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ANALYSIS OF CHIRONOMID COMMUNITIES IN THE ECOLOGICAL MONITORING OF THE GALDA RIVER, ROMANIA

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Abstract: Macrozoobenthic communities, especially Chironomidae, serve as an essential tool for biomonitoring the quality of running waters due to their sensitivity to organic load, eutrophication, and toxic contaminants, as well as their limited mobility and relatively long-life cycle. The present study aims to assess the quality of the aquatic environment of the Galda River (Alba County) using benthic macroinvertebrate communities, with emphasis on the taxonomic and functional structure of chironomids. Macrozoobenthos sampling identified 28 taxa belonging to 11 families, with a total density of 5,789 individuals/m^2. The community was dominated by Chironomidae (13 taxa, 62.5% of individuals) and Oligochaeta (7 taxa, 35.5% of individuals), with the group of chironomids tolerant to organic pollution (*Chironomus thummi*, *C. plumosus*, *Chironomus* sp.) being well represented. The simultaneous presence of taxa tolerant to organic load (*Tubifex tubifex*, *Limnodrilus hoffmeisteri*, *Nais bretscheri*) together with others showing moderate tolerance to organic enrichment (e.g., *Gammarus balcanicus*, *Rheocricotopus fuscipes*, *Monopelopia tenuicalcar*) suggests a benthic environment subjected to a significant input of anthropogenic organic matter, yet undergoing an active self-purification process. The results confirm the usefulness of chironomids in diagnosing the degree of eutrophication and the ecological status of running waters, and illustrate the potential of these communities for detecting diffuse impacts and fluctuations in organic loading.
Keywords: running waters, biomonitoring, quality, Macrozoobenthic communities, Chironomidae, diagnosing

1. INTRODUCTION

River water plays a crucial role in maintaining ecological balance; however, surface waters are increasingly threatened by pollution from human activities, including the food industry and population pressures, posing risks to both ecosystems and human health.[1] The Galda River in Alba County, Romania, although medium-sized, is significantly impacted by anthropogenic pollutants. Effective restoration of its ecological integrity requires continuous and comprehensive monitoring of water quality from the river's source to its mouth.[2,3]

Eutrophication and organic pollution, represent one of the main pressures on continental aquatic ecosystems, being caused primarily by excessive inputs of nitrogen and phosphorus from urban wastewater, industrial sources, and diffuse agricultural runoff.[4] These inputs lead to an increase in algal and macrophyte biomass, intensive oxygen consumption during the decomposition of organic matter, and ultimately to episodes of hypoxia or anoxia in the bottom layer, with effects on benthic fauna and fish.[5]

Water quality monitoring cannot be limited to physico-chemical indicators, as these provide only a snapshot of the ecosystem's condition. To capture long-term ecological changes that reflect cumulative or seasonal anthropogenic pressures, the use of bioindicators is necessary—biological communities that respond to environmental changes.[6] Macrozoobenthos, particularly aquatic insects, oligochaetes, and mollusks, is recognized as a reference indicator, given that its organisms have low mobility, life cycles ranging from several months to several years, and varying degrees of tolerance to pollution.[7] Recent studies [8,9] confirm the value of these communities in the integrated assessment of water quality; for example, the analysis of aquatic macroinvertebrates has been successfully used to evaluate the ecological status of a tropical river, demonstrating the correlation between the distribution of taxa and the degree of organic pollution.

Chironomidae constitute one of the most diverse and abundant families of aquatic insects, with over 7,300 species described worldwide.[10] Their larvae inhabit virtually all types of freshwater

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ecosystems, from mountain springs to eutrophic lakes, and their variable tolerance to organic load, hypoxia, and toxic contaminants makes them extremely valuable as bioindicators of water quality and sediment conditions. Numerous studies highlight clear relationships between the composition of chironomid communities and the degree of anthropogenic disturbance, including eutrophication, organic pollution, and contamination with heavy metals and pesticides.[11,12]

The study aims to characterize the structure of benthic macroinvertebrate communities along a section of the Galda River (Alba County), with a special focus on the family Chironomidae; to assess the degree of organic loading and the ecological status of the watercourse and to analyze the potential of chironomids as indicators of eutrophication and self-purification processes in the context of local anthropogenic pressures.

