# MODIFICATIONS INDUCED BY ANTHROPIC ACTIVITIES UPON THE MACROZOOBENTHIC INVERTEBRATE COMMUNITIES FROM THE BRĂTCUȚEI VALLEY (BIHOR COUNTY, ROMANIA)

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**Abstract.** The aim of the present study was to highlight the dynamics of macrozoobenthic invertebrate communities from Brătcuței Valley, in three different areas impacted by anthropic factors in different ways. The changes occurred due to this impact were observed in spring, summer and autumn periods with the purpose to determine whether the different seasons of the year can amplify or diminish the effects of human activities upon the benthic communities. The modifications of the macrozoobenthos were correlated with the variations of certain physico-chemical parameters of water (temperature, conductivity, the dissolved oxygen content, total dissolved solids TDS). We have analysed the ecological parameters which reflect the modifications of the macrozoobenthic communities such as species richness, diversity (Shannon-Wiener index), the percent of Oligochaeta and Chironomids larvae (%OC) from the total macrozoobenthos, the percent of Ephemeroptera, Plecoptera an Trichoptera larvae (%PT) from the total macrozoobenthos. We have observed changes in the structure of the macrozoobenthic communities in the areas of the valley affected by the effluents of a trout farm, which are very obvious especially in the warm season. Also the river stretch affected by domestic waste waters has a modified macrozoobenthic community, in a greatest degree from the all investigated sampling points.

**Keywords:** macrozoobenthos, anthropic impact, trout farming, domestic waste waters.

**Rezumat. Modificări ale comunităților de nevertebrate macrozoobentice din Valea Brătcuței (județul Bihor, România), induse de activitățile antropice.** Prezentul studiu a avut drept scop urmărirea dinamicii comunităților de nevertebrate macrozoobentice din Valea Brătcuței, în trei zone ale acesteia supuse în mod diferit impactului antropic. Modificările datorate acestui impact au fost urmărite în perioadele de primăvară, vară și toamnă, pentru a urmări în ce măsură perioada anului intensifică sau diminuează efectele activității antropice. De asemenea, modificările au fost corelate și cu variația unor parametrii fizico-chimici ai apelor (temperatura, conductivitatea, conținutul de oxigen dizolvat, cantitatea totală de substanțe solide dizolvate - TDS). Parametrii ecologici care reflectă modificările comunităților macrozoobentice avute în vedere au fost bogăția de specii, diversitatea (exprimată prin indicele Shannon-Wiener - H), procentul de Oligochete și larve de Chironomide (%OC) din total macrozoobentos și procentul larvelor de Efemeroptere, Plecoptere și Trichoptere (%EPT) din total macrozoobentos. S-a constatat că există modificări ale structurii comunităților macrozoobentice în zonele afectate de funcționarea unei ferme salmonicole, ale cărei efecte sunt vizibile în special în sezonul cald. De asemenea, pe sectorul studiat, comunitatea macrozoobentică este afectată în măsura cea mai mare, în zona de deversare a apelor reziduale menajere.

**Cuvinte cheie:** macrozoobentos, impact antropic, salmonicultură, ape uzate menajere.

## INTRODUCTION

Mcrozoobenthic invertebrates are important components of the freshwater environment. They represent an important trophic compartment for the functioning of the running water ecosystems, elements of the biodiversity and biological indicators of water quality (FABRIZI et al., 2010; GUILPART et al., 2012).

The structure and dynamics of the macrozoobenthic invertebrate community is determined by the hydrological characteristics of the watershed they inhabit, its trophicity and degree of pollution (MUNOZ, 1989; STOIANOVICI et al., 2017).

One of the most widespread sources of pollution are domestic waste waters. These are especially present in the area of small localities where the sewage plants are lacking, so some of the domestic waste waters reach the surface waters (ATASOY et al., 2006; BADRUZZAMAN et al., 2012; CAREY et al., 2013). The pollution with domestic waste waters is characterised by a high organic content, the presence of the detergents and microorganisms (HELGESON & MCNEAL, 2009; BADRUZZAMAN et al., 2012). These pollutants modify the physico-chemical parameters of the waters they flow in and influence the structure of the macrozoobenthic community.

