# AGROECOSYSTEMS AND THEIR EFFECTS ON THE STRUCTURE OF BENTHIC INVERTEBRATE COMMUNITIES IN THE NATURE RESERVE ALLUVIUM ŽITAVY

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**Abstract:** *Agricultural activity permanently affected ecosystems – agroecosystems are particularly in terms of ensuring of nutrition for human society, very important functional units of the biosphere. Represent economically important organisms and their environment. Very often are surrounded by natural ecosystems, which are usually very closely linked. Although their relationship is two-sided, agroecosystems can induce not only reduce the heterogeneity of the country but also may affect the biodiversity of the surrounding terrestrial and aquatic habitats. In order to assess the impact of agricultural activities on the water quality characteristics, as well as on the biodiversity and the structure of communities of aquatic organisms, we carried out sampling of water from six sampling sites at regular quarterly intervals, 24 water samples was collected, in the year 2007 in the Nnature reserve Alluvium Žitavy located in the southwestern part of Slovak Republic, in the geomorphologic unit of Podunajská rovina,. As the basic biological material we used organisms of macrozoobenthos living at the bottom of the aquatic habitats. This group of individuals is an important indicator of water quality, based on their species and numerical representation can be evaluated the water quality of monitored biotopes. Analysis of samples of water we obtained 9920 individuals, deterministic as 110 species of fourteen systematic groups of invertebrates. Of them, the largest proportion in the structure of benthic macrozoobenthos had Gastropoda (24.01%), Isopoda (13.47%), Ephemeroptera (10.60%), Heteroptera (9.33%), Coleoptera (8.49%), individuals of family Chironomidae (8.25%) and Diptera(7,40%). The species with the smallest proportion in the structure of zoobenthos of monitored wetlands (ranging from 1.61% to 4.32%) included representatives of systematic groups Turbellaria, Odonata, Hirudinea, Trichoptera, Amphipoda, Bivalvia and Oligochaeta. The most of species that formed monitored community of aquatic organisms belongs to the good indicators of water quality. Therefore, not only based on the structure of community of macrozoobenthos but also based on the calculated saprobic index (Si), the water which is used by this community as their habitat corresponds to β-mezosaprobic zone, slightly polluted water. Between sampling sites the significant differences in the quality and purity of water was recorded, even not only in the numerous represented of benthic fauna. Some differences in representation of species were observed, because each of the representatives of zoobenthos has different requirements for water quality characteristics. Despite this, agriculture fertilizer application, spillage of the oil substances and their floating could result in deterioration of water quality of monitoring wetlands and thus the structure and biodiversity of benthic invertebrates.*

***Key words:*** *Slovak Republic, Alluvium Žitavy, agroecosystems, water, zoobenthos*

## INTRODUCTION

Water is considered for the one of the basic element of the landscape and is also existentially necessary component of the environment. For some species of plants, animals and microorganisms water constitutes a basic living space. Its quantitative and qualitative characteristics promote or limit the development of economic activities but on the other hand water properties can be affected by any of the human activities. In the natural landscape, which includes the agroecosystems are water properties influenced mainly by the agriculture. Aquatic and wetlands ecosystems are exceptional in this type of country, which mostly belong to the