2. MATERIALS AND METHODS

The study was conducted on a section of the Galda stream in Alba County, Romania, located in an area strongly influenced by human activities (settlements, agricultural land, and industrial activities). The Galda River is a watercourse, a tributary of the Mureș River. Figure 1 shows the Galda River and its tributaries, as well as the river into which it flows.

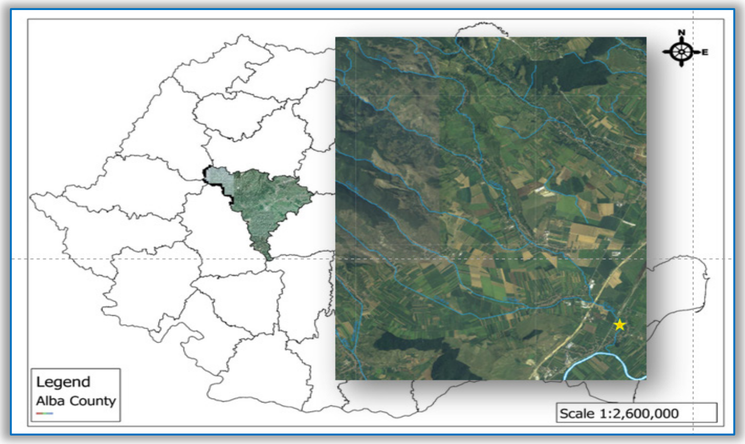

Figure 1. Map of Romania showing Alba County and the sampling point on the Galda River

Although hydrological and chemical parameters are not the primary focus of this work, field observations and the structure of benthic communities indicate a significant organic load, dominated by inputs of anthropogenic detritus. The monitoring program was designed to capture the state of benthic communities under medium-flow conditions, avoiding extreme periods (floods or very low water levels). Macrozoobenthic communities were selected as the primary bioindicator group, in line with current European practices, which prioritize macroinvertebrates in the assessment of the ecological status of watercourses.[13] The monitoring was based on a single sampling campaign in April 2025, conducted in a section considered representative of the studied stretch, which includes several types of microhabitats (rocky substrate, areas with gravel and sand, detritus deposits, and zones with macrophytes).

Sampling of macroinvertebrates

Macrozoobenthos sampling was carried out in April 2025. The sampling method is an adaptation of the SR EN 16150/2012 standard [14], combined with the principles of the European AQEM/STAR method [15] and with modifications proposed in the M10 method used at the national level.

Sampling was carried out using a 25×25 cm (625 cm²) limnological hand net with a 0.5 mm mesh, and the analyzed sample consisted of a composite formed from 10 sampling units distributed proportionally to the main habitat types in the studied section (hard substrate, fine deposits, areas with aquatic vegetation, etc.), resulting in a total investigated area of 6,250 cm².

Sampling was performed as follows: the lower part of the net was positioned against the current, and stones and substrate deposits upstream, within a 25×25 cm square, were manually disturbed so that organisms were washed into the net. Organisms attached to stones were manually detached and added to the sample. Fine deposits were stirred to ensure that organisms were carried into the net. This procedure was repeated for the 10 sampling units, covering the diversity of microhabitats. Samples were sieved to remove coarse particles, transferred to labelled containers, and immediately fixed in 4% formaldehyde (prepared from a 37% solution), ensuring complete coverage of the biological material.

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Subsampling and sorting (Caton device)

In the laboratory, samples were processed using the Caton device, a metal frame with a 500 µm mesh bottom divided into 30 grids (6×5), placed in a plastic tray. The fixed sample was transferred into the device and rinsed with a water jet to remove fine particles and formaldehyde, after which the material was evenly distributed across the grids by placing the device in a thin layer of water.

Of the 30 grids, 5 were randomly selected for sorting, with the aim of reaching a minimum of 350 individuals—a threshold that was exceeded in this case without the need for further processing. Organic material was examined under a stereomicroscope (6–10×), and organisms were extracted with forceps and transferred into containers with water. For very abundant groups, such as Oligochaeta, only 50–100 individuals were counted, and the total number per grid was subsequently extrapolated; the same method was applied to the remaining grids to optimize processing time.

