4.3 PHYTOBENTHOS

4.3.1 Introduction

Phytobenthos community was included in JDS sampling programme. The main objective was to obtain comparable and reliable data on phytobenthic organisms.

Phytobenthos is the totality of algae living on the surface of substrata in the river bed, thus being mainly autotrophic organisms (Rott, 1991). The ecological niche of phytobenthos algae can be characterized by a long list of environmental variables (hydrology, substratum, light, water chemistry, temperature and other biota) showing river type specific variation ranges. The response of a particular species is determined mainly by species-specific tolerances, such as the range between minimum and optimum requirements for a set of quality criteria of the water and of the environment. Species-inherent properties such as size, morphology of colonies and average life span can be modified fundamentally by properties of the system.

Phytobenthos is normally a well structured community consisting of organisms of a large size spectrum, from a few microns to several centimetres. However, In many phytobenthos studies in rivers, a significant portion of macroalgal species belonging into different taxonomic groups has been neglected. On a long-term scale, phytobenthos communities respond to environmental stress (e.g. abrasion, siltation, instability of substratum, seasonal and horizontal shade pattern, turbidity, hardness, nutrient content, diurnal and seasonal variations, grazing by zoobenthos, fish, shading by riparian vegetation) primarily by changes in species composition.

4.3.2 Methodology

Sampling procedure

Phytobenthic algae live attached to sediment particles in the uppermost milimeter of the sediment where sun irradiation is available for photosynthesis. For identification of phytobenthos algae, the upper milimeter of the sediment on stones, woods, leaves and other artificial materials in the water coarse was sampled. The stones, woods or other artificial material were scraped with a blade or tweezers or washed by brush. The microalgae were transferred into glass bottles with river water. Leaves of the trees were pressed and the liquid was added to the sample. Macroscopic filamentous algae were taken by tweezers to a separate bottle. Samples were preserved in formaline (38 %) in the 1:10 ratio immediately after sampling. Samples of phytobenthos were taken together with macrophytes.

Identification of phytobenthic organisms

The determination of phytobenthic organisms was carried out to the lowest possible level (mainly to the species level). Some problems occurred in the identification of individual taxa because for their determination the living stage and certain characteristic features are needed to recognize. This was impossible since the samples were conserved. Species from groups of Cyanobacteria, Rhodophyta, Heteroconthophyta and Chlorophyta were determined. The available literature records were used for determination. The identification of some problematic taxa was discussed with the experts from Slovakia and the Czech Republic. A total of 223 bottles of samples of the Danube and its tributaries were analysed.

Quantification

While phytobenthos samples were not taken quantitatively, only very rough estimation of relative abundance was used to obtain semiquantitative data. These data were needed for the calculation of Saprobic Index. The estimation of relative abundance was done on the 1-5 scale according to the following table.

Relative abundance	Occurrence
1	isolated
2	rare
3	abundant
4	very abundant
5	mass

Calculation of Saprobic Index

The obtained data were processed by the calculation of Saprobic Index. To calculate the Saprobic Index, the Slovak List of Indicators was used.

Regarding the method, the Pantle & Buck formula modified by Zelinka & Marvan (1961) was used:

$$SI = \frac{\sum h_i * s_i * I_i}{\sum h_i * I_i}$$

with h_i = quantity of species "i" in sample (in case of JDS-phytobenthos samples the "estimation of relative abundance" was used in the scale 1-5)
I_i = weight of species "i" in sample.
s_i = saprobic index of species "i".

Quality control/quality assurance

The Slovak National Reference Laboratory was accredited by the Slovak National Accreditation Service on 28th April 1998 (certificate No. 21/1998). The quality of work is maintained by an internal and external control system. The external control is assured by participation in inter-laboratory comparison tests for individual areas of analyses. Biological analyses (microscopic methods) are controlled by the inter-laboratory comparison tests provided by ASLAB Prague. The internal quality assurance system includes uncertainties of measurements, validations of analytical methods, internal audits and a system of internal and external personnel training. The whole system is supported by the Standard Operational Procedures for all analytical activities, metrological regulations and other documents (Standards, Regulations).

The determination of phytobenthic organisms (mainly cyanobacteria, diatoms and filamentous green algae) of some samples was paralelly carried out by specialists from the Institute of Botany of the Slovak Academy of Sciences in Bratislava. All samples of phytobenthos collected during JDS were conserved more intensively again and stored in the collection of the National Reference Laboratory for Water Sector in Slovakia.