ecosystem negatively affected and often degraded by human activities. In agricultural land, however, water and wetlands are vital part of this habitat, because no only complete the country, but in lowland areas, intensive irrigation, are also extremely important source of life. In addition, wetlands play an important role in the biodiversity of the Earth, which is compared with the terrestrial ecosystems more threatened, thus their communities rarely occur in the natural species composition. Information about the status of wetlands in Slovakia are insufficient because their monitoring by various scientific institutions and individuals are received less attention compared to, for example, monitoring of flowing surface water. In the view of status and evolution of the areas located on wetland habitats, as well as their importance for nature of our Earth and for human, it is necessary to take measure to maintain and achieve favorable status of biotopes and species. This can be achieved by the solution of projects aimed at monitoring of status of wetland areas of different character in different regions of Slovakia, management and protection of areas and species and their revitalization. In the Slovak Republic to those ecosystems that their monitoring has not received attention, include the Nature Reserve Alluvium Žitavy. Alluvium is located in the area of river Žitavy mouths into the river Nitra. Its central part is open water surface, marsh communities are located mainly in the trainer reducing on the edge of the alluvium of river Žitavy. On the shores are quite generously represented riparian vegetation. The most attention from the researchers was the Nature Reserve Alluvium Žitavy, but also to other similar types of ecosystems paid by ornithologists because their territory serves as a staging point for migratory birds, but is also an important nesting habitat for several species wetland birds. Ornitofaun of various wetlands monitored for example LENGYEL (2004), TRNKA ET AL. (2003), MURÁNSKY ET AL. (2004), IMRICHOVÁ, 2012. Researches were carried out continuously in other systematic groups of individuals too. *Mollusca* monitor ČEJKA (2007), communities of *Coleoptera* monitored PORHAJAŠOVÁ et al.(2010); *Odonata* monitored for example ŠÁLEK (2003) and ŠÁCHA (2007). Occurrence of representatives of *Amphibia* in wetlands has been paid RYBANIČOVÁ (2004), *Mammalia* watched NOGA et al. (2004) and BRIDIŠOVÁ et al. (2006) too. Water quality in the nature reserve alluvium Žitavy in terms of its physicochemical properties watched NOSKOVIČ et al. (2011). With the exception of isolated research projects focused on the wetlands aquatic invertebrates (eg RAKOVSKÁ ET AL., 2010, SVITOK et al., 2012) extensive research of communities of aquatic invertebrates was not realized, respectively was only partially realized. Because these animals, generally referred by the term zoobenthos" are not only an important part of the aquatic habitats, where they play very important role in the decomposition of organic matter and the self-cleaning processes taking place in the water, are also an important component of the food chain, because they serve as food for fish. They are also excellent indicators of water quality. In order to expand knowledge in this area of research, we focused on the evaluation of community structure of zoobenthos and quality – the ecological status of the aquatic habitat located near the agro-ecosystems. This habitat is Nature Reserve Alluvium Žitavy located in the southwestern part of Slovak republic.

## MATERIAL AND METHODS

Nature Reserve Alluvium Žitavy as a complex of the wetlands and forest habitats with the well-preserved floodplain forest, with the suitable conditions for nesting, shelter and rest of wetland birds primarily at the instigation of ornithologists for "protected area" in the year 1993 was declared. Nature reserve with the area of 32.53 hectares, comprising an area located in the southwest, the most fertile part of the Slovak Republic, with the longest growing season. Situated is in the geomorphological region of Podunajská nížina, in Nitra region, district Komárno, in the administrative area of the village Martovce and town Hurbanovo (*Fig.1*), at an

altitude of 106-115 m above the sea level, in the area of mouths of river Žitava into the river Nitra. Protected area is part of the European network NATURA 2000 (part of the protected landscape area "Dunajské luhy") has a high biological value and is extremely important for the conservation of genetic resources of rare species of flora a fauna. Across the board there is the represented marsh vegetation (e.g. *Fragmites australis, Glyceria maxima, Nuphar lutea, Typha latifolia*). Biologically value wetland habitats created favorable conditions for different representatives of fauna, of which the most valuable are about 76 kind of Aves (e.g. *Ardea cinerea, Anas platyrhynchos, Upupa epops* ). The rich representation (12 species) has also Osteichthyes. Nature reserve immediately adjacent to the surrounding agrocoenoses, surround the remains of the original meanders of the river Nitra and Žitava. Central part is open water table with growing of variety plant species. In a field reducing smaller wetland ecosystems was developed. The area has a warm, relatively homogeneous climate. The average annual temperature is 11- 12°C, annual rainfall is 550-750 mm. A considerable part of nature reserve is flooded during the year especially in spring.

In that territory has been collecting of benthic material realized at regular quarterly intervals at six sampling sites, where the water depth ranged from 0.30 to 0.40m:
1st sampling sites – a tributary of the river Žitava to the Alluvium, 47° 51´ 88´´ north latitude and 18 ° 09'89" east longitude). On the grassy waterlogged shores growing trees, at the bottom was mud with deat parts of aquatic plants and tree leaves, 2nd sampling sites (47° 51´ 92´´ north latitude and 18 ° 09'25" east longitude) and 3rd sampling sites (47° 51´ 83´´ north latitude and 18 ° 09'25" east longitude) – typical wetland ecosystems. Both were situated below the sparse canopy of trees, the water table is cover by *Lemna minor*. To the muddy bottom were algae, aquatic plants and leaves of trees, 4th sampling sites (47° 51´ 58´´ north latitude and 18 ° 08'38" east longitude) – situated under the bridge, on which was the communication forming the entrance to the village Martovce. On the rangy, pebble bottom were located stones covered by algae, 5th sampling sites (47° 51´ 09´´ north latitude and 18 ° 07' 99" east longitude) and 6th sampling sites (47° 50´ 81´´ north latitude and 18 ° 07' 67" east longitude) – typical wetland ecosystems with open water table, on the banks of the sparse canopy of trees. At the bottom mud, algae and aquatic plants with a predominance of *Typha latifolia* was situated.