The increased quantity of the organic content intensifies the activity of the microorganisms from water sediments. This increased metabolic activity of microorganisms consumes the oxygen from the water and can generate hypoxia (VITOUSEK et al., 1997). The detergents contained in these waste waters add a significant quantity of nutrients and create favourable conditions for algal bloom (BADRUZZAMAN et al., 2012).

Another source of pollution of anthropic origin are waste waters from trout farms situated near small mountainous water courses. These farms use water from the nearby streams and their effluents are periodically released in these surface waters. The effluents from the farms have a high content in N and P compounds, generated by the metabolism of the fishes or by food and drugs remains in the water. There are several studies in Europe concerning the effects of these waste waters from trout farms upon the quality of the receiving waterbodies and on the macrozoobenthic invertebrate communities (MUNOZ, 1989; CAMARGO, 1992; HARRISON et al., 2007; SINDILARIU et al., 2008; MESA et al., 2013; STOIANOVICI et al., 2017). These studies underline the impact of these waste waters loaded with nutrients and microorganisms upon the macrozoobenthic invertebrate communities.

During our study we have examined the macrozoobenthic community from Brătcuței Valley, tributary of Crișul Repede River. The valley is a mountainous stream which has an upper course on a stony riverbed, with a high speed, passing a beech forest and with no localities in the area or evident anthropic activity with a negative impact on the water quality. In the middle course the valley passes an area with some week-end houses and a trout farm. In this area it is possible that domestic waste waters from the houses and trout farm effluents might be spilled in the valley, especially in the warm season of the year. In the inferior course, the valley flows through Bratca village before it reaches the Crisul Repede River. In this portion the pollution with organic wastes and garbage, especially PET bottles, is obvious.

Considering these facts, we analysed the effects of these types of anthropic impact factors upon the macrozobenthic community in the analysed portions of the valley in different periods of the year (spring, summer and autumn).

## MATERIAL AND METHODS

The samples were collected from Brătcuța Valley, tributary of Crișul Repede River, from three sampling sites chosen to be different from a hydrological point of view and with a different anthropic impact intensity.

The samples were collected in the spring, summer and autumn from each sampling site, in order to follow the dynamics of the macrozoobenthic communities due to life cycle particularities.

The samples were collected with a Surber dredge, with a surface of 0,9 $m^2$, and a mesh size of 250 µm. The samples were preserved in the field in 4% formaldehid solution and transported to the lab. In the lab the samples were sorted under a 40X magnification stereomicroscope, the different invertebrate groups were transferred into 80% ethylic alcohol and determined using specific keys for each group.

The samples were collected from the following sites:

- **Brătcuței Valley upstream** (B1) – situated 6 km upstream from Bratca village. The valley passes through a beech forest, near a road, in a hilly region. The valley is 2-3 m wide, with fast flowing portions. The riverbed is covered by pebbles and boulders. The aquatic macrophysics vegetation is absent and the phytobenthic is very scarce, located only on the slow flowing portions. The allochthonous debris is present in small quantities because the fallen leaves are washed away by the current. No localities or human activities are performed in this area or upstream.
- **Brătcuței Valley downstream the trout farm** (B2) – situated at 4 km upstream Bratca village. The valley passes a more flat region, there is a trout farm and some week-end houses in the area. The valley is 3-4 m wide, 20-50 cm deep, the riverbed is covered by boulders, rocks and pebbles and near the banks with gravels and sand. The macrophytic aquatic vegetation lacks, the phytobenthos is scarce, but there are greater allochthonous material accumulations.
- **Brătcuței Valley at Bratca** (B3) – the sample site is located in Bratca village. The banks of the valley are dammed, on the shore there is a treeline of genus Alnus and Salix, and also a rich herbaceous vegetation. The valley is 6-8 m wide, the phytobenthos on the rocks is scarce, but the riverbed includes a lot of allochthonous material, including domestic waste (vegetable debris, plastic waste, glasses and others).

The physico-chemical parameters were measured with a Hanna HI 9829 multimeter. The following indexes were calculated: species richness, Shannon-Wiener diversity index, percent of Ephemeroptera, Plecoptera and Trichoptera larvae from total macrozoobenthos (%EPT) and percent of Oligochaeta and Chironomids larvae from total macrozoobenthos (%OC).