Fragments of organisms were included in the analysis only if they met strict identification criteria, such as the presence of the head capsule and thorax in arthropods, a sufficient number of segments in oligochaetes, or a shell occupied by a specimen in the case of mollusks.

Taxonomic identification

The material was initially sorted into major systematic groups, followed by detailed taxonomic identification under a light microscope, using slide preparations when necessary. For the family Chironomidae, larvae were treated with a 10% KOH solution for four days to highlight the structures of the head capsule, after which they were mounted in a suitable inclusion medium. For oligochaetes, clearing was performed using lactophenol solution, with specimens kept in this reagent for three days before mounting.

Identification was based on specialized taxonomic literature and updated digital resources, such as Fauna Europaea, aiming to reach a target taxonomic level (genus or species) wherever morphology allowed. Juvenile larvae or partially damaged specimens were assigned to the corresponding taxon only if association with mature forms was certain; otherwise, they were classified as separate taxa at a higher taxonomic level.

The sorting process took approximately four days, while detailed microscopic identification required about seven additional days, preceded by a stage of documentation and consultation with specialists in chironomid and oligochaete identification.

Calculation of densities

Density (D) was calculated by relating the number of individuals identified in the sorted grids to the actual analyzed area and extrapolating the result to 1 m². The area of a hand net is 25 × 25 cm, i.e., 625 cm², and the total sampled area (10 units) is 6,250 cm². The Caton device is divided into 30 grids, so the 5 grids selected for sorting correspond to an effectively sorted area of 1,042 cm² of the total 6,250 cm². Density was calculated using the formula: $D = (10{,}000\ cm^2 \times N_{ind}) / \text{sorted area}\ [ind/m^2]$, where N_{ind} represents the number of individuals identified in the sorted subunits.

3. RESULTS AND DISCUSSION

Structure of benthic macroinvertebrate communities

In the analyzed sample (figure 2 and 3), 28 taxa belonging to 12 families were identified, with a total of 5,789 individuals/m². The community is clearly dominated by two taxonomic groups, both in terms of the number of taxa and numerical abundance. The family Chironomidae is represented by 13 taxa and accounts for approximately 62.5% of the total individuals (3,620 ind./m² out of 5,789 ind./m²), while the class Oligochaeta, with 7 taxa, represents around 35.5% of individuals (2,057 ind./m²).

Other groups, including aquatic insects from different orders (*Baetis rhodani*, *Dicranota* sp., *Simulium* sp., *Heleodromia* sp.), Crustacea (*Gammarus balcanicus*), Hirudinea (*Glossiphonia complanata*), Nematoda (*Dorylaimus* sp.), and aquatic mites (Hydrachnidia – *Lebertia* sp.), had much lower abundances (<2% combined), but remain important for interpreting ecological status, as they include taxa more sensitive to organic pollution.

