COMPLEX HYDROBIOLOGICAL RESEARCH ON THE BOVILLA RESERVOIR IN ALBANIA

A joint research SCOPES project Nr. IB7320-111032 'Limnologic and hydrologic assessment of the Buvilla basin (Tirana, Albania) and its watershed, focused on drinking water use' supported by Swiss National Science Foundation (SNSF) through an International Co-operation program SCOPES (Scientific Co-operation with Eastern Europe).

Importance of the ecosystem

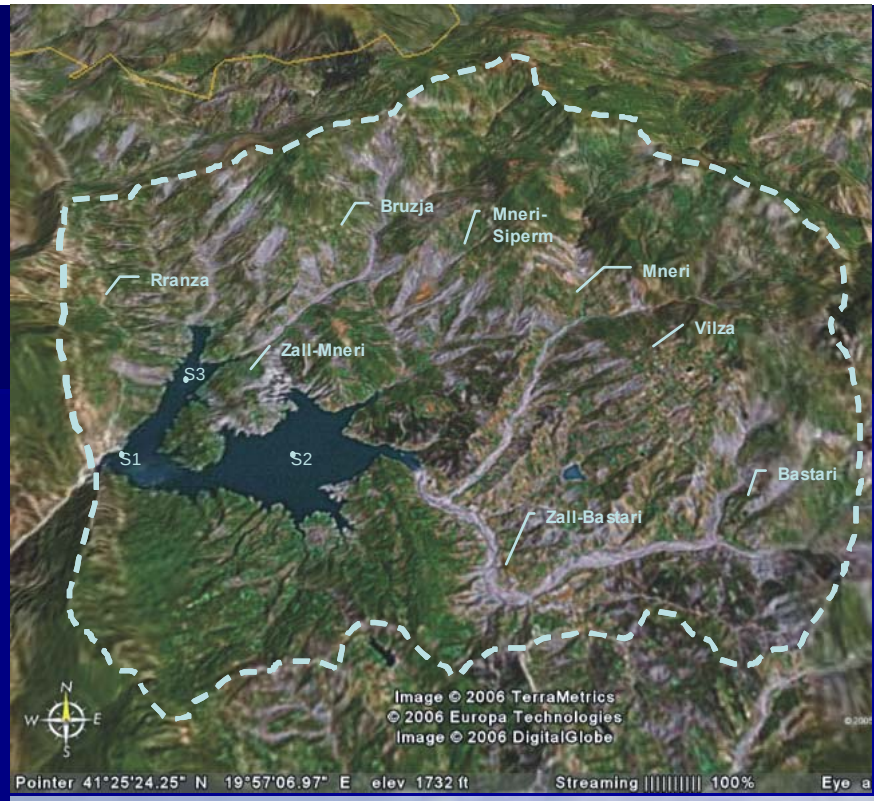
- Since year 1998, the reservoir is the main source of drinking water for the city of Tirana (more than 700'000 inhabitants)

Geographical position

- The reservoir was constructed in 1998, located about 15 km North-East of Tirana city.
- It has a surface of 4575 km^2, maximum volume of 80 x 10^6 m^3, and average depth of 18 m (original max. 60 m, near the dam); actually up to 45 m of depth was measured. Residence time of the water 1.5 years.

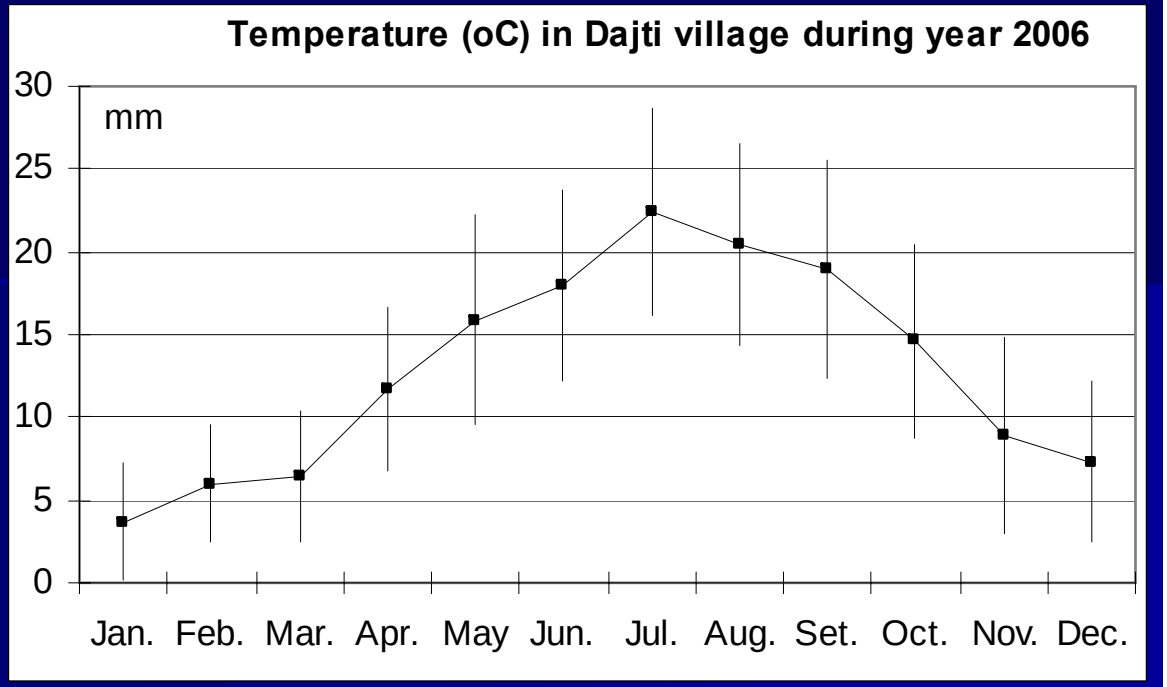
Watershed area

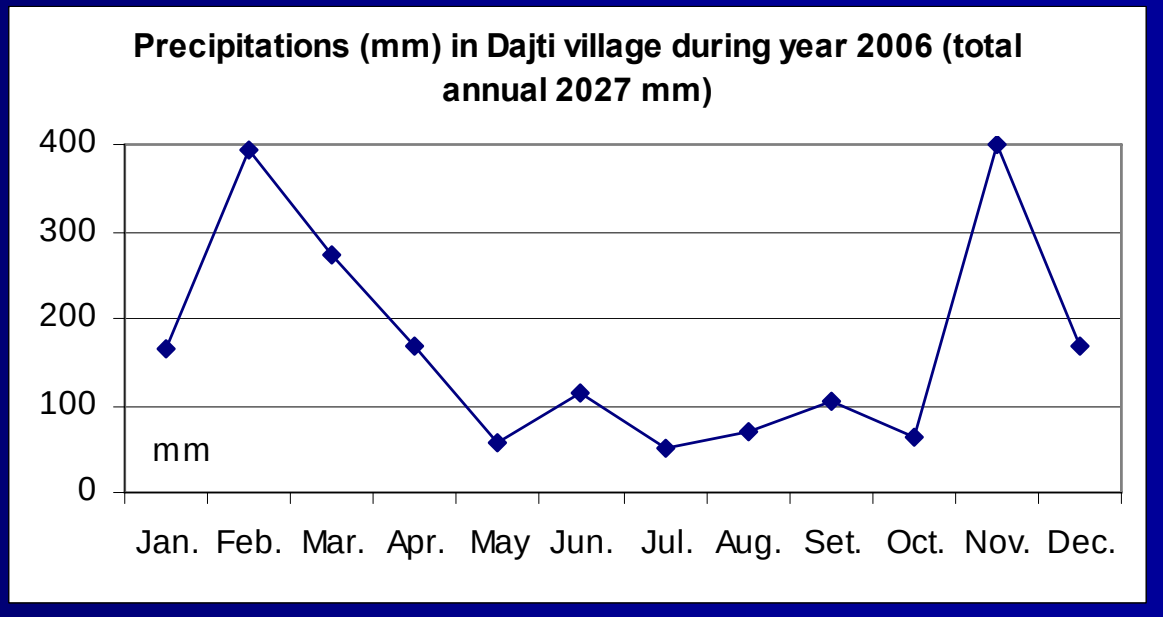
- The lake drains an area of approximately 98 km^2, with as main source the river Tërkuza with a total discharge of about 10^5 x 10^6 m^3/year.
- The relief of the region is mainly hilly to mountainous.



Climate of the zone

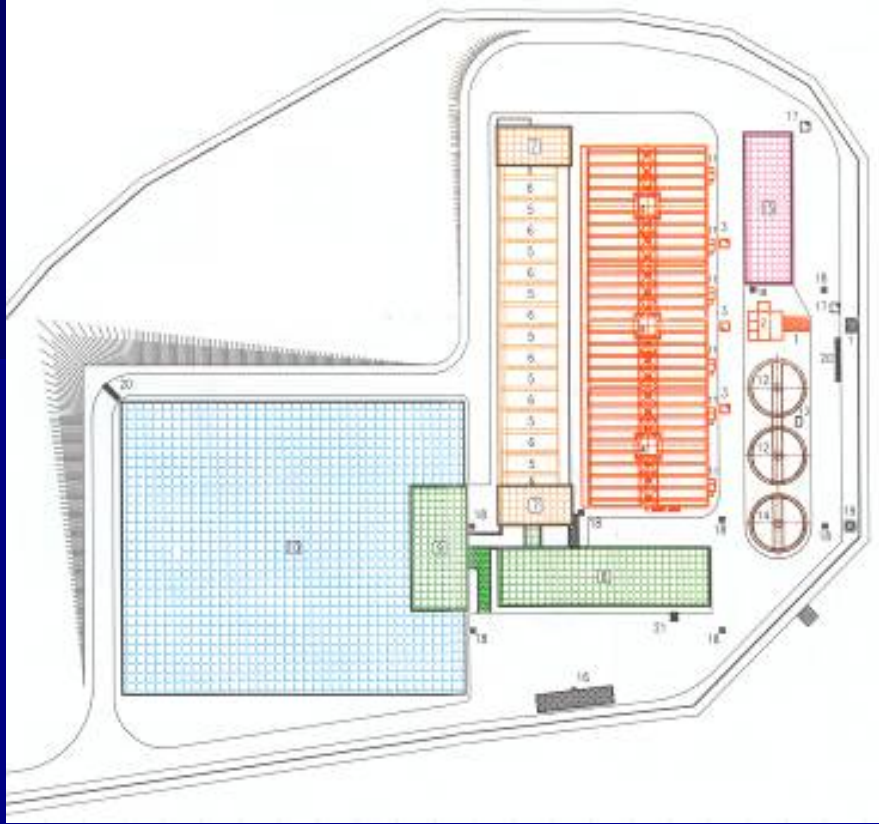
- The territory belong to subhilly Mediterranean climate, with heavy precipitations (1200-1300 mm/yr), mainly during the end of the winter and end of the autumn.
- Average temperatures oscillate: min 7.6, max 18.2 and average 12.9 ºC.





Treatment Plant of Buvilla - Tirana

- **Standard treatment from Treatment Plant of Buvilla in Tirana:** pre-disinfection, coagulation, clarifloculation, decantation, filtration, post-disinfestations.
- In case of extreme emergency a powdered activated carbon at clarifloculation step, is added, using a PAD Dosing System with a silo storage.
- Capacity of water supply for Tirana Town about 1800 l/s.

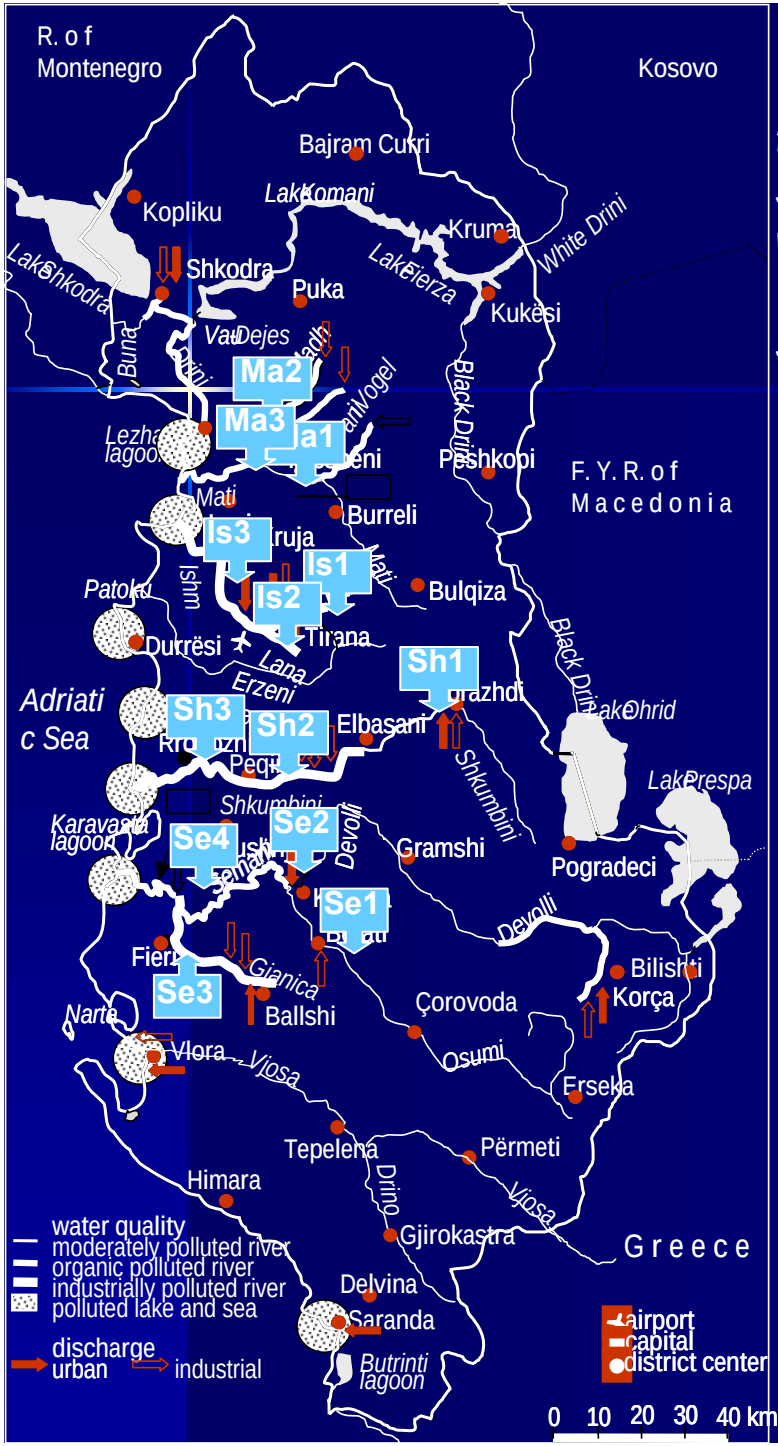


Aim of study

- **The study was initiated in response to concern over the deteriorating water quality manifesting by an unpleasant smell and taste first detected on September 2001.**
- Collect sufficient baseline quality data to define current limnological conditions at Buvilla Lake and provide a basis for future water quality monitoring and protection.
- Collect data about surrounding watershed, in the human activity, focused always in water quality

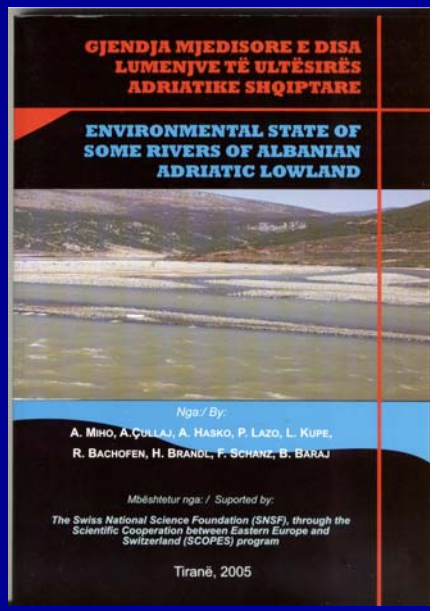
Involved Institutions

- Prof. Reinhard Bachofen, Project Copordinator, Institute for Plant Biology, University of Zurich, Swisse.
- Dr. Ferdinand Schanz, Limnological Station, University of Zurich
- Dr. Helmut Brandl, Institute of Environmental Sciences, University of Zurich.



