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Integration of the hydrological processes in the dynamics of ecological factors

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Abstract:
Sustainable management of water resources requires an integrated approach of the hydrological and the ecological factors. Concerns in this area exist in several research centers and of some universities.
Since 1999, our department has organized the national workshop of the ecohydrology and also introduced for the first date country a curriculum for students with Ecohydrology course.
The paper studies the eco hydrology processes on the slopes of the catchments based distributed rainfall-runoff model and is analyzed the trophic evolution of the aquatic ecosystems (lake, lakes and ponds).
Follow-up are presented the hydrological regime and the ecological potential on the lower sector Danube as well as the ecohydrological model of Danube Delta.
Key words: eco hydrological potential, trophic study, ecohydrological processes

1. INTRODUCTION

Among the definitions given to ecohydrology [1] we started in this study from the one according to which ecohydrology represents the integration of hydrological processes into the dynamics of biotic factors, on a spatial and temporal scale, aiming at long - term forecast for a lasting management of water resources [2].

In Romania there are preoccupations in the field of ecohydrology in a lot of research centers, universities, local administrations of water management and environment.

The National Workshop of Ecohydrology organized in Timisoara - Romania, in 1999, by "Politehnica" University, Hydrotechnical Faculty and the National. Romanian Committee PHI - UNESCO, facilitated an exchange of opinions on current and future preoccupations, most of them being supported by PHI - V Project 2.3/2.4 and PHI - VI.

2. PREOCCUPATIONS IN THE FIELD OF ECOHYDROLOGY IN ROMANIA

We emphasize the importance of versant - related processes within ecohydrology approaches, in which micro - scale approaches refer to the formation processes of water flow and alluvial deposits.

The link between the atmospheric processes (precipitations) and the hydrographic ones is achieved through distributed modeling which allows the use of patterns for screen scale components and catchments scale integration.

The following numerical solution has been found:

$$\frac{h_{k-1} - h_k}{\Delta t} + \frac{\alpha h_{k-1}^m - \alpha h_k^m}{\Delta x} = i_k \qquad (1)$$

$$h_{k-1} + \frac{\Delta t}{\Delta x} \cdot \alpha h_{k-1}^m = h_k - \frac{\Delta t}{\Delta x} \cdot \alpha h_k^m + i_k \cdot \Delta t \qquad (2)$$

Where: the height of water column h is influenced by the state of the system. In these relations:

i - rain force

$\alpha = \sqrt{\frac{S}{n}}$ - scale parameter

S - slope

m - shape parameter

n - roughness coefficient

On the basis of distributed flow modeling (Fig. 1), the approach to erosion processes becomes accessible through screen scale coupling of easy rules (cause - effect) studied on the flow lots.

Sediment concentration C_t as a result of rain impact can be estimated through a linear relation with rain force it, in accordance with parameter at where:

$$a_t = a_o \cdot e^{-k}, \qquad (3)$$

with an exponential latent evolution:

$$C_t = a_o \cdot e^{-k} \cdot i_t \qquad (4)$$

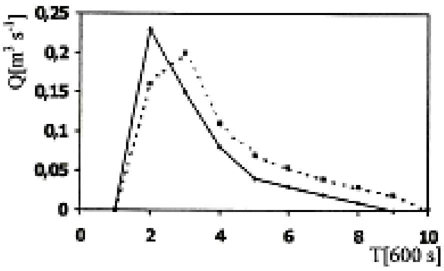

Figure 1. The simulation of flow hydrograph

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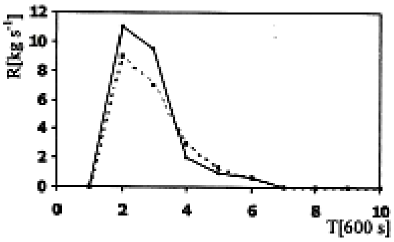

Figure 2. The simulation of silt hydrograph

Alluvial deposits flow

$$r_t = \beta \cdot C_t \cdot q_i^m \qquad (5)$$

Where: β - scale parameter

m – shape parameter

q_t – water discharge

and screen scale water balance is rendered by continuity equation:

$$\frac{\Delta C}{\Delta t} + \frac{\Delta r}{\Delta x} = 0\,, \qquad (6)$$

and water it is dependent on water flow.

Water dynamics issues generally refer to effects accumulated on large scales over long periods of time, and can be explained through micro - scale analyses.

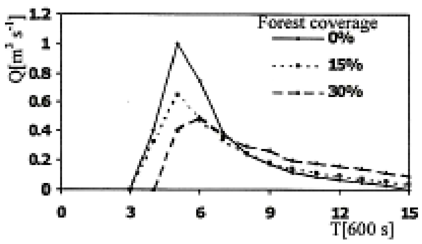

Figure 3. The forecast effect of forecast coverage on the maximum flow

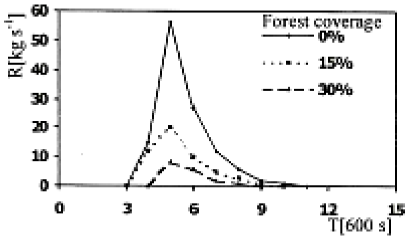

Figure 4. The forecast effect of forecast coverage on the maximum silt flow

The effect of vegetal covering over flow area reflects the role of interception viewed as a factor of land stabilization against water action.

