensable for the ecological interpretation of the observations made on fish populations and then for the development of appropriate management measures. The aquatic ecosystems investigated and described in the 4PS / 2017 project are presented in this paper, with the name of: the Danube Study Area (ZS Danube), the Siret Study Area (ZS Siret), the Prut Study Area (ZS Prut). The ZS Danube stretches between the confluence with the Siret River and the Bendul Cobului area. This sector has about 26 km long with an average width of 800 m, such that the total area covered is 20.8 km^2*. ZS Siret stretches between Sendreni village and the confluence with the Danube. This sector of approx. 12 km long, with an average width of 100 m, has a total area of 1.2 km2. ZS Prut, stretches between Cîşlița village and the confluence with the Danube. This sector of about 10 km long, with an average width of 50 m, covered a total area of 0.5 km*^{2}*.*

Keywords: banks, productivity, rivers.

1. INTRODUCTION

The river systems provide to people a large range of goods (fish, riparian forests, reed, potable water, irrigation and industry supply) and services (transharbor, energy, recreation) and a range of ecological services (floods, nutrients recycling, microclimate, biodiversity) (Naiman et al., 2002). The anthropic use of river systems with the purpose to maximize socio-economic services has led to the loss of more than 40% of ecosystem services, thus compromising their natural functioning and affecting 40% of the world's population by 2050 (Millennium Ecosystem Assessment, 2005) .

In the last few centuries, the river ecosystem is the subject of many conflicts of interest between energy gaining, transharbor, flood defenses, improving the water quality class and the ecological status of ecosystems, maintaining biodiversity. Good functioning of river systems and adjacent aquatic ecosystems is crucial to ensuring local ecological balance and human well-being. The implementation of measures leading to integrated management of activities and conflicts in the river system area requires a profound understanding of river processes, among these being the relationship between the dynamic characteristics of habitats and the dynamics of the biological community.

Many worldwide studies have demonstrated the imharborance of research to assess the characteristics of the river habitat for different objectives. According to given definitions, river

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habitats are local stretch of the river with physical, chemical and biological characteristics appropriate for the installation of river-specific living species (Jowett, 1997). The medium and long term monitoring upun the physical characteristics of river habitats has a standardized methodology at european level through the European Guideline for the Assessment of River Hydromorphological Characteristics (Diego et al., 2011). In addition of this standardization, there is a wide variety of methodologies for characterizing river habitats these satisfying different environmental objectives (assessment of river quality, ecological reconstruction of river, conservation of water resources, management of biotic resources, monitoring of connectivity, etc.). Depending on the environmental objective pursued, different habitat characteristics are assessed (Thomson et al., 2001; Raven et al., 2010; Robinson et al., 2013).

Methodologies for river habitat characterization differ mainly regarding four features: (1) the objectives for which they were designed, (2) the time required to apply them, (3) whether they measure the characteristics or evaluate them, (4) spatial measurement scales (Fernandez et al. , 2011). For rivers fish communities, the structure and composition of these communities are determined by the characteristics of the river habitats (Barquın and Martınez-Capel, 2011).

2. MATERIALS AND METHODS

In order to assess the current state of the fish populations and the diversity of the ichthyofauna in the aquatic ecosystems surrounding of the Galati town, in this paper were evaluated the conditions provided by the river banks in three study areas (figure 1). Thus, the three study areas were:

- The Danube River Study Area (Danube RSA): from the confluence of Danube River with the Siret River to the confluence of Danube River with the Prut River (km 150-Mm 60).
- The Siret River Study Area (Siret RSA): Lower Siret, from Sendreni village to Galati town, to the confluence with the Danube River.
- The Prut River Study Area (Prut RSA): Lower Prut, from Cislita village (Republic of Moldova) to Galati town, to the confluence with the Danube River.

Figure 1. Galati town and the surrounding rivers

Observations, measurements and samples were taken both on water and on land, during the three expeditions of May 11, 2018; June 7, 2018 and September 13, 2018, and covered a series of parameters that characterize natural and anthropic aspects offered by the banks for aquatic habitats.

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Danube RSA is a sector with a length of about 23 km, with an average width of 962 m. In this sector there are fishing patch suitable for a series of 5 piece gillnets (5 x 42 m = 210 m). Total, there are 16 such fishing patch used by authorized fishermen to carry out commercial fishing activities. From these fishing patch, at the decision of the scientific staff involved in the project, we selected two most imharborant patch for carrying out the habitat assessment, these patch namely the Mila 77 patch and the Mila 78 patch.

