

BIOLOGICAL RESEARCH ON THE DANUBE WATER QUALITY IN THE BAZIAS - PRISTOL SECTOR

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INTRODUCTION

The description of surface water quality is a widely used procedure within various environmental protection works and it can be understood on the base of qualitative and quantitative structure of trophic compartments studied in biological analyses.

To describe as objectively as possible the ecological state of an aquatic ecosystem it is necessary to know the two main components, the abiotic (biotop) and the biotic (biocenosis) as well as their interrelationships.

Biological analysis implies the knowledge of all responses of living beings towards environment; the result is a selection of the best adapted organisms to life conditions.

Aquatic flora and fauna can be used to estimate water quality as they respond to the action of different biotic or abiotic, natural or anthropic factors.

The bacteriological assessment of freshwater ecosystems such as Danube River is strongly required by the new EU regulations (Water Frame Directive/2000) as a significant parameter, which indicates the ecological changes in the natural state of rivers (JDS, 2002).

Inadequately treated wastewater released into aquatic ecosystems can carry bacteria, viruses, protozoa and Helminthes that cause a wide variety of diseases ranging from gastroenteritis and infectious hepatitis to typhoid fever and chronic anemia (Astratinei, 2000).

In this study bacterial indicators such as total coliforms, faecal coliforms (thermotolerant coliforms -E. coli) and Faecal streptococci (enterococci) were applied for the assessment of the Danube water quality.

According to the EU Framework Directive of Waters 60/2000, the quality of aquatic ecosystems cannot be measured and determined only by physico-chemical indicators; the response of ecosystems should be measured biologically and evaluation methods should take into consideration the factors that determine the structure and functionality of the aquatic ecosystems.

MATERIAL AND METHOD

In the period 2003-2005, within INCD-PM-ICIM Bucharest investigations were made to estimate the Danube water quality on the Bazias (km1071) - Pristol

(km 834) sector that is characterised by peculiar hydrological and geo-morphological attributes; these characteristics appear due to the Iron Gates I reservoir that determines the half-stagnant character of the river whose horizontal bed profile is greatly enlarged and whose velocity is diminished.

Biological and physico-chemical samplings were taken out of the representative control sections: Bazias, Orsova, Iron Gates I, Gruia and Pristol. (map)

Biological samplings of the Danube River were taken, preserved, processed and interpreted according to the set of norms enforced and agreed upon by the EU countries as well:

“Methodological guide for surveillance of water quality by means of biological analyses” – ICPGA- CAN-1984 ;

“Methodological directions for surveillance of the trophic evolution of reservoirs and natural lakes”- ICIM, 1995;

Framework Directive of Waters - EU 60/2000.

For the microbiological analyses, water samples were collected aseptically from the (mentioned) sampling sites along the Danube River, in 250 cm³ sterilized glass bottles, from a water depth of 0.2–0.3 m. Samples were processed in the laboratory, within 24 hours.

Before analyzing, the bottles were shaken vigorously to guarantee a minimal alteration of bacterial contents in the flasks; aliquot volumes were then examined by Most Probable Number Method, according to national (STAS 3001/1991) and international standards (ISO 9308-1,2 : 1990; APHA, 1995).

The microbiological results were related to the national (Ordin 1146/2002) and international standards (New EU - Expert Proposal), according to Table 1.

Table 1. Class limit values for bacteriological determinands

Determinand	Unit	MAPM* regulation 1146/2002 1 st class	MAPM* regulation 1146/2002 2 nd class	New EU - Expert Proposals /2002 Good	New EU - Expert Proposals /2002 Moderate	New EU - Expert Proposals /2002 Critical
Total Coliforms -TC	number/100 ml	500	10 000	<500	>500-10000	10000 -100000
Faecal Coliforms	number/100 ml	100	2 000	<100	>100-1000	1000-10000
Faecal Streptococci- FS	number/100 ml	-	-	<50	>50-100	>100-1000

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RESULTS AND DISCUSSIONS

The biological research performed on the Danube water in Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections have put into evidence a series of aspects related to the structure of biotic component of the aquatic ecosystem: there are three main functional groups: producers, consumers and decomposers.

Coexistence of species is based on the principle of competitiveness, which differs from one trophic compartment to another (Begon & Others, 1990). According to this, each species is limited by a different or similar resource, but in different compartments of habitat or different periods.

