

ORIGINAL ARTICLE

## Indicative species for the ecological state assessment of Ukrainian part of the River Siret

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The overall objectives of the article are determination and describing of the benthic algae species in the Ukrainian part of the River Siret. The investigations will give an opportunity to create the database of indicative species for the ecological assessment of the River Siret and planning strategy of ecological monitoring of the River Siret and other water bodies of the same types.

**Keywords:** Indicative species; river Siret; ecological status assessment; phytobenthos; monitoring

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### Introduction

The ecological assessment of various water sources today is extremely relevant due to increased pressure on all environmental systems. Water sources are one of the susceptible objects of this influence. Few of the water bodies are valuable as healthy ecosystems and meet sanitary requirements nowadays. Therefore, the systematical monitoring of the ecological quality of water sources is very important today and needs to apply a variety of assessment and evaluation methods.

The modern approach to the assessment of the ecological status of water bodies brings to the foreground the biological methods of water quality studies and prediction of their status (DeNicola & Kelly, 2014). In Ukraine surface water quality is determined mostly by chemical indicators, although European experience shows that this is not enough to identify the actual state of the aquatic ecosystem. Recent years Ukraine tends to the development of biological methods of the determination of ecological state of water bodies too (Afanasyev, 2006; DeNicola & Kelly, 2014).

Biological indicators usually are able to detect changes in the aquatic environment long before they can become critical for aquatic biocenosis and humans. One the approaches is the determination of the biological variety of some hydrobionts, as well as using them as indicators of the ecological conditions of the aquatic environment. A convenient object for such studies is algae phytobentos. These organisms are especially indicative for determining of the ecological conditions of mountain rivers and rivers of foothills.

The subject of the presented study was to describe the species composition of the microphytobenthos of the Ukrainian part of the River Siret (hereinafter - Upper Siret) and to identify the indicators of environmental conditions for the preliminary assessment of the ecological state of the river (Karavan, 2012a, 2012b, 2014).

### Literature review

As the problem of water pollution is one of the most severe ecological problems all over the world. It is worth emphasizing that most of the modern approaches to the ecological monitoring includes biological methods for the assessment of ecological state of the water bodies as the most important (Directive, 2000). Although, many scientific research are devoted to these methods (Slàdecek, 1973, Van Dam, Mertenés & Sinkeldam, 1994; Komulainen, 2003; Dell'Uomo, 1999; Barinova, 1999, Pantle, 1955; Round, 1993; Bailey & Norris, 2004, Dean & Martyn, 2014; Andressa & Nicolli, 2017; Dutta, Dutta & Bhagobaty, 2018 etc), there are no data about the algae communities of the Siret river, since there were no such type of scientific study in the region until this time.

### Materials and methods

The sampling was carried out according to the basin principle, respectively, the creatures were also assessed on some

tributaries of Upper Siret (River Sukhyy, River Mikhidra, River Maliy Siret). The research was conducted in 2007-2012 and complemented by data which have been got at the period of 2014-2015 throughout the course of Upper Siret to the border with Romania. Samples were taken at the 8 sites (DeNicola & Kelly, 2014; Raund, 1993). Previously, a typology of the water body was carried out and 2 water bodies were identified: type 1 - a large river in limestone dumps on the low mountains (Lopushna Village – Lukavtsi Village); type 2 - a large river in sedimentary rocks on the foothills (Lukavtsi Village - Cherepkivtsi Village) (DeNicola & Kelly, 2014; Pantle, 1955). Sampling from different layouts and results analyzis were done according to this typology. The samples of the algae were taken twice in a season along the entire length of the River Siret (to the border with Romania), including its tributaries: River Sukhyy, River Mikhidra, River Maliy Siret (Figure 1).