## RESULTS AND DISCUTIONS

From the collected samples in the three sampling points, we have identified a number of 12 systematic groups of invertebrates including worms, crustaceans and also aquatic insect larvae such as: Ephemeroptera, Plecoptera, Coleoptera larvae, as well as imago, Chironomids, Trichoptera, Simuliids and other Diptera. The best represented insect larvae in terms of number of species were the Coleoptera, Trichoptera and Ephemeroptera.

The measured values of the physicochemical parameters showed a great variation of the dissolved oxygen content between the three sample sites, with their greatest values at B1 (23.9 to 265%). The variation tendency is for the concentration to raise at lower temperature and vice-versa, because the solubility of oxygen in water is negatively correlated to water temperature (Fig. 1). The values at the sampling site B2 are much smaller at comparable temperatures. These lower values show an anthropic impact due to waste waters released in the valley from the houses and also from the trout farm. These waste waters have high microbial content, these microorganisms consume the oxygen in their metabolism (ALABASTER, 1982; MUNOZ, 1989). The recorded values for the dissolved oxygen at this sample site were between 4.7 and 6.6% (Fig. 1).

At the sample site B3, the measured values of the dissolved oxygen were even lower because in this sector of the valley the human impact is the greatest from all investigated sites. The valley passes through Bratca village, where a significant amount of domestic waste waters reach the water course. Also, the values of the water temperature measured at this sampling site were the highest, so the solubility of the oxygen was the lowest. The high temperature and the great organic content from the waste waters were the causes of the severe oxygen content drop to 0. 9 - 1% (Fig. 1).

The temperature had seasonal variations according to the air temperature, so the greatest values were measured in July, smaller in October and the smallest in March. Between the three sampling sites there were significant variations of the water temperature. At site B1 between 3.21$^0$C and 7.08$^0$C, at B2 between 5.83$^0$C and 9.03$^0$C, and at B3 between 15.38$^0$C and 19.4$^0$C (Fig. 1).

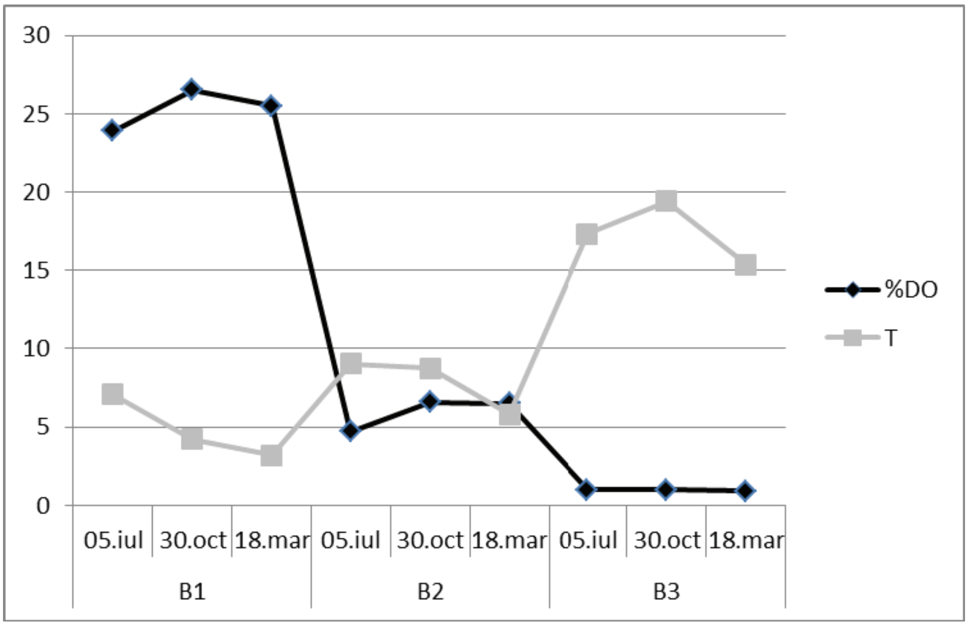


Figure 1. The values of temperature and dissolved oxygen in each sample site and period.

These differences between the water temperatures in the three sampling sites are due to the different microclimate of the sites and the particularities of the terrain. At B1 the valley is narrow, shaded almost all day long, at B2 the valley is broader and not so shaded during the day, and at B3 there is an open area with lot of sun shine and less shade.

