Anthropogenic influence to protected area of Plitvice Lakes National Park

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Why Plitvice Lakes?

National park – protected (1949, 1979 – UNESCO)

Pli

Pr

Ob **c**

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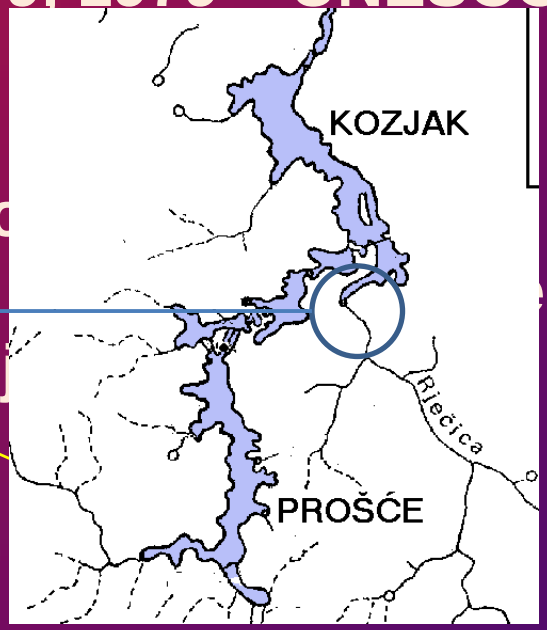
br **z**



Climate change (Majority of analyses, yes)

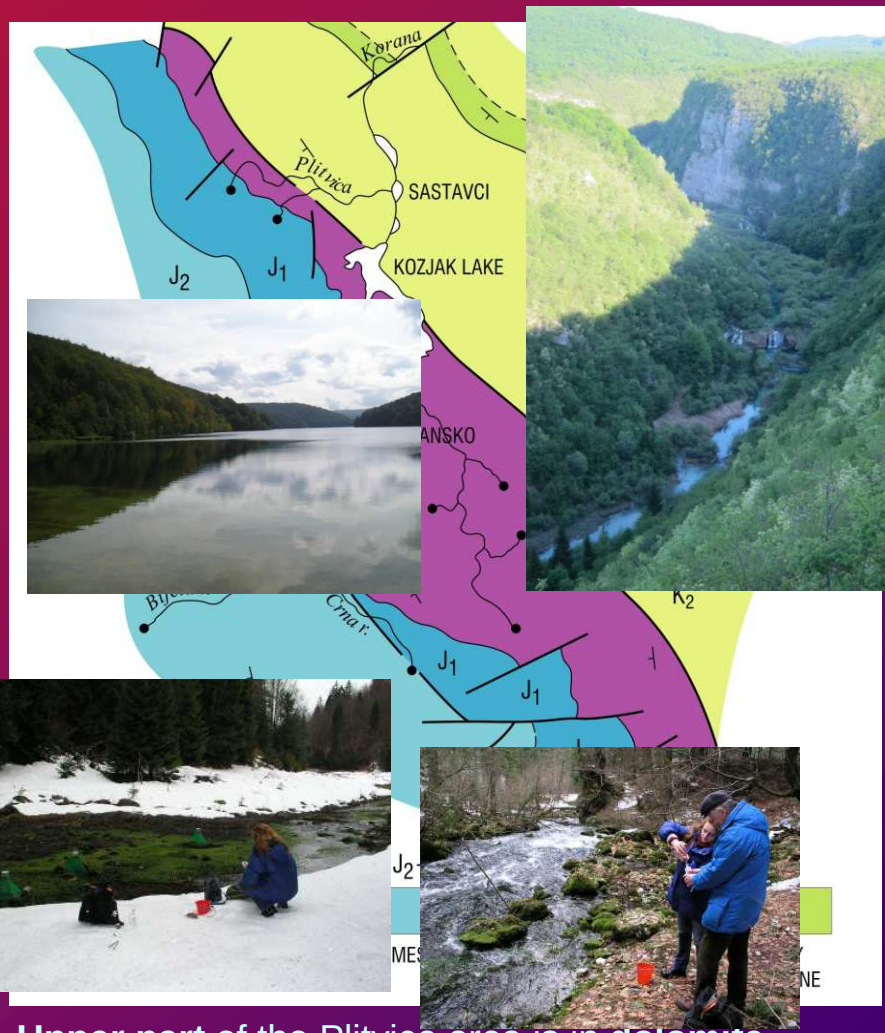
Tourism – 1000000 visitors/year

Road – above the lakes, in close vicinity of the lakes

Lake water – very clean (Physico-chemical measurements in water,
trace elements concentration low)

What about the trace elements conc. in the lake sediments:
High?
Natural or anthropogenic origin?
Distribution within the sediment core?
Distribution within the lakes, downstream?
Their leaching from the sediments into the lake water – calcite, selfpurification?