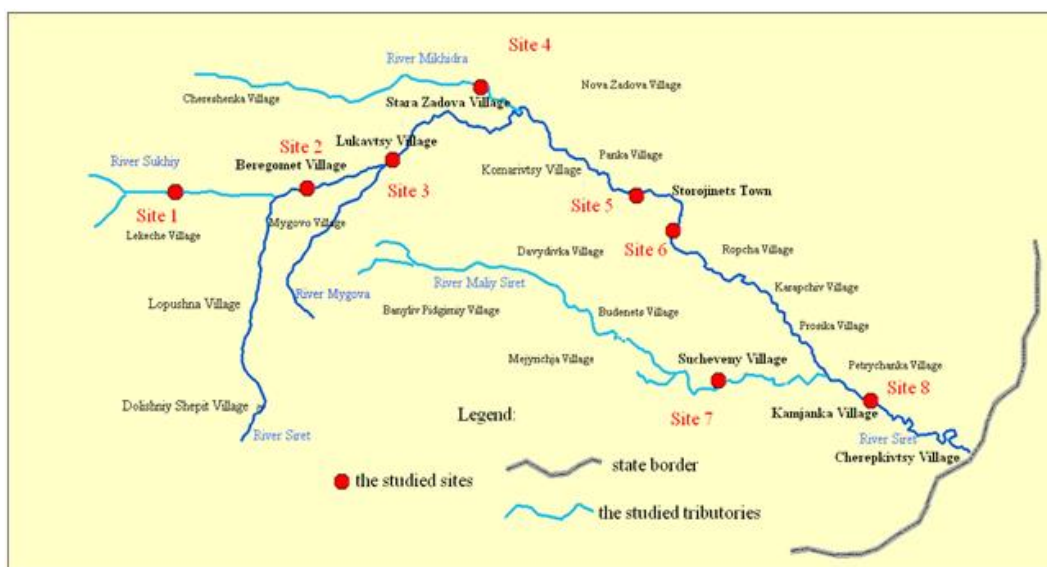


Figure 1. Location of the sites on the River Siret and its tributaries.

## Results and discussion

139 species of algae, which belonged to 57 genera, 31 families, 20 orders, 11 classes and 5 divisions, were identified for the entire period of study.

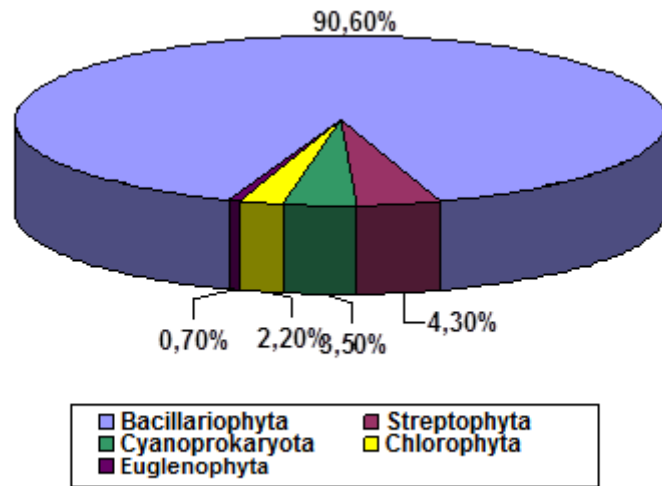
The largest percentage contribution to the study group comes from the Bacillariophyta. During the mentioned period, 124 species of algae of this division were found. They are related to 46 genera, 20 families, 9 orders and 3 classes. The most numerous genera in this division were: *Navicula* (19 species), *Cymbella* (10 species), *Nitzschia* (12 species), *Gomphonema* (12 species).

In the Cyanoprokaryota division the 5 species, which are related to 5 genera, 5 families, 5 orders and 1 class were identified. The Cyanoprokaryota was represented by the following genera: *Microcystis*, *Calotrix*, *Rhabdoderma*, *Phormidium*, *Chlorococcus*.

The Green algae (Chlorophyta) and Euglenophylls (Euglenophyta) throughout the research period were represented by organisms that were constantly founded in small number. The most representative in number of species among green algae were the following families: *Rhizoclonium*, *Ulotrix*, *Desmodesmus*.