Sampling were collected in March, June, August and October, semi-quantitative using sampling network, sieve, but also by „kicking method " and individual collection, which was used tweezers, plastic spoon and scraper. For washing and rinsing the obtained biological material was used white photographic plate. The obtained material was partially purified on the site, transferred into the plastic containers intended for the transfer of samples, preserved with 4% formaldehyde solution and subsequently sorted and determined in the laboratory of the department. The following parameters were evaluated: systematic affiliation and species composition of benthic fauna, number of species, number of individuals and dominance. Water quality characteristics were evaluated based on the calculated saprobic index and requirements of the Government regulation of the Slovak Republic.


Figure 1. Map of Slovak republic and monitoring area of Nature Reserve Alluvium Žitavy

**RESULTS AND DISCUSSIONS**

Research focused on investigate the structure of benthic invertebrates (individuals inhabiting the bottom of the aquatic habitats) and water quality – the ecological status of their habitat, in 2007 at selected six sampling sites in Nature Reserve Alluvium Žitavy was carried out. In that period, was gradually in the seasonal aspects: spring, early summer, end of summer and autumn, by collection of 24 water samples 9920 exemplars was obtained and 110 taxons of benthic animals at the level of species, order, respectively family were determined. Relatively wide numerically represented were larvae of the family *Chironomidae* but this family was not included in the number of representatives of the order *Diptera.* Numbers shown in table 1 as „*Chironomidae*" reflect only the number of exemplars of that family. All determinate taxa listed systematic groups are either better or worse biomarkers, so provide basic information about the current ecological status of aquatic habitats. It was divided into the following systematic groups: *Turbellaria, Oligochaeta, Hirudinea, Gastropoda, Bivalvia, Isopoda, Amphipoda, Ephemeroptera, Odonata, Heteroptera, Coleoptera, Trichoptera, Diptera* and *Chironomidae*. Of the 14 systematic groups have the greatest number of individuals and species represented a systematic group of *Gastropoda*, whose proportional of the overall structure of the benthic fauna amounted to 24.01%. To increasing of abundance of gastropods, as stated Collier et al. (2000), occurs in catchments located in the deforested sections of agricultural land. Disposal of floodplain forests in the territory, which currently occupies Nature Reserve Alluvium Žitavy, may be one of the factors that influenced their increased occurrence. During our research for these habitat 2382 exemplars of 25 species of *Gastropoda* and 382 exemplars of six species of *Bivalvia* was identified. Total it was only 31 species of *Mollusca*. Therefore does not share with the view of authors Saxa and Černecký (2010), under which the aquatic and wetland environments are commitment only 7 species of *Mollusca*.

A slightly smaller proportion of the representatives the *Isopoda* and it was 13.47%. The third most numerous systematic groups were *Ephemeroptera*, which with number of 1052 exemplars in the structure of zoobenthos accounted for 10.60%. Based on the autoecological characteristics of *Ephemeroptera* at individual sampling sites should have a significant representation particular euryvalent species, tolerant to worse ecological status of monitored habitats. Only occurrence of the certain larvae of *Ephemeroptera* in Natural Reserve Alluvium Žitavy, therefore fully match the quality of its water. However individuals that systematic group absent, or in lesser number of individuals were on the sampling sites located in close proximity to management agricultural land, identified ecological status of water of Alluvium

Žitava could be affected not only being a stagnant water, but also their pollution by farmers. Despite the fact that HAVIAR (2006) regarded *Ephemeroptera* as an indispensable ingredient of aquatic community of insect of flowing waters, based on the results listed in table 1 and figure 2 we consider them as an important component of the benthic invertebrate community of stagnant water and wetlands. In the waters of the Alluvium Žitavy were important dominant to subdominant community.

