Evaluation of eutrophication of Ostravice river depending on the chemical and physical parameters

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Abstract: The main objective of this study was to evaluate which selected environmental parameters in rivers affect the concentration of chlorophyll a and the distribution of macrozoobenthos. The data were collected on selected profiles of the Ostravice mountain river in the Moravian-Silesian Region. The examined chemical and physical parameters include dissolved oxygen (DO), flow rate, oxidation-reduction potential (ORP), conductivity, temperature, pH, total nitrogen and phosphorus concentration.

1. Introduction
One of the important elements of the assessment of the ecological status of surface water under the Water Framework Directive (WFD 2000/60 / EC) is the quantity and condition of phytoplankton [1]. The level of nutrients in rivers has increased dramatically over the last 50 years. The result is the excessive growth of algae (phytoplankton) called eutrophication. Eutrophication mainly affects the stagnant water with a low flow rate. Due to human activity, eutrophication is spreading to the lower parts of the rivers of surface running waters, near large cities with high atmospheric deposition and around agricultural areas due to the spillage of fertilizers [2]. Last but not least, the nutrient addition to the recipient by discharging water from small domestic treatment plants that cannot effectively remove pollution [3].

This research was inspired by a study carried out in 2002-2007 in the Czech Republic (at the lower reaches of the Berounka river), where annual changes in phytoplankton biomass values were observed. Significant influence of temperature and flow on the development of phytoplankton biomass was found. The significant effect of nutrient concentration has not been demonstrated [4]. One of the objectives of this research is to verify the hypothesis whether these effects are reflected to the same extent on the gravel-flowing parts of the river. Also, the abundance and composition of the macrozoobenthos community (i.e., organisms> 1 mm) is considered to be a reliable indicator of our water quality [5]. These organisms are usually bound in flowing waters to the surface of stones (epibenthos), where they inhabit the top or bottom of the stones [6].

2. Matherial and methods

2.1. Locality selection
Three locations (sampling points) on the Ostravice river were selected. The sampling points were chosen so as not to be affected by point contamination (e.g. effluent from the sewage treatment plant), which led to a distortion of the concentration of phytoplankton concentration on the measured parameters. Other conditions were good site availability, good hydraulic conditions for discharge
measurement and taking samples. It was also found that the sampling point was not under the bridge or in its immediate vicinity, possibly before or under the weir.

2.1.1. Locality 1 – Pržno
This site is near Pržno near Frýdlant nad Ostravici. Sampling was done approximately 100 meters from the bridge across the river before the effluent from the wastewater treatment plant. In the river were seen boulders (12-25%), stones (25-50%), rough gravel (12-25%), gravel (6-12%), small gravel (6-12%), submerged vegetation (6-12%), emerald vegetation (12-25%), marginal vegetation (> 50%). The river width was 12.3 m and depth was about 0.5 m. The width and the depth of the river fluctuated depending on the rainfall. The flow in this section of the river was slightly turbulent. In this area, the banks were covered with trees and grasses. The cover the river of vegetation was less than 10%. On the shores were the stands of Salix alba, Alnus glutinosa, Impatiens glandulifera and grasses (e.g. Phragmites spp.)

2.1.2. Locality 2 – Staré město near Frýdek Místek
Sampling was collected out approximately 200 m above the mouth of river Morávka. In the river were boulders (6-12%), stones (25-50%), rough gravel (12-25%), gravel (6-12%), small gravel (12-25%), submerged vegetation (<6 %), emerald vegetation (6-12%), marginal vegetation (25-50%). At this site, the width of the river was 7.2 m, and the depth was approximately 1-1.5 m. The flow was slightly turbulent in this section. The cover the river of vegetation was less than 10%. On the banks were determined these species: Corylus avellana, Swida spp., Populus spp., Acer spp., Dipsacus fullonum, Impatiens glandulifera, Solidago virgaurea.

2.1.3. Locality 3 – Frýdek Místek – Lískovec
The locality is located in Frýdek Místek in local area Lískovec, about 200 m from the railway station Frýdek-Lískovec. In the river were boulders (12-25%), stones (> 50%), rough gravel (12-25%), gravel (6-12%), small gravel (12-25%), submerged vegetation (6-12%) and marginal vegetation (> 50%). The river width was about 12 m and the depth was about 1.5 m, both values vary depending on the rainfall. The flow in this section of the river was slightly turbulent. The riverbanks were overgrown with grasses, sometimes Swida spp and Sambucus nigra. Larger distance from the shore was a deciduous forest that did not reach the river. The cover the river of vegetation was less than 10%.