Siret RSA is a sector of approx. 8.6 km long with an average width of 113 m, but fishing with a 3 piece gillnet (3 x 42 m = 126 m) will be done in the harborions where the Siret River width is higher than of the average calculated for the entire sector. Using these dimensions, we calculate a total fishing area of 1512 km2, but from this area we selected the most two imharborant fishing patch, about 1 km long each of them. Specific to this area is the inclination of the slope from the north and northwest to the south and south-east, the reduced depth of the minor river bed with little obvious shores, very low slope below 0.52 meters/kilometer, strong meandering, course changes, presence of areas with excess humidity and specific hygrophilous vegetation. The banks with 2-3 meter high are sometimes affected by collapsing processes, and the sector located between 2 and 5 meters wide on both banks is slightly elevated and made of fine mud and sands, due to periodic floods (Rowater, 2016).

Prut RSA is a sector of about 13 km long with an average width of about 55 m, the width of the fishing patch is only enough for one fishing net (1x42m = 42 m). From this area, the scientific fishing activity was carried out on two fishing patch, about 2 km 1 km long each of them.

3. RESULTS AND DISCUSSIONS

Temperature and water levels in rivers are the most imharborant environmental parameters these ones determine the evolution of other physico-chemical and biological parameters of aquatic ecosystems. Recent changes to the hydrological regime of the river (caused by climatic and anthropogenic factors) affect the status of aquatic ecosystems in several respects (Gastescu and Țuchiu, 2015).

During land expeditions from: spring (May 11), summer (June 7), and autumn (September 13) of 2018 year, air temperature and water temperatures have normal values for these periods, the water level is lower than the average of these periods (table 1).

Table 1. Researched ecosystems and average values of temperatures and levels

Ecosystem	Danube RSA	Siret RSA	Prut RSA
Day	May 11,2018/ June 7, 2018	June 7, 2018	Sept. 13, 2018
Air temperature, Galati (^{0}C) (max./min.)	25/11 - 28/17	28/ 17	28 / 15
Water level (cm)	390 / 224	224	255
Water temperature, Galati (7,00pm)	19.9 /24	24	20,5
Water transparency (cm)	30-35/20-25 /	5-10	5-7

During the analyzed period (figure 2) the air and water temperature had a slow increase in the spring of 2018 and the summer temperatures of 2018 were significantly lower than the summer temperatures of 2017. The analysis of the water level in the same period (figure 3) shows that the spring flood of 2018 had moderate values at the beginning of spring (around 450 cm), a higher level of the 600 cm was made during a week at the end of April. In conclusion, these factors evolved without excesses and overtakes of the usual values.

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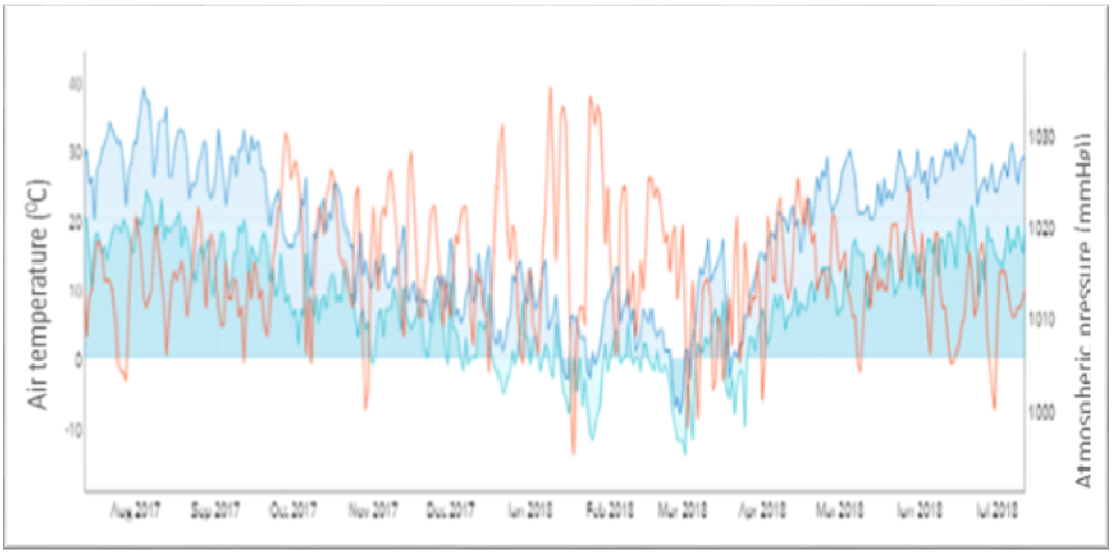