4.3.3 Results

Species diversity

A total of 340 taxa (genera, species, varieta, forma) were identified in the Danube and its tributaries during Joint Danube Survey (Fig. PB-1 and Tab.PB-1).

Four groups of sub-communities were selected. Diatoms were attached to clay, muddy and sandy substratum. Filamentous cyanophytes/cyanobacteria were connected to the fine clay layer (oscillatorietum). Some epiphytic cyanobacteria were found growing together with other taxa (Bacillariophyceae, Chlorococcales and Xanthophyceae) on the upper layer of green macro-algae. The macro-algae created a separate group consisting of representatives of Xanthophyceae, Rhodophyta - Bangiophyceae, Chlorophyceae and Zygnematophyceae.

The richest group was Bacillariophyceae (264 taxa). Pennate-species of diatoms predominated, mainly the genera of *Navicula, Nitzschia, Achnanthes, Amphora, Cocconeis, Cymbella, Diatoma, Fragillaria, Gomphonema, Gyrosigma, Pinnularia* and *Surirella*.

Among the epipelic-benthic species, some typical planktonic diatoms of Centrales occurred (e.g. *Aulacoseira, Cyclostephanos, Cyclotella, Skeletonema, Stephanodiscus, Thalassiosira*). Besides diatoms, green coccal algae (e.g. *Coelastrum, Pediastrum, Scenedesmus*), flagellates (*Gonium pectorale*) and litoral-liking desmidia (*Cosmarium, Closterium*) also appeared. Melosira varians occurred in the samples abundantly.

A special ecological niche is made up of filamentous green macro-algae (*Cladophora, Oedogonium, Stigeoclonium, Rhizoclonium, Spirogyra*) attached mainly to stony and sandy substrate. Their surface is covered by coccal and filamentous cyanobacteria (*Chroococopsis, Clastidium, Chamaesiphon, Heteroleibleinia*), green coccal algae (*Charatium*), Xanthophyceae (*Characiopsis*) and Bacillariophyceae (*Cocconeis, Cymbella, Rhoicosphaenia*).

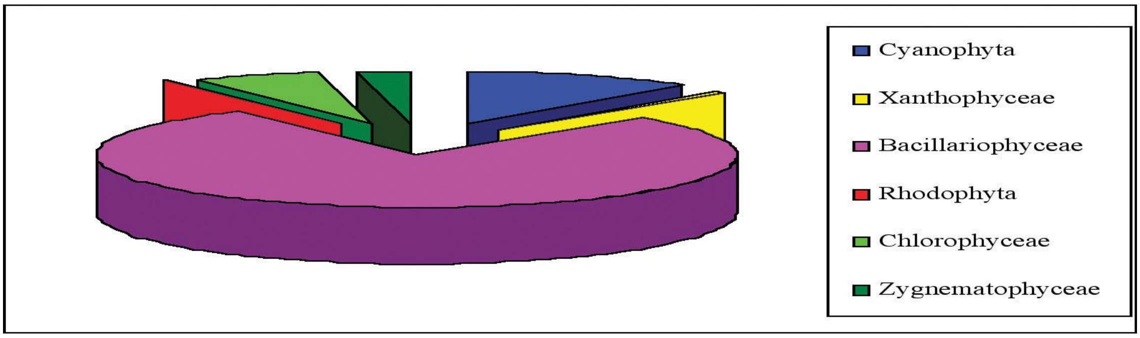

FIGURE PB-1. The percental distribution of numbers of taxa for individual groups of phytobenthos identified during Joint Danube Survey.

A fine surface layer of clay or mud is usually inhabited by filamentous cyanobacteria (*Gleotrichia, Plectonema, Homeothrix, Heteroleibleinia, Leibleinia, Leptolyngbya, Lyngbya, Phormidium*).

Species distribution in the longitudinal section of the Danube and its tributaries

The number of species in the individual stations of the Danube varied in the range of 20-96 and in the tributaries it ranged between 16-109 (Fig. PB-2). The most species were determined in the upper part of the Danube from Neu Ulm to Passau, from Wallsee to Persenbeug and than upstream and downstream of the Drava. Downstream of Kozloduy, the number of identified species decreased significantly. This was the due to the type of substratum (mud and sand). An extremely low number of species was found in the Danube Delta (20-36 taxa).