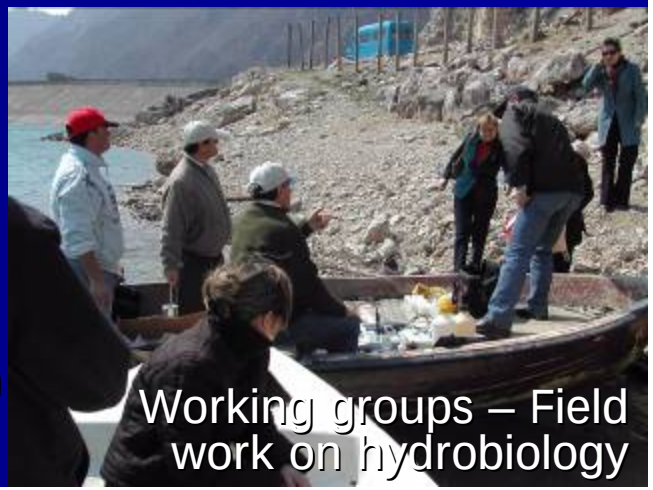
The Swiss National Science Foundation (SNSF), through the Scientific Cooperation between Eastern Europe and Switzerland (SCOPES) program, supported a monitoring work in 13 stations of the main rivers of Albanian Western Lowland: Mati and Fani, Tirana, Lana and Ishmi, Shkumbini, Osumi, Gjanica and Semani

Miho A., Cullaj A., Hasko A., Lazo P., Kupe L., Schanz F., Brandl H., Bachofen R., Baraj B. (2005): Gjendja mjedisore e disa lumenjve të Ultësirës Adriatike Shqiptare. SCOPES program (Swiss National Science Foundation - SNSF), Tirana (In Albanian with a summary in English) : 1-235 (http://www.fshn.edu.al/biologjia/SCOPES/007-008-Pasqyra-Content.htm)



Involved Institutions

- **Chemistry**: Prof. A. Çullaj, S. Duka (PhD st.), L. Pjeshkazini - Department of Chemistry, Faculty of Natural Sciences, University of Tirana
- **Hydrology:** B. Murtaj (MSc st.) - Institute of Hydrometeorology, Tirana
- **Microbiology and chemistry:** Ing. A. Emiri, F. Hoxha, E. Buzo - Drinking Water Treatment Plant (Babru)



Working groups – Field work on hydrobiology

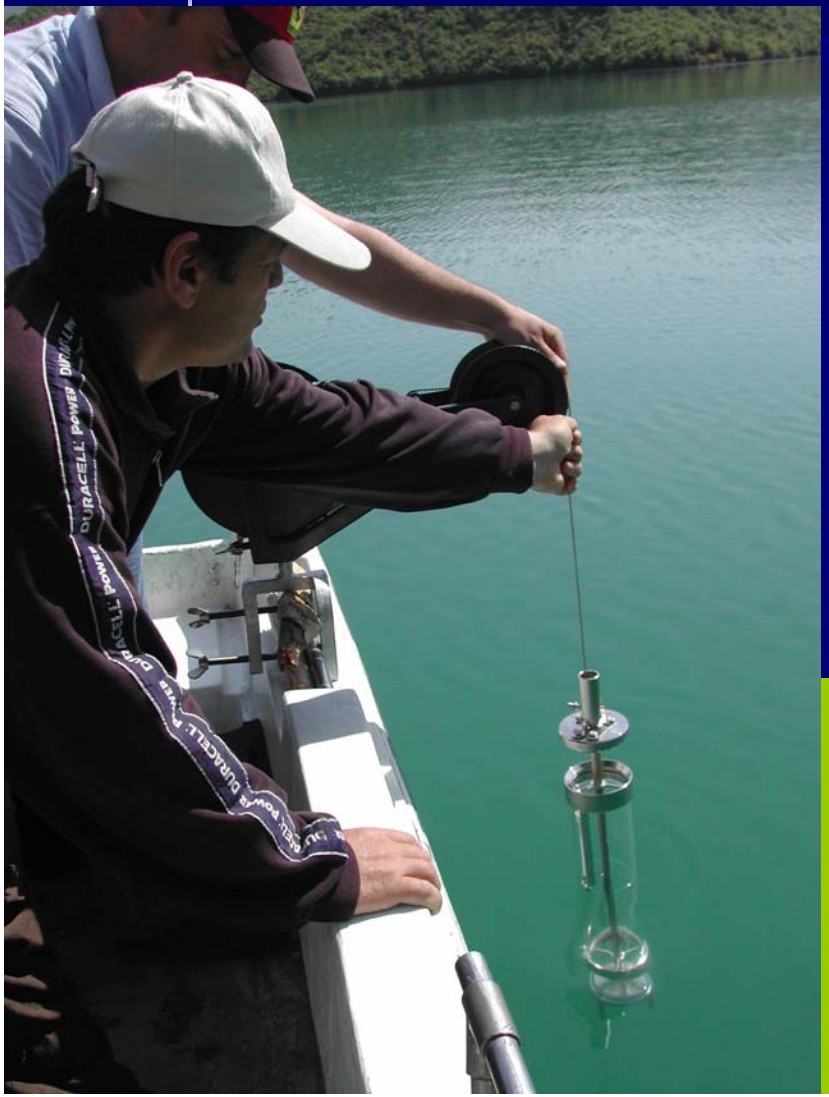
Involved Institutions

- **Phytoplankton**
  - Prof. A. Miho, Department of Biology, Faculty of Natural Sciences, University of Tirana;
  - E. Koni (MSc and PhD st.), Institute of veterinary Food Security, Tirana
  - Dr. L. Kupe, Agricultural University of Tirana
- **Zooplankton:** Prof. S. Shumka, E. Nikleka (PhD st.) - Agricultural University of Tirana

Involved Institutions

- **Terrestrial watershed, flora, vegetation and human impact**
- Prof. M. Xhulaj, Prof. M. Mersinllari, Prof.as. L. Shuka, J. Marka (MSc and PhD st.), Prof. A. Miho, A. Liçaj (Dpl. st.) Department of Biology, Faculty of Natural Sciences, University of Tirana;
- Prof. B. Draçi, Department of Geography, Faculty of Natural Sciences, University of Tirana

Methods of study



Depth profile (1m, 3m, 5m, 10m, 15m, 20m, 30m, 40m) using a Niskin bottle (2 l) with the aid of a hand-winch mounted in the boat at three sites (S1, S2, S3) with a frequency of two months, during May 2006 – May 2008

Methods of study

- **Chemistry**: Measured parameters using a Multi-Parameter Meter HACH: water temperature, pH, dissolved oxygen (Winkler method), conductivity, alkalinity, total dissolved solids, turbidity, permanganate index, UV absorbance and Secchi disk transparency (with a black and white quadrant disk, of 20 cm of diameter).
- **Photosynthetic pigments - c**hlorophylls: a, b, c and pheophytin using a SF UV-VIS Shimadzu 2401PC Spectrophotometer
- **Phytoplankton**, qualitative and quantitative (cell/ml) (Utermöhl, 1958; EU Guidance Standard: prEN 1524:2005) , using a Microscope inverse, XDS-1R and Microscopes Paralux L2000
- **Zooplankton**, qualitative and quantitative (cell/ml). Saprobic analysis was done by using standard Pantle-Buck method (1955) based on qualitative and relative quantitative composition of Rotifera, Cladocera and Copepoda species.
- **Microbiology** (total *coli*, coli-faecal and streptococcus-faecal), with filtration through a vacuum pomp with filters, cultivated in three different media in thermostat in different temperatures, after EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water (BMZ, 1995).
- **Terrestrial watershed**: Assessment of flora, vegetation and the human impact in the terrestrial watershed.

Methods of study – Physico-chemistry

Parameter	Methods	Instrument	Literature
Temperature	Thermometry	Multi-Parameter Meter HACH	1
pH	Potentiometry		
Conductivity	Conductometry		
TDS			
Dissolved Oxygen (DO)	Winkler Method and Electrometry		1, 2
DO %			
TSS	Filtration with membrane 0,45 μm and dry at 105°C	Filtering Unit	2
NO_3-N	Spectrophotometer UV-VIS	SF UV-VIS Shimadzu 2401PC	
NO_2-N			
NH_4-N	Spectrophotometer UV-VIS (Indophenols blue method)		
PO_4-P	SF UV-VIS (method of the reduction of molybdenum blue)		
Fe, Zn	SAA in flame air-acetylene	SAA Varian SpektrAA 10+	3, 4, 5
Chlorophyll (a, b, c and phytophytin)	Spectrophotometry UV-VIS	SF UV-VIS Shimadzu 2401PC	2
Transparency	A black and white quadrant disk, of 20 cm of diameter		6

1, Hach (2001); 2, APHA, AWWA, WPCF (1985), 3, Haswell (1991);
4, Price (1985); 5, Welz (1985); 6, Carlson & Simpson (1996); 7, Utermöhl, 1958

Methods of study - Hydrobiology

Parameter	Methods	Instrument	Literature
Phytoplankton, -qualitative -quantitative (cell/ml)	Utermöhl	Microscope inverse, XDS-1R Microscopes Paralux L2000	2
Zooplankton, -qualitative -quantitative (cell/ml)		Microscope inverse	1
Microbiology, -total *coli* -coli-phaecal -streptococcus-phaecal	Filtration through a vacuum pomp with filters, cultivated in three different media in thermostat in different temperatures		3

1, APHA, AWWA, WPCF (1985); 2, Utermöhl (1958); 3, EU Directive 75/440 (1975); 4, Carlson & Simpson (1996)

RESULTS

- After the norms of EC Environmental Directive 440, water quality comply with A1 nearly for all physico-chemical parameters,
- Total Suspended Solids (TSS) often exceed 25 mg/L, for raw drinking water quality standards of EU Directive 75/440:1975
- Ammonia and nitrates – quality class A2 for only few samples
- DO and %DO - quality class A2 for hyplimnion during the stratification periods

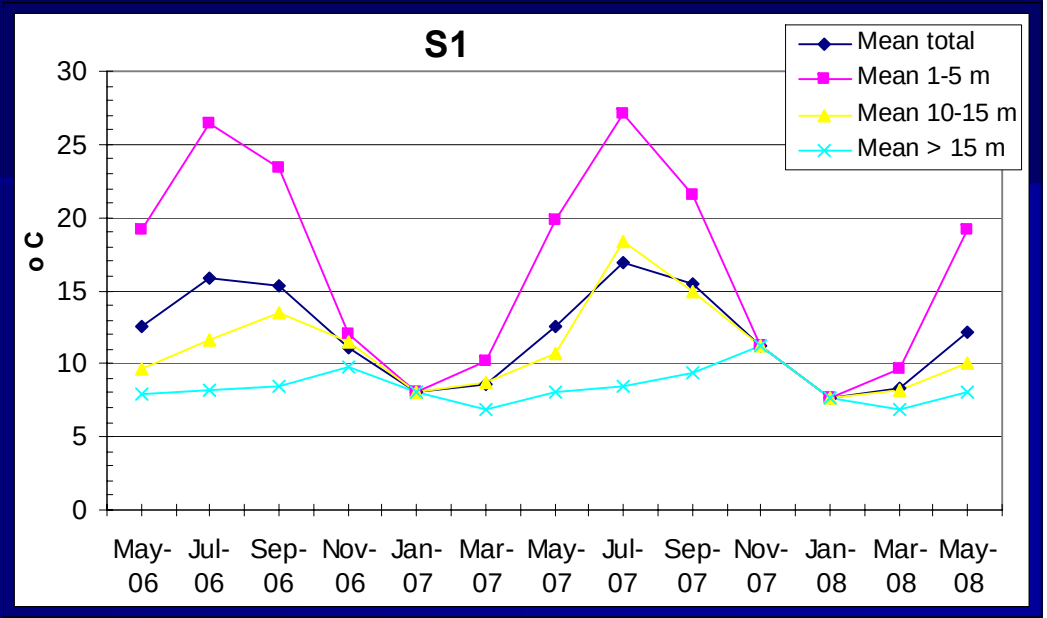
Temperature (stratification)