Figure 2. Variation of weather parameters in Galati during July 04, 2017 - July 12, 2018 (https://www.bendele-dunarii.ro/Galati)

Figure 3. Variation of water level (cm) and water temperature (0C) in Galati during July 04, 2017 - July 12, 2018 (https://www.bendele-dunarii.ro/Galati)

The condition of the navigable channel or of the minor river bed, through which small and medium-sized waters pass, was considered imharborant in assessing the potential of natural and fish productivity and as a consequence was assessed during field expeditions by evaluating two imharborant parameters the width of the minor river bed and the depth of the minor river bed, for Danube RSA (table 2), for Siret RSA (table 3) and for Prut RSA (table 4).

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Table 2. The width of the minor river bed of Dunbe RSA in June 7, 2018

Cod	GPS coordinates	Stage name	Width of river (m)	Length of left bank (m)
D1	45.468374, 28.219501	downstream Ostrov Prut	903	996
D2	45.468912, 28.206654	confluence r.Prut	1400	586
D3	45.468093, 28.199329	Ostrov Prut	1740	1550
D4	45.456767, 28.188411	upstream Ostrov Prut	1500	1400
D5	45.444019, 28.186057	downstream Bendu Pisicii	978	2710
D6	45.421692, 28.190023	beach Bendu Pisicii 2	748	905
D7	45.417585, 28.184516	beach Bendu Pisicii 1	844	1430
D8	45.423283, 28.167663	Zatun SA	720	2990
D9	45.440202, 28.136822	S.P.A Dunare	509	2230
D10	45.443539, 28.109084	harbor Bazinul Nou	618	2140
D11	45.440736, 28.082362	harbor Docuri	636	2360
D12	45.429134, 28.056549	Vega hotel	774	2260
D13	45.416477, 28.033549	float bridge	1050	1000
	The average width of the minor river bed of Danube RSA		961,46	Σ = 22557

Table 3. The width of the minor river bed of Siret RSA in June 7, 2018

Cod	GPS coordinates	Stage name	Width of river (m)	Length of left bank (m)
S1	45.403476, 28.023631	confluence r.Dunare	113	
S2	45.401875, 28.014999	bridge Galati- Braila	97	698
S3	45.400627, 28.011656	bridge SIDEX	126	286
S4	45.397297, 28.007216	downstream bend 1	96	517
S5	45.397359, 28.001699	upstream bend 1	93	425
S6	45.400091, 27.997974	downstream bend 2	101	422
S6	45.399481, 27.990964	upstream bend 2	133	605
S8	45.393695, 27.988014	downstream bend 3	147	678
S9	45.392043, 27.982403	upstream bend 3	113	656
S10	45.394531, 27.979640	railway bridge	123	357
S11	45.402517, 27.959319	Barbosi	138	1860
S12	45.406013, 27.945789	water supply Malina	100	1110
S13	45.406781, 27.940792	downstream Sendreni	140	415
	The average width of the minor river bed of SiretRSA		113,57	Σ =8609

Table 4. The width of the minor river bed of Prut RSA in Sept. 13, 2018

Cod	GPS coordinates	Stage name	Width of river (m)	Length of left bank (m)
P1	45.471048, 28.197683	Giurgiulesti bridge	67	752
P2	45.479304, 28.183869	Giurgiulesti road	68	1590
P3	45.483452, 28.179159	bend 1	61	629
P4	45.494632, 28.176288	upstream Giurgiulesti	40	1250
P5	45.499726, 28.172654	downstream bend 2	49	639
P6	45.500785, 28.169541	upstream bend 2	54	361
P7	45.499884, 28.163843	downstream bend 3	70	463
P8	45.501133, 28.161820	upstream bend 3	60	253
P9	45.506571, 28.163940	downstream bend 4	49	620
P10	45.508375, 28.159881	upstream bend 4	48	505
P11	45.509004, 28.154865	downstream bend 5	60	402
P12	45.510950, 28.155999	upstream bend 5	55	324
P13	45.519774, 28.166047	downstream bend 5	44	1440
P14	45.524892, 28.156475	bend 5	52	1030
P15	45.525289, 28.165464	upstream bend 5	46	1310
P16	45.535587, 28.164587	Cislita-Prut	65	1610
	The average width of the minor river bed of Prut RSA		55,70	Σ =13178