The number of taxa found in the tributaries varied greatly. Very poor benthic micro-flora was observed in the Jantra where only a few diatoms occurred, probably due to the sandy substratum. The number of species found in the Siret River was also low since the tributary is polluted and so was the number found in the Inn, an alpine tributary with cloudy, glacier waters. In contrast, the highest number of species was found in the Soroksar and Rackeve-Soroksar Danube arms. All other tributaries can be described as medium colonized (49-89 taxa).

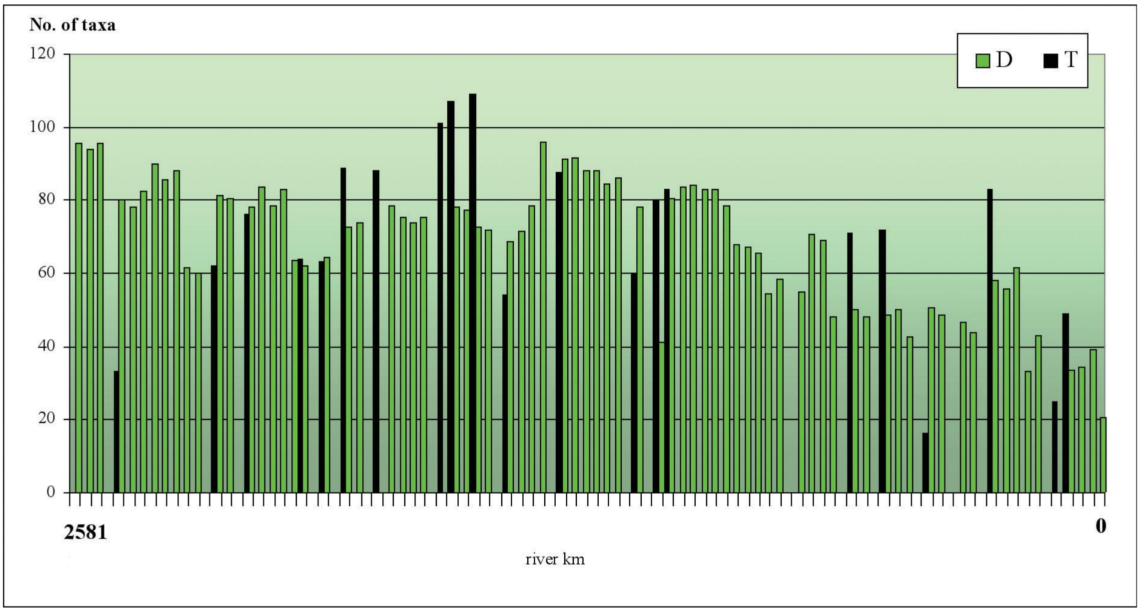

FIGURE PB-2. Number of taxa determined during JDS in the Danube (D) and its tributaries (T).

As for the distribution of individual phytobenthos groups in the Danube, diatoms create the most dominant group. Based on the obtained results, the distribution of individual groups (Cyanophyta, Rhodophyta, Bacillariophyceae, Xanthophyceae and Chlorophyta) along the course of the Danube is presented in Figure PB-3.

Cyanophytes occurred only in the samples that contained a fine layer of mud and were overgrown by filamentic species (0-9 %). Nevertheless, they created only a small portion of microalgae. Like cyanophytes, green algae (Chlorococcales, Ulotrichales, Siphonocladales, Zygnematophyceae) were also rare (0-11 %). Only a few species occurred regularly.

Red algae (Rhodophyta) were represented only by *Bangia arthropurpurea*. This alga was present mainly in the upper part of the Danube. *Cladophora glomerata* was the most frequently occurring filametous green alga both in the Danube and its tributaries. In a few cases the filaments of this species were completely (95%) covered by *Cocconeis* cells. In some sampling stations *Spirogyra* appeared forming green hair tufts. Similarly, the genera of *Vaucheria* was characteristic by slime tufts in some stations of the Danube.