The values of the conductivity and total dissolved solids (TDS) show no significant differences between the three sample sites (Fig. 2). The greatest values were measured in all three sampling sites in March and the smallest in July. We consider that the dissolved substances were consumed by the aquatic organisms, in the warm season, when they have the greatest density and a high metabolic rate.

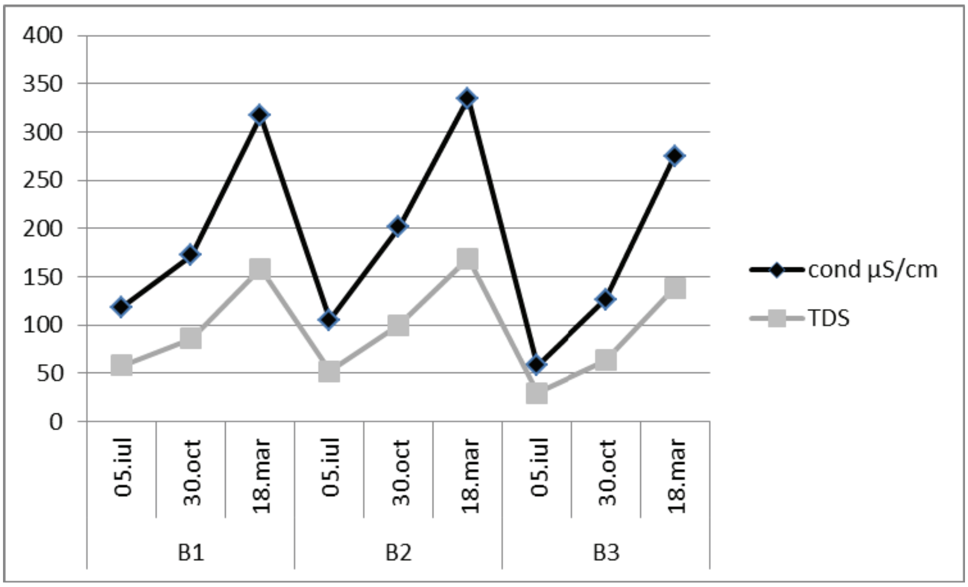


Figure 2. The values of conductivity and total dissolved solids in each sample site and period.

The species richness have the greatest values in all three sampling sites in July, because during summer most of the species with aquatic larval stage can be found in the water. During autumn some specimens of insects emerge, leaving the aquatic environment, so the richness of species decreases. In the spring period, the richness of species had the lowest values, because water is cold and a small number of species and individuals are active after the winter diapause. Also, some of them do not survive winter, because the valley has a small water volume along its course and most of it can freeze during winter (Fig. 3).

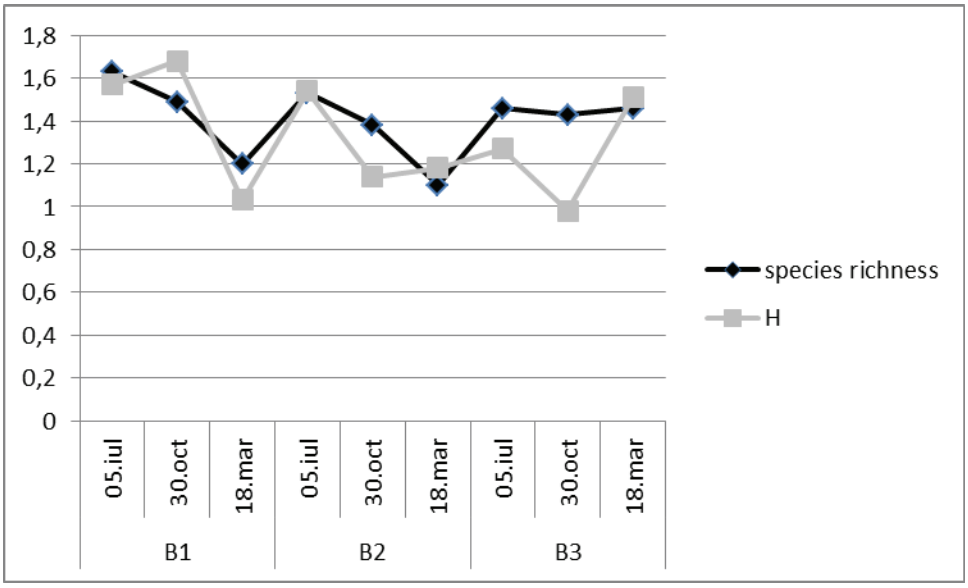


Figure 3. The values of species richness and Shannon-Wiener diversity index in each sample site and period.