2.2. Methodology of measurement of physical and chemical parameters
Selected parameters (dissolved oxygen (DO), temperature, pH, conductivity, oxidation-reduction potential (ORP) and flow rate) were measured 1 x monthly from November 2016 at all locations, except for flow rate measurements that were measured only at Locality 1 and 2. At location 3 the flow was taken over from the Czech hydrometeorological institute. Dissolved oxygen and temperature values were measured by the Oxi 3310 SET 1 (incl. CellOx® 325), pH and ORP values were measured with the pH 3310 SET 2 (incl. SenTix® 41) and conductivity was measured by a pocket conductivity meter HQ 30d with electrode CDC401, from HACH company. Flow rate was determined using the hydrometric method. For this measurement was used hydro propeller STS 005 (range 5 cm – 5 m s⁻¹) from Greisinger company. Total phosphorus and total nitrogen were measured using the cuvette tests (LCK 138, range 1-16 mg/L TN and LCK 349, range 0.05-1.50 mg/L PO₄-P) and spectrophotometer DR 6000 from HACH company. The methodology of chlorophyll a determination is defined by the legislation ČSN ISO 10260 [7].

2.3. Method of sampling of macrozoobenthos
Macrozoobenthos was taken 1 x in November 2016. Four sites were selected for each of the selected localities - macrozoobenthos sampling microhabitats: (upper side of stones, bottom of stones, side of stones and sampling in surplus using Surber sampler). Macrozoobenthos was collected using the
Surber sampling method using the semi-quantitative method as a standard three-minute multi-habitat sampling using kick sampling methods by ČSN 757703 [8].

To evaluate statistical dependencies, regression and correlation analysis and Principal Component Analysis (PCA) were selected. For data processing were used MS Excel and Canoco for Windows 4.0 [9].

3. Results and discussion

The data comes from research that has not yet been completed and is a subset of data. The data was obtained by measuring 1 x monthly at each locality from November 2016 to August 2017. At each locality, the measured data was subjected to a correlation analysis to determine the dependence between the individual parameters. The results are expressed using the determination coefficient $R^2$, see table 1.

**Table 1.** Expression of dependence on individual localities between the selected parameters using the determinative coefficient.

| DEPENDENCE                  | Locality 1 | Locality 2 | Locality 3 |
|-----------------------------|------------|------------|------------|
| Chlorophyll $\alpha$ and flow rate | 0.012      | 0.112      | 0.002      |
| Chlorophyll $\alpha$ and total N       | 0.003      | 0.301      | 0.001      |
| Chlorophyll $\alpha$ and total P         | 0.573      | 0.385      | 0.420      |
| Chlorophyll $\alpha$ and temperature     | 0.043      | 0.060      | 0.301      |
| Chlorophyll $\alpha$ and DO             | 0.016      | 0.010      | 0.329      |

It can be seen from table 1 that there is a significant dependence between chlorophyll $\alpha$ and phosphorus only at locality 1 (in Pržno), where the correlation coefficient $R^2$ reached 0.573 (see figure 1).

![Figure 1](image1.png)

**Figure 1.** Dependence of chlorophyll $\alpha$ concentration and concentration of total phosphorus - Locality 1.

The data on the frequency of individuals and species of macrozoobenthos found in November 2016 were subjected to a PCA analysis in Canoco for Windows 4.0. The output is the ordination graph shown in figure 2. Thus, two axes are apparent from the intensity of the correlation relationship between the variables and the major axes. Both of these axes (axis 1 (x) and axis 2 (y)) show dependencies of the measured parameters on the occurrence of certain species at localities and microhabitats. Numbers 1-10 in the ordination chart represent a particular habitat on a particular site, for clarity the numbers are assigned to the individual microhabitats and localities in table 2.
Figure 2. Graph of PCA analysis.