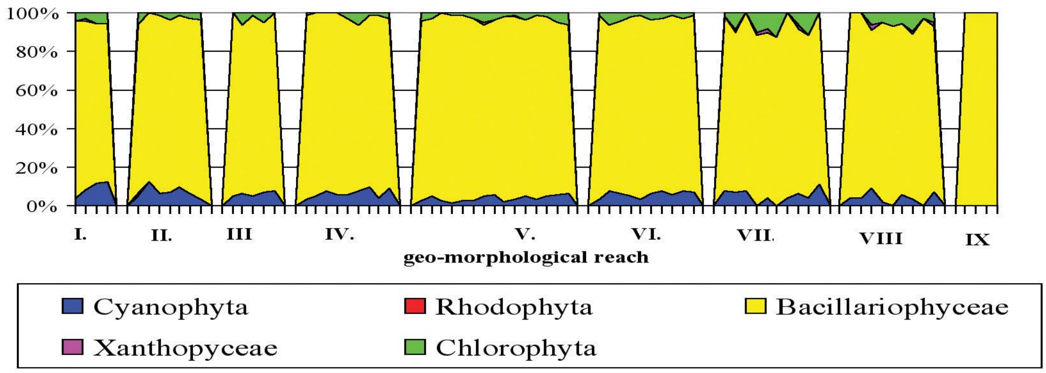

FIGURE PB-3. Relative distribution of taxa numbers of the individual algal groups (Cyanophyta, Rhodophyta, Bacillariophyceae, Xanthophyceae and Chlorophyta) along the nine geo-morphological reaches.

A similar situation (Fig. PB-4) to that in the Danube River itself was observed in the tributaries, where the main group of phytobenthic organisms was made up of diatoms. Only a small percentage of species belonged to cyanophytes and chlorophythes.

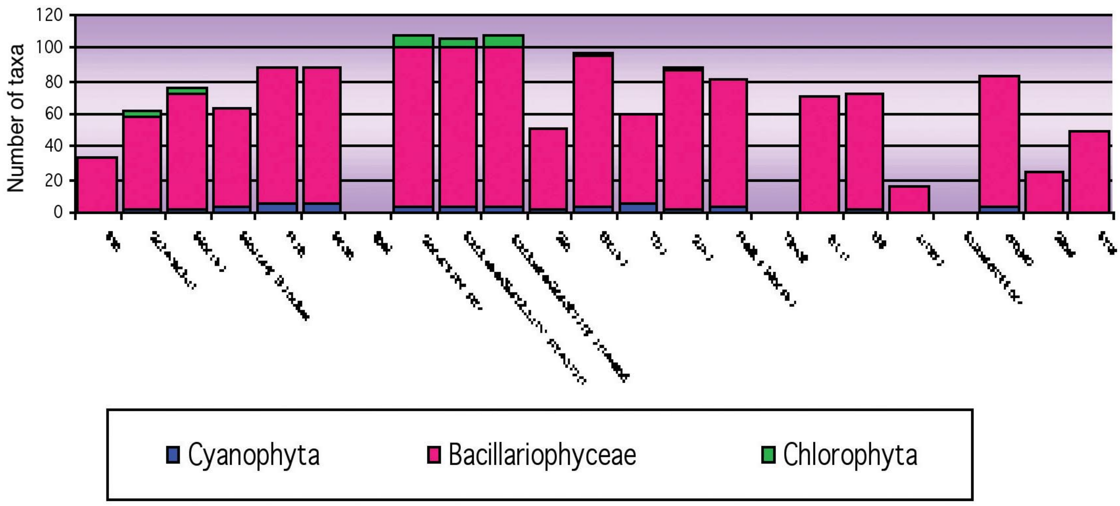

FIGURE PB-4. Distribution (taxa number) of the main algal groups of phytobenthic algae in the Danube tributaries.

TAB.PB-1. List of species found during JDS

CYANOBACTERIA
Chroococcales
Chroococopsis epiphytica Geitler, 1980
Chroococcus sp.
Clastidium setigerum Kirchner
Chamaesiphon carpaticus Starmach
Chamaesiphon incrustans Grunow
Chamaesiphon polymorphus Geitler
Chamaesiphon polonicus (Rostafinski) Hansgirg
Merismopedia punctata Meyen
Pleurocapsa aurantiaca Geitler
Pleurocapsa minor hansgirg em Geitler
Nostoccales
Calothrix parietina Thuret
Calothrix sp.
Oscillatoriales
Anabaena oscillarioides Bory ex Bornet et Flahault
Gleotrichia natans Bory ex Bornet et Flahault
Plectonema tomasianum Bornet
Nodularia sp.
Homeothrix janthina (Bornet et Flahault) Starmach
Heteroleibleinia fontana Komárek
Heteroleibleinia kuetzingii (Schmidle) Compere
Leibleinia epiphytica (Hieronymmus) Anagnostidis & Komárek
Leptolyngbya boryana (Gomont) Anagnostidis & Komárek
Leptolyngbya faveolarum
Lyngbya martensiana Meneghini ex Gomont
Lyngbya major Meneghini
Oscillatoria limosa Aghard
Oscillatoria sancta Kutzing x Gomont
Oscillatoria sp.
Phormidium autumnale Aghard ex Gomont
Phormidium corium Gomont
Phormidium chalybeum (Mertens ex Gomont) Anagnostidis & Komárek
Phormidium cf. chloroxanthum
Phormidium nigrum
Phormidium retzii (Aghard) Gomont
Phormidium subfuscum
Phormidium tagestinum
Phormidium tenue
Pseudanabaena galeatab Bocher
Pseudanabaena limnetica (Lemmerman) Komárek
Pseudanabaena catenata Lauterborn