The diversity (H) has the greatest values at site B1 excepting March, when due to the very cold water a small number of species are active. At sites B2 and B3 the lowest values of H index were reached in October because the species richness drops due to the emergence of adults for many species. At sample site B3 the greatest diversity was reached in March when water temperature was the lowest so the microbial activity was minimal. In the absence of the decomposing action of bacteria the oxygen consumption remained low and other toxic metabolites produced by microorganisms had low concentration and they did not affect the macrozoobenthic community (CAREY et al., 2013). The differences between H index in the three sampling sites are not too high, and this situation was observed also in other rivers affected by pollution with fish farming waste waters (STOIANOVICI et al., 2017) or with domestic waste waters (BADRUZZAMAN et al., 2012).

At site B1 the macrozoobenthic community is made up mostly by Plecoptera larvae which have a density of over 200 specimens/m$^2$ in March (Fig. 4). Also abundant were the Ephemeroptera larvae, which have the most constant effectives in all investigated seasons compared to Plecoptera. With a smaller density we also found Coleoptera imagos and Trichoptera larvae, but also well represented in the community.

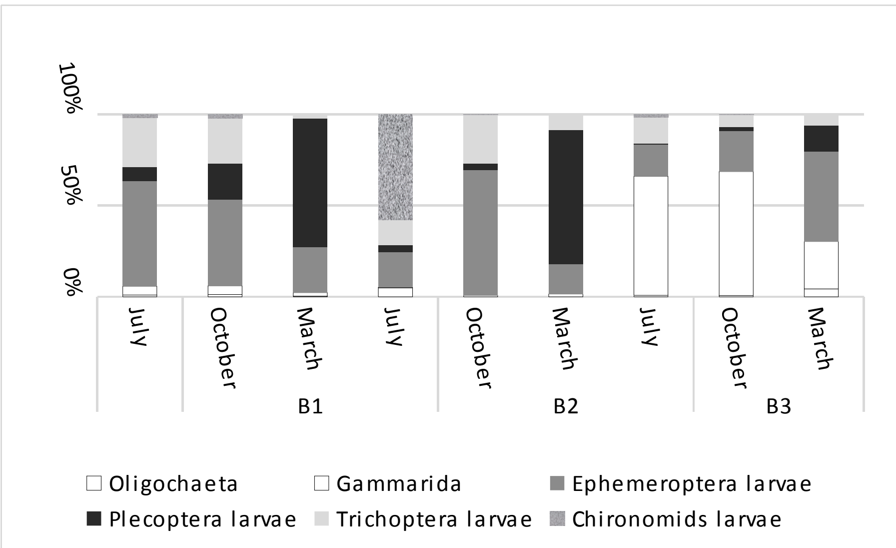


Figure 4. The proportion of the main macrozobenthic groups in each sample site and period.

Gamarida had small densities because the quantity of debris in the riverbed is small, so they lack the required nutrients to develop big populations. The Diptera larvae (Chironomids, Simuliids and other Diptera groups) have very small densities, they are not characteristic for this altitudinal and hydrographic sector. Oligochaeta as detitivorous group are present with very low densities at this sampling site.

The structure of the macrozoobenthic community at this site is characteristic for this mountainous area being dominated by Plecoptera, Ephemeroptera and Trichoptera larvae; this structure indicates good water quality, also confirmed by the values of the physico-chemical parameters.

The general structure of the macrozoobenthic community in this sampling site by its taxonomic structure and number of specimens characterises good water quality, without a significant human impact, characteristic for the mountainous sector.

At site B2 the macrozoobenthic community is dominated by Ephemeroptera, Chironomids and Plecoptera larvae. Ephemeroptera larvae have the greatest abundance in October, probably due to the presence of a new larvae generation resulted from the summer reproduction. In March their abundance decreases especially due to mortality in the winter season and their consumption by predators.