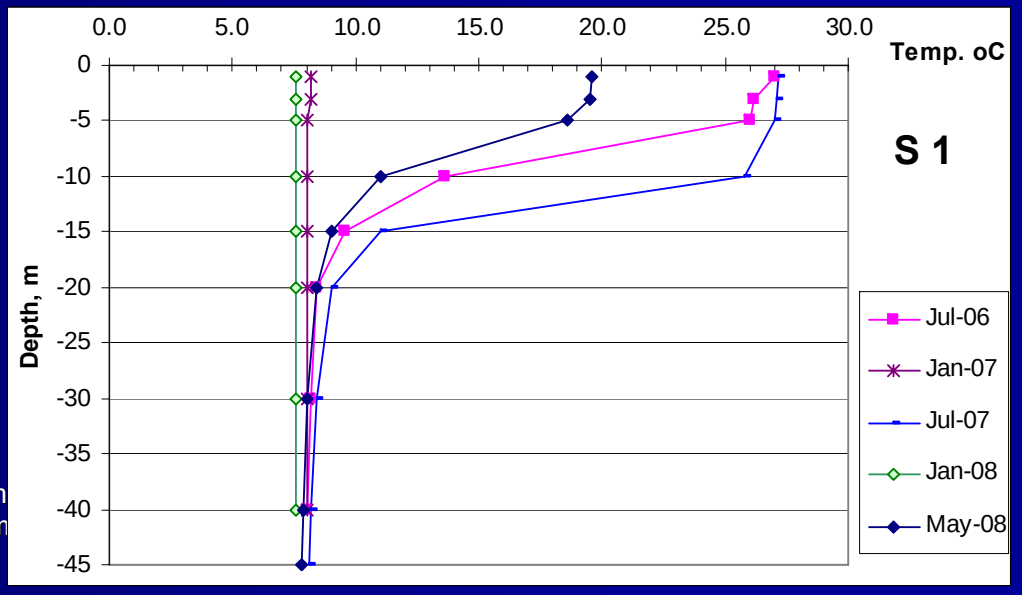
- **Buvilla is typically deep reservoir able to stratify similarly to lakes**
- Range of temperatures:

(i) on epilimnion layer was 19.6 degrees (max 27.2 ^{0}C on July 2007, min 7.6 ^{0}C on January 2008)

(ii) in hypolimnion was 4.4 degree (max 11.2 ^{0}C on November 2007, min 6.8 ^{0}C on March 2007)

- Five specific thermal situations were observed: three fully developed stratifications and two overturns





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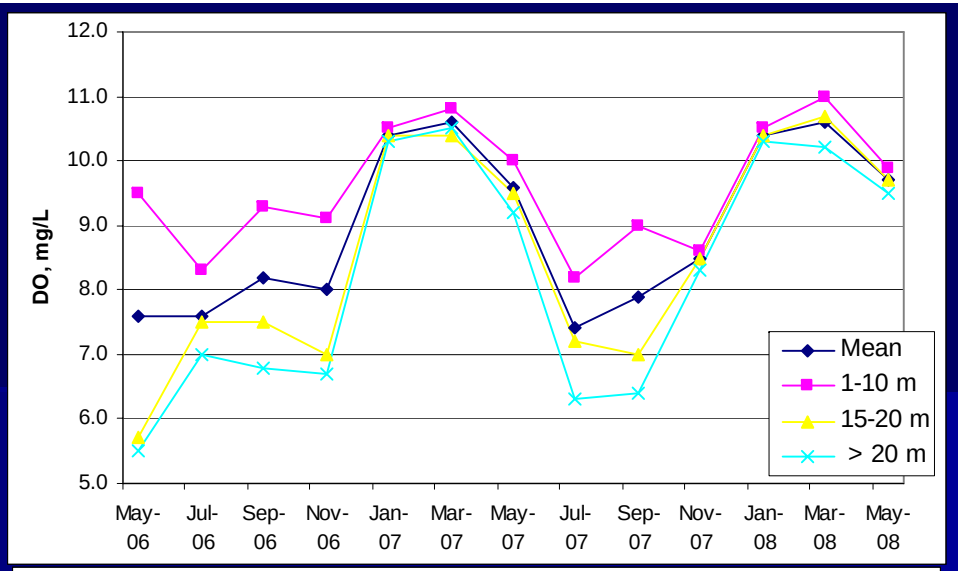
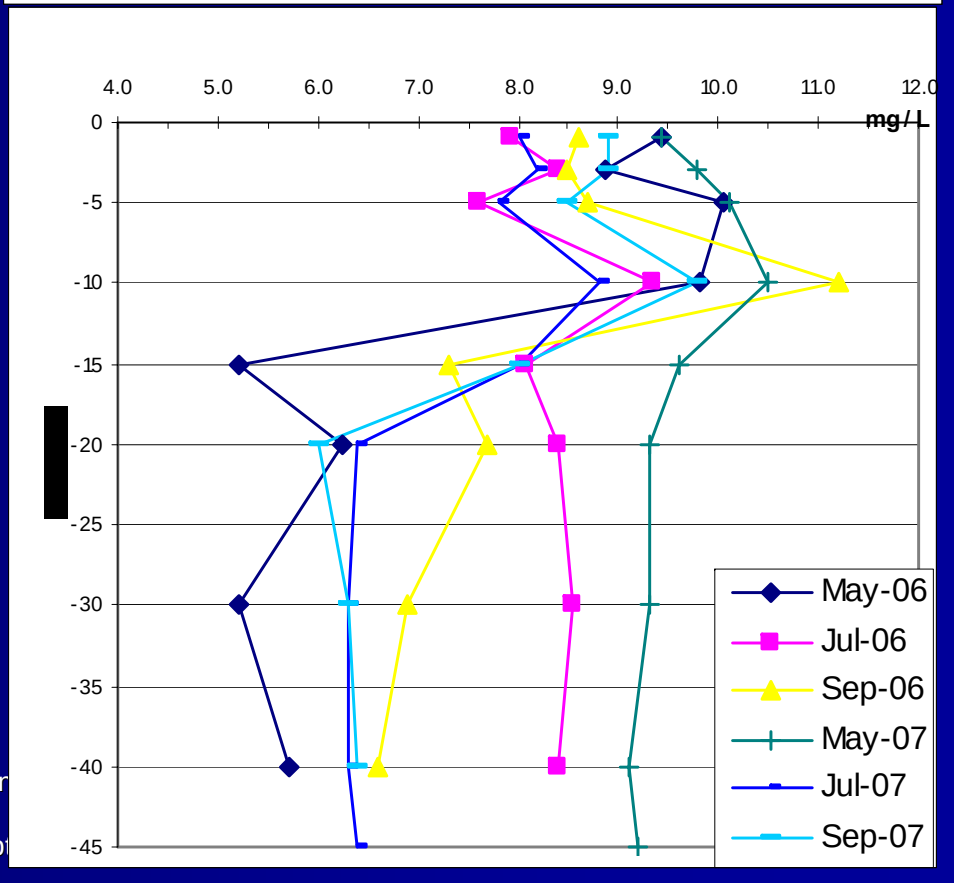
Oxygen

- DO was characteristic for oligotrophic state
- Deep layers were well oxygenated during all the year: min. %DO in hypolimion ranged 45-55% (av. %DO =73%)





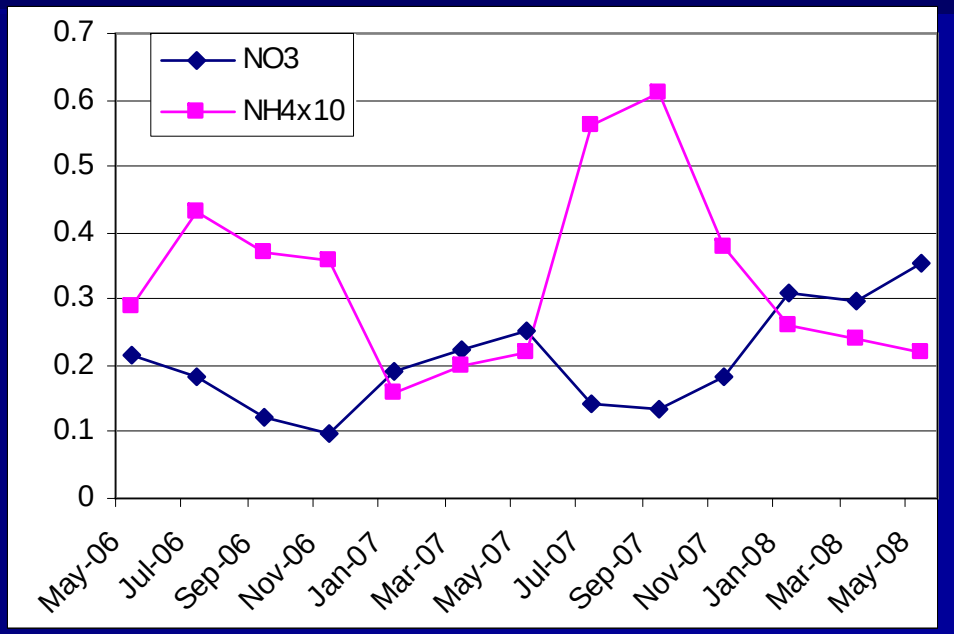
Phosphorus

- **Phosphorous was less than 10 µg/l, corresponding to an evident oligotrophic state according OECD–1982 limit values (UNECE Guidelines and according EEA)**
- Overall mean concentration was 4.85 µg/l (n = 170)

  Min. = 2 µg/l (LD), Max. = 14.7 µg/l
- Mean conc. in epilimnetic layer (1-15 m) was 4.3 µg/l, in hypolimnion (20-40 m) was 3.7 µg/l and. In bottom was 5.3 µg/l
- Higher levels were observed only scarcely during overturns (but not very distinct)
- There was a direct influence of rainfall on phosphorus
- Mean values were scarcely higher at stations 2 and 3, showing that the principal source is the discharge from tributaries and watershed (**erosion**)

Nitrogen - $N\text{-}NO_3$, $N\text{-}NO_2$, $N\text{-}NH_4$

- Nitrates ($N\text{-}NO_3$) oscillated from 0.02 mg/l up to 0.39 mg/l with an overall mean 0.18 mg/l (n=176). Mean value in 0-10 m was 0.16 mg/l (max. in 15 m) and in 15–45 m was 0.25 mg/l
- Nitrites ($N\text{-}NO_2$) oscillated from 0.26 μg/l up to 27.5 μg/l with an overall mean 5.8 μg/l (n=176) (limit for DW 100 μg/l). Mean value in 0-10 m was 5.3 μg/l (max. in 15 m, 6.5 μg/l) and in 15–45 m was 0.73 μg/l
- Ammonium oscillated from 0.01 mg/l up to 0.198 mg/l with an overall mean 0.0356 (n=173). Low values were observed during overturn and spring, higher during stratification (and hot period).

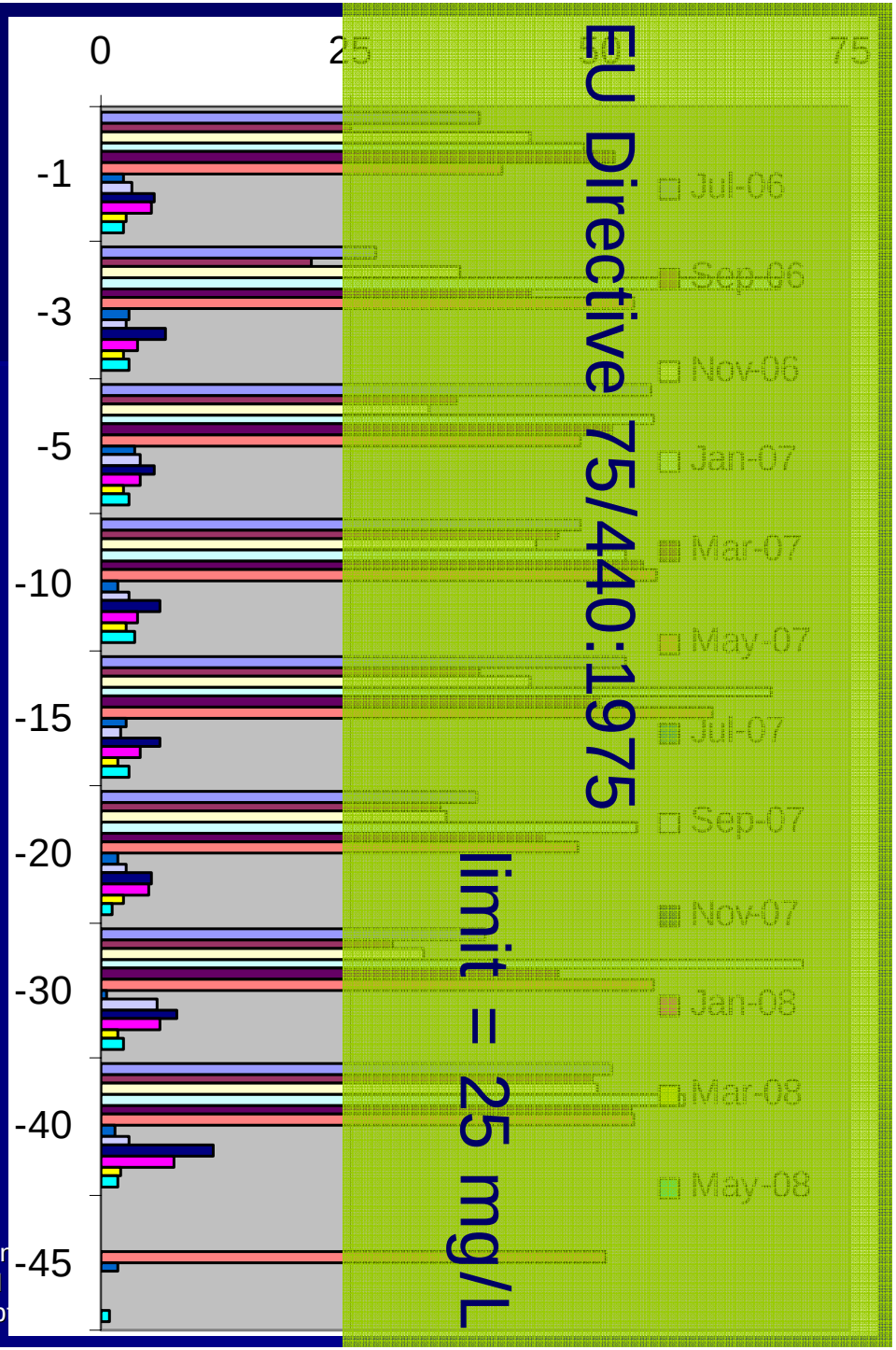


Opposite trends of changes for ammonium and nitrate (R^2=-0.83), and for ammonium and DO (R^2=-0.714, n=13) (due the impact of oxidizing conditions)

S2 and S3 > S1

Turbidity and Total Suspended Solids (TSS)

- Erosion from heavy rains and fast moving streams are principal factors for high turbidity, TSS and low value of Secchi Disk depth (and not algae). Correlation Turbidity – Rainfall: 0.711 (n=13) and Turbidity – Secchi Disk: -0.853 (n=13). Also (S2, S3> S1)