RHODOPHYTA
Bangiales
Bangia arthropurpurea (Roth) Agardh

HETEROCONTOPHYTA
Xanthophyceae
Characiopsis sp.
Vaucheria cf. intermedia
Vaucheria sp.
Bacillariophyceae
Centrales
Actinocyclus normanii (Gregory) Hustedt
Aulacoseira ambigua (Grunow) Simonsen
Aulacoseira granulata (Ehrenberg) Simonsen
Aulacoseira granulata m. curvata
Aulacoseira muzzanensis (Heisler) Krammer
Aulacoseira subarctica (O.Muller) Haworth
Cyclostephanos delicatus
Cyclostephanos dubius (Fricke) Round
Cyclostephanos invisitatus (Hohn & Hel.) Therm. Stoerm. & Haakansen
Cyclostephanos sp.
Cyclotella atomus Hustedt
Cyclotella bodanica var. lemanica (O.Muller) Bachmann
Cyclotella distinguenda Hustedt
Cyclotella meneghiniana Kutzing
Cyclotella ocellata Pantocsek
Cyclotella pseudocomensis
Cyclotella pseudostelligera Hustedt
Cyclotella pseudostelligera/woltereckii Hustedt
Cyclotella pseudostelligera/stelligeroides Hustedt
Cyclotella quadrijuncta (Schroter) von Keissler
Cyclotella stelligera Cleve
Cyclotella sp.
Cyclotella cf.cyclopuncta Haakansson & Carter
Melosira varians Aghard
Pleurosira laevis (Ehrenberg) Compere
Skeletonema potamos (Weber) Hasle
Stephanodiscus hantzschii Grunow
Stephanodiscus hantzschii var. tenuis/ binderanus (Hustedt) Haakansson
Stephanodiscus neoastrea Haakansson & Hickel
Stephanodiscus cf. parvus
Stephanodiscus sp.
Thalassiosira incerta
Thalassiosira lacustris
Thalassiosira pseudonana Hasle & Heimdal
Thalassiosira weissflogii (Grunow)Fryxel
Thalassiosira cf. duostra
Thalassiosira cf. faurii
Thalassiosira sp.
Pennales
Achnanthes clevei Grunow
Achnanthes delicatula (Grunow) Kutzing
Achnanthes hungarica (Grunow) Grunow
Achnanthes lanceolata (Brebisson) Grunow
Achnanthes lanceolata var. rostrata (Oestrup) Hustedt
Achnanthes minutissima Kutzing
Achnanthes cf. ploenensis Hustedt
Achnanthes spp.
Amphora cf. inariensis Krammer
Amphora libyca Ehrenbergh
Amphora montana Kraske
Amphora ovalis (Kutzing) Kutzing
Amphora pediculus (Kutzing) Grunow
Amphora thumensis (Mayer) Cleve-Euler
Amphora veneta Kutzing
Amphora sp.
Anomoeoneis sphaerophora (Ehrenbergh) Pfitzer
Asterionella formosa Hassal
Caloneis amphisbaena (Bory) Cleve
Caloneis bacillum (Grunow) Cleve