*Table1*

Numerous and percentage representation of systematic macrozoobenthos groups at the sampling sites (SS)

| **Systematic group** | **1.SS** | | **2.SS** | | **3.SS** | | **4.SS** | | **5.SS** | | **6.SS** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pcs | % | pcs | % | pcs | % | pcs | % | pcs | % | pcs | % |
| Turbellaria | | | 60 | 4,27 | 16 | 1,58 | 46 | 1,53 | 8 | 0,50 | 30 | 1,56 |
| Oligochaeta | 40 | 4,21 | 38 | 2,70 | 100 | 9,90 | 74 | 2,45 | 78 | 4,84 | 98 | 5,09 |
| Hirudinea | 12 | 1,26 | 64 | 4,55 | 16 | 1,58 | 78 | 2,58 | 16 | 0,99 | 30 | 1,56 |
| Gastropoda | 276 | 29,05 | 440 | 31,30 | 258 | 25,55 | 642 | 21,29 | 266 | 16,50 | 500 | 25,96 |
| Bivalvia | | | 6 | 0,43 | | | 102 | 3,38 | 92 | 5,71 | 182 | 9,45 |
| Isopoda | 108 | 11,37 | 228 | 16,22 | 256 | 25,35 | 392 | 13,00 | 298 | 18,49 | 54 | 2,80 |
| Amphipoda | 14 | 1,47 | 116 | 8,25 | 44 | 4,36 | 32 | 1,06 | | | 54 | 2,80 |
| Ephemeroptera | 160 | 16,84 | | | 76 | 7,52 | 498 | 16,51 | 216 | 13,40 | 102 | 5,30 |
| Odonata | | | 8 | 0,57 | 2 | 0,20 | 88 | 2,92 | 40 | 2,48 | 26 | 1,35 |
| Heteroptera | 54 | 5,68 | | | 18 | 1,78 | 498 | 16,51 | 132 | 8,19 | 224 | 11,63 |
| Megaloptera | 32 | 3,37 | 156 | 11,09 | 110 | 10,90 | 164 | 5,44 | 174 | 10,79 | 206 | 10,70 |
| Coleoptera | 108 | 4,65 | 190 | 3,27 | 92 | 2,12 | 110 | 1,90 | 98 | 3,49 | 234 | 3,60 |
| Trichoptera | | | 56 | 3,98 | | | 132 | 4,38 | | | 32 | 1,66 |
| Diptera | 78 | 8,22 | 100 | 7,11 | 40 | 3,96 | 210 | 6,96 | 174 | 10,79 | 132 | 6,85 |
| *Chironomidae* | 176 | 18,53 | 134 | 9,53 | 74 | 7,32 | 60 | 1,99 | 118 | 7,32 | 256 | 13,29 |
| Total | 950 | 100,00 | 1406 | 100,00 | 1010 | 100,00 | 3016 | 100,00 | 1612 | 100,00 | 1926 | 100,00 |

Slightly smaller but relatively balanced (fig.2) were incidence of representatives of *Heteroptera* (9.33%), *Coleoptera* (8.49%), *Chironomidae* (8.25%) and *Diptera* (7.40%). Significantly smaller number of individuals and thus a smaller proportion in the structure of the assessment community in *Oligochaeta* (4.32%), *Bivalvia* (3.85%) and *Amphipoda* (2.62%) was found. The item "Others" include the systematic groups of species *Trichoptera* (2.22%), *Hirudinea* (2.18%) and *Odonata* (1.65%) and *Turbellaria* (1.61%), which had the smallest proportion in the evaluated period on the structure of zoobenthos of Nature Reserve Alluvium Žitavy. Representatives of referred systematic groups, was not regularly collected at all sampling sites and each sampling. Therefore we did not confirm the results of research by ŠÁCHA (2000) in Nature Reserve Žitavská luh. We recorded the occurrence of a large number of pieces of exemplars, total up to 18 species of *Odonata*.