Phyto-plankton helps, together with phyto-benthos and macrophytes, the energy to get into the ecosystem; at the same time the element get into the circuit. The algal microflora plays a decisive role in maintaining the

Ecological equilibrium of an aquatic ecosystem; for this reason, observations on the structure and dynamics of phytoplankton are highly important.

Plankton dynamics could be evaluated based on the results of the biological analyses carried out in Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections of the Danube River between 2003-2005. This enabled the next step: the saprobic description and estimation of water quality.

The quantitative and qualitative structure of a river phytoplankton is influenced by a series of natural and anthropic factors out of which the most important ones are: water flow velocity, flow variations, water temperature, existence of pollution sources, etc.

The quantitative evolution - density (cell/l) and biomass (mg/l) - of the Danube phytoplankton in the summers of 2003-2005 is presented in tables: 2, 3, 4, 5, 6, 7.

Table 2. Density values (cell/ l) and density abundance (%) of the Danube - phytoplankton in 2003

No	Sampling Points	Total Density (thousand cell/l)	Systematic Groups					
			<i>Bacillariophyta</i>		<i>Euglenophyta</i>		<i>Chlorophyta</i>	
			cell/l	%	cell/l	%	cell/l	%
1	BAZIAS	3333	2500	75	-	-	833	25
2	ORȘOVA	3400	2400	71	-	-	1000	29
3	Am. PF I	2833	1833	65	-	-	1000	35
4	GRUIA	3833	2334	61	-	-	1499	39
5	PRISTOL	2333	1667	71	166	7	500	22

Table 3. Biomass values (mg/ l) and biomass abundance (%) of the Danube phytoplankton in 2003

No	Sampling points	Total Biomass (mg/l)	Systematic Groups					
			<i>Bacillariophyta</i>		<i>Euglenophyta</i>		<i>Chlorophyta</i>	
			mg/l	%	mg/l	%	mg/l	%
1	BAZIAS	2,604	2,189	82	-	-	0,465	18
2	ORȘOVA	4,065	3,455	85	-	-	0,61	15
3	Am. PF I	2,632	1,999	76	-	-	0,633	24
4	GRUIA	3,344	3,344	79	-	-	0,89	21
5	PRISTOL	3,291	1,282	39	1,660	50	0,349	11

Table 4. Density values (cell/ l) and density abundance (%) of the Danube phytoplankton in 2004

No	Sampling Points	Total Density (thousand cell/l)	Systematic Groups									
			<i>Cyanophyta</i>		<i>Chrysophyta</i>		<i>Bacillariophyta</i>		<i>Euglenophyta</i>		<i>Chlorophyta</i>	
			cell/l	%	cell/l	%	cell/l	%	cell/l	%	cell/l	%
1	BAZIAS	1236	165	13,34	-	-	796	65	-	-	275	22,24
2	ORȘOVA	1718	366	21,30	200	11,64	756	44	32	1,86	364	21,19
3	Am. PF I	2416	266	11,01	266	10,75	1286	53,23	-	-	532	10,74
4	GRUIA	1297	308	23,75	238	18,35	514	39,63	-	-	237	18,27
5	PRISTOL	1210	166	13,72	-	-	686	56,69	-	-	358	29,59

Table 5. Biomass values (mg/ l) and biomass abundance (%) of the Danube phytoplankton in 2004

No	Sampling Points	Total Biomass (mg/l)	Systematic Groups									
			Cyanophyta		Chrysophyta		Bacillariophyta		Euglenophyta		Chlorophyta	
			mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
1	BAZIAŞ	2,006	0,014	0,69	-	-	1,882	94	-	-	0,11	5,48
2	ORŞOVA	1,380	0,023	1,67	0,070	5,07	1,047	75,9	0,038	2,75	0,20	14,6
3	Am. PF I	2,275	0,023	1,01	0,049	10,95	1,604	70,5	-	-	0,25	10,9
4	GRUIA	1,015	0,019	1,87	0,083	8,18	0,712	70,2	-	-	0,20	8,18
5	PRISTOL	2,016	0,004	0,20	-	-	1,821	90,3	-	-	0,19	9,47

Table 6. Density values (cell/ l) and density abundance (%) of the Danube phytoplankton in 2005