Table 2. The numbers of individual microhabitats in individual localities.

| MICROHABITATS                | Locality 1 | Locality 2 | Locality 3 |
|------------------------------|------------|------------|------------|
| The upper side of the stones | 2          | 6          | 10         |
| The underside of stones      | 3          | 7          | 11         |
| The side of the stones       | 4          | 8          | 12         |
| Surber sampler               | 1          | 5          | 9          |

From the PCA analysis graph, the variability of the environmental parameters, which corresponds to the time of measurement, can be observed. From the point of view of the biotopes, the similarity of the habitats forming the cluster in the 3rd quadrant and the biotopes corresponding to the side and bottom of the stones, eventually the gravel deposits (abstraction through the binary network) of the localities 1, 2, 3 with the most frequent grain fractions of the stones and the rough gravel. Locality 1 shows slightly different properties due to its strong torrential character, which corresponds to the composition of the composition of Heptagenia sulphurea, Hydropsyche juvenile, Elmis aenea, Orectochilus villosus, Baetis lutheri, Rhyacophila nubila. Other biotopes corresponding to the top and bottom sides of the stones (2, 3) at locality 1 differ (less oxygen on the underside, strong stream on the upper side), lower dependence on these biotopes occurred in Polycentropus flavomaculatus, whose larvae form nets and are capable with the stones to snap. Taxa of biotopes 6, 10 (upper sides of stones) at locations 2 and 3 show a negative correlation with ORP and flow, including species representation on the given biotopes. The occurrence of Baetis sp. and the family Chironomidae, slightly Dugesia gonocephala. Baetis sp. and Chironomidae, however, exhibit higher variability of occurrence within given samplings. Biotope 5 (Surber sampler) at locality 3 is significant for the presence of representatives of the highly variable species Gammarus pulex. The occurrence of this species is negatively correlated with the oxygen content. Negative correlations with oxygen are also found in Hydropsyche pellucidula, Lumbricus variegatus (both benthic) and Asellus aquaticus (bottom of stones) on locality 3.

4. Conclusion
When evaluating the data in this work, a low dependence between chlorophyll a and temperature was found by regression and correlation analysis at all localities. The relationship between chlorophyll a and pH was not established. At site 2, there was a weak relationship between chlorophyll a and total nitrogen. The localities showed a weak (locality 1 and 2) to no (location 3) dependence between chlorophyll a and flow rate. Hypothesis, which results from a study carried out in 2002-2007 on the river Berounka (Desortová, Punčochár, 2010) was not confirmed at the Ostravice mountain river. Our
research shows that chlorophyll a concentration is dependent on temperature and total phosphorus concentration, the effect of flow rate has no significant effect on chlorophyll a concentrations. It should be noted that the data were obtained from November 2016 to August 2017 and the results presented here may change in the future, as research is still ongoing.

In terms of macrozoobenthos data, Dugesia gonocephala, Baetis sp., Gammarus pulex, Asselus aquaticus, Hydropsyche pellucidula and Lumbriculus variegatus and Chironomidae were found to be dependent on temperature, pH and conductivity. The narrow dependence of species on temperature, pH, flow and conductivity can be found in Lumbriculus variegatus and Leuctra fusca. On the other hand, dependence on these parameters has not been demonstrated for these species: Radix peregra, Baetis vernus, Simulium sp., Ameletus inopinatus, Psychomyia pusilla, Habroleptoides confusa, Ephemera danica, Diceranota sp. and Chironomidae. The following species depended on ORP and oxygen Habroleptoides confusa, Hydropsyche juvenile, Heptagenia sulphurea, Elmis aenea, Orectochilus villosum, Baetis lutheri, Erpobdella octoculata and Rhyacophila nubila, Rhithrogena semicolorata, Baetis juv., Baetis sp., Ancylus fluviatilis, Polycentropus flavomaculatus, Heptagenia sulphurea, Atheris ibis and Isoperla oylepis. These species are closely related to pH value: Baetis alpinus, Radix peregra, Dugesia gonocephala, Asselus aquaticus, Habroleptoides confusa, Erpobdella octoculata and Hydropsyche juv. Temperatures, oxygen and flow are dependent species Hydropsyche fulvipes, Paraleptophlebia sp. and Ephemera ignites. Conductivity and ORP are dependent species of Psychomyia pusilla, Ameletus inopinatus, Ancylus fluviatilis, Ephemera danica and Diceranota sp. The species Simulium sp., Baetis sp., Baetis scambus, Baetis juv., Atheris ibis, Isoperla oylepis, Rhithrogena semicolorata, Baetis lutheri and Baetis rhodani do not show any dependence on any of the measured parameters. Except for pH value, the taxa always depended on more parameters.

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