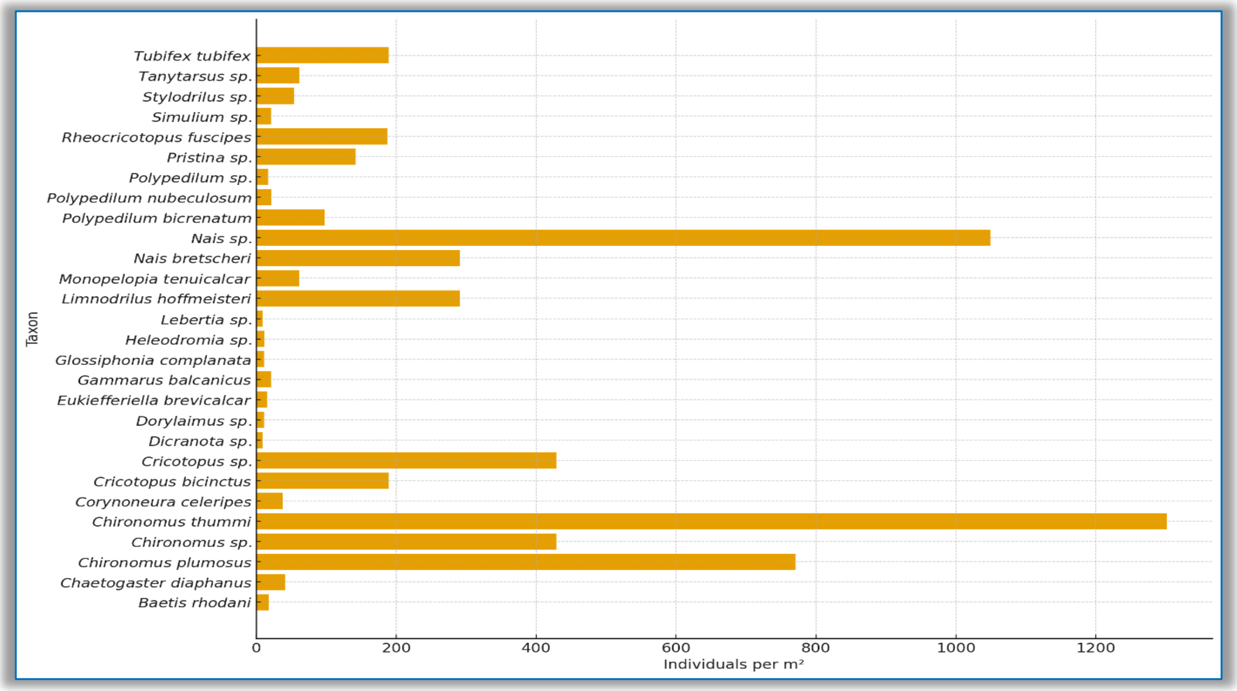

Figure 2. Abundance of Benthic Macroinvertebrate Taxa

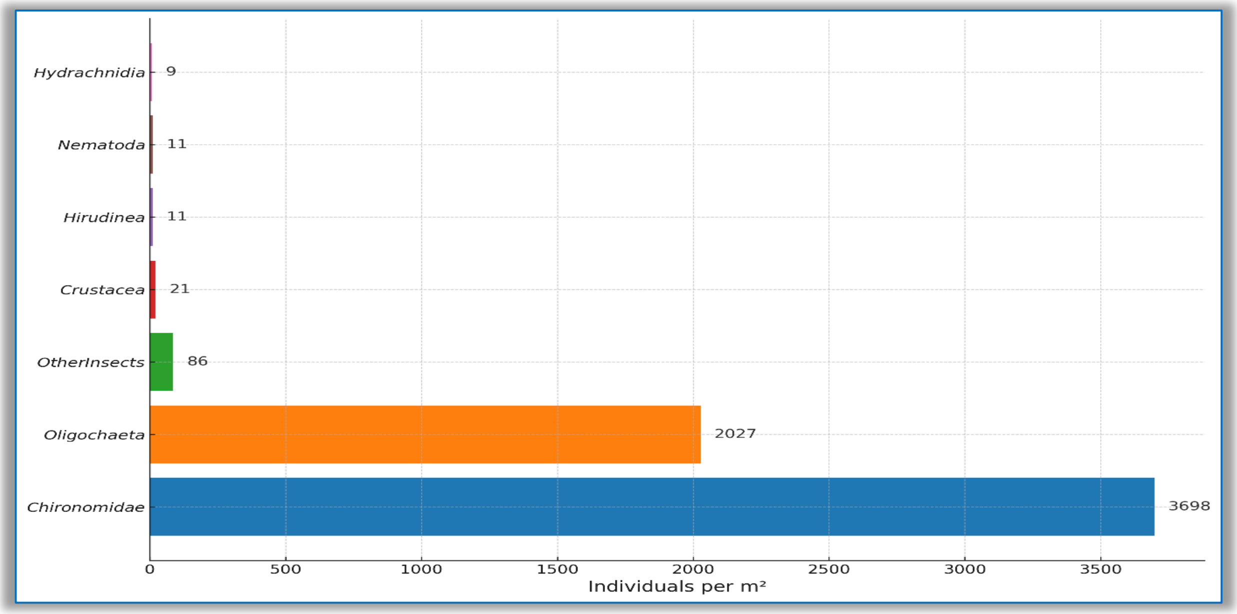

Figure 3. Distribution of taxa across major taxonomic groups

Within the family Chironomidae, the highest densities were recorded for *Chironomus thummi* (1,301 ind./m²), followed by *Chironomus plumosus* (771 ind./m²) and *Chironomus* sp. (429 ind./m²). Other frequently occurring taxa include *Cricotopus* sp. (429 ind./m²), *Cricotopus bicinctus*, *Rheocricotopus fuscipes*, *Tanytarsus* sp., *Eukiefferiella brevicalcar*, *Polypedilum bicrenatum*, *Polypedilum nubeculosum*, *Polypedilum* sp., *Corynoneura celeripes*, and *Monopelopia tenuicalcar*.