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The measurements made on the width of the minor river bed of selected study areas (tables 2, 3, 4) highlighted the fact that they vary greatly from one course to another, and from one sector to another on the same river. Thus, at the Danube RSA, the width ranged between a minimum of 509 m at the stage with cod D9 and a maximum of 1740 m, at the stage with cod D3 (table 2). This means that the maximum width is 3.41 times higher than the minimum width. In contrast, on the Siret RSA, the maximum width is 2 times higher than the minimum width (table 3) and on the Prut RSA the maximum width is 1.7 times the minimum width (table 4). For Prut RSA and Siret RSA, this means a greater constant of the cross-sectional profile and consequently a greater constant of the flow capacity, a constant of the speed distribution, of the direction of the longitudinal and transversal currents. The average width of the minor bed, at the time of the measurements, was of 961.46 m for Danube RSA, of 113.57 m for Siret RSA, of 55.70 m for Prut RSA (tables 2, 3, 4).
Measurements of the depth of the minor river bed in several stage of the selected study areas highlighted the cross-sectional shape of the minor river bed, which can be assimilated either with a rectangle, trapeze, parabola or combinations of these geometric figures (figure 4).

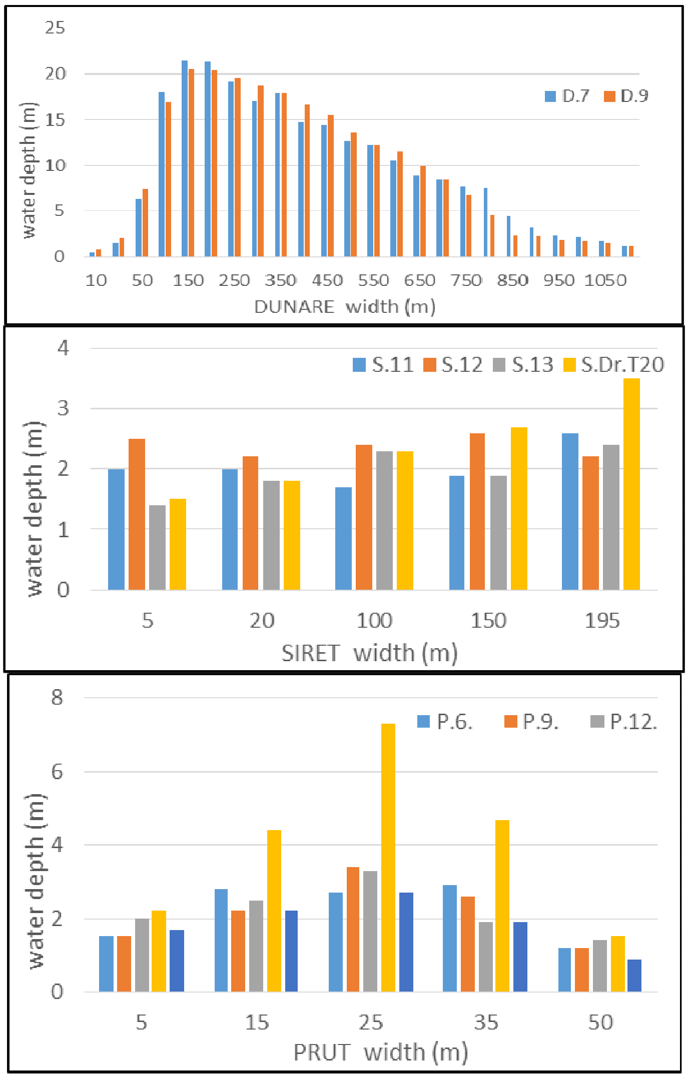

Figure 4. The cross-sectional shape in different stage of the Danube RSA, Siret RSA, Prut RSA

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The cross-sectional shape (figure 4) is variable and differs from one river to another and along the same river, being influenced by the shape and structure of adjacent relief forms.

The conditions of the river banks in study areas (tables 5, 6, 7) has been assessed from the point of view of the total length of the banks, the percentage of existing anthropic facilities on the banks of the river, as well as the percentage of banks cover by forest and pasture. In addition, the banks have been characterized in terms of the type of sediments present (clay, sand, mudd), but also from the point of view of the percentage of banks with deep water or banks with small water.

