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CHARACTERIZATION OF THE TRANSFER PHENOMENA FOR AN AQUATIC ECOSYSTEM

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abstract: The present work is treating principal aspects of the transfer phenomena between abiotic and biotic compartments of an aquatic ecosystem. The experimental part of the studies is based on two sampling campaigns organized in Iron Gates area (Portile de Fier) from Romania.

key words: organic micropollutants, aquatic ecosystem, transfer phenomena.

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Introduction

The distribution – transfer phenomena of the inorganic and organic micropollutants from the abiotic to the biotic compartment or in the same compartment (water – sediment) is a complex phenomena depending on a series of factors.

The matrices characterizing the biotic compartment (macrophytes, fish fauna, invertebrates, bivalves, gastropods) accumulate differently both inorganic and organic micropollutants. In case of fish fauna and macrophytes appear the bioaccumulation and bioconcentration phenomena, more important for the case of macrophytes – well known as water fitoremediators due to their high accumulation capacity for the heavy metals [1-4].

Environmental risk assessment implies, as a preliminary phase, estimation of the considered distribution in different environments (water/soil/air). For this reason it is necessary to use the behavior characteristic of the pollutant defined as the distribution in the environment or in different organisms and the changes suffered in time (concentration changes) [5-7].

Depending on the entry path (direct and/or indirect) and on the pollutant properties, fractions of repartitions in the environment compartment and recapture concentration respectively will be differentiated.

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In Table 1 are presented the elements characterizing the distribution phenomena for the heavy metals and for the organic micropollutants in the same compartment (abiotic water – sediment) and between compartments (abiotic – biotic).

Table 1 Elements related to the organic micropollutants and heavy metals in aquatic environment.

Process	Observations	Organic micropollutants	Heavy metals
The transfer of micropollutants in the same or between different environment compartments	Volatilization(air);	+	+
	Sorbtion/desorbtion on the suspended matter	+	+
	Decantation (sediments) resuspension;	+	+
	Deposit and accumulation in sediment;	+	+
	Percolation in underground water;	+	+
	accumulation in the biotic compartment (macrophytes, fish fauna, invertebrates)	+	+

Experimental part

In order to characterize the transfer phenomena for the inorganic and organic micropollutants between biotic and abiotic compartments were organized two sampling campaigns in august 2006 and in may 2007 in Iron Gates I area; were taken water, sediment, macrophytes, fish fauna and invertebrates samples.

In 2006 campaign the gastropods were sampled only for the Coronini section.

In 2007 campaign it couldn't be sampled fish fauna samples due to the prohibition period, the gastropods samples were sampled only for the Bazias section. For the Bazias section due to the sandy border it wasn't possible to sample sediment (s. Table 2).

Table 2 Samples taken for the two campaigns ("+" - sampled, "-"– not sampled).

Danube Km	Sampling site	2007					2006				
		Water	Sediment	Fish fauna	Macrophytes	Invertebrates	Water	Sediment	Fish fauna	Macrophytes	Invertebrates
1073	Bazias	+	+	-	+	+	+	+	+	+	-
1043	Coronini	+	+	-	+	-	+	+	+	+	+
955	Orsova	+	+	-	+	-	+	+	+	+	-
951	Up Iron Gates 1	+	+	-	+	-	+	+	-	+	-
927	Simian	+	+	-	+	-	+	+	-	+	-

"+" sampled, "-" not sampled

The organic micropollutants were analyzed as follows: for sediment samples were used pretreatment method US EPA 3550 and US EPA 3610 (extraction and cleaning) and US EPA 8081 and US EPA 8270 for gas chromatographic analysis; for water samples were used methods SR EN ISO 6468:2000 and method US EPA 625. The analyses were performed on a HP 5890 series II gas chromatograph with an HP MS 5972 detector.

For the biota samples the analysis methodology was adapted using international indication from specialty literature. Unfortunately there still isn't an international standardized method. Special care was taken for the drying and purification steps (due to the fat content interfering with the analysis).

Results and discussion

For the interpretation of the transfer phenomena we choose to study a group of organic micropollutants from the priority substances list as indicated from the Water Framework Directive EC 60/2000. From that list PAH's (polycyclic aromatic hydrocarbons - sum of 15), lindane, sum of hexachlorocyclohexane (HCH) isomers, 4, 4' DDT (p, p'), aldrin and atrazine were selected for investigation. After establishing the concentration levels for each matrix (water, sediment and aquatic organisms) the bioconcentration/bioaccumulation factors (BCFs) were calculated in order to characterize the transfer phenomena between abiotic and biotic compartments and to evaluate the possible risk that these substances may induce. [8, 9]

The bioconcentration/bioaccumulation factor was calculated using the formula:

$$BCF = \frac{C_o}{C_w}, \quad \left\langle \frac{\text{L}}{\text{Kg}} \right\rangle \tag{1}$$

where: C_o – indicator concentration in organism; C_w – indicator concentration in water (sediment).