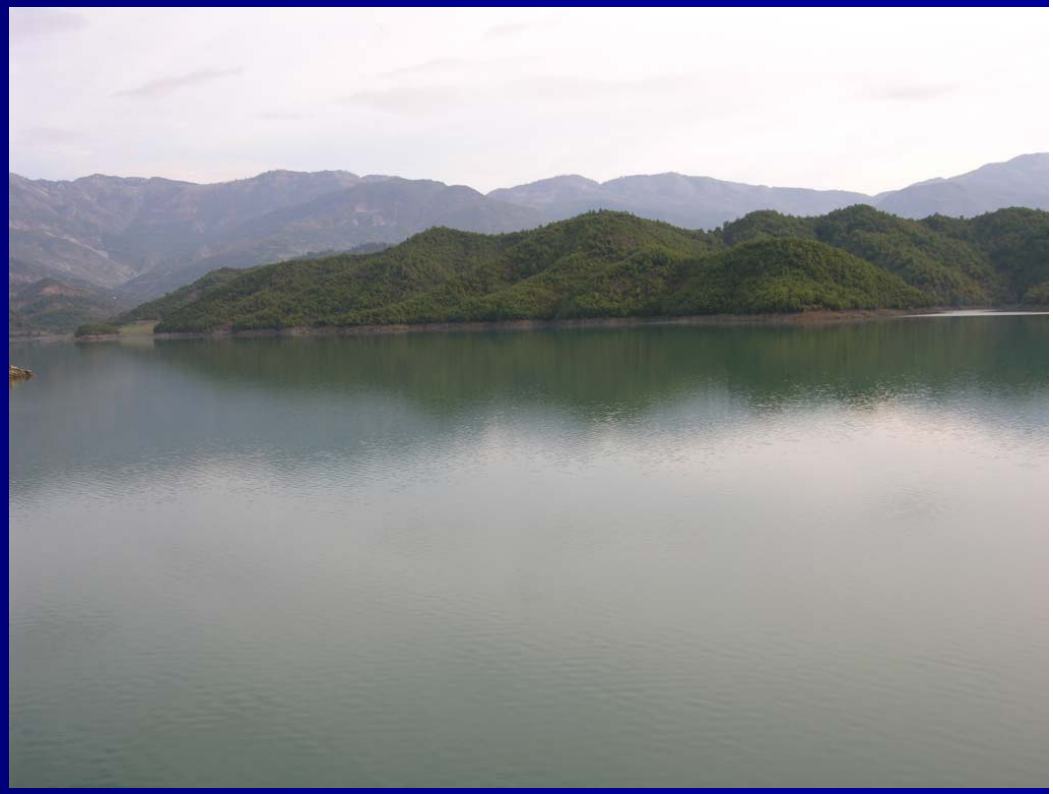
Transparency (Secchi Disk, m) and related Trophic State (TS_{SD})

Depth, m	Mean values of stations S1, S2 and S3						Assessed only station S1						
	May-06	July-06	Spet-06	Nov-06	Jan-07	March-07	May-07	July-07	Sept-07	Nov-07	Jan-08	March-08	May-08
Mean	2.6	2.4	3.0	2.3	2.1	3.1	2.5	3.1	2.6	1.3	2.0	3.1	3.2
TSI	46	47	44	48	49	44	47	44	46	56	50	44	43
Trophy	Mesotrophic									Eutrophic		Mesotrophic	

- **Considering Chl a and TP , Buvilla waters show an oligotrophic state, which do not coresopnd to the values and the related trophic index calculated from transparency**
- Erosion from heavy rains and fast moving streams are principal factors for high turbidity, TSS and low value of Secchi Disk depth (and not algae). Correlation Turbidity – Rainfall: 0.711 (n=13) and Turbidity – Secchi Disk: -0.853 (n=13). Also (S2, S3> S1)

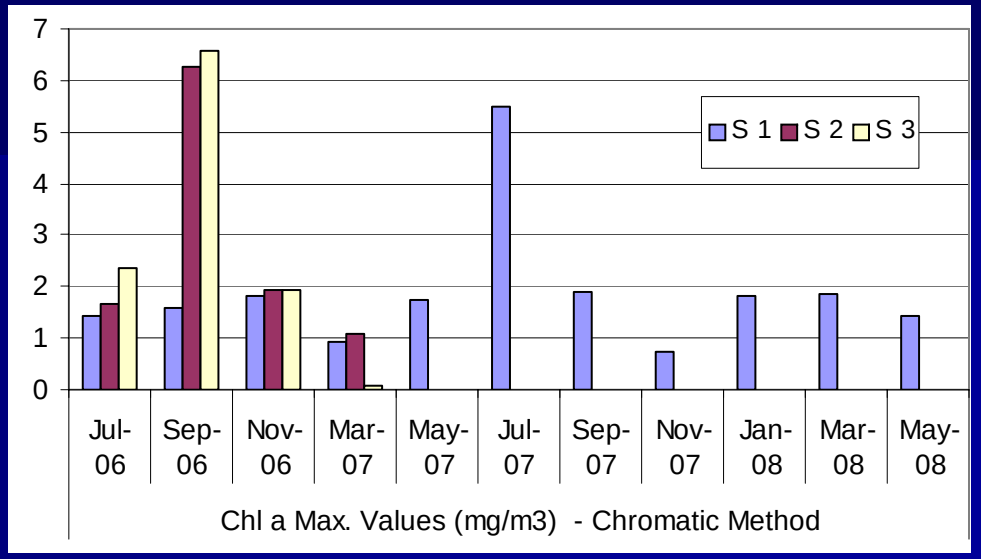
Organic Matter Content: $UV_{253.7}$, $KMnO_4$ Index, TOC and BOD

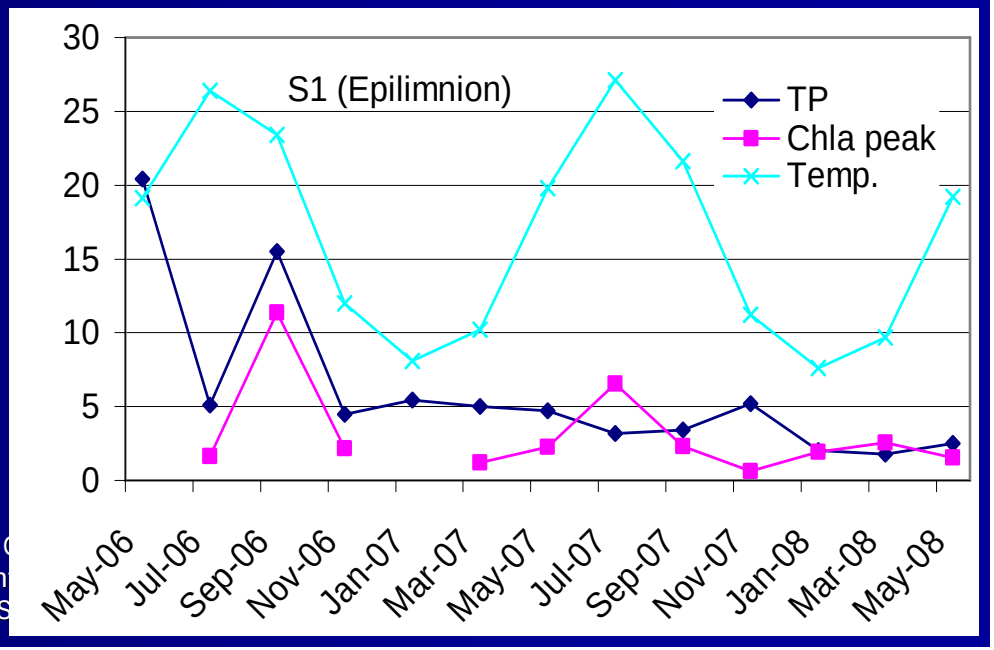
- Relatively low content of organic carbon in waters were observed: TOC = av. 5 mg/l C (0.90-16.7); BOD_5 < 20%



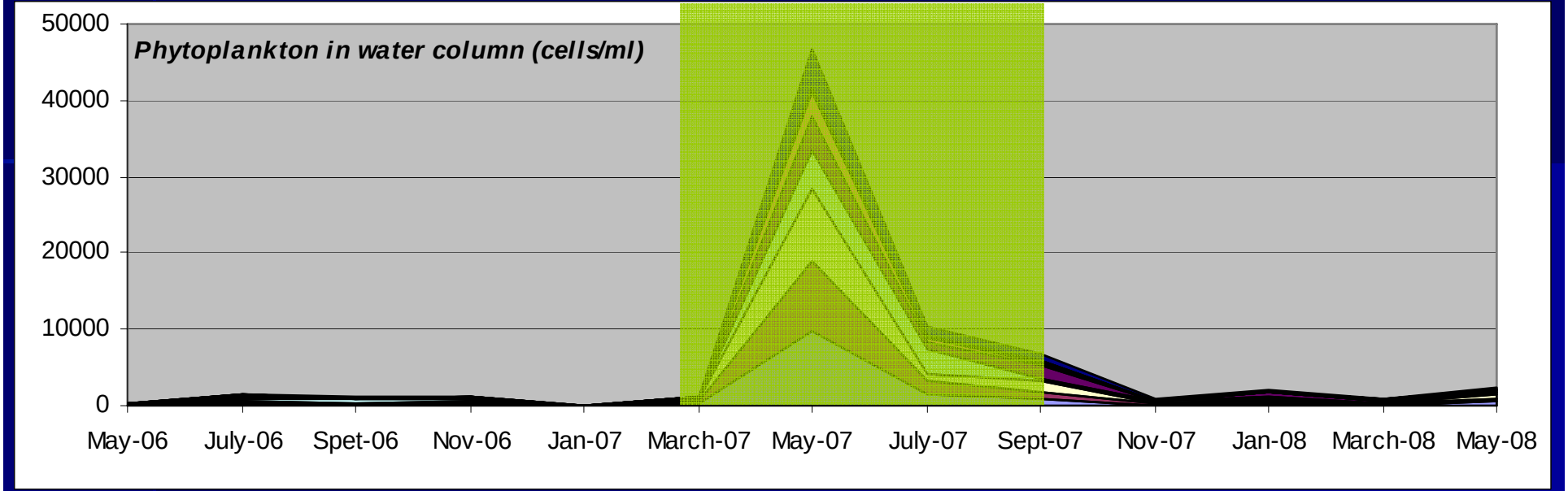
Photosynthetic pigments

- **Chlorophyll values were characteristic for oligotrophic level:**
  - Chl *a* peak values varies from 0.55 μg/l on March 07 (site S3) up to 11.36 μg/l on Sept. 06 (site S1); overall mean of peak values resulted 3.2 μg/l, and overall annual mean in epilimnion was 2.35 μg/l
  - There was observed a positive correlation between Peak Chl *a* with TP: Chl *a* = 0.0178 + 0.642 TP (R^2 = 0.771), showing that TP is limiting factor
- **Temperature in epilimnion is also important. The highest CHl *a* corresponded to the m maximal values of temperature.**





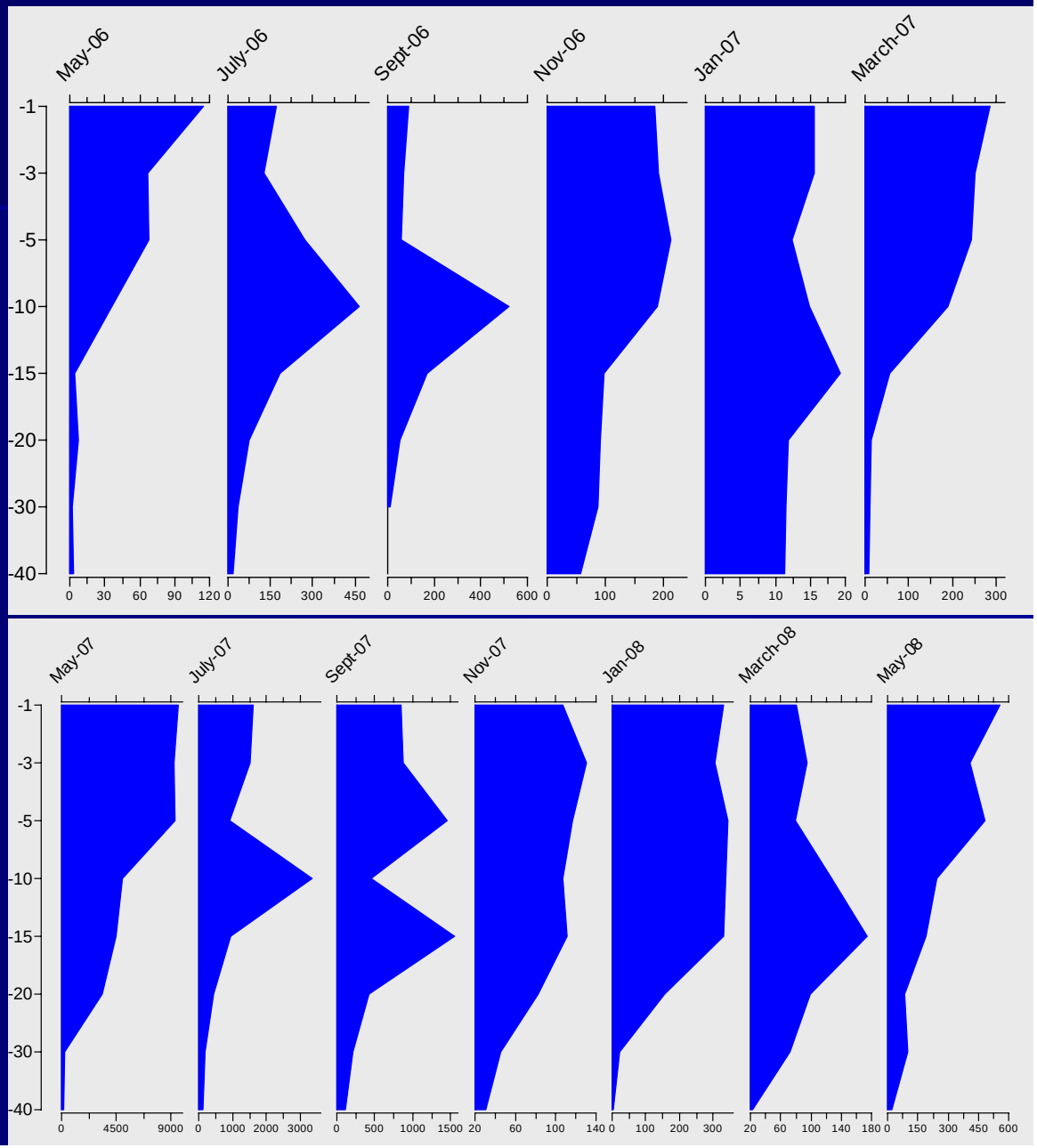
Phytoplankton



- The reservoir presented only ONE evident peak of phytoplankton growth in late spring – autumn (May –September 07), the rest was very low.
- Dominat microscopic algae in phytoplankton belonged to two main groups: *DIATOMS* (*Centricae* and *Pennate*) and *DINOPHAGELLATES.* Other groups like: *Chlorophyceae, Chrysophyceae, Euglenophyceae* and Cyanophyceae were in small quantity.