Caloneis permagna
Caloneis silicula (Ehrenbergh) Cleve
Caloneis schumanniana (Grunow) Cleve
Caloneis sp.
Campylodiscus sp.
Cocconeis pediculus Ehrenbergh
Cocconeis placentula Ehrenbergh
Cocconeis placentula var.1
Cocconeis sp.
Cymatopleura elliptica (Brebisson) W.Smith
Cymatopleura solea (Brebisson) W.Smith
Cymbella amphicephala Nageli
Cymbella cf. affinis Kutzing
Cymbella caespitosa (Kutzing) Brun
Cymbella cistula (Ehrenbergh) Kirchner
Cymbella cf. delicatula Kutzing
Cymbella ehrenbergii Kutzing
Cymbella helvetica Kutzing
Cymbella helmckei/lanceolata (Ehrenbergh) Kirchner
Cymbella lanceolata (Brebisson) W.Smith
Cymbella leptoceros (Ehrenbergh) Kutzing
Cymbella cf.mesiana Chalnoky
Cymbella microcephala Grunow
Cymbella minuta Hilse
Cymbella prostrata (Berkeley) Cleve
Cymbella silesiaca Bleisch
Cymbella sinuata Gregory
Cymbella cf. turgidula
Cymbella tumida (Brebisson) van Heurck
Cymbella cf. tumidula Grunow
Cymbella sp.
Denticula tenuis Kutzing
Diatoma ehrenbergii Kutzing
Diatoma mesodon (Ehrenbergh) Kutzing
Diatoma moniliformis Kutzing
Diatoma tenuis Aghardh
Diatoma vulgaris Bory
Didymosphenia geminata (Lyngb) M.Schmidt
Diploneis cf. elliptica (Kutzing) Cleve
Diploneis cf. modica
Diploneis oblongella (Nageli) Cleve-Euler
Diploneis sp.
Epithemia sp.
Epithemia cf. sorex Kutzing
Eunotia bilunaris (Ehrenbergh) Millis
Eunotia soleirolii (Kutzing) Rabenhost
Fragilaria arcus (Ehrenbergh) Cleve
Fragilaria berolinensis
Fragilaria cf. bicapitata A.Mayer
Fragilaria bidens Heiberg
Fragilaria brevistriata Grunow
Fragilaria capucina var. capitellata Krammer & Lange-Bertalot
Fragilaria capucina var. „gracilis"
Fragilaria capucina var. mesolepta (Rabenhorst) Rabenhorst
Fragilaria capucina var. perminuta
Fragilaria capucina var. radians (Rabenhorst) Rabenhorst
Fragilaria capucina var. vaucheriae (Kutzing) Krammer & Lange-Bertalot
Fragilaria construens (Ehrenberg) Hustedt
Fragilaria construens f. binodis (Ehrenberg) Hustedt
Fragilaria crotonensis Kitton
Fragilaria elliptica
Fragilaria fasciculata
Fragilaria aff. lapponica
Fragilaria leptostauron
Fragilaria montana
Fragilaria parasitica
Fragilaria parasitica var. subconstricta
Fragilaria pinnata
Fragilaria cf. tenera
Fragilaria ulna var. acus
Fragilaria ulna
Fragilaria ulna var. oxyrhynchus
Fragilaria sp.
Frustulia vulgaris
Gomphonema angustatum
Gomphonema gracile
Gomphonema minutum
Gomphonema olivaceum
Gomphonema parvulum
Gomphonema tergestinum
Gomphonema truncatum
Gyrosigma acuminatum
Gyrosigma attenuatum
Gyrosigma parkerii
Gyrosigma scalproides
Hantzschia amphioxys
Meridion circulare
Navicula accomoda
Navicula cf. atomus
Navicula bacillum
Navicula capitata
Navicula capitata var. lueneburgensis
Navicula capitatoradiata
Navicula cf. capitatoradiata
Navicula citrus
Navicula cf. constans
Navicula cf. costulata
Navicula cryptocephala
Navicula cryptotenella/menisculus
Navicula cuspidata
Navicula cf. decussis
Navicula cf. erifuga
Navicula cf. exigua
Navicula gastrum
Navicula goeppertiana
Navicula gregaria
Navicula laevissima
Navicula lanceolata
Navicula lenzii
Navicula libonensis
Navicula menisculus
Navicula microrhombus
Navicula minuscula
Navicula cf. mutica
Navicula oblonga
Navicula protracta
Navicula aff. pseudanglica
Navicula pupula
Navicula pupula var. mutata
Navicula pygmaea
Navicula radiosa