Tables 3 and 4 summarize the organic micropollutants concentrations in water and in sediment for both years at each sampling point.

Table 3 Organic micropollutants concentrations in water.

Sampling point	*Lindan* (μg/L)		*HCH isomers sum* (μg/L)		*Aldrin* (μg/L)		*Atrazine* (μg/L)		*PAH's sum* (μg/L)		*p,p' DDT* (μg/L)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Bazias	0.026	0.013	0.041	0.013	0.023	0.024	0.024	0.034	0.145	0.059	0.094	0.073
Koronini	0.031	0.017	0.059	0.017	0.021	0.018	0.012	0.023	0.101	0.102	0.127	0.123
Orsova	0.020	0.019	0.031	0.031	0.023	0.028	0.027	0.027	0.121	0.069	0.089	0.083
Portile de Fier I	0.042	0.020	0.062	0.020	0.037	0.023	0.028	0.018	0.054	0.046	0.138	0.075
Simian	0.032	0.043	0.050	0.064	0.032	0.040	0.026	0.013	0.099	0.206	0.124	0.137

Looking at the values indicated in these two tables an important aspect to underline is the big difference between the concentration levels in the two matrices for the sum of PAH's; the higher concentrations for the sediment samples reflects the chemical characteristics of these compounds. Transport and partitioning of PAH's in the environment are determined to a large extent by physicochemical properties such as water solubility, vapor pressure, Henry's law constant, octanol-water partition coefficient (K_{ow}), and organic carbon partition coefficient (K_{oc}). In general, PAH's have low water solubility. The Henry's law constant is the partition coefficient that expresses the ratio of the chemical's concentrations in air and water at equilibrium and is used as an indicator of a chemical's potential to volatilize. The K_{oc} indicates the chemical's potential to bind to organic carbon in soil and sediment. The K_{ow} is used to estimate the potential for an organic chemical to move from water into lipid and has been correlated with bioconcentration in aquatic organisms.

Table 4 Organic micropollutants concentrations in sediment.

Sampling point	Lindan (mg/kg)		HCH isomers sum (mg/kg)		Aldrin (mg/kg)		Atrazine (mg/kg)		PAH's sum (mg/kg)		p,p' DDT (mg/kg)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Bazias	0.028	-	0.089	-	0.014	-	0.016	-	4.079	-	0.046	-
Koronini	sld	0.012	sld	0.033	0.012	0.015	0.009	0.007	0.197	0.22	0.021	0.122
Orsova	sld	0.033	0.033	0.033	0.009	0.012	0.013	0.015	0.889	1.011	0.023	0.121
Portile de Fier I	0.015	0.018	0.067	0.027	sld	0.031	0.012	0.011	0.879	0.876	0.011	0.149
Simian	0.045	0.009	0.169	0.018	0.007	0.023	0.014	0.013	1.290	0.985	0.061	0.105

"sld "- under the detection limits ; "-" not sampled

Fig. 1 reflects the distribution of the bioconcentration factors values for the fishes sampled in 2006 campaign. The samples collected are representing the same specie (*Carassius carassius*).

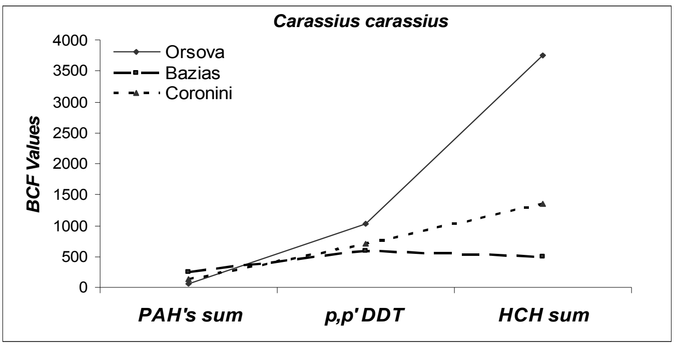

Fig. 1 *BCF for fishes.*

For fishes is interesting to underline the correlation between BCF values and the influence of the anthropogenic factor - BCF values are increasing from the entrance point of Danube river in Romania – Bazias - (no anthropogenic influence) till final point (Orsova town). As it can be notice this correlation stands for all 3 parameters.