Complex hydrological systems can be reduced to a set of parameters having a high degree of reliability (Fig. 3 and Fig. 4). Information transfer becomes a computing issue, and different climate scenarios regarding field use can be transformed into hydrological estimations, reliable enough to draw coherent conclusions regarding the relation between vulnerability degree and the modifications of the basin.

A detailed description of the variability of the environment factors allows the possibility of an appropriate framework for analysis and prediction of ecological dynamic issues.

We can say that distributed modeling is an advanced instrument for analyzing environment issues where integrated management and lasting development focus on using non-structural measures and on the advantage of visualizing area components.

3. THE TROPHIC STUDY OF AQUATIC ECOSYSTEMS

The trophic evolution of reservoirs in Romania has been studied for quite a long time relying on a unified methodology. It has focused on global biological and chemical aspects.

Table1a – The limits of some valuation indicators for the reservoirs trophical stage

Indicator		Trofic stage	ultraoligo-trophical	oligo-trophical	mezo-trophical	eu-trophical	hiper-trophical
The nutrient concentration	Total Phosphorus	mg dm^{-3}	<0.005	0.005-0.01	0.01-0.03	0.03-0.1	>0.1
	Total of mineral nitrogen	mg N dm^{-3}	<0.2	0.2-0.4	0.4-0.65	0.65-1.5	1.5
O_2 saturation		%	>70		10-70	<10	
Aerobic mineralization capacity		%	0-30		30-100	>100	
Phytoplankton biomass		mg dm^{-3}	0-1	1-3	3-5	5-10	>10
Chlorophyll "a"	Annual average	mg m^{-3}	<1	<2.5	2.5-8	8-25	25-75
	Maximum values average	mg m^{-3}	<2.5	<8	8-25	25-75	>75

The goal is to prevent and slow down the eutrophication phenomena, which has consequences on the quality of water resources.

The main assessment criteria for reservoir quality having the characteristic of eutrophication indicators are: concentration of nutrients, saturation in oxygen, aerobian mineralisation capacity, bio-phytoplankton biomass,chlorophyll concentration "a", organism-indicators.

The limits of guiding indicators for the assessment of trophic stage and the quality of reservoirs in Romania are given in the following tables (Tab.1a, Tab. 1b).

Table 1b – The classes of indicator species

Trophic stage / Indicators class	oligotrophic	eutrophic
Algae	*Chlorophita* *Desmidiales* *Staurastrum* *Diatomeae* *Tabellaria* *Cyclotella* *Chrysophyta* *Dinobryon*	*Cyanophita* *Anabaena* *Aphanizomenon* *Microcystis* *Oscillatoria rubescens* *Diatomeae* *Melosira* *Fragilaria* *Asterionella*
Zooplankton	*Cladocera* *Bosmina Obtusiostris* *Bosmina Coregoni*	*Cladocera* *Bosmina Longirostris* *Daphnia Ancullata* *Diaptomus Gracilis*
Fish	*Salmon* *Trout*	*Pike* *Perch*

The analysis of the data regarding the trophic stage of aquatic ecosystems (reservoirs, lakes, ponds) belonging to all hydrographic basins of order 1 in Romania shows (Fig. 5) that the majority of them are affected by eutrophication. Reservoirs display less eutrophication symptoms due to the nature of exploiting which determines water stagnation over shorter periods of time. Due to the anthropic impact, the phenomenon is extending so that solutions to reduce it and assure the quality of water are necessary.

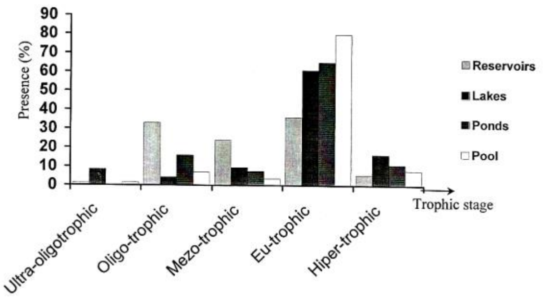

Figure 5.Trophic stage on types of aquatic ecosystems in Romania

4. HYDROLOGICAL REGIME AND ECOLOGICAL POTENTIAL ON DANUBE INFERIOR REACH

Ever since 19th ceI1tury Romania has turned its attention to the study of the hydrological regime of Danube and its tributaries [5] and benefited from the last 1075 km from the Black Sea (out of the 2912 km total).

For over four decades there have been systematical measures of water flow and alluvial deposits along the Romanian stretch in more than 30 hydrometrical sections (between Bazias - km 1075 - and the point of flowing into the Black Sea, including the Danube Delta).