No.	Sampling Points	Total Density (thousand cell/l)	Systematic Groups					
			Bacillariophyta		Pyrrophyta		Chlorophyta	
			cell/l	%	cell/l	%	cell/l	%
1	BAZIAŞ	10 500	1 833	17,46	0	0	8 667	82,54
2	ORŞOVA	5 833	3 833	65,71	0	0	2 000	34,29
3	Am. PF I	11 166	3 833	34,33	0	0	7 333	65,67
4	GRUIA	3 334	1 834	55,0	167	5,0	1 333	40,0
5	PRISTOL	2 000	1 333	66,65	0	0	667	33,35

Table 7. Biomass values (mg/ l) and biomass abundance (%) of the Danube phytoplankton in 2005

No.	Sampling Points	Total Biomass (mg/l)	Systematic Groups					
			Bacillariophyta		Pyrrophyta		Chlorophyta	
			mg/l	%	mg/l	%	mg/l	%
1	BAZIAŞ	4,15	1,65	39,76	0	0	2,5	60,24
2	ORŞOVA	4,45	3,75	84,27	0	0	0,7	15,73
3	Am. PF I	4,95	2,85	57,57	0	0	2,1	42,42
4	GRUIA	2,8	1,7	60,71	0,8	28,57	0,3	10,71
5	PRISTOL	1,5	1,3	86,67	0	0	0,2	13,33

In analysing tables 1-6 one can notice that in the studied years, the present groups of phytoplanktonic algae (*Cyanophyta*, *Chrysophyta*, *Bacillariophyta*, *Pyrrophyta*, *Euglenophyta*, *Chlorophyta*) of the Danube river have average densities and biomasses of average values between: 2 333 000 - 3 833 000 cell/l; 2,60 - 4,06 mg/l (2003); 1 210 000 - 2 416 000 cell/l; 1,01 - 2,27 mg/l (2004); 2 000 000 - 11 166 000 cell/l; 1,5 - 4,95 mg/l (2005)

Heavy rains were reported all over the country in the summer of 2005, including the Danube catchment area but despite this, the greatest number of phytoplanktonic algae was registered.

As regards control sections, the maximal phytoplanktonic density was signalled at Iron Gates I (2004-2005); this phenomenon can be explained by the half-stagnant nature of the Danube river waters in that zone, which was caused by the construction of the reservoir.

Both diatomaceae and chlorophytes registered high density of more than 50%, sometime even 80-90% of the total algae.

The maximum of the total phytoplanktonic biomass corresponding to the density was registered in the control section upstream the Iron Gates I in 2005 as well; it was again the diatomaceae that were 86,67% of the total biomass.

Out of the total number of registered taxa-26(2003), 55(2004) and 41(2005)- diatomaceae had the greatest number (7, 28, 10) followed by chlorophyceae (8, 17, 10).

In Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections of the Danube river the qualitative structure of the phytoplankton revealed the presence of the algae belonging to the following systematic groups: *Cyanophyta*, *Chrysophyta*,

Bacillariophyta, *Pyrrophyta*, *Euglenophyta* and *Chlorophyta*.

The following species were registered frequently:

Bacillariophyta: *Asterionella gracillima*, *Astrionella formosa*, *Cyclotella meneghiniana*, *Cyclotella kützingiana*, *Cymatopleura solea*, *Fragilaria crotonensis*, *Melosira granulata*, *Melosira granulata* var. *angustissima*, *Navicula* sp., *Nitzschia actinastroides*, *Nitzschia holsatica*, *Surirella ovata*, *Synedra acus*;

Chlorophyta: *Actinastrum hantzschii*, *Closterium acerosum*, *Coelastrum microporum*, *Eudorina elegans*, *Pandorina morum*, *Pediastrum boryanum*, *Pediastrum duplex*, *Pediastrum simplex*, *Scenedesmus acutus*, *Scenedesmus quadricauda* *Volvox* sp.;

Pyrrophyta: *Ceratium hirundinella*, *Peridinium* sp.

Many of the existing phytoplanktonic species are bioindicators belonging to one type or another of the saprobic zones (oligo-, beta-, alpha-, polisaprobic) and showing the degree of load with biodegradable organic matter.

Based on these bioindicators, the value of the saprobic index (S) was determined by using Pantle-Buck method which was agreed upon by European Community. The index indicates the degree of relative cleanliness or dirtiness of water.

During the three years of analysis, on the studied Danube sector, the values of the saprobic index were between 1,8-2,3 thus indicating a moderate load with biodegradable organic matter, which corresponds to the β - mezosaprobic zone; all this points out that water is good qualitatively, and in conformity with the enforced norms.