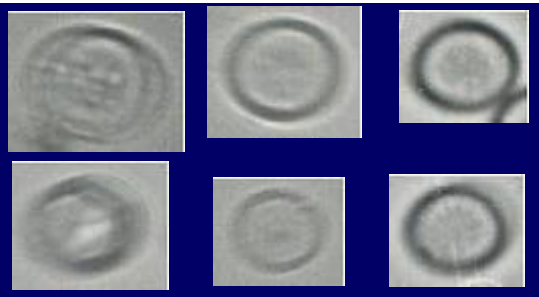
Phytoplankton

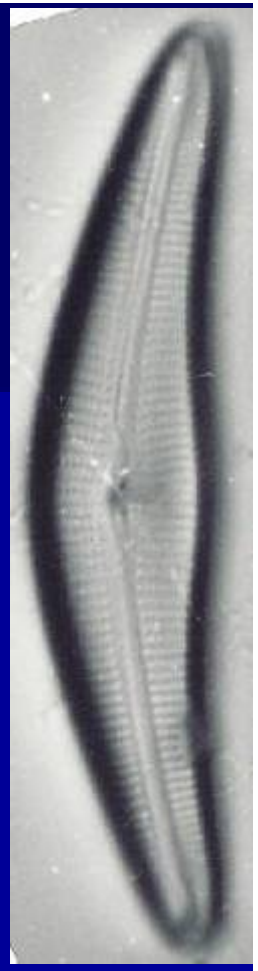
- The most productive layers extend up to 15 m of depth, and the maximum of productivity was observed between 5-10 m depth.
- Considering the phytoplankton biomass (after Willen, 2000), waters show an oligotrophic state as confirmed also from the phsphorous and chlorophylls, with some trends to mesotrophy in late spring or autumn.



Phytoplankton

- The most common species dominating the phytoplankton were centric diatoms of *Cyclotella* sp. *diverse*, composed mainly from *C. commensis*, a typical species in reservoirs throughout the region; its abundance goes even higher than 90% of the total phytoplankton. *Cyclotella* representatives are known mainly as oligotraphent species that grows in the clean habitats





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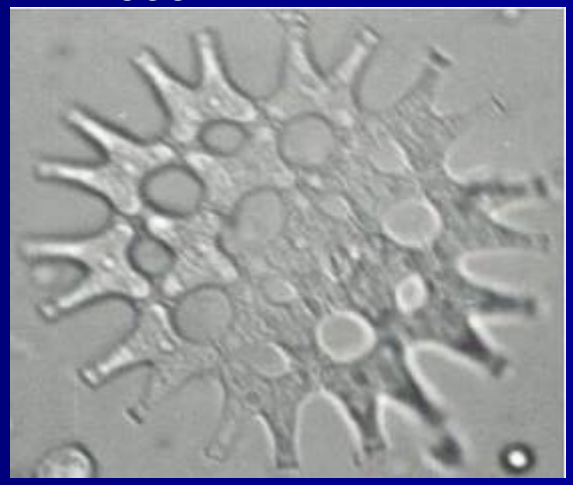

Fig. 1-6: *Cyclotella* comensis

Fig. 7: *Navicula radiosa*

Fig. 8: *Cymbella cymbiformis*

Fig. 9: *Pediastrum boryanum*

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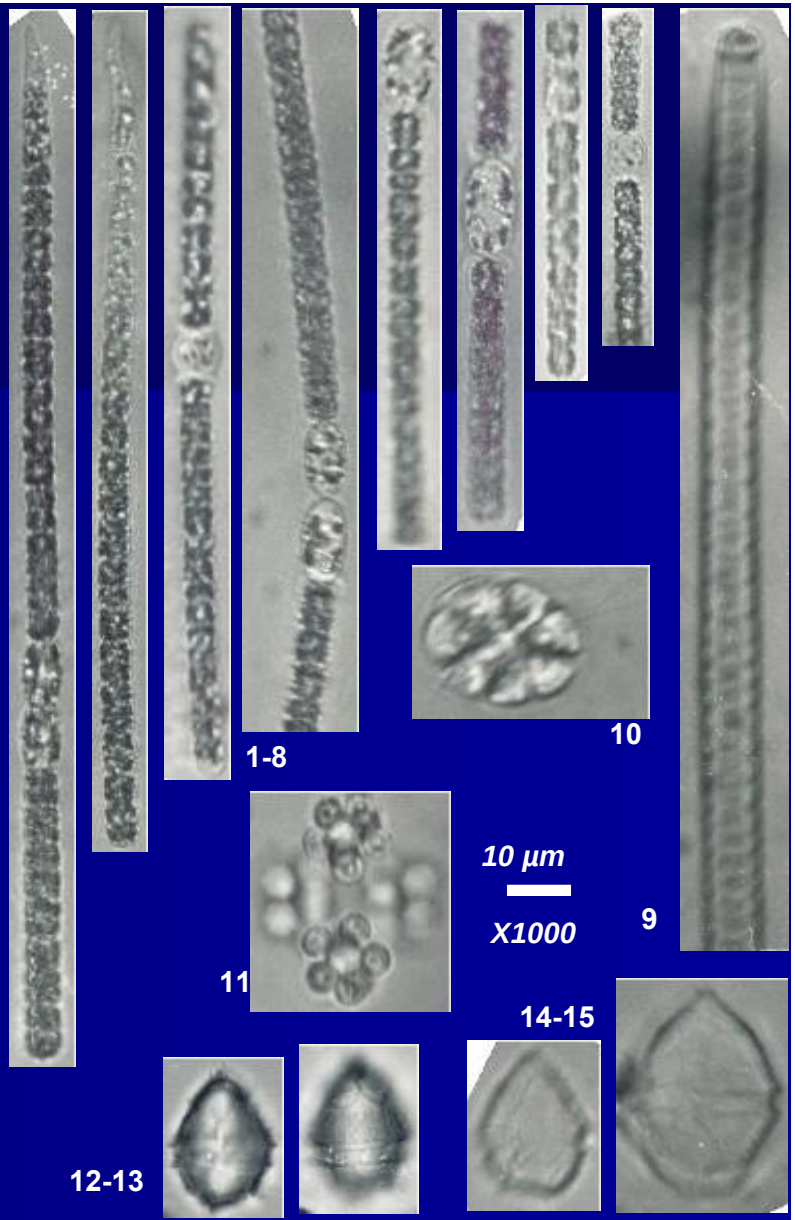
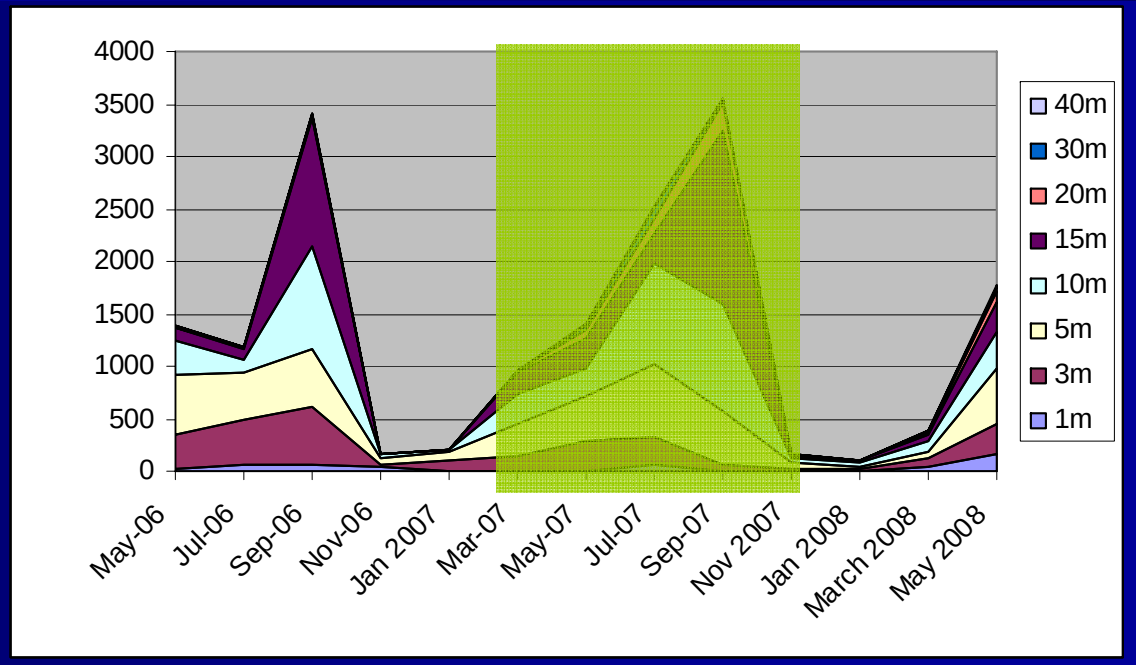


Fig. 1-8: Anabaena cf. affinis
Fig. 9: Oscillatoria sp.
Fig. 10: Sinura sp.
Fig. 11: Crococcidiopsis sp.
Fig. 12-13: Peridinum sp.
Fig. 14-15: Peridiniopsis cf. cunningtonii

Zooplankton

- Cladocera and Rotatoria species were dominant, followed then by copepods.
- Zooplankton growth reached the maximum the total during the summer and autumn; the peaks were registered in July – September 2007 and 2008.
- It seams that the zooplankton growth is following more or less the same trend as phytoplankton
- Values of saprobity index varied from 1.2 to 2.16, which corresponds with oligosaprobic and β−mesosaprobic waters



The total zooplankton dynamics (x 1000 ind/m3) in water column

Zooplankton

- Dominant species the *Bosmina, Keratella* and *Macrocyclops albidus*
- **Species belonging to the subclass *Copepoda* were dominant, especially the larval and kopepodid stages.**
- The abundance of unusual zooplankters, like*Bosmina* species shows that Buvilla is still an unsaturated ecosystem with concern to a define species number (and composition) to a higher extend than lakes.