Plecoptera reach the greatest abundance in March and are less abundant in the rest of the investigated periods. This fact is due to their preference to live in cold, well oxygenated waters, and they have this condition in the early spring period. Trichoptera larvae have a similar dynamics of abundance with the Ephemeroptera, because they are influenced by the same environmental factors.

Chironomids larvae have small abundancies except July when they are the most abundant in the community. This phenomenon can be caused by the warm water in the summer period together with the increase of the organic decomposition process and a probable human impact represented by a high quantity of water discharge from the houses and the trout farm. The nearby houses are inhabited especially during the summer period, these are not connected to a sewage plant so they discharge their waste waters in the valley. The domestic and trout farm effluents have a high organic content, so they ensure a very good nutritive support for Chironomids larvae. Also the waste waters from the trout farm have a high organic content so they create favourable conditions for Chironomids larvae development (MUNOZ 1989; MESA et al., 2013; STOIANOVICI et al. 2017).

We can′t know for sure which is the exact cause of the Chironomids population explosion, but we suppose it occurred as a result of a short term impact, because their density dropped in autumn and the abundance of Grammarian, which are indicators of high organic content is low. If the organic substances would be present permanently in high load the abundance of Gammarida would be much higher.

At this sample site we also found relatively high abundance of Coleoptera and low abundance of Turbelariata, Oligochaeta, Coleoptera larvae, Simuliids larvae and other Diptera larvae.

The structure of the macrozoobenthic community at sample site B2 shows a water with good physico-chemical quality which allow the existence of sensitive groups with high abundancy, but the increased abundance of Chironomids larvae in July shows an anthropic impact, which even if it is localised can threat for the investigated community.

At site B3 Gammarida are highly dominant in the community. Their maximum abundance was observed in july, when the water temperature was the highest and the organic load the greatest. The high abundance of the Gammarida during the whole studied period suggests a long term human impact seen especially in a high organic load resuted from discharge of domestic waste waters and vegetal debris directly into the valley.

Ephemeroptera larvae had a relatively hig abundance, but lower compared to the previous sample sites. Plecoptera larvae were present in very low number because they represent the most sensitive group to the depreciation of the water quality. The hydrological conditions of the valley offer the possibility for Plecoptera to populate this area, but their absence confirm the presence of the human impact which affects the water quality, by its high organic content and oxygen deficiency.

Trichoptera larvae also have smaller populations than in the former sample sites, emphasizing the decrease in water quality. Turbelariata, Oligochaeta, Coleoptera (larvae and imago) Simuliids and Chironomids larvae have small abundancies comparable with the first two sample sites. Their sensitivity to water quality change is lower than those of the former groups.

The anthropic impact at sample site B3 is the highest and longest in time from all three investigated sites. Together with the increase of human impact from site B1 to B3 we can also observe a modification of the valley hydrography, the slope of the terrain decreases, the valley is wider and it is less shaded during the day. These factors modify the temperature of water in the three sites, from cold to warmer ones as we move downstream along the valley. These modifications associated with the constant human impact at B3 modify significantly the macrozoobenthic community structure compared to the other two sampling sites.

The proportion of EPT in the three sampling sites during the investigated period shows important differences. At the sample site B1, %EPT is over 70% (Fig. 5) for the entire period, and in the spring is even over 90%. At site B2 the proportion of EPT is over 80% except July when it drops under 40%. This decrease is due to the enrichment of the water environment in organic content caused by waste water discharge in the valley. At sample site B3, the proportion of EPT is under 30%, except March when it reaches values over 60%. This increased value in

March is due to lower water temperature, higher oxygen content and lower microbial activity, factors which create conditions for the development of the EPT group in the waterbed.