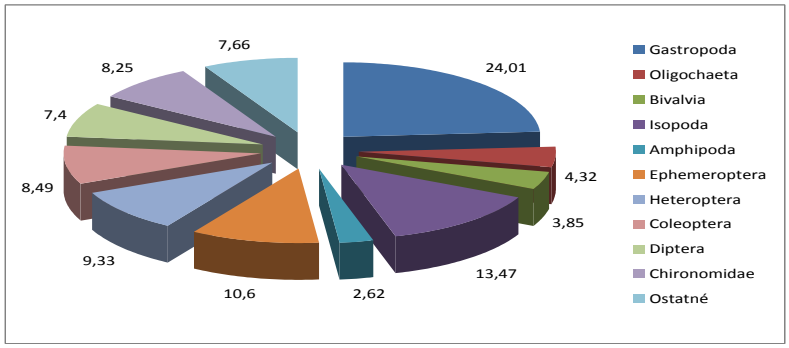


Figure 2. The percentage representation of systematic groups of water of Nature Reserve Alluvium Žitavy

Of the 9920 benthic fauna was the smallest number of individuals (950) recorded at the 1st sampling site, the largest at the 4th sampling sites, which were found to 3016 individuals. Throughout the study period was the highest value of the abundance of the species *Asellus aquaticus* (1336). His numerous representations were highest at the 4th sampling sites (392). The least numerous of this species was at the 6th sampling site, from which it was obtained by sampling only 54 individuals. Second the highest value of abundances was representatives of the family *Chironomidae*, which were obtained in the number of 818 individuals. At the 6th sampling site was their abundance the greatest (256), at the 4th sampling sites the smallest (60). Very low abundance, almost unique occurrence of benthic fauna (less than 10 exemplars), has been reported in up to 20 taxons, of which the lowest frequency observed in species *Ochtera mantis*, *Oxycera meigenii* and *Stratiomys chamaeleon* and individuals of genus *Donacia sp.*and *Ilibius sp*.

By calculation of dominance the species with the highest dominance was *Asellus aquaticus* (13.57%). Lower value of dominance in representatives of the family *Chironomidae* (8.35%) and species *Cloeon dipterum* (4.68%) was found. *Asellus aquaticus* was at the 1st -5th sampling sites eudominant species, with the occurrence above 10%. Greater fluctuation only at the last 6th sampling sites was observed, in which the recendent species with dominance 2.80%. From systematic group of *Gastropoda*, which individuals were in the waters of Alluvium Žitavy represented in the greatest number of individuals and species, the species *Valvata piscinalis* was present at all sampling sites in the relatively large number of individuals, therefore as subdominant species was assessed. Among the species with the lowest incidence of individuals and thus with the smallest proportion in the structure of zoobenthos of Nature Reserve Alluvium Žitavy was for example. *Calopteryx splendens*, *Coelambus impressopunctatus*, *Gyraulus riparius*, *Hemiclepsis marginata*, *Limnephilus rhombicus*, *Pericoma cannescens* and *Tetanocera ferruginea*.

In the evaluated period at all sampling sites occurrence of species preferring to oligosaprobic and betamezosaprobic aquatic environment was recorded. Claim of different species in their habitat to qualities properties correspond to its findings ecological status. The most numerous species inhabiting oligosaprobic aquatic habitats were *Gammarus fossarum*

(246). Between the oligosaprobic species that occurred in a small number of individuals, for example *Anisus leucostoma* (46), *Sericostoma sp.* (18) and *Oxycera meigenii* (2). Among the individuals preferring betamezosaprobic aquatic ecosystems are species *Bithynia leachii* (392), *Caenis robusta* (254), *Valvata cristata* (300), *Gyraulus albus* (264) and *Haliplus ruficollis* (208), which also belonged to species occurring in taken water samples in the greatest number of individuals.

Slovakia's entry into the European Union has brought our country obligation to harmonize the assessment of surface water quality with a quality assurance system, which was developed at EÚ level. Such a system was in October 2000 framework defined in the "Directive 2000/60/EC" as called Water Framework Directive, which is binding on all states. EU Member States are therefore required to implement the directive into national legislation and regulations in water management practice. For this reason, Slovakia abandoned the previously used system of water quality assessment, and has been developed and put in place a new evaluation method, corresponding to the requirements of EU Directive 2000/60/EC. On the basis of the Directive in Slovakia no longer a "quality", but assess the "state". This is assessed complex on the basis of several evaluation criteria. Especially to the fore, instead of assessment "status" based on physical and chemical parameters given biological assessment based on species composition and abundance of biological communities (biological quality elements = "biota"). Biological condition caused by the presence of organic compounds in aqueous medium, at the same time can affect and change the quantitative and qualitative composition of biocenosis.