Rotatoria species from Buvilla

Brachionus angularis

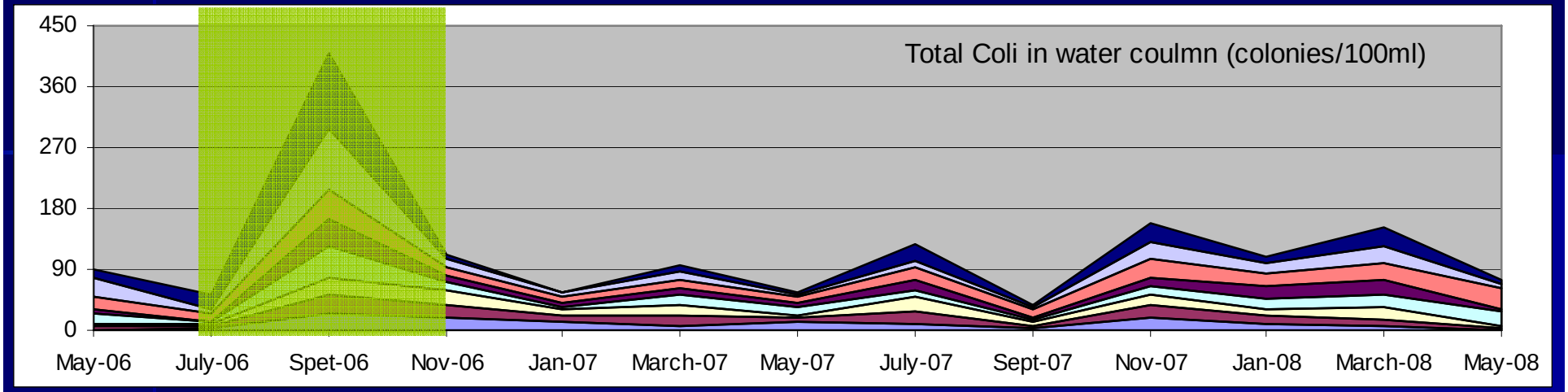
Asplanchna priodonta

Bosmina longirostris

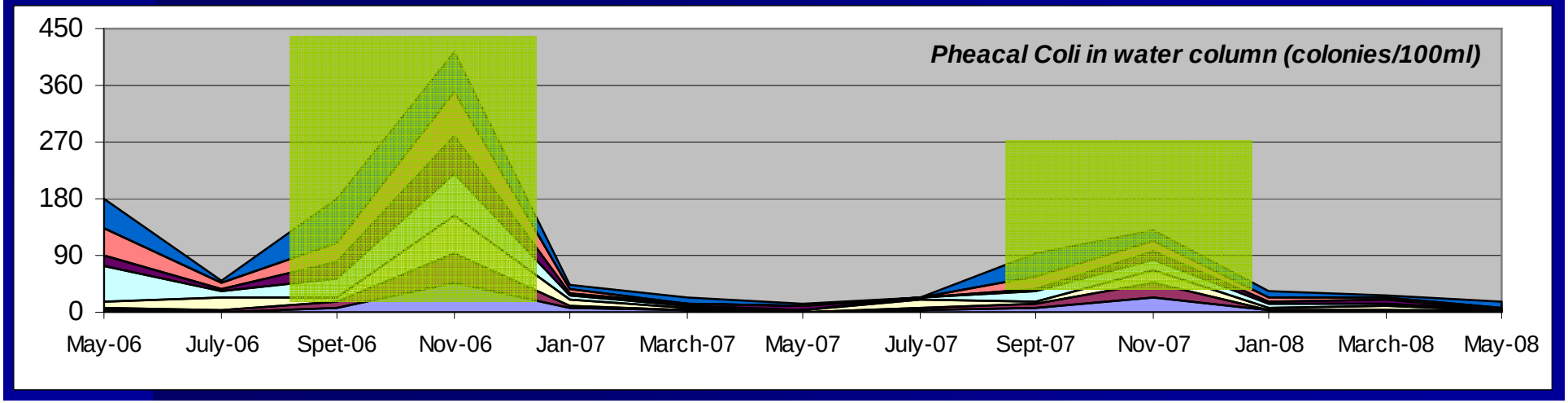
Diaphanosoma brachiurum

Cladocera species from Buvilla

Microbiology

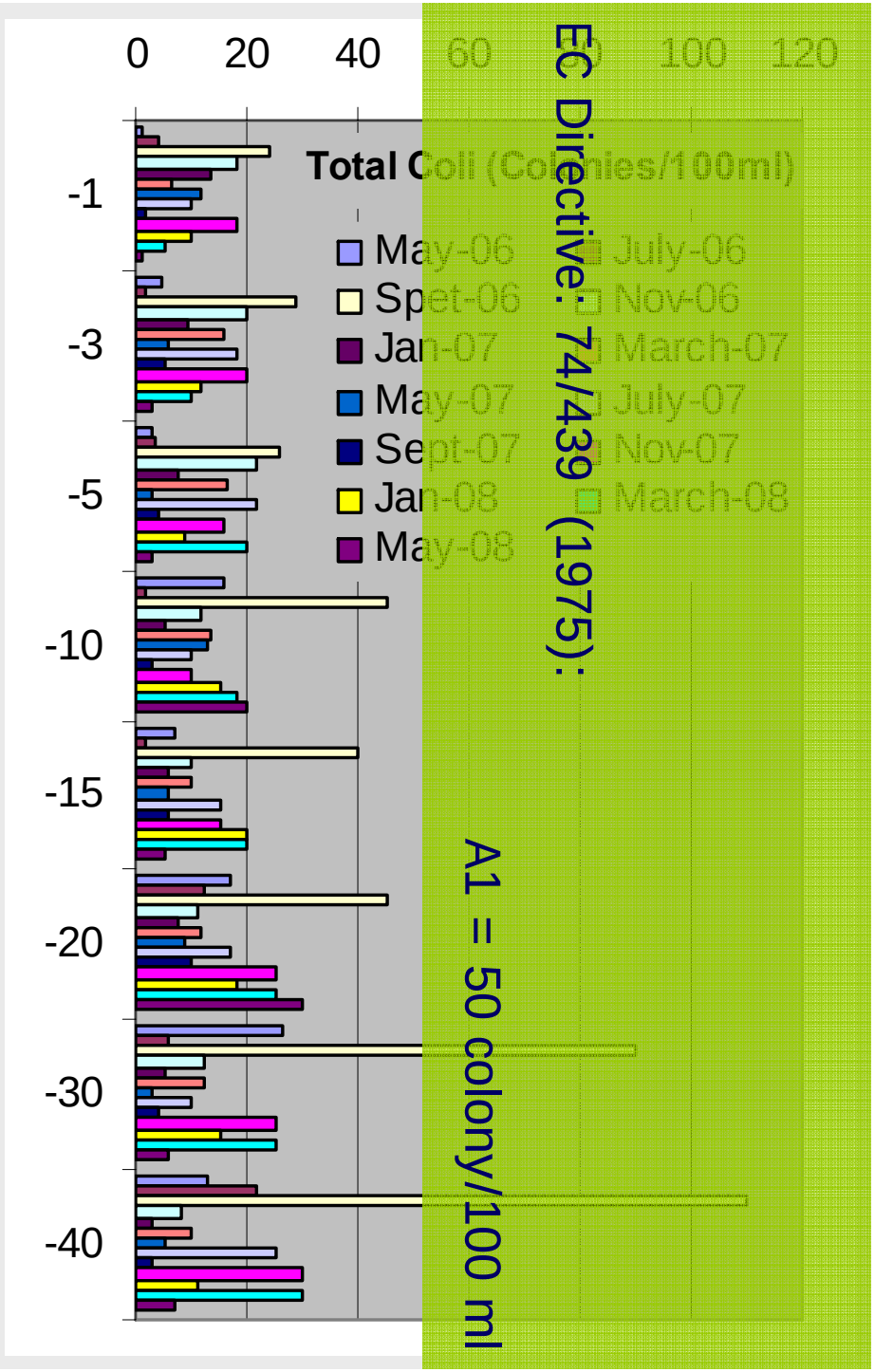


Total coli (*above*) and *Pheacal* Coli (*below*) (colonies/100 ml) in water column



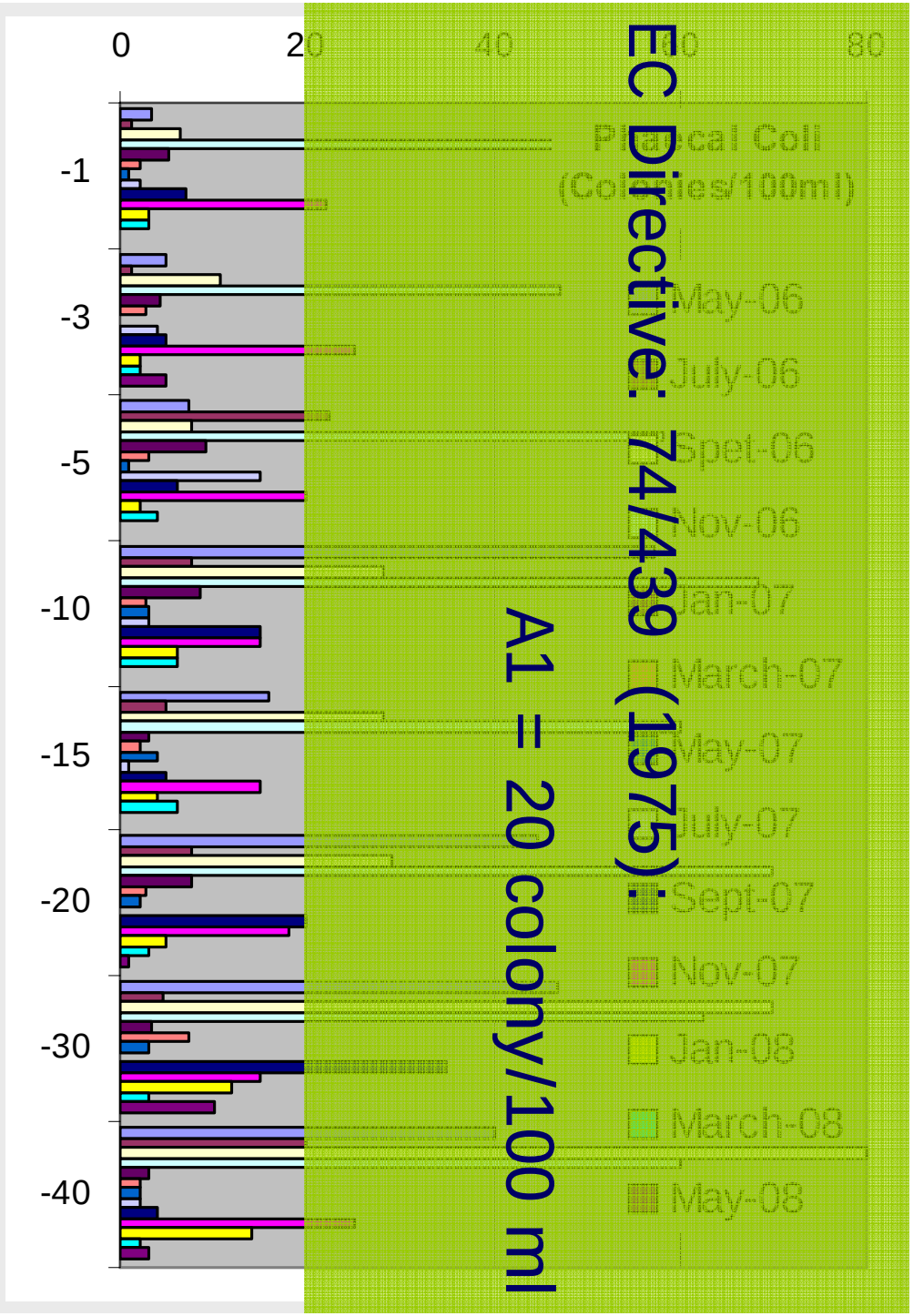
Microbiology - Total *Coli*

- Total *Coli* was found in rather high quantities mainly in September 06, in the bottom layers (up to 110 colonies/100 ml in 45 m of depth), values between A1 (waters that need simple physical treatment) and A2 (standard physical and chemical treatment and sterilization) (BMZ, 1995: EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water).

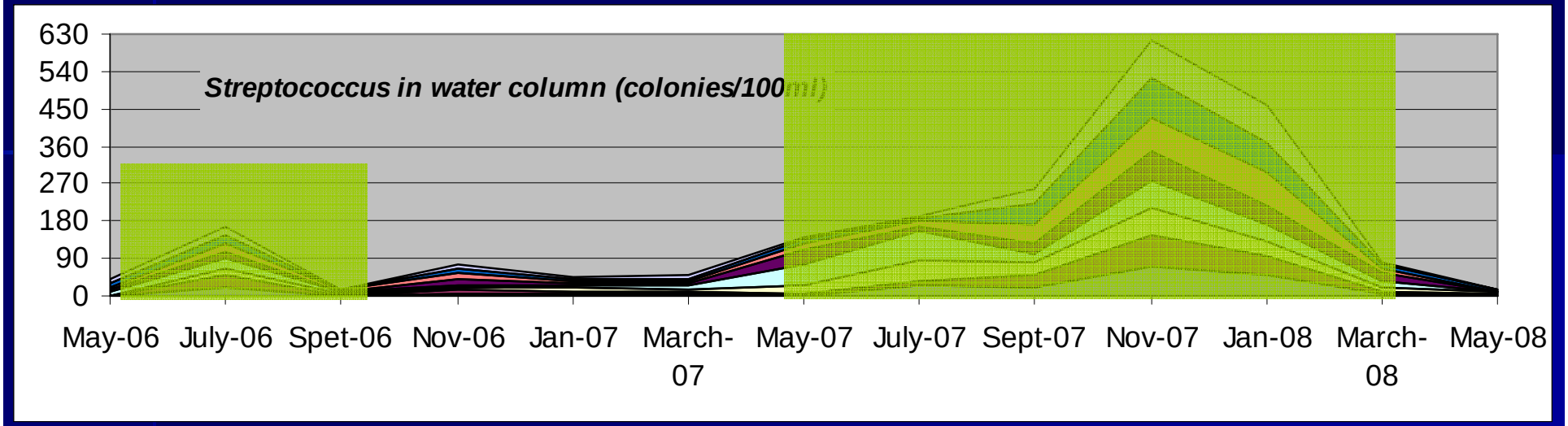


Microbiology - *Coli-faecal*

- *Coli-faecal* was high in November 06 in almost all layers; there was also an increase in the hypolimnion even in May 07. The highest values were again in September 06 at the bottom (up to 80 c/100ml in 45 m), values between A1 (waters that need simple physical treatment) and A2 (standard physical and chemical treatment and sterilization) (BMZ, 1995: EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water).



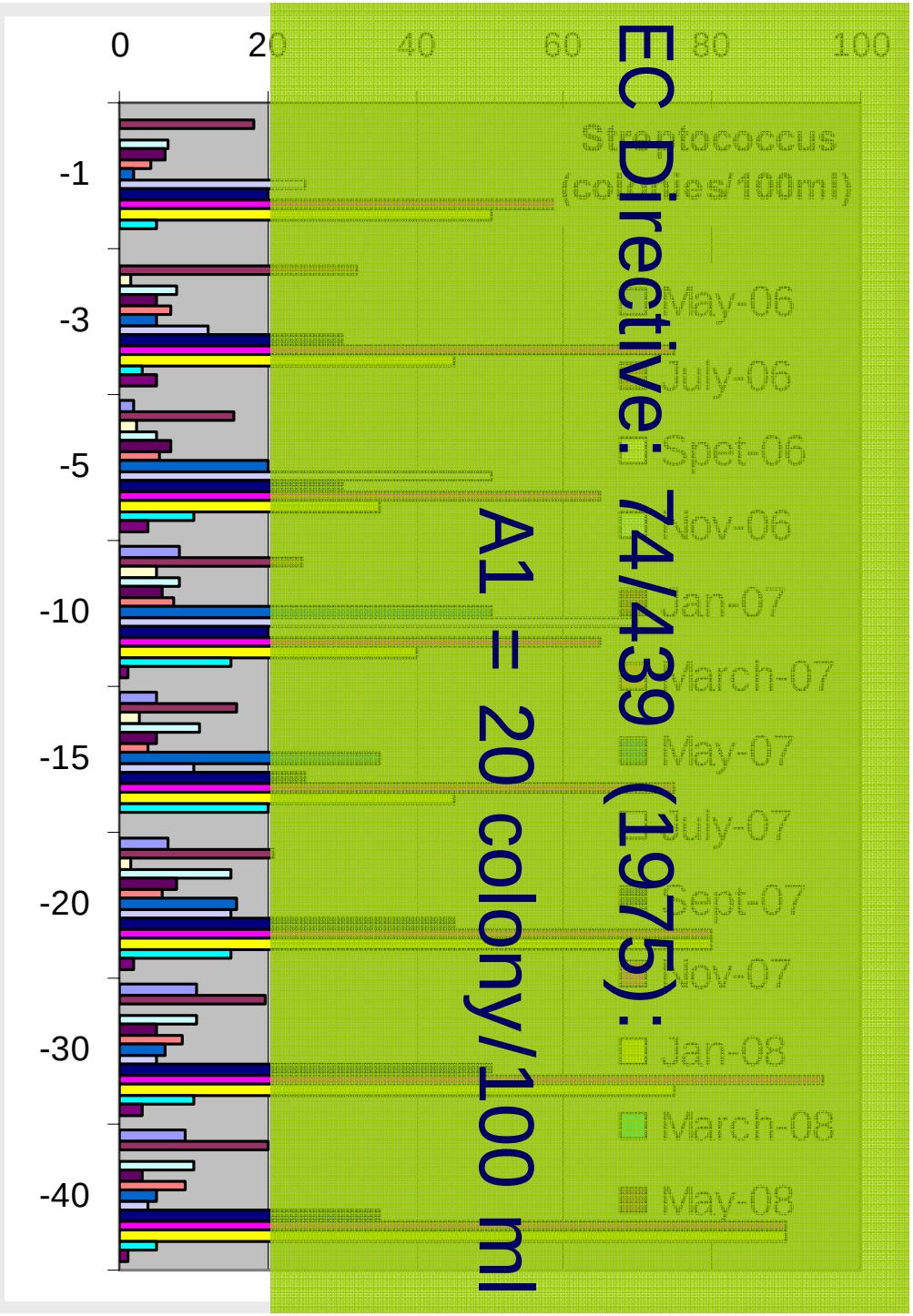
Microbiology



***Streptococcus* (colonies/100 ml) in water column**

Microbiology - *Streptococcus-faecal*

- **Values of *Streptococcus-faecal* were relatively low**; the highest values were measured in May 07, between 10-15 m of depth (up to 80 c/100 ml in May 07 in 10 m), values between A1 (waters that need simple physical treatment) and A2 (standard physical and chemical treatment and sterilization) (BMZ, 1995: EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water).