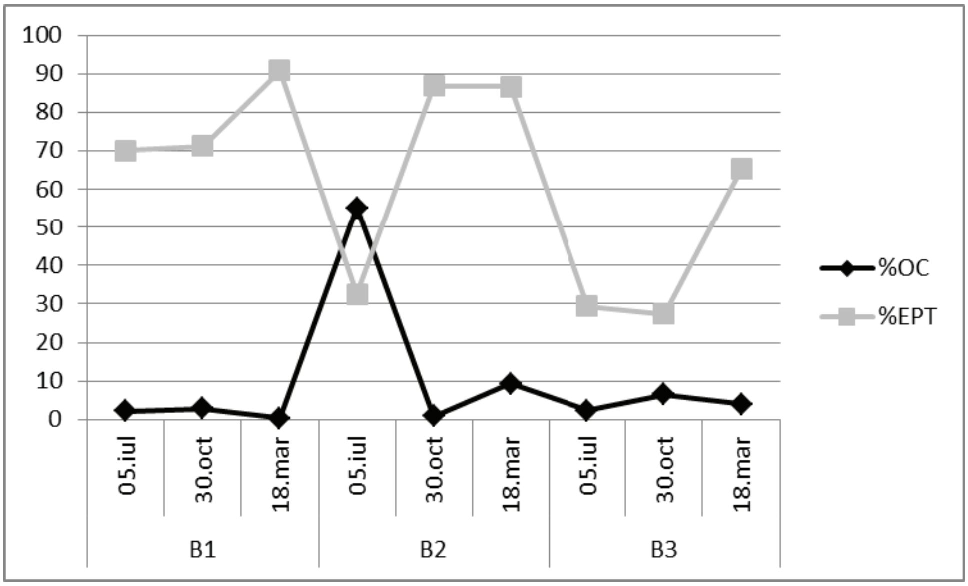


Figure 5. The values of %OC and %EPT in each sample site and period.

%OC have very low values at B1, a site where the environmental conditions are not favourable to these groups. At B2 the values are also low except July when due to the high organic charge the proportion of OC increases spectacularly. The general conditions for the development of Oligochaete and Chironomids larvae at this sample site are not favourable, they only develop larvae populations under human impact.

At B3, %OC are low and very similar during the study period, unless water has a high organic load. The riverbed made up by stones is not very favourable for these groups and probably the domestic wastes contain detergents and other chemicals which can be tolerable by these groups which are otherwise expected to be found in high proportion in these kind of sectors (ROSENBERG & RESHT, 1993; DOBSON et al., 2002; HARRISON et al., 2007).

## CONCLUSIONS

The invertebrate macrozoobenthic community living in the sample site B1 from Brătcuței Valley is made up mostly by Ephemeroptera, Plecoptera and Trichoptera larvae, characteristic to waters from mountainous regions, with high flowing speed, high oxygen content, with low temperatures and a rocky riverbed. At this site the human impact is minimal so we can say that these waters are in natural state and can represent reference conditions for the upstream sector.

At B2, the hydrological conditions are slightly modified, the physico-chemical parameters are also different, the oxygen content is lower, the pH has lower values, the conductivity increases as well as TDS. The structure of the macrozoobenthic community does not change very much, except July when we have observed a significant increase of the Chironomids larvae abundance. Their increase, together with the alteration of the physico-chemical parameters is caused by an anthropic impact caused by waste water discharge.

At B3 we have observed an alteration of the physico-chemical parameters as the valley passes through Bratca village. At this site the human impact is permanent and lasting for a long period. This impact is reflected in the modifications of the physico-chemical parameters values. The structure of the macrozoobenthic community at this site is very modified, comparing to the former two sites. The community is dominated by Gammarida, represented by very dense populations in these waters with a high detritus content.

We can observe along the valley a gradual modification of the physico-chemical parameters and of the macrozoobentic community structure due to the different antropic impact from the point of view of its frequency and intensity.

We consider that Brătcuței Valley is a water body which in the upstream sector has a good water qualiy which allow the development of a macrozoobenthic community made up by sensitive species. The middle and downstream sectors are affected by human impact which affects the macrozoobenthic communities, and for that reason we consider that it is important to monitorize the evolution of the intensity of the impact in the places where already happens.Also it is important to monitorize the whole valley to follow if other sectors will be affected by the anthropic impact as there is a tendency to extend the built area and the human activity upstream on the valley.

We recomend to monitorize the valley sector which is not affected in order to detect any modifications of the physico-chemical parameters and of the macrozoobenthic community structure as soon as the water quality decrease in time to stop the irreversible depreciation of the quality of aquatic environment.

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