Navicula recens
Navicula reinhardtii
Navicula cf. rhynchocephala
Navicula cf. schroeteri
Navicula splendicula
Navicula slesvicensis
Navicula cf. subhamulata
Navicula subminuscula
Navicula aff. tenera
Navicula tripunctata
Navicula trivialis
Navicula veneta
Navicula viridula var. rostellata
Navicula viridula
Neidium ampliatum
Neidium binodis
Neidium dubium
Nitzschia acicularis
Nitzschia cf. amphibia
Nitzschia angustata
Nitzschia cf. angustatula
Nitzschia brevissima
Nitzschia calida
Nitzschia capitellata
Nitzschia cf. clausii
Nitzschia constricta
Nitzschia dissipata
Nitzschia dubia
Nitzschia aff. flexa
Nitzschia fonticola
Nitzschia frustulum
Nitzschia fruticosa
Nitzschia gracilis
Nitzschia graciliformis
Nitzschia heufleriana
Nitzschia hungarica
Nitzschia inconspicua
Nitzschia intermedia
Nitzschia levidensis
Nitzschia linearis
Nitzschia microcephala
Nitzschia palea
Nitzschia paleacea
Nitzschia cf. plana
Nitzschia recta
Nitzschia sigmoidea
Nitzschia sinuata var. delognei
Nitzschia sociabilis
Nitzschia cf. subacicularis
Nitzschia umbonata
Nitzschia cf. wuellerstorfii
Nitzschia lanceola var. minutula
Nitzschia hantzschiana
Nitzschia cf. tubicola
cf. Simonsenia delognei
Nitzschia sp.
Pinnularia appendiculata
Pinnularia borealis
Pinnularia gibba
Pinnularia cf. maior
Pinnularia microstauron var. brebissonii
Pinnularia cf. neomajor
Pinnularia subcapitata
Pinnularia cf. viridis
Rhoicosphenia abbreviata
Stauroneis lundii
Stauroneis phoenicenteron
Stauroneis cf. producta
Stauroneis smithii
Surirella angusta
Surirella bifrons
Surirella cf. biseriata
Surirella brebissonii var. kuetzingii
Surirella aff. elegans
Surirella gracilis
Surirella linearis
Surirella linearis var. helvetica
Surirella minuta
Surirella ovalis
Surirella cf. splendida
Surirella tenera
Surirella cf. crumena
Surirella sp.
Tabellaria flocculosa
Tabellaria sp.
Chlorophyceae
Volvocales
Gonium pectorale
Chlorococcales
Charatium acuminatum
Characium angustum
Charatium sp.
Coelastrum astroideum
Pediastrum boryanum
Scenedesmus acuminatus
Scenedesmus communis
Scendesmus obliqus
Scenedesmus intermedius
Scenedesmus brasiliensis
Scenedesmus opoliensis
Ulotrichales
Stigeoclonium tenue
Ulothrix tenerrima
Binuclearia sp.
Siphonocladales
Cladophora glomerata
Cladophora sp.
Oedogonium itzigsohnii
Oedogonium cf. sociale
Oedogonium sp.
Rhizoclonium hieroglyphicum
Rhizoclonium sp.
Zygnematophyceae
Cosmarium botrytis
Cosmarium leave
Cosmarium sp.
Closterium moniliferum
Closterium praelongatum var. breave
Closterium calosporum
Closterium closteroides
Closterium sp.
Spyrogyra maxima (Hass.) Wittr.
Spyrogyra sp.

Saprobity

Based on species diversity and relative abundance of phytobenthos, the Saprobic Index (SI) of the Danube and its tributaries was calculated at each station. The values ranged between 1.77 – 2.11 in the Danube and between 1.80 – 2.11 in the tributaries. (see Annex - Phytobenthos). This phytobenthic results characterise a beta-mesosaprobic status for all JDS samplings sites. The highest values were found in the Sió and the Jantra tributaries, and other tributaries are comparable to the Danube from the point of view of phytobenthos SI. Of all stations along the Danube, those in the Delta (Reni Chilia arm, Vilkova Chilia arm) reported the highest saprobic value. Saprobic indices calculated for the left and right banks of the sampling sites showed only minimal differences (0-0.06 SI values). There was only a very slight increase in SI values in the Danube section at river km 1800 – 1100 and downstream of river km 641. However, in the longitudinal profile of the Danube the differences in the Saprobic Indices were low and therefore insignificant. The only rough estimation of relative abundance and the preservation of the samples have to be taken into account in evaluating the saprobic status based on phytobenthos.

Calculating the Saprobic Index for the phytobenthos community in the Danube according to the method used proved to be less significant than the saprobic evaluation based on macrozoobenthos. This might be due to the fact that, on the one hand, primary producers such as phytobenthic algae should be used for assessing the trophic status, but compared to zoobenthos they are not the best indicators for the biological assessment of organic pollution (saprobity). On the other hand, bearing in mind that diatoms make up the main group of phytobenthos community in the Danube and its tributaries, it would be advisable to use additional diatom indices in future (e.g. Diatom Index by Descy and Coste, Generic Diatom Index, Trophic Diatom Index, Diatom-Analyses according to Lange-Bertalot).