Table 5. The parameters of the river banks of the Danube RSA

Stage cod	Length of the banks (m)	Anthropic facilities (%)	Forest (%)	Pasture (%)	Type of sediments (clay, sand, mudd)	Water deep in shore area (small water, deep water)
D2	996 x2	0	100	0	- 1x sand -1x mudd	- 1x small water - 1x deep water
D3	586 x2	0	100	0	- 1x sand - 1x mudd	- 1x small water - 1x deep water
D4	1550 x2	0	100	0	- 0,25x clay - 1x sand -0,75x mudd	- 1x small water - 1x deep water
D5	1400 x2	0	100	0	- 0,25x clay - 1x sand -0,75x mudd	- 2x small water
D6	2710 x2	0	50	25	- 2x sand	- 2x small water
D7	905 x2	0	50	20	- 2x sand	- 2x small water
D8	1430 x2	0	50	10	- 1x clay - 0,5x sand - 0,5x mudd	- 1x small water - 1x deep water
D9	2990 x2	50	50	0	- 1x clay - 0,5x sand - 0,5x mudd	- 1x small water - 1x deep water
D10	2230 x2	50	50	0	- 1x clay - 0,5x sand - 0,5x mudd	- 1x small water - 1x deep water
D11	2140 x2	50	50	0	- 1x clay - 0,5x sand - 0,5x mudd	- 1x small water - 1x deep water
D12	2360 x2	50	0	50	- 1x clay - 1x sand	- 1x small water - 1x deep water
D13	2260 x2	50	0	50	- 1x clay - 1x sand	- 1x small water - 1x deep water
D14	1000 x2	50	0	50	- 1x clay - 1x sand	- 1x small water - 1x deep water

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Table 6. The parameters of the river banks of the Siret RSA

Stage cod	Length of the banks (m)	Anthropic facilities (%)	Forest (%)	Pasture (%)	Type of sediments (clay, sand, mudd)	Water deep in shore area (small water, deep water)
S2	698 x2	100	0	0	- 2x clay	- 2x deep water
S3	286 x2	100	0	0	- 2x clay	- 2x deep water
S4	517 x2	0	75	0	- 1x clay - 0,5x sand -0,5x mudd	- 2x deep water
S5	425 x2	0	100	0	- 1x clay - 1x sand	- 1x small water - 1x deep water
S6	422 x2	0	100	0	- 1x clay -1x mudd	- 1x small water - 1x deep water
S7	605 x2	50	50	0	- 1x clay - 1x sand	- 1x small water - 1x deep water
S8	678 x2	0	100	0	- 1x clay - 0,5x sand -0,5x mudd	- 2x small water
S9	656 x2	0	75	25	- 0,5x clay - 1x sand -0,5x mudd	- 1x small water - 1x deep water
S10	357 x2	0	75	25	- 1x clay - 1x sand	- 2x deep water
S11	1860 x2	25	75	25	- 1x clay - 0,5x sand -0, 5x mudd	- 1x small water - 1x deep water
S12	1110 x2	0	100	0	- 0,5x clay - 0,5x sand -1x mudd	- 1x small water - 1x deep water
S13	415 x2	0	100	0	- 1x clay - 1x sand	- 1x small water - 1x deep water
S14	580 x2	25	75	0	- 2x clay	- 2x deep water

All these characteristics (tables 5, 6, 7) can be quantified as having a positive or negative influence on the natural productivity, respectively fish productivity of the rivers. Thus, the higher coefficient of sinuosity of the river, it positively influences the natural river productivity. Also, positively affects a large percentage of vegetation, especially forests, as well as a larger percentage of banks with small water and banks where the mudd substrate are present. Instead, the presence of a large proharborion of man-made facilities has a negative impact on river's natural productivity. The presence of banks with deep water as well as with sand and clay substrates does not have a negative impact, but they are considered less productive.