*Table 2*

Values of saprobic index of water of Nature Reserve Alluvium Žitavy

| *Number of sampling sites* | Sampling | | | | Average |
|---|---|---|---|---|---|
| | I. (pcs) | II. (pcs) | III. (pcs) | IV. (pcs) | |
| **1.** | 2,173 | 2,049 | 2,141 | 1,945 | 2,077 |
| **2.** | 2,014 | 1,776 | 1,743 | 1,753 | 1,822 |
| **3.** | 1,997 | 1,868 | 1,913 | 1,891 | 1,917 |
| **4.** | 2,07 | 2,06 | 1,976 | 1,98 | 2,022 |
| **5.** | 1,854 | 1,895 | 1,866 | 2,085 | 1,925 |
| **6.** | 1,973 | 1,812 | 1,929 | 1,827 | 1,885 |

Based on the requirements of the European Union, the status of habitats of Nature Reserve Alluvium Žitavy on the basis of species composition and abundance of aquatic invertebrate communities and subsequently calculated index of saprobic was evaluated. Calculated values of saprobic index (table 2), depending on the sampling sites, were the highest at 1$^{st}$ sampling sites (2.077); and the lowest at 2$^{nd}$ sampling sites (1.822). The first sampling site was located on a tributary of the river Žitava into the alluvium, because we assume that the sources of higher pollutant concentrations and thus the cause of the deterioration of the aquatic habitat, was the river itself. On the other sampling sites (micro-habitats) were saprobic index roughly balanced. Although in their vicinity were located agroecosystems, their state by agriculture or other economic activities of man, was not adversely affected. Balanced

ecological status of these habitats has been identified within the individual sampling made during the year.

According to the Government regulation of the Slovak republic no. 269/2010 coll. establishing requirements for achieving good water status is the limit value of saprobic index Si = 1.3, taking into account the average index value of saprobic throughout the year. In our monitored area was in the year 2007 the average annual index Si = 1.941. This means that water of Nature Reserve Alluvium Žitavy reached above the limit value of saprobic index, therefore does not comply with the requirement in the above Regulations. However, it is a wetland ecosystem, findings results corresponding with qualitative properties i.e. ecological status of such habitats.

## CONCLUSIONS

In this paper we present results of evaluation of the zoobenthos structure and quality - ecological status of water of Nature Reserve Alluvium Žitavy. Since area of interest is located close to the agro-ecosystems, we consider the possibility of affecting the assessed indicators by agriculture. In that territory has been collecting of benthic material realized at regular quarterly intervals at six sampling sites. Sampling were collected in March, June, August and October, semi-quantitative using sampling network, sieve, but also by „kicking method " and individual collection of individuals. Analysis of samples of water we obtained 9920 individuals, deterministic as 110 species of fourteen systematic groups of invertebrates. Of them, the largest proportion in the structure of benthic macrozoobenthos had *Gastropoda* (24.01%), *Isopoda* (13.47%), *Ephemeroptera* (10.60%), *Heteroptera* (9.33%), *Coleoptera* (8.49%), individuals of family *Chironomidae* (8.25%) and *Diptera* (7,40%). The species with the smallest proportion in the structure of zoobenthos of monitored wetlands (ranging from 1.61% to 4.32%) included representatives of systematic groups *Turbellaria, Odonata, Hirudinea, Trichoptera, Amphipoda, Bivalvia* and *Oligochaeta*.

In the evaluated period at all sampling sites occurrence of species preferring to oligosaprobic and betamezosaprobic aquatic environment was recorded. Claim of different species in their habitat to qualities properties correspond to its findings ecological status. Based on the requirements of the European Union, "Directive 2000/60/EC" and the Government regulation of the Slovak republic no. 269/2010 the status of habitats of Nature Reserve Alluvium Žitavy on the basis of species composition and abundance of aquatic invertebrate communities and subsequently calculated index of saprobic was evaluated. Calculated values of saprobic index, depending on the sampling sites, were the highest at 1$^{st}$ sampling sites (2.077); and the lowest at 2$^{nd}$ sampling sites (1.822). Although in their vicinity were located agro-ecosystems, their state by agriculture or other economic activities of man, was not adversely affected.

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