The dominant species/genera, particularly those of the genus *Chironomus*, are well known for their preference for sediments rich in organic detritus and high tolerance to low oxygen concentrations, and are frequently associated with mezzo- to polysaprobic waters and eutrophicated ecosystems.

Role of Oligochaetes and the self-purification process

The oligochaetes identified in the sample (*Chaetogaster diaphanus, Limnodrilus hoffmeisteri, Nais bretscheri, Nais* sp., *Pristina* sp., *Stylodrilus* sp., *Tubifex tubifex*) totaled 2,027 ind./m², representing approximately one-third of the total density, confirming a significant input of fine organic matter deposited in the channel, mainly of anthropogenic origin (wastewater, agricultural sources).[16] The very high density of *Nais* sp. (1,049 ind./m²), along with high values for *Limnodrilus hoffmeisteri, Nais bretscheri, Tubifex tubifex,* and *Pristina* sp., indicates a substrate rich in detritus and repeated episodes of organic enrichment.[17]

At the same time, these populations play a key role in the self-purification process: by fragmenting and ingesting detritus and through the activity of sediment-disturbing organisms, they accelerate the mineralization of organic matter and the release of nutrients, contributing to the gradual improvement of oxygen conditions in the sediments.[18] In this context, the presence of taxa preferring relatively clean water, such as *Gammarus balcanicus* (21 ind./m²), shows that although the benthic environment is under significant pressure, self-purification processes are functioning, allowing the persistence of species with higher water quality requirements.[19]

Chironomids as a tool for fine-scale diagnosis of toxic stress

Although the present study focuses on community structure and the saprobic index, it is worth noting that in certain contexts, chironomids can also provide information on toxic stress through the analysis of morphological deformities, particularly at the level of the head capsule. [20,21]

In the case of the Galda River, larval deformities were not systematically analyzed; however, the high densities of taxa tolerant to chemical stress suggest that, in addition to organic loading, the presence of contaminants in the sediments cannot be excluded. Incorporating chironomid deformity analysis in future studies would provide an additional level of resolution for detecting toxic stress. The results obtained for the Galda River highlight several implications relevant to water body management. Chironomid and oligochaete communities prove to be sensitive indicators of rapid changes in organic loading and eutrophication processes, even in situations where diffuse pressures cannot be detected through point-based chemical monitoring.

The simultaneous presence of tolerant and sensitive taxa indicates an ecological system in a fragile equilibrium, yet with real potential for recovery under conditions of reduced anthropogenic pressures, such as the reduction of nutrient discharges from industrial and agricultural activities.[22] In line with international literature [23], the use of chironomids as an indicator group represents an efficient and sustainable strategy for monitoring watercourses, being particularly valuable in areas where financial and logistical resources are limited and there is a need to implement robust yet accessible monitoring programs.

4. CONCLUSIONS

Benthic macroinvertebrate communities in the Galda River are dominated by Chironomidae and Oligochaeta, with high densities of taxa tolerant to organic loading (*Chironomus* spp., *Tubifex tubifex, Limnodrilus hoffmeisteri, Nais bretscheri*), indicating a strong anthropogenic influence on the benthic environment. The simultaneous presence of tolerant taxa and more demanding species (e.g., *Gammarus balcanicus, Rheocricotopus fuscipes, Monopelopia tenuicalcar*) suggests that the benthic biocoenosis is undergoing a dynamic process of self-purification and self-regulation, in which detritivores (oligochaetes and chironomids) contribute to the mineralization of organic matter and the gradual improvement of environmental conditions. The methodology applied proved effective for assessing the ecological status of a watercourse, providing an integrated view of the cumulative impact of anthropogenic pressures. Chironomids are confirmed as a highly valuable bioindicator group for evaluating the quality of running waters, in line with international literature. Their integration into national and local monitoring programs, together with other biological and physico-chemical indicators, can significantly support water resource management decisions and the achievement of the objectives of the Water Framework Directive.

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