Zooplankton of the Danube River was analysed in Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections in the same period of three years 2003-2005.

After studying this trophic level involved in secondary production, the results showed a relatively

poor taxonomic range, qualitatively as well as quantitatively.

The quantitative values of zooplankton closely related to the abiotic factors (flow, current velocity, temperature and water chemistry) are presented in tables 8, 9 and 10.

Table 8. Density values (ex/ l) and desity abundance (%) of the Danube river zooplankton in 2003

No.	Sampling Section	Total Density ex/l	Systematic Groups					
			ROTARORIA		CLADOCERA		COPEPODA	
			ex/l	%	ex/l	%	ex/l	%
1	Bazias	5	-	-	1	20	4	80
2	Orşova	5	1	20	3	60	1	20
3	Am. P.F.1	3	1	33	1	34	1	33
4	Gruia	3	1	33	2	67	-	-
5	Pristol	13	4	31	7	64	2	15

Table 9. Density values (ex/ l) and desity abundance (%) of the Danube river zooplankton in 2004

No	Sampling Section	Total Density – ex/l	Systematic Groups							
			ROTARORIA		CLADOCERA		COPEPODA		MOLLUSCA	
			ex/l	%	ex/l	%	ex/l	%	ex/l	%
1	Bazias	41	36	88	-	-	5	12	-	-
2	Orşova	20	12	60	-	-	8	40	-	-
3	Am. P.F.1	18	15	83,3	-	-	-	-	3	16,7
4	Gruia	27	13	48,4	2	7,4	7	26	5	18,51

Table 10. Density values (ex/ l) and desity abundance (%) of the Danube river zooplankton in 2005

No	Sampling Section	Total Density – ex/l	Systematic Groups					
			MOLUSCA - BIVALVIA		ROTATORIA		COPEPODA	
			ex/l	%	ex/l	%	ex/l	%
1	Bazias	22	4	18,18	14	63,63	4	18,18
2	Orşova	30	4	1,33	26	86,6	0	0
3	Am. P.F.1	44	14	31,82	30	68,18	0	0
4	Gruia	32	14	43,75	18	56,25	0	0
5	Pristol	8			4	50,0	4	50,0

Quantitatively (numerically), the dominance of Cladocera was registered in 2003, and in the following years, that of the Rotifera which were over 50% of the total zooplanktonic organisms in the studied control sections.

Zooplanktonic biomass corresponding to the density was very poor, below 0,1mg/l.

The taxonomic range was less varied and was represented by species belonging to the following systematic groups: *Mollusca - Bivalvia*, *Rotatoria*, *Copepoda*.

The following types were registered:

Bivalvia - Dreissena polymorpha;

Rotatoria - Ascomorpha ecaudis, Asplanchna priodonta, Brachionus angularis, Brachionus diversicornis, Colurella s., Keratella cochlearis, Keratella quadrata, Lecane cornuta, Polyarthra remata, Trichocerca stylata.

Macrophytes are considered together with phytoplankton the main primary producers of living organic matter in an aquatic ecosystem.

On the studied Danube sector (Bazias-Pristol), the following species were identified: *Lemna minor, Ceratophyllum sp., Potamogeton crispus, Potamogeton gramineus, Potamogeton perfoliatus, Salvinia natans, Spirodella polyrriza*, their highest value of development was registered in Bazias control section.

One should mention the important role of macrophytes: they improve water quality by

providing oxygen released from photosynthesis, and the submersed types become support for the development of spawn and other organisms that are fish food.

The biological analysis put into evidence a great variety of macroinvertebrates: oligocheta, mollusca (gasteropodes, lamellibranchiates), amphypodes, insects (coleoptera, diptera, ephemeroptera, heteroptera, ordonatae, plecoptera, trichoptera).

While in Bazias control section Mollusca-gasteropodes of all types (*Litoglyphus, Viviparus, Teodoxus*) and amphypodes - gamarides were the dominant species, at Orsova bivalves (*Corbicula, Dreissena, Unio*) and oligocheta prevailed.

In 2005, macrobenthos of the studied control sections was represented by a small number of organisms than in 2003 and 2004 because of unfavourable hydrological conditions, namely the heavy rains all over the Danube catchment area, which increased river water volume and flow.