Comparison of the nine geo-morphological reaches

For the purpose of JDS, the course of the Danube was divided into nine reaches based on geo-morphological features and potential anthropogenic impacts caused by large impoundments and/or significant point sources of pollution represented by big settlements (see Chapter 3). As shown in Fig. PB-5, the highest number of identified taxa was found in Reach 1. The last three reaches show a lower number of taxa due to the type of substratum at individual stations. It is evident that the last reach was characterised by diatoms, while in others at least a small number of Chlorophyta and Cyanophyta appeared. On the basis of the results, it is clear that species diversity in the lower section of the Danube decreases compared to the middle and upper section of the River.

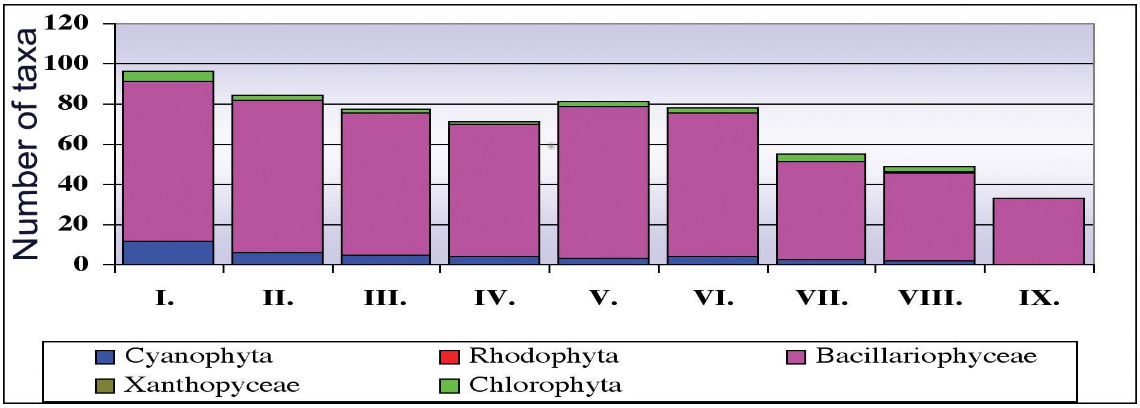

FIGURE PB-5. Number of taxa determined along the Danube distributed according to the nine geo-morphological Reaches.

4.3.4 Summary and Conclusions

A total of 340 taxa of phytobenthos were identified in the Danube, its side-arms and tributaries during the 2001 Joint Danube Survey.

Four groups of sub-communities were selected. Diatoms were attached to clay, muddy and sandy substratum. Filamentous cyanobacteria were connected to the fine clay layer (oscillatorietum). Some epiphytic cyanobacteria were found growing) together with other taxa (Bacillariophyceae, Chlorococcales and Xanthophyceae) on the upper layer of green macro-algae. Macro-algae created a separate group consisting of representatives of Xanthophyceae, Rhodophyta - Bangiophyceae, Chlorophyceae and Zygnematophyceae.

The richest group was Bacillariophyceae (264 taxa). Pennate-species of diatoms predominated, mainly the genera of *Navicula, Nitzschia, Achnanthes, Amphora, Cocconeis, Cymbella, Diatoma, Fragillaria, Gomphonema, Gyrosigma, Pinnularia* and *Surirella.*

The number of species identified at the individual sampling sites varied in the range of 20-96 in the Danube and between 16 and 109 in the tributaries. Downstream of Koszloduy, the number of phytobenthic species decreased significantly. This seemed to be due to the type of substratum (mud and sand). Extremely low numbers of species were found in the Delta (20-39 taxa).

Saprobic indices calculated by the use of phytobenthos data did not produce a differentiated picture of organic pollution. Therefore, it is recommended to further develop the indication values of phytobenthic organisms or use other indices for the assessment of phytobenthic communities, such as trophic indices, diatom indices, etc.

For future monitoring and repetition of JDS it is also strongly recommended that phytobenthos samples should be analysed directly on board to allow the ratio between individual groups and dominances to be identified and to facilitate the identification of species according to their special characteristic features in the living stage. This would provide a better overview about the status of phytobenthic community,

4.3.5 References

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