Genus Streptophyta was represented by such species: *Closterium* (3 species), *Cosmarium* (1 species), *Klebsormidium* (1 species), *Mesotaenium* (1 species) (Karavan, 2012b, 2014).

Consequently, the basis of the list of the River Siret phytobenthos group were Diatoms (90,6%), the percentage of Blue-Green, Green, Streptophyte and Eugenic algae as a whole was small - 3.5%, 2.2%, 4.3% and 0,7% respectively (Figure 2).



**Figure 2.** The percentage of the basic taxons of the benthic algae of the River Siret.

Hence, the species richness of the benthic algal flora of the studied rivers was determined by Diatoms, which is typical for the mountain rivers. The main cenosis-forming species of Diatoms were: *Navicula cryptocephala* Kütz., *Navicula cincta* (Ehrenb.) Ralph, *Planothidium lanceolatum* (Bréb. Ex Kütz.) Lange-Bert, *Achnanthis minutissimum* (Kütz.) Czarn., *Rossethidium lineararis* (W. Sm.) Round to Bukht., *Achnanthis pyrenaicum* (Hust.) H.Kobayasi, *Gomphonema constrictum* var. *Capitatum* Ehrenb., *Gomphonema olivaceum* (Hornem.) Bréb., *Gomphonema parvulum* (Kütz.) Kütz., *Gomphonema acuminatum* var. *Trigonocephala* (Ehrenb.) Grunow, *Diatoma vulgare* Bory, *Cymbella affinis* Kütz., *Reimeria sinuata* (W. Greg.) Kociolek, Stoermer; *Cymbella alpina*, *Cymbella ventricosa* var. *Ovata* Grunow, *Stauroneis anceps* Ehrenb., *Nitzschia palea* (Kütz.) W. Sm, *Nitzschia acicularis* (Kütz.) W. Sm., *Eunotia exigua* (Bréb. Ex Kütz.) Rabenh.

Among the whole variety of algae, species-indicators of environmental conditions have been identified.

**Place of extinction:** Most of the detected algae belonged to benthic (including periphyton) (67.4%) and benthic-planktonic (24.2%) organisms. Among these ecological groups there were following species: *Fragilaria amphicephaloides*, *Meridion circulare*, *Cymbella affinis* Kütz., *Encyonema elginense* (Krammer), *Didymosphenia geminata*, *Achnanthis affine*, *Stauroneis anceps*, *Gomphonema acuminatum*, *Closterium acerosum*.

**Flow velocity:** 54.3% of all studied algae belonged to the indifferent and 25% were representatives of flowing waters. There was also found a small percentage of standing water algae and aerophiles. Indicators of flowing waters were: *Meridion circulare*, *Cymbella cymbiformis*, *Encyonopsis microcephala*, *Pinnularia biceps*, *Navicula exigua* and others; indifferent: *Melosira varians*, *Diatoma anceps*, *Tabellaria fenestrata*, *Didymosphenia geminata*, *Navicula lanceolata*, *Amphora ovalis* and others.

**Temperature mode:** Most species were indicators of moderate temperatures (71.4%). Eurithermic and coldwater species met the same number (11%), thermophilic species accounted for 5.7%. Among the types of indicators of moderate temperatures were observed: *Melosira varians*, *Stephanodiscus hantzshii*, *Cymbella affinis*, *Ulnaria biceps*, *Pinularia maior*, *Diploneis elliptica*, *Nitzschia acicularis*, *N. amphibia*, etc. Eurithermic organisms were represented by the following species: *Achnanthis minutissimum*, *Sellaphora pupula*, *Euglena oblonga*. Cold-loving - *Diatoma anceps*, *D. hiemalis*, *Gyrosigma acuminatum*.

**pH:** 56.7% of all species were attributed to alkaliphils, 30% were indifferent. Also, a small percentage of acidophils, alkalibionts and neutrophils were found. Representatives of alkaliphils were: *Melosira varians*, *Stephanodiscus hantzshii*, *Cymbella affinis*, *Placoneis exigua*.

