PARTICULATE ORGANIC MATTER (POM) AS ENERGY BASIS FOR A MOUNTAIN BROOK ECOSYSTEM AND ITS DISTRIBUTION IN SPACE AND TIME

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S u m m a r y :

The Ecosystem-concept is discussed in respect of energy bound to matter as connection between the components of the system. Thus, energy flow and circulation of matter are the basic principles in ecology. According to ELLENBERG (1973) an "incomplete" ecosystem accepts its energy bound to allochthonous organic matter from outside like in a mountain brook as it is studied here. Organic matter enters the system either dissolved or particulate like leaves, dust, soil-particles or woody debris. Most of it is not readily available for the consumers unless it is conditioned by the microbenthos (fungi, bacteria a.s.o.). The latter mediates between organic matter and the macrofauna, extremely abundant and diverse in mountain brooks. POM as food increases in quality and availability with increasing microbial biomass and their adhesive bound metabolic products. Energy flows mainly from allochthonic organic matter to the microbiocoenosis and finally to the macrofauna.

CUMMINS and his collaborators designed a welldefined system for POM, based solely on the size of the particles, replacing the not clearly defined terminus "detritus". POM became also a basic compartment in the "River-Continuum Concept" described by the same team of researchers.

Bedsediments are forming the river channel. Their biocoenosis is dominated by epigeic species. At the study site (RITRODAT experimental area), the brook biocoenosis has distribution maxima deep in the bedsediments (20 to 40 cm). The vertical distribution shows that the bedsediments are a prefered biotope, offering sufficient living space, oxygen and food. Therefore, the aim of this study is the quantitative description of the in situ distribution of POM in the bedsediments and in time.

The RITRODAT experimental area is a 100 m long stretch of the "Oberer Seebach", a second order mountain stream in the northern limestone formation of the Alps near Lunz/See, Lower Austria (600m a.s.l.). The study site is described in detail.

POM is determinded by analyzing three main elements of organic molecules: Carbon (OC), nitrogen (N and ON) and phosphorus (P and OP). The chemical methods used in this study are described in detail and discussed.

The food-quality of POM is described too, using nitrogen as an indicator for proteins. Thus, food-quality is correlated positively with the nitrogen content and negatively with the C/N ratio. The reliability of this method is discussed.

Samples of brook sediments are taken by two methods: the RITRODAT standpipe trap allows the collection of interstitial sediments and water from a defined sediment depth. The N_2-freeze-core method allows the collection of the entire sediment-water-complex and the separation of the sample according to sediment depth.

A method to differentiate between organic and inorganic nitrogen and phosphorus is described.

The surface area of sediment grains is determined by assuming the grains as spheres (underestimation) and with an AREAMETER (overestimation). The mean between both measurements is used as the nearest approximation.

The distribution of POM is highly influenced by the availability of surface area of sediment grains. Since small grainsize-classes offer extremely more surface area than larger grainsize-classes if they are based on a unit of weight, the first ones are most important for POM distribution. The correlation between grainsurface, graindiameter and POM holds only down to a grainsize-class of 0,5 to 1,0 mm in diameter. Below, POM-content per unit of surface area is decreasing.

Nitrogen and phosphorus, dissolved in surface- and sedimentwater, display no pattern in time. Variations of N and P in time are parallel. Annual means of N and P concentration are decreasing slightly with increasing sediment depth.

The granulometric analysis reveals the domination up to 96,8 % weight of grainsizes larger than 10 mm ø. Upstream of a gravel bank (4B) the relative amount of fine grainsize-classes is increasing with sediment depth, increasing the available sediment surface area by a factor of three. In the main channel (8A) grainsize distribution is roughly the same in all sediment depths, when based on a layering of 0-20, 20-40 and 40-60cm. If the topmost layer is separated at a sediment depth of 10cm, fine grainsize-classes increase with sediment depth, exhibiting the influence of the high current of surface water. Although sediments have been deposited downstream of the gravel bank (12B) over the whole study period, the distribution pattern of grainsize-classes is not influenced.