Next, in Fig. 2 are presented the distributions for macrozoobentos species (intervertebrates) at Bazias sampling point (2007). As indicated in Table 2 intervertebrates samples were collected both in 2006 (Coronini) and 2007 (Bazias); still, due to the fact that in 2007 we were able to collect different species (*Anodonta, Unio tumidus and Viviparus*) and in 2006 it was sampled only one specie we prefer to use for characterization data from 2007.

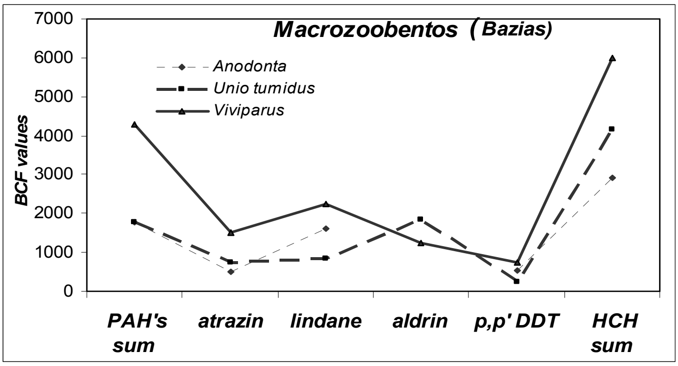

Fig. 2 *BCF values for macrozoobentos.*

BCF values for macrozoobentos ($1000<BCF<10^5$) indicates for 2007 in Bazias area an ***bioaccumulation*** process rather than ***bioconcentration*** ($BCF >10^5$).

Figs. 3 and 4 represent the distribution for BCF characterizing the transfer of organic micropollutants from water (Fig. 3) and from sediment (Fig. 4) to macrophytes.

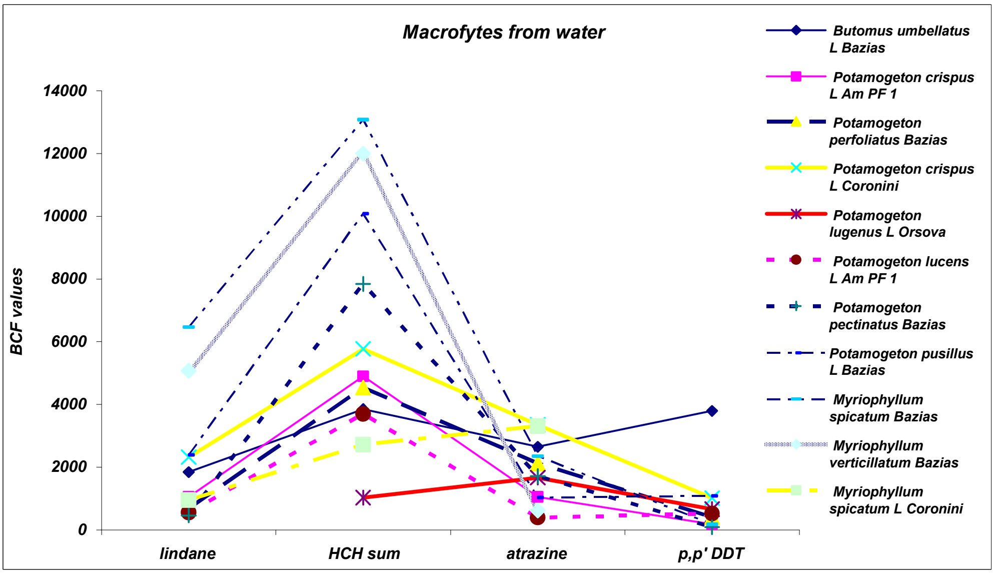

Fig. 3 *BCF for macrophytes (water).*

From the three areas where it was possible to obtain at least two different samples, only for the entry area – Bazias – the results indicates close values for BCF, and so it can be stated that an important part in transfer process from water to macrophytes is represented by it's nature and properties.

In case of water transfer to macrophytes higher values for BCF resulted - for all species – for the sum of all 4 isomers of HCH.

In case of sediment – macrophytes transfer the sediment properties are more important (closer values for the same sampling point). Higher values for sediment – macrophytes transfer are registered for the HCH isomers sum and for atrazine.