The main hydrological monitoring activities on Danube are:

- permanent, daily and random observations and measurements of water level and flow, ice, turbidity;
- determining quality, physical, chemical and radioactive indicators of water, alluvial deposits and sediments;
- supervising the hydrological regime;

The results of hydrological measurements confirm that water flowing and alluvial deposit transport on the inferior sector of Danube are subject to long-term and isolated temporal variability quantified through characteristic parameters.

The damming of inferior Danube at Iron Gates I in 1971 and then at Iron Gates II in 1984 has changed the flowing regime of solid and liquid flow including the grading composition of the suspension alluvial deposits and of the riverbed sediments through a discontinuity of their longitudinal variation.

With respect to the ecological potential of Danube waters on Bazias (point of entrance in Romania) - Iron Gates Dam section [3], analysis has been carried out regarding the dynamics of the dissolved oxygen and the major ions.

It can be noticed (Fig. 6) that in no section O_2 had values below the limit accepted by the enforced standards (4 mg dm^{-3}), Its value was close to the limit because of the high water temperature and the presence of some reducing elements, whereas the suspension materials varied within broad limits (4 - 145 mg dm^{-3}),

The spatial dynamics of CCO-Mn (indicator of ecological potential) points out that in channels one can notice increased chemical consumption of oxygen while in bays, where decantation occurs, there is a decreased chemical consumption of oxygen. The values frequently exceed 10 mg dm^{-3}, optimal value when waters can be considered conventionally clean.

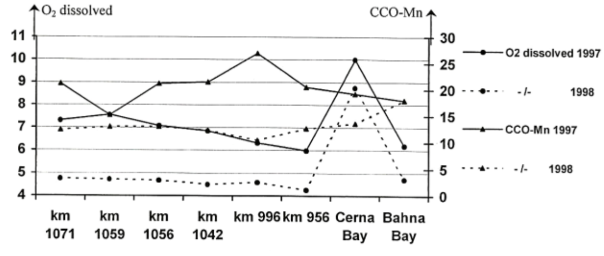

Figure 6. Dynamics of O_2 dissolved and CCO-Mn in the Danube River on the Bazias - Iron Gates I reach

The chemical load of Danube waters changes dramatically the regime of the dissolved oxygen and indirectly the potential of aquatic organism habitat. Monitoring the chemical composition is necessary since the analysis of the concentrations in some chemical elements of the aquatic organisms has pinpointed special cases. (Tab. II)

Table II - Some chemical elements concentration in the aquatic organisms located in the Cerna's Bay

Species / Chemical Elements	Crucian Carp	Carp	Pike Perch	Pike	Sterlet	Sheat Fish
Pb ($\mu g\ dm^{-3}$)	13.5	5-6	1.5-2	< 7	—	—
Mn ($\mu g\ dm^{-3}$)	—	6	9.5	1.2	0.12	1.5

5. ECOHYDROLOGICAL MODEL OF THE DANUBE DELTA

The Danube Delta [4] is an open, complex natural system in which man's interference is strongly manifested (affecting about 30% of the area), through modifications in the channel network, in lacustrian complex, lateral damming on the main branches, agricultural, piscicultural, sylvicultural arrangements. The Danube Delta system includes the following subsystems: hypsographic, climatic, hydrological, ecological, and anthropic.

The hydrological model can be expressed through the balance relation:

$$\left(X+Y_1+U_1\right)-\left(Z+Y_2+U_2\right)=\pm V \qquad (7)$$

Where:

X - rainfalls on the subsystem area
Y_1 - Danube's water contribution
U_1 - underground contribution
Z - evaporation and evapo-perspiration in this area
Y_2 - flowing into the sea
U2 - underground loss (insignificant)
V - stored volume in the reference period

Since, the balance of evaporation and rainfalls is deficient under the circumstances of the Danube Delta Reservation climate:

$$Z \geq (2-3)X \qquad (8)$$

Y_1, Y_2 components in the balance equation become quite important for maintaining a certain water volume to assure an appropriate trophic and ecological level.

Under such circumstances two issues are required:

- the necessity of an efficient link between the inland spaces and the Danube branches and an active water flowing
- the identification of the boundary-limits at which the annual cycles of the delta ecosystems evolve naturally; at the moment polluting substances and nutrients exceed the assimilation and self-cleaning capacity.

The model is characteristic of the Danube Delta and cannot be extrapolating the models of other deltas from the subpolar and intertropical regions where the X/Z ratio can regulate Y_2.

For the Danube Delta the X/Z ratio varies between 0.25 in reed thickets and 0.35 in lakes. The amounts of nutrients have increased lately - nitrates 1.7 times, phosphates 1.5 times - with direct consequences in the intensification of the euotrophication process. The refreshment rate of the water flow in the lacustrian ecosystems represents the main objective of the hydrological- ecological model.
The intensification of the water flow refreshment rate in the lacustrian ecosystems having Danube water with nutrients could determine the increase of concentration in these aquatic environments. Consequently constructive measures need to be adopted to avoid / diminish nutrient loading and storage in the lacustrian ecosystems.

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