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Table 7. The parameters of the river banks of the Prut RSA

Stage cod	Length of the banks (m)	Anthropic facilities (%)	Forest (%)	Pasture (%)	Type of sediments (clay, sand, mudd)	Water deep in shore area (small water, deep water)
P2	752 x2	50	50	0	- 2x mudd	- 2x deep water
P3	1590 x2	25	50	25	- 2x mudd	- 2x deep water
P4	629 x2	0	50	50	- 1x mudd - 0,25x sand -0,75x clay	- 1,25x small water - 0,75x deep water
P5	1250 x2	0	50	25	- 0,75x mudd - 0,25x sand -1x clay	- 2x small water
P6	639 x2	0	100	0	- 0,5x mudd - 0,75x sand -0,75x clay	- 1,5x small water - 0,5x deep water
P7	361 x2	0	100	0	- 1x mudd - 0,5x sand -0,5x clay	- 1x small water - 1x deep water
P8	463 x2	0	50	50	- 1x mudd -1x mudd	- 1x small water - 1x deep water
P9	253 x2	0	50	25	- 1x clay -1x mudd	- 1x small water - 1x deep water
P10	620 x2	0	50	50	- 1x clay -1x mudd	- 1x small water - 1x deep water
P11	505 x2	0	50	50	- 1x clay -1x mudd	- 1x small water - 1x deep water
P12	402 x2	0	50	25	- 1x clay -1x mudd	- 1x small water - 1x deep water
P13	324 x2	0	50	25	- 1x clay -1x mudd	- 1x small water - 1x deep water
P14	1440 x2	0	75	25	- 1x clay -1x mudd	- 1x small water - 1x deep water
P15	1030 x2	0	50	50	- 1x clay -1x mudd	- 1x small water - 1x deep water
P16	1310 x2	0	75	25	- 1x clay -1x mudd	- 1x small water - 1x deep water
P17	1610 x2	0	75	0	- 1x clay -1x mudd	- 1x small water - 1x deep water

4. CONCLUSIONS

The location of Galati town near many waters, such as Danube River, Prut River, Siret River, Brateş Lake, but also many ponds and swamp, makes that water resources are valued for their socio-economic value and also for their intrinsic value.

The three major running waters which are found in the neighborhood of Galati town present by hydrographically and hydrologically point of view different characteristics, the most imharborant being the average of multiannual flow rate, which for the Danube River is 6300 m3 /s, for the Siret River is 225 m3 /s, and for the Prut River is 110 m3/s.

In the study areas of the three rivers, the conditions offered by the aquatic habitats were evaluated by investigating some parameters that reflect the condition of the river banks and the condition of the navigable channel.

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The percentage of anthropic facilities on the river's banks is high, with values of 28.77% in Danube ZSA and 22.0% in Siret ZSA, instead, in Prut ZSA the anthropic facilities has a small level, which is 5.86% of the total length of the banks.

The vegetation of the banks has been evaluated as a percentage of forest, shrub and grazing that cover of the total length of the banks. The vegetation has a different degree of involvement in the bioeconomy of aquatic ecosystems, so the forest is the one that contributes to the greatest extent to the intake of organic matter. At Danube ZSA the forest is presented almost as half of the total length of the banks (54.21%), instead at Siret ZSA and Prut ZSA the forest is more developed on the banks, covering 69.66% and respectively 62.06% of the total length of the banks. Even if the Siret ZSA percentage of forest is higher than the Prut ZSA, intake of organic matter in water is higher in Prut ZSA due to the greater proximity of the forest to the river banks and due to the greater width of the forest area, these area being flooded annually.

The main two types of banks, banks with deep water and banks with small water, have almost similar development in the three study areas. In the Danube ZSA dominate more the banks with small water (61.11%), as well in the Siret ZSA the banks with small water covered 50.66% of the total length of the banks. Instead, in the Prut ZSA the banks with small water covered 47.66% of the total length of the banks line banks. The presence of a larger percentage of banks with small water means the higher natural productivity respectively higher fish productivity of the river.

The type of sediments in the shore area also influences natural productivity, the most productive shore areas are muddy ones, then the sandy ones and the clay ones are less productive. According to this criterion, in the Danube ZSA dominates the sandy sediment (48.27% of the total length of the banks), in the Siret ZSA dominated the clay sediment (53.95% of the total length of the banks) and in the Prut ZSA dominated the muddy sediment (56.48% of the total length of the banks).

The maximum widths in the three study areas differ greatly, being 1740 m in the Danube ZSA, 147 m in the Siret ZSA and only 70 m in the Prut ZSA. The same is true for the maximum depths, these being of 21.5 m in the Danube ZSA, 11, 9 m in the Siret ZSA and 8.7 m in the Prut ZSA.

The minor river bed in the three study areas has a "U" shape, this shape being the characteristic of large, evolved running waters.

The presence of aquatic micro-habitats in the shore area is very imharborant for the productivity of running waters, the quantification of the banks characteristics in these three study areas shows that the Prut ZSA has the largest diversity of microhabit with a positive influence on the productivity of the river.

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