**Salinity:** Indifferent according to the salinity have been accounted for 74% of the total number of indicator algae. Among the representatives of this ecological group, the following species were met in quite large number: *Synedra parasitica* var. *subconstricta*, *Ulnaria acus*, *Cymbella affinis*, *C. tumida*, *Encyonema elginense*, *Gomphonema acuminatum*, and others. Halophilic species accounted for 14% of all species (they were *Melosira varians*, *Cymbella meneghiniana*, *Diatoma anceps*, *Navicula cincta*, etc.).

**Organic matter (by Sladeczek):** The beta-mesosaprobionts and oligo saprobionts were observed in 16% of all indicator species. Among the representatives of beta meso-saprobionts, the following species were found: *Ulnaria acus*, *Diatoma anceps*, *Gomphonema acuminatum* var. *trigonocephala*, *Reimeria sinuata*, *Achnanthis exiguum* var. *heterovalvum*, *Nitzschia gracilis*, and others. In the course of observations, species-indicators of practically all areas of saprobity were identified as the main and intermediate ones.

**Organic matter (by Watanabe):** 60% of all the indicators in this category belonged to the eurosaproxies (*Melosira varians*, *Fragilariforma virescens*, *Ulnaria ulna*, *Meridion circulare*, *Tabellaria fenestrata*, *Placoneis exigua*, *Nitzschia acicularis*, etc.). 30% of the investigated algae have been identified as saproxens (*Cyclotella comta*, *Synedra parasitica*, *Diatoma anceps*, *Cymbella affinis*, *Gomphonema constrictum* var. *capitatum*, *Navicula capitatoradiata*, etc.).

**Nutrition:** According to this parameter 54% of indicators were autotrophs with increased need in organic nitrogen (*Diatoma vulgare*, *Meridion circulare*, *Eunotia exigua*, *Reimeria sinuate*, *Gyrosigma acuminatum*, etc.). A small number of mikсотrophs were found too. (*Nitzschia acicularis*, *Melosira varians*, *Stephanodiscus hantzshii*, *Cymbella meneghiniana*, etc.).

**Trophy:** The largest percentage in this ecological group were eutrophic and meso-eutrophic algae (35% and 20% respectively).

Representatives: *Cymbella affinis*, *Gomphonema acuminatum*, *G. olivaceum*, *Luticola mutica*, *Halamphora veneta*, *Navicula exigua* (e) and *Fragillaria sonstruens*, *Diatoma vulgare* var. oval, *Encyonopsis microcephala*, *Sellaphora pupula* (me).

The species composition of phytoplankton depends on the conditions of the river flowing (river bed, geomorphological parameters of the territory, anthropogenic impact etc.). Therefore, these preconditions were taken into account during the data analysis.

According to the obtained data, the upper flow of the River Siret was characterized by an insignificant variety of phytoplankton and benthos, which was associated with natural conditions (temperature conditions, flow velocity, bedding of the bedrock, etc.). These preconditions were also reflected during the typology of the Siret River. Sites of sampling which have been located in the upper reaches belong to the part of the river basin, which flows on limestone rocks and is located in the low-lying area, which causes the lowered water temperature, low-alkaline pH and moderate flow velocity. These conditions were reflected in the species composition and diversity of algae, respectively. Thus, for this territory the dominant benthic algae were represented by followed species: *Meridion circulare*, *Navicula cryptocephala* Küt., *Navicula cincta*; *Achnanthydium minutissimum* (Kütz.) Czarn., *Planothydium lanceolatum*, *Fragillaria capucina*, *Rossethodium lineararis* (W. Sm.) Round et Bucht., *Cymbella ventricosa* var. *Ovata* Grunow, *Gomphonema constrictum* var. *capitatum* Ehrenb., *Gomphonema acuminatum* var. *trigonocephala*.