Considerations about the unpleasant smell and taste events on Buvilla water

- Assessment made in two water samples taken in March 2008, in Zurich University showed an unusual gas chromatograph-pattern, with a sum of monoterpenes, from which Carvon dominated, that probably forms the smell.
- The most common compounds in other similar systems (geosmine and 2-MIB) were definitively not present
- The most common opinion is that the decaying of the remaining stems and roots underwater may produce terpenes for many years. It can be enhanced also from terrestrial bordering areas that are regularly flooded with water as the lake level varies to about 10 m in altitude.

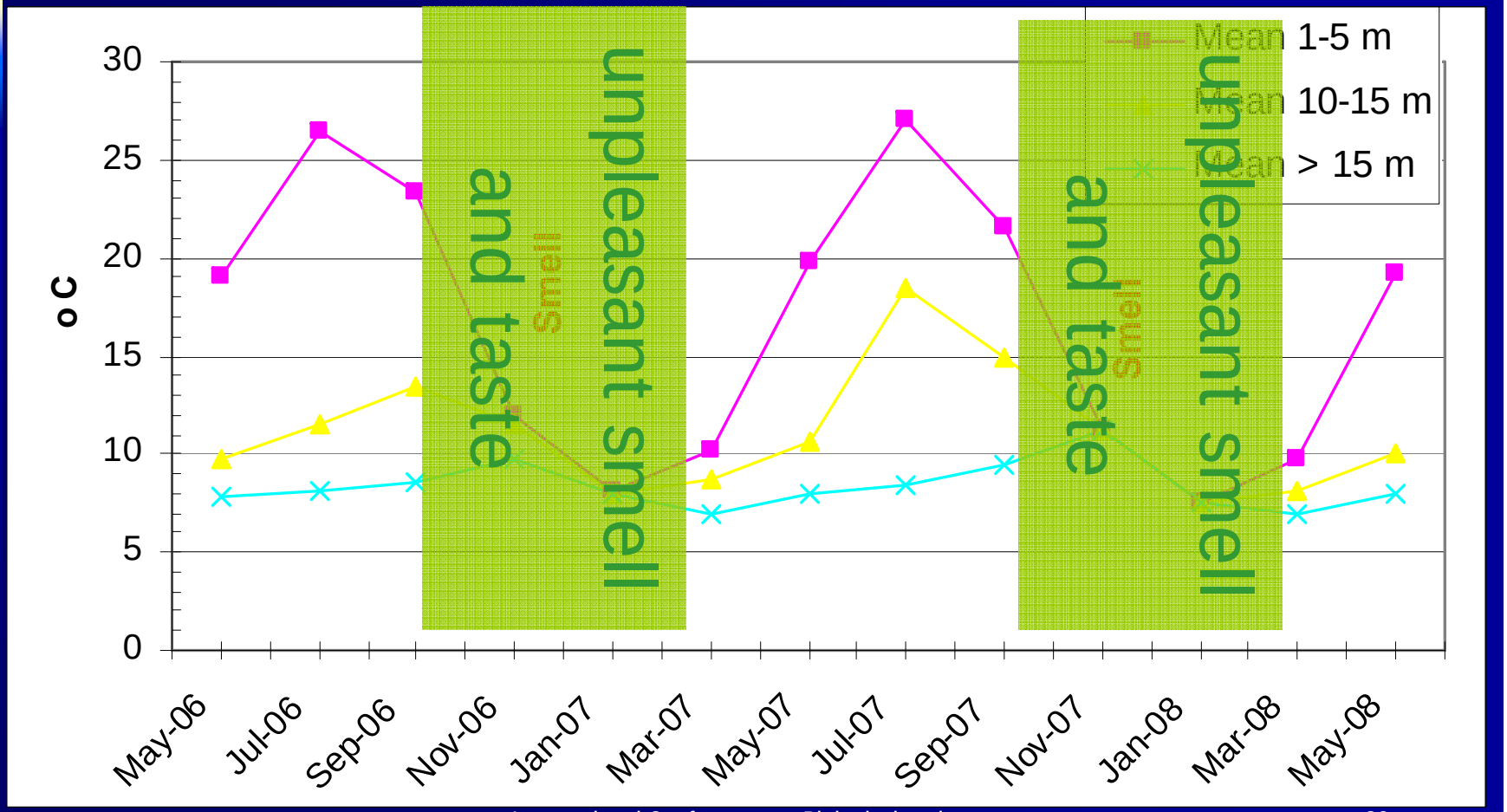
Eventual relations between smell and taste events and water chemical quality variables

- **It CANNOT be originated from the microscopic algae present in phytoplankton**
- There is an evident relation between unpleasant smell and taste period and stratification situation: **problems seems to start when stratification begins to weaken, and it ends after the overturn when stratification is developed**
- Periods of treatment of water with active carbon for two monitoring years are:
  - 6/10/2006 ÷ 24/04/2007
  - 17/09/2007 ÷ 30/04/2008

Stratification				Overturn		
May-06	July-06	Sep-06	Nov-06	Jan-07	March-07	
			Smell and test problems			

Stratification			Overturn			Stratification
May-07	July-07	Sep-07	Nov-07	Jan-08	March-08	May-08
		Smell and test problems				

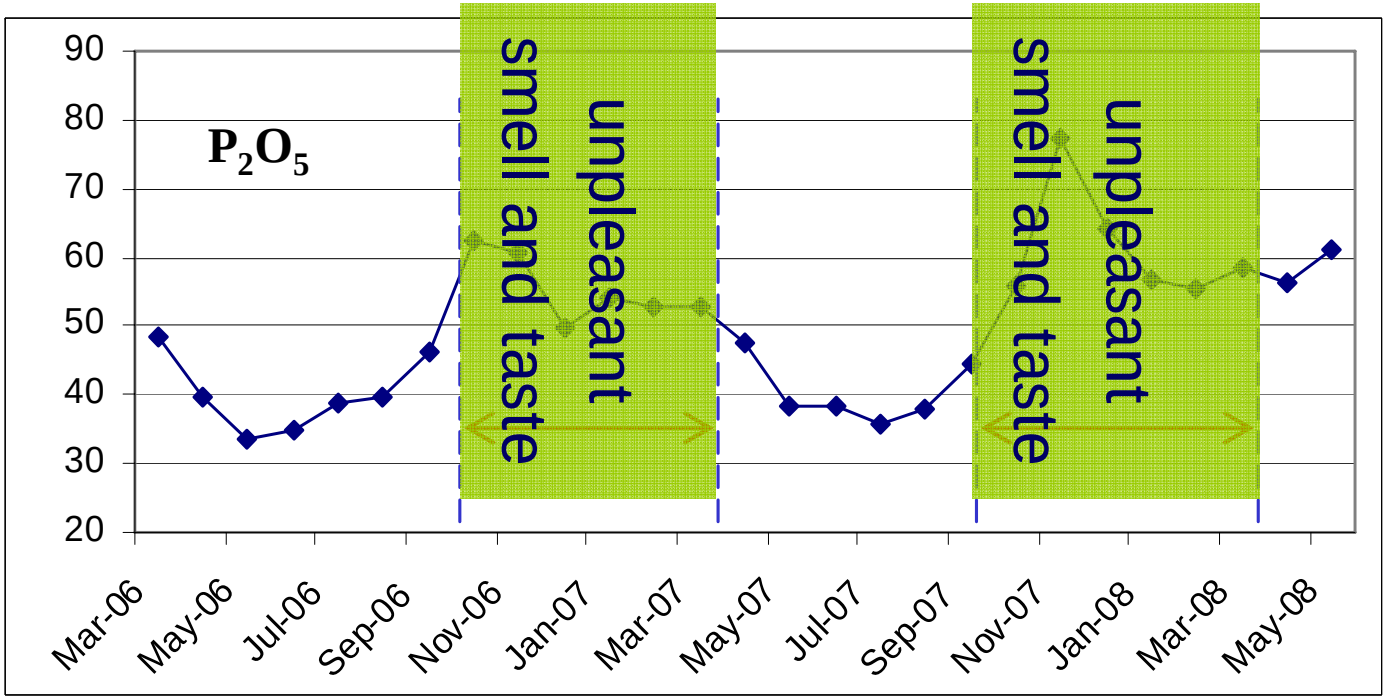
Relation between smell and test periods and stratification of lake Bovilla during May 2006-May 2008 - change of water temperature in three layers

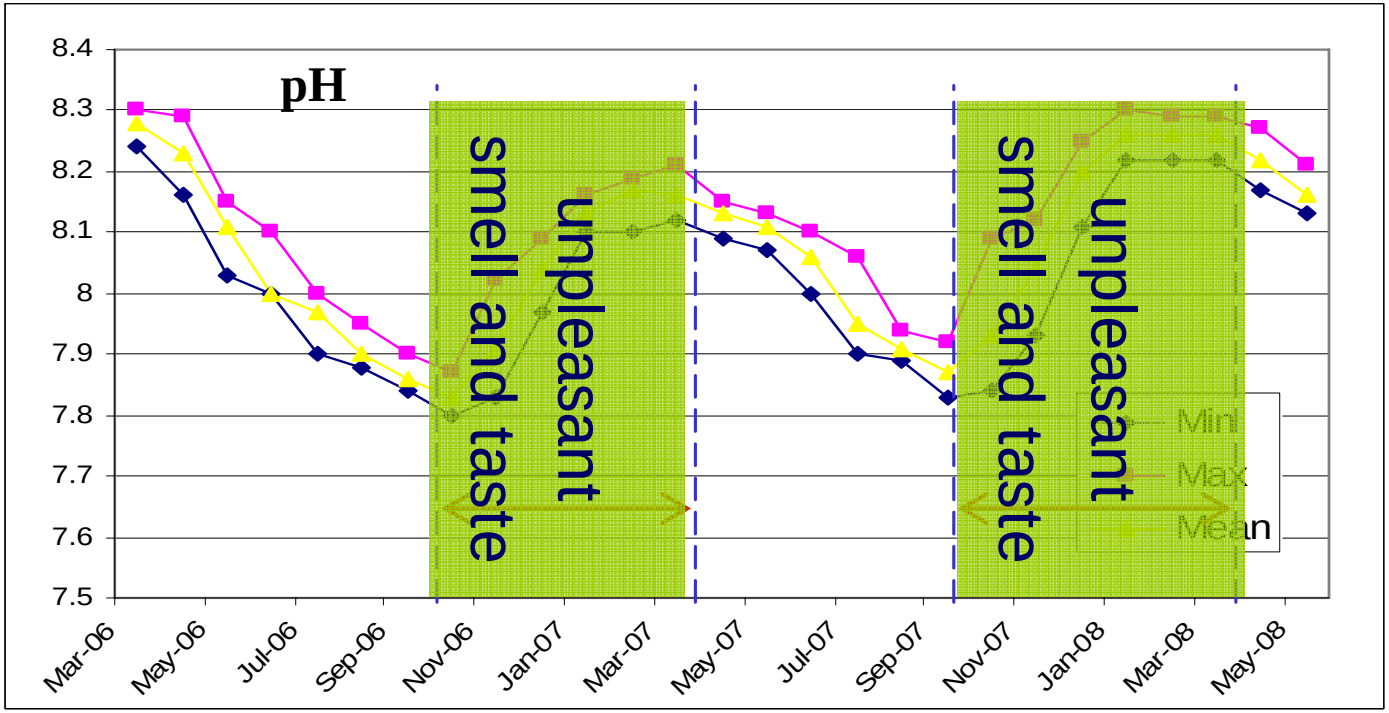


Relation of smell and taste events with other chemical parameters

- Monthly mean P_2O_5 conc. (mg/m^3) during the monitoring: max. values during smell and taste events
- pH values (mean, max. and min.) during the monitoring: increase of pH values during smell and test events

(data from laboratory of treatment plant)