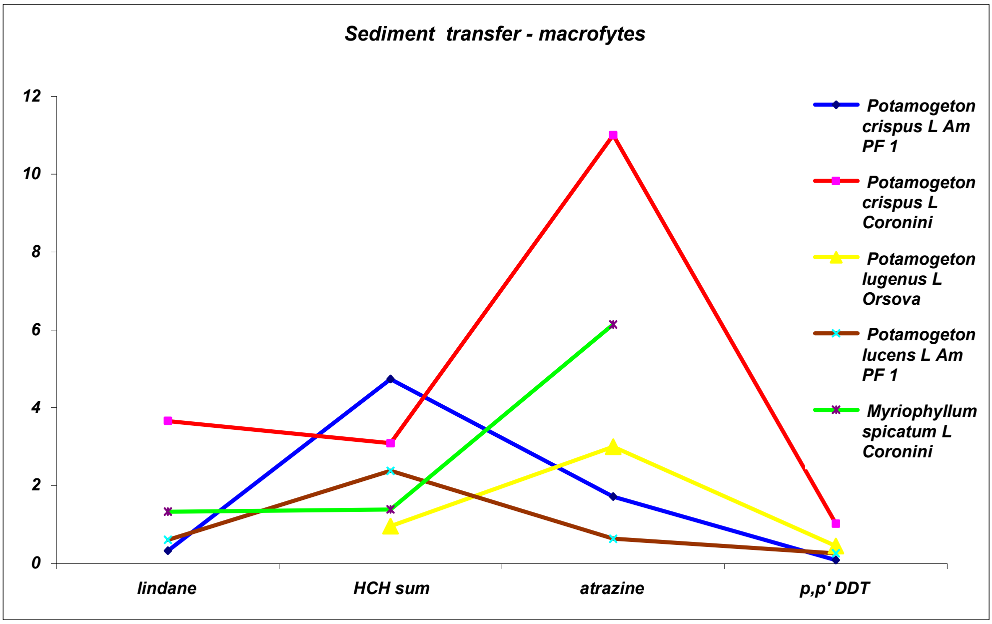

Fig. 4 *Organic micropollutants transfer from sediment to macrophytes.*

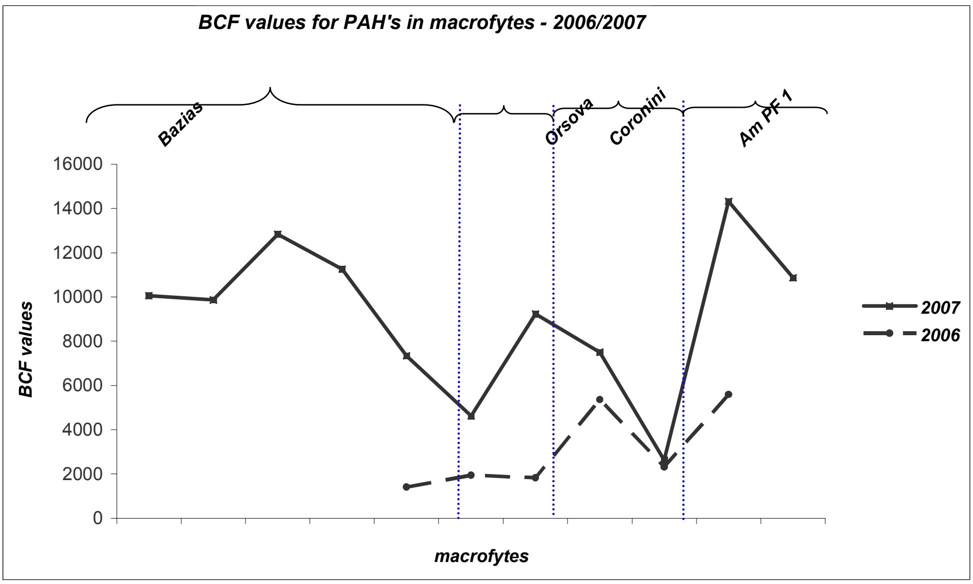

Fig. 5 *BCF for PAH's in macrophytes.*

Fig. 5 shows a comparison between the values characterizing PAH's transfer from water to macrophytes. It can be notice a more intense bioaccumulation in 2007 than in 2006, this due to the fact that 2007 was a rainless year while 2006 was a rainy one.

Conclusions

For the macrophytes is important the correlation between transfer phenomena (BCF values) with the sampling areas; this is due to the fact that macrophytes – sediment contact is a "constant" while macrophytes – water contact is strongly depending on the transport phenomena.

Also the macrophytes are characterized by a bioconcentration process of the organic micropollutants (BCF $>10^5$) from water, while for fishes and intervertebrates (macrozoobentos) bioaccumulation ($1000<BCF<10^5$) is the dominant process.

Regarding the influence of the area peculiarities trough it's abiotic compartment characteristics over the transfer phnomena in biotic compartment the most intense transfers are for the macrophytes; this could be because for the fishes and for macrozoobentos besides the continue transport of the water body occur their's own transports: fishes, nails and shells movement from one place to another.

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