Dominant species belonged to the representatives of moderately flowing waters, euriterms, alkaliphils, indifferent species by salinity. Most of the investigated algae were representatives of oligo and xeno saprobility, eurisabrobic organisms, oligo eutrophic. According to the type of nutrition all dominant algae belonged to autotrophs that can live with a sufficiently large amount of bound nitrogen. The index of saprobity ranged from 0.5 to 2.7. Species diversity in this segment was low, which is typical for foothill ecosystems of this type.

Analysis of these data allowed to establish, that the upper reaches of the River Siret refers to the oligo-xeno saprobic zone, anthropogenic impact there was on minimal level.

From the middle reaches to the border with Romania, the River Siret was attributed to another type - a large river in sedimentary rocks on the foothills (Directive, 2000). The species composition and variety of phytoplankton were also changed in accordance with changes in natural conditions. The richest biodiversity was observed near Lukavtsy Village. The following species were dominant there: *Mesotaenium macrococcum*, *Planothydium lanceolatum*, *Fragillaria capucina*, *Rossethodium lineararis* (W. Sm.) Round et Bucht., *Achnanthydium minutissimum*, *Navicula cryptocephala* Kütz., *Navicula minima* Grunow, *Nitzschia gracilis* var. *capitata*.

These dominants of the middle reaches of Upper Siret belonged to the representatives of moderately flowing waters, temperate and partially to euriterms. Most of them were alkaliphilic, but the third part of all species belonged to indifferent ones. Concerning water salinity most of identified algae were indifferent. In their capacity, most of them belonged to the representatives of oligo-beta, xeno-oligosaprobity, euriterms and a small part of the saproxene; oligo-eutrophic and sometimes mesotrophic. By the type of nutrition, most of the dominant representatives belonged to autotrophs that could live with a sufficiently large amount of bound nitrogen, but there was a small proportion of myxotrophs. The index of saprobity was ranged from 0.5 to 2.7.

Significant changes in species composition and composition of indicator types of phytoplankton were observed below Storozhynets Town. There was no clear dominance of certain species, and most of the detected indicators related to benthic and periphyton forms, representatives of moderately flowed waters, moderate temperature regime, most alkaliphils and species indifferent to the pH. As regards to the salinity of water, most of species were classified as indifferents. The majority of indicators related to the representatives of the oligo-alpha, and the alpha-saprobity. With respect to organic matter most of identified algae belonged to the saproxene and the eurosaprobis, mesoeutrophs and, in some cases, oligoeutrophs, most of them belonged to autotrophs, which can live on a sufficiently large amount of bound nitrogen. The index of saprobity ranged from 1.8 to 2.7.

## Conclusion

Consequently, the middle part of the River Siret was characterized by a sufficiently large variety of phytoplankton and an increase in the content of organic matter in water compared to the upper stream. On the one hand, such increasing is one of the natural characteristics for this type of water body, and on the other that means the intensification of economic activity in the adjoining territories. Increasing number and variety of indicators of saprobity were the evidence of such changes. Most of the indicators were corresponded to the beta saprobic zone (*Diatoma anceps*, *Ulnaria acus*, *Diatoma vulgare*, *Encyonopsis microcephala*, etc.). This part of the river was characterized as the alpha saprobic zone (*Navicula cryptocephala*, *Amphora ovalis*, *Closterium acerosum*, *Melosira varians*, etc.).

The lower current of the Ukrainian part of the River Siret was characterized by a significant decrease in the diversity of the phytoplankton species as compared with the upper course. The presence of representatives of moderately flowing, moderate temperature regime was typical of the sections of this part of the River Siret; concerning pH, most species were alkaliphils and indifferent species; concerning salinity of water - indifferents and halophils were present in most sites.

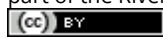
Unfortunately, in Ukraine the rate of a poor status running waters increasing very fast. This is the reason to provide the development of the effective methods of the ecological state assessment for rivers and lakes. Use of biological methods could be inexpensive, environment friendly and accurate approach for this challenge.

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