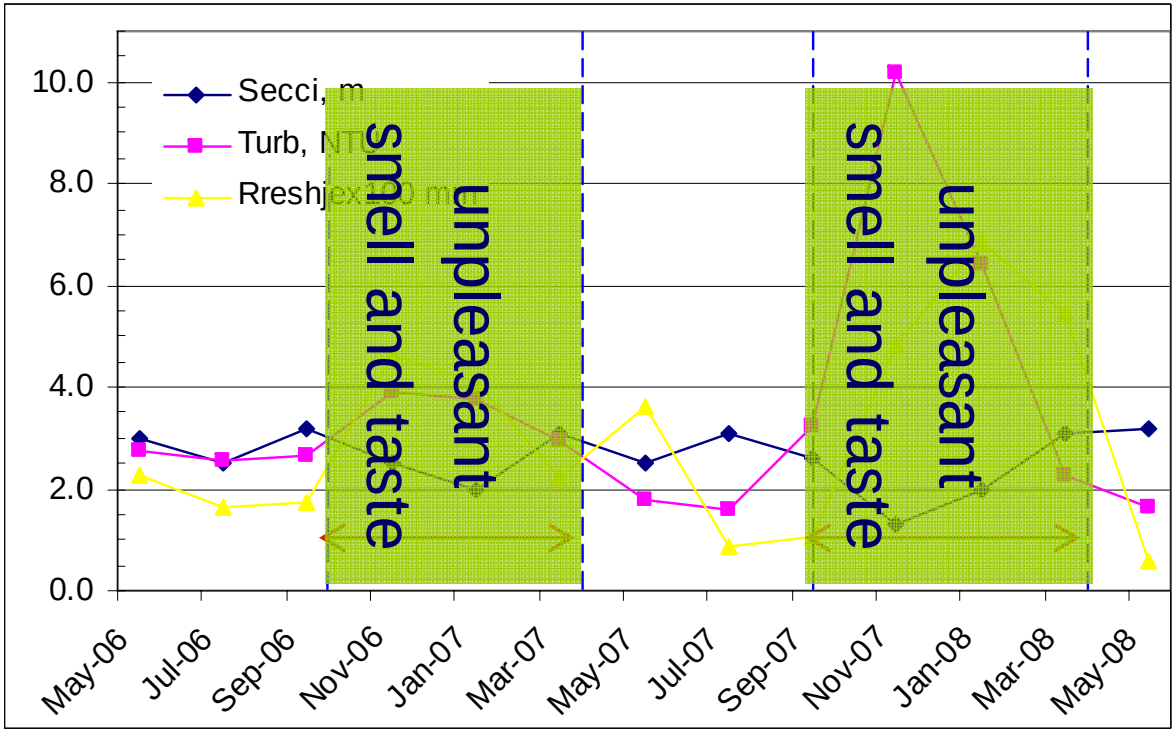


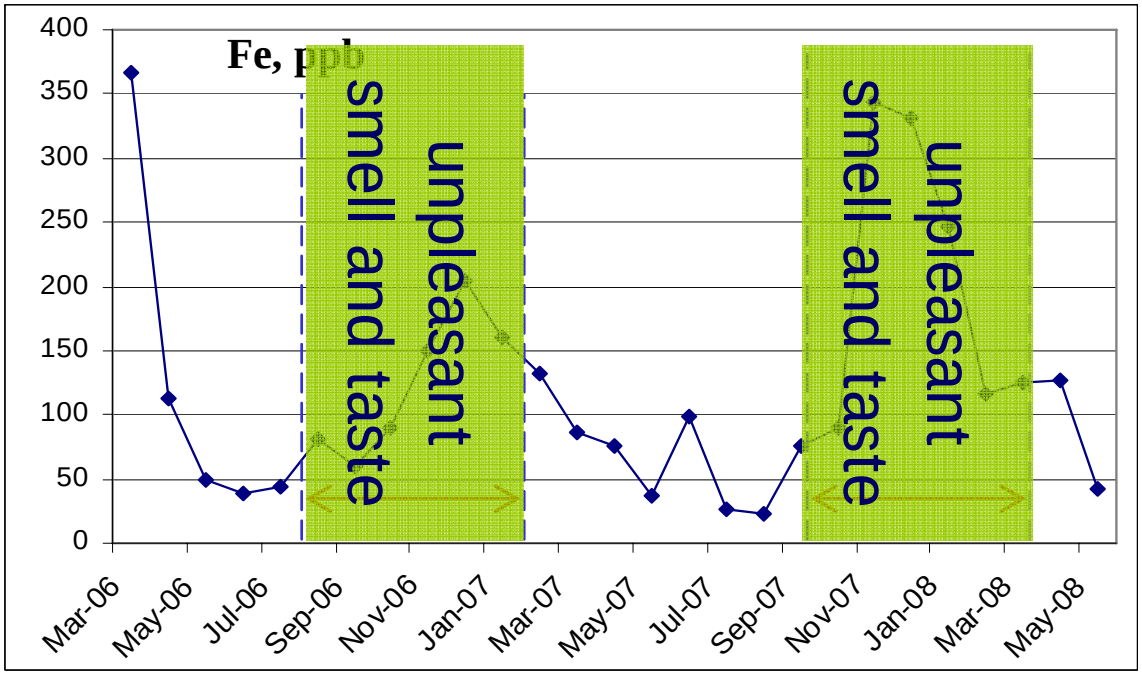


Relation of smell and taste events with other chemical parameters

- Max. values of turbidity and rainfall during smell and taste events and minimum value for Secchi Disc depth *(our data)*
- Iron conc. during monitoring study: max. values during smell and taste events

(data from laboratory of treatment plant)





Vegetation cover

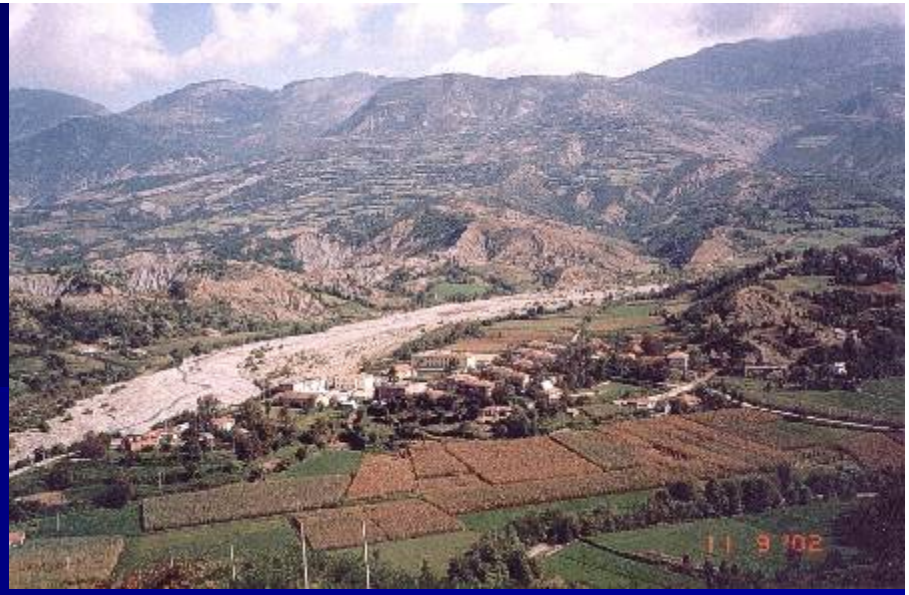
- **The state of vegetation looks better in the upper part of the beech belt and mountainous meadows; but even there over exploitation of vegetation exists.**
- **Human activities (woodcutting, overgrazing etc.) enhance the massive erosion of the soil, formation of gravel beds along the torrents, substitution of vegetation with resistant, but not very useful species, such as *Pyrrocantha coccinea*, *Sparthium junceum*, etc.**
- **Efforts to reforest the territory with pine-trees, mainly *P. halepensis and R. pseudoacacia*, carried out some decades before, protected from erosion, but decreased plant diversity of the basin.**
- **It is important that some typical species of river valleys, as *Platanus, Salix*, etc., must be protected and restored, considering their capacity to limit erosion.**

Human impact

- About 8 villages with a total of about 5600 inhabitants live within the watershed area, dealing mainly with traditional agriculture (cereals), livestock (sheep, goats and cattle), and forestry.
- Some of villages are practically isolated from the main centers (municipalities) and only linked by mountainous roads. As the region is typically mountainous the arable land is very scarce. Furthermore, the soil is poor and not fertile.

Human impact

- The economic situation is difficult. Although the region is close to Tirana, the living standards in these villages cannot be compared to the ones in the town. Above all, infrastructure, communication, water and electricity supply, is minimal.
- As a consequence, agricultural products, cereals and fruits, do not assure a normal survival and development of the population.

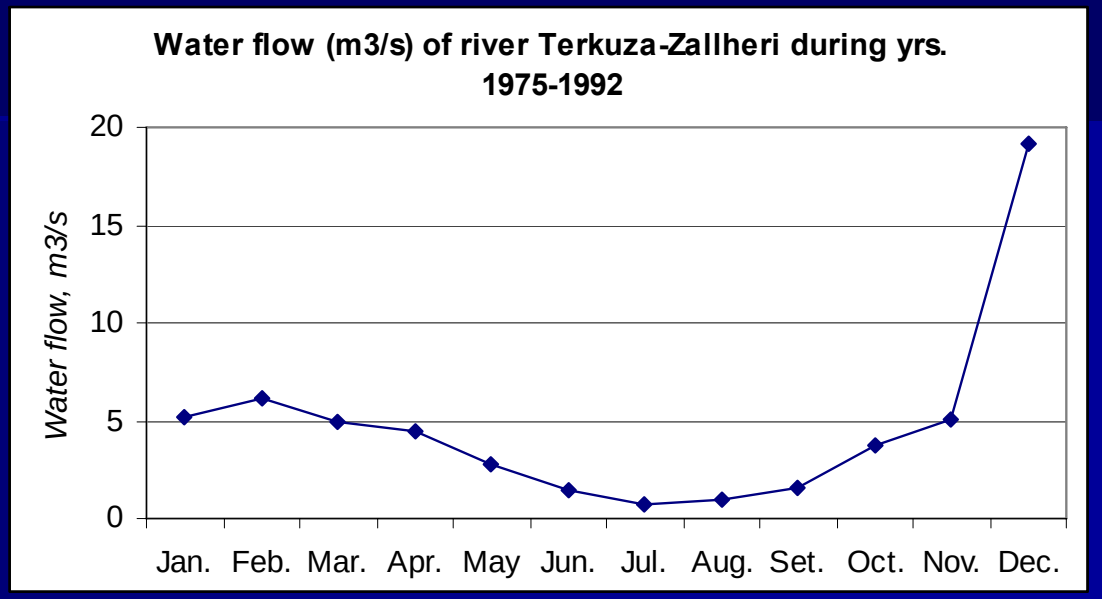


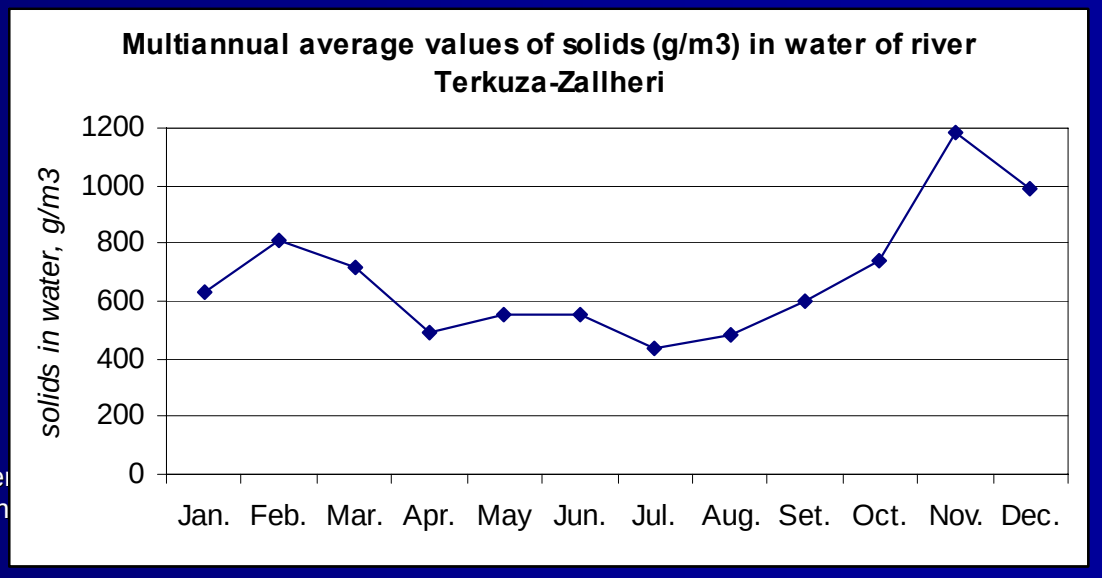
Human impact

- It is quite evident that the lowest slopes, up to 700-800 m a.s.l., are eroded, mainly during winter.
- The riverbed of Terkuza is the largest, filled of gravel tenting to expand even more. Their contents are collected to Buvilla reservoir. This is also helped by the unstable structure of the hills.
- The lowest slopes are the most exploited from the agricultural farms of the inhabitants; hence, degradation of vegetation occurs, i.e. that of mixed oaks, of some pastures, forests and Mediterranean shrubs.

Watershed area - Erosion

- Erosive formations, woodcutting and denuding from vegetation, and intense rainfall have favored and strengthened clayey torrents, erosion spots, erosion of slopes, and landslides, that end in and fill continuously the reservoir.
- It is foreseen a rate of 1 m per year of sedimentation in the lake bottom.





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CONCLUSIONS – POSITIVE 1

- ✓ From the evaluation of water quality of Buvilla Lake relative the norms of EC Environmental Directive 440 for "Quality of surface water intended for the abstraction of drinking water" results that water comply with norm A1 of quality classification for nearly all physico-chemical parameters.
- ✓ From the limnological point of view, Buvilla has the characteristics of a deep reservoir similar to a classical lake. Vertical thermal stratification was observed from late spring up to early fall and only one overturn is developed beginning from late fall up to early spring (fully developed on January). However stratification process and relative changes of chemical and biological parameters appear more weakly because the high water volume which flows into the treatment plant.
- ✓ DO levels are high during all year: epilimnion waters are always saturated and hypolimnion layer contains relatively high oxygen (min. 45-55%) and thus not presents anoxic situation.

CONCLUSIONS – POSITIVE 2

- ✓ Phosophorus is limiting nutrient, as proved not only from the very low levels (and very high ratio TN:TP), but also from the important correlation between P and CHla (= 0.77). Principal source of P is discharge from watershed (mainly erosion caused from rainfalls). The internal loading from sediments have little impact due the sufficiently oxidizing conditions in the overlying bottom layer, high alkalinity, calcium and iron concentrations.
- ✓ Prevalent trophic state is oligotrophy, as resulted from the physico-chemical data (OECD 1982, Carlson state trophic index, ratio TN:TP, and others).
- ✓ Considering the phytoplankton biomass (after Willen, 2000) and zooplankton, waters were mainly oligotrophic, with some trends to mesotrophy in late spring or autumn.
- ✓ Microbic values (total Coli , phecal-Coli and Streptococcus) were between A1 (waters that need simple physical treatment) and A2 (standard physical and chemical treatment and sterilization), after EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water (BMZ, 1995).

CONCLUSIONS - PROBLEMS

- The unusual smelling and taste are probably coming by a sum of monoterpenes, dominated by Carvon caused by the decaying of the remaining stems and roots underwater may produce terpenes for many years, enhanced also from terrestrial bordering areas that are regularly flooded with water as the lake level varies to about 10 m in altitude.
- Unpleasant smell and taste events seems to be related to the characteristic changes of some parameters as overturn situation, increase of TP, pH and iron. These parameters (and perhaps others) can be used as predictors of the occurrence of such events.
- Total Suspended Solids (TSS) exceed 25 mg/L, for raw drinking water quality standards of EU Directive 75/440 1975: Quality required of surface water intended for the abstraction of drinking water (BMZ, 1995). TSS would be directly related with relatively high trophic status based on the transparency (SD) that showed mainly the state of mesotrophy.
- Human activities (woodcutting, overgrazing etc.) was quite evident, enhancing the massive erosion of the soil, formation of gravel beds along the torrents, substitution of vegetation with resistant, but not very useful species.

RECOMANDATIONS

- Follow-up the monitoring, increasing the frequency and measuring sites, especially the evaluation of tributary impact
- More complete study of unpleasant smell and taste events attempting to find the causes and avoid them;
- Strong measures against the pollution for conservation of good quality of water through protection of oligotrophic status.
- Urgent measures to reduce the high erosion and restore the vegetation cover in its surrounding watershed, through forestation and other management activities.

Acknowledgements

This study was another effective cooperation between different groups in Albania and experts of Zurich University, within the common joint project SCOPES (no. JRPIB 7320-111032/1) supported by Swiss National Science Foundation (SNSF). In occasion, we express our gratitude to all the coworkers groups, and especially the Swiss National Science Foundation (SNSF) for the kind financial support.

THANK YOU!

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