If one wants to describe the ecological state of an aquatic ecosystem as objectively as possible, one should know the two basic components of the ecosystem, biotop and biocenosis, as well as their interrelationships.

The biological analysis by the study of the main biotic communities in an aquatic ecosystem allows one to describe water quality, namely the degree of water impurification or cleanliness.

Chemico-physical, biological and bacteriological research performed in Bazias-Pristol control sections of the Danube river in 2003-2005 enabled the estimation of the river water quality; the results were put in relation to water chemistry (dissolved oxygen concentration, nutrients quantity, organic load, presence of toxic substances, etc.).

The main trophic compartments (phytoplankton, zooplankton, zoobenthos) were analysed quantitatively – density, density abundance, biomass, biomass abundance - as well as qualitatively- systematic groups, species, dominant forms, the represented saprobic zone.

The presence and frequency of the bioindicators (determined by Pantle-Buck method) in the Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections indicate that the Danube river waters belong biologically to the beta-mezosaprobic zone corresponding to the category II of quality; this reflects a good ecological state of water in conformity with the enforced norms.

The microbiological data, collected in August 2005 are presented in the Table 11. According to this the water quality of the Danube River (sections Bazias-Pristol) in August 2005 has been corresponding to the 2nd category of surface water quality, showing a *moderate* to *critical* bacteriological contamination. A range of values of 700 to 9200 total coliforms/100 ml was identified for the sampling sites Bazias, Orsova, upstream Iron Gate I, Gruia and Pristol. The maximum value of total coliforms (TC) was detected for the Pristol site (9200 TC/100ml), followed by Bazias and Gruia (5400 TC/100ml). Faecal coliforms showed the tendency to increase at Bazias and Pristol sites reaching critical values of 3300 and 4700 FC/100ml, according to EU-New Experts Proposal Classification/2002. The pollution was mainly determined by faecal and residual effluents released into Danube by different wastewater treatment plants (WWTP) and the microbial growth of has been influenced by the high temperatures (Zarnea, 1994) of 2005 summer. The values for Faecal streptococci indicated a good quality status (1st class of quality) of Danube water.

Table 11. Bacteriological determinands in the Danube River Basin (Bazias-Pristol area) -August 2005

Sampling site	TC/ 100 ml	FC/ 100ml	FS/ 100 ml
Bazias	5400	3300	5
Orsova	700	110	5
Upstream Iron Gate I	700	140	5
Gruia	5400	330	8
Pristol	9200	4700	30

□ 1st class of quality; good status; according to "Ordin MAPM" 1146/2002 and *New EU - Expert Proposals/2002*;

■ 2st class of quality; moderate status; according to "Ordin MAPM" 1146/2002 and *New EU - Expert Proposals/2002*;

■ critical status; according to *New EU - Expert Proposals/2002*

REZUMAT

Taking into consideration the general context of water quality control related to some aquatic ecosystems, the monitoring of the Danube River is an important activity within the National Research Development Institute of Environmental Protection.

The correct evaluation of the ecological state of the Danube river and its water quality requires the integrated study and a complex analysis of the physico-chemical (temperature, pH, oxygen regime, nutrients quantity, specific indicators of pollution: pesticides, heavy metals), biological (main trophic compartments: taxa, density, biomass as saprobic index) and bacteriological (total and faecal coliforms, faecal streptococci) factors in conformity with DCA-EU 60/2000.

The biological method of studying water quality is based on the in the unbreakable relation between organisms and their living conditions. According to this biological principle, an aquatic lotic or lentic ecosystem is populated by certain vegetal and animal species adapted to the environment; any change of the living conditions entails a series of qualitative and quantitative changes of the organisms of the ecosystem.

To describe biologically the Danube water quality on Bazias - Pristol sector, the river waters were studied in five representative control sections in the period 2003 -2005.

The presence and frequency of the bioindicators (determined by Pantle-Buck method) in the Bazias, Orsova, Iron Gates I, Gruia and Pristol control sections indicate that the Danube river waters belong biologically to the beta-mezosaprobic zone corresponding to the category II of quality; this reflects a good ecological state of water in conformity with the enforced norms.

The Danube water (Bazias-Pristol area) has shown in 2005 a *moderate* to *critical* bacteriological contamination, which is raising further health and environmental concerns for the human and animal populations living in this area. The high fluctuations of microbiological determinands demonstrated the contribution of particular sources of pollution to the Danube contamination, mainly WWTP, which are inadequately functioning.

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