The mean annual porosity, measured as water content, varies between 18 and 37 %. Based on a layering of 0-20, 20-40 and 40-60cm porosity increases with sediment depth at 4B and 8A, but decreases at 12B. Based on a layering of 0-10, 10-40 and 40-60cm the correlation between porosity and sediment depth disappeares at 4B and 8A but persists at 12B.

Interstitial sediments have been sampled with standpipes in sediment depths of 0, 20, 40 and 60cm at the sites 4B and 12B. Because of the sediment depositions, sampling depths changed at site 12B but stayed constant at site 4B during the study period. The horizontal distribution is studied in a sediment depth of 20cm.

The organic matter is described either as concentration (C, N or P per unit of weight of the dried sample) or as content (C, N or P per unit of volume of the entire sample).

During the periods of low discharge in winter and flood periods in summer there is a connection between the amount of interstitial sediments and the frequency of high discharge events between successive sampling dates. Spring floods, mainly fed by melting snow, do not influence interstitial sediments. Below a sediment depth of 40cm, amounts of interstitial sediments are highest.

The distribution in time of TOC, N and P concentrations are surprisingly parallel. Annual concentration means are not significantly correlated with sediment depth, repeating the distribution of interstitial sediments.

Concentrations as well as contents are determinded by seasons and the frequency of high discharge events:

	concentration	content	discharge
spring	low	low	high
summer	low	high	high
autumn	low	low	low
winter	high	high	low

The interstitial sediment at site 4B has C/N ratios between 7 and 15, indicating a high quality as food. The topmost sediment layer combines low POM contents and low C/N ratios. High C/N ratios in autumn and low ones in summer reflect the composition of the imported material: in summer material, already processed by microbes (mainly eroded soil) is dominating, where else in fall leaves just shed are dominating. Concentrations and contents of TOC and N as well as C/N ratios are linear and positively correlated. The correlations are independend of the amount of interstitial sediments.

Site 12B is characterised by a steady deposition of sediments and consequently highly variable sampling depths of the permanently installed standpipes. Because of the relative slow process of deposition, three periods of time are discernable with comparable sampling depths. During deposition , great amounts of large and fine POM are buried in the bedsediments. In the first year of the study interstitial sediments are increasing with increasing sediment depth and their absolute amounts are 5 times higher in the first year than in the second year and 7 times higher than in the third year. At site 4B the factor of decreasing is only 3. A possible reason are the extreme summer floods in the first year. Their effect is enforced by sediment deposition at site 12B.

In time, concentrations as well as contents of the three OM parameters are again surprisingly parallel but contents are parallel and concentrations are antiparallel to the distribution pattern of interstitial sediments. Vertically, only contents are positively correlated with

Results gained from interstitial sediment samples are in full agreement with those gained from fraction C of bedsediments.

At site 8A (the main channel) distribution patterns are comparable with those found at site 4B. Only the topmost sediment-layer (0-10cm) shows the influence of the hight current speeds of the surface water: POM-quantity is lowest, POM-concentrations and food-quality is highest. TON- and TOP-contents under $100cm^2$ are with 1,7 and 0,65g, respectively, similar to those found at site 4B. Since TOC contents are half as high as at site 4B, C/N ratios are lowest and therefore food quality is highest here. The POM-pattern in time is roughly opposite to that found at site 4B like the correlation between TOC and C/N, wherelse the correlation (positive, linear) between TOC and TON is the same at both sites.

Site 12B is unique because of permanent sediment depositions. POM-contents and relative amounts of fraction C are highest here. Although TON-contents are with 2,1 and 2,2g (annual means) below $100cm^2$ highest here, too, C/N ratios are around 13. Generally, a C/N ratio of 13 indicates a good food quality, relative to the other sites in the RITRODAT-area it has to be classified as medium. The distribution pattern in time is rather to compare with site 8A than with site 4B. In contrary, correlation- and regression analyses between TOC and TON and between TOC (conc.) and C/N ratios are more similar to that found at site 4B.

R e f e r e n c e s:

CUMMINS, K.W., 1979: The Natural Stream Ecosystem (7-24).- In: WARD, J.V., STANFORD, J.E., (Edts.), The Ecology of Regulated Streams, Plenum Press New York and London, 398 pp

ELLENBERG, H. (Edt.), 1973: Ökosystemforschung.- Springer Verlag, 280 pp