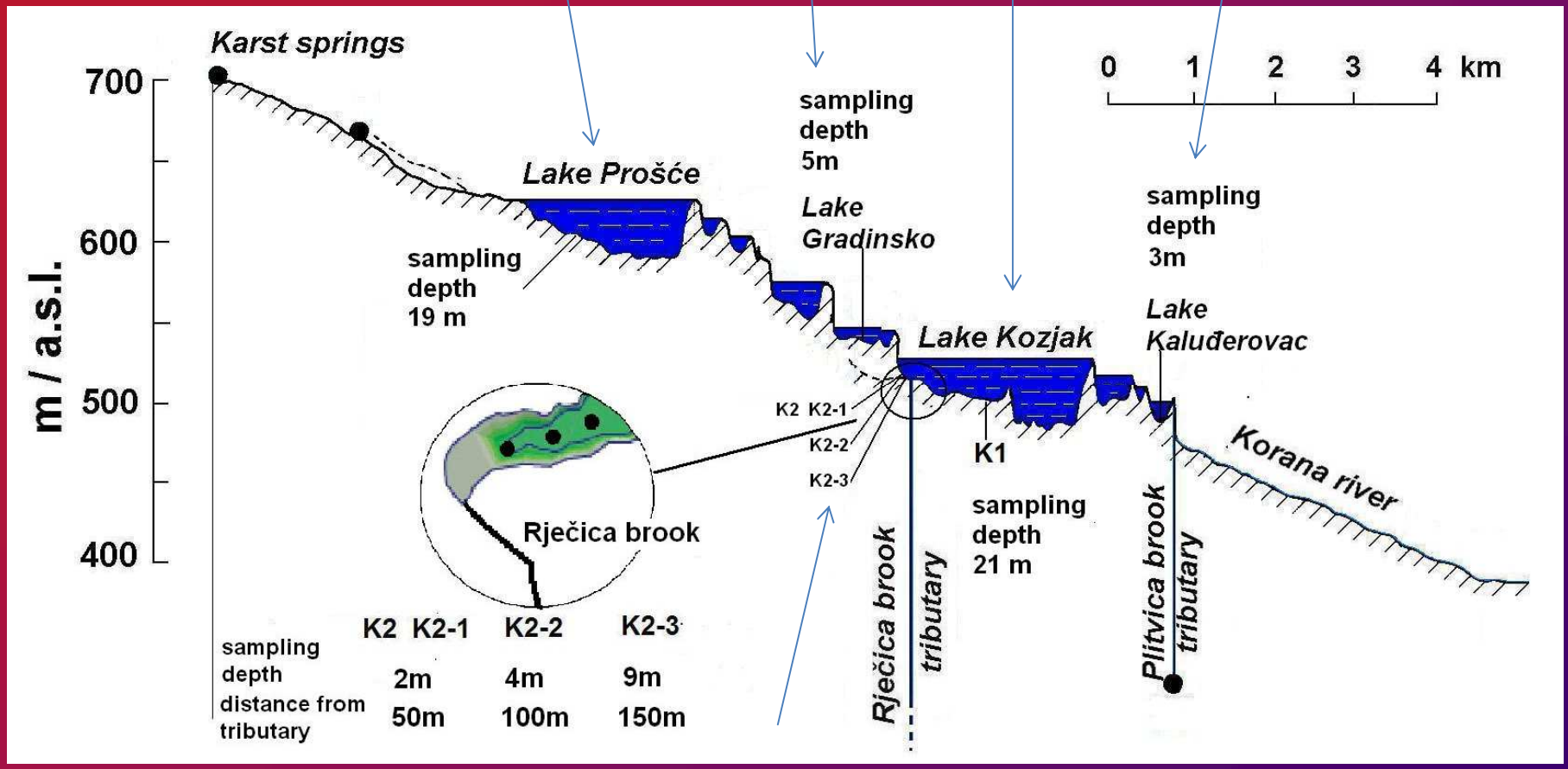
Forest area - 298 km^2 (National Park), water (2.2 km^2)



Upper part of the Plitvice area is in **dolomite** which is less permeable than limestone. Moreover, dolomite covers older, impermeable rocks, and together they represent a barrier for the loss of the surface flow.

Lower lakes were formed in well karstified and highly permeable **limestone** with numerous caves in the canyon.

Study site:



With additional attention - confluence of Rječica brook to the Lake Kozjak

Retrieving of sediment cores
Previous investigations: dowstream (ATHROPOLPROT, ICP-MS)

Sediment cores: app. 45 cm l, 10 cm d (100-150 year, ^{210}Pb dated, Horvatinčić et al. 2008)


ALPHA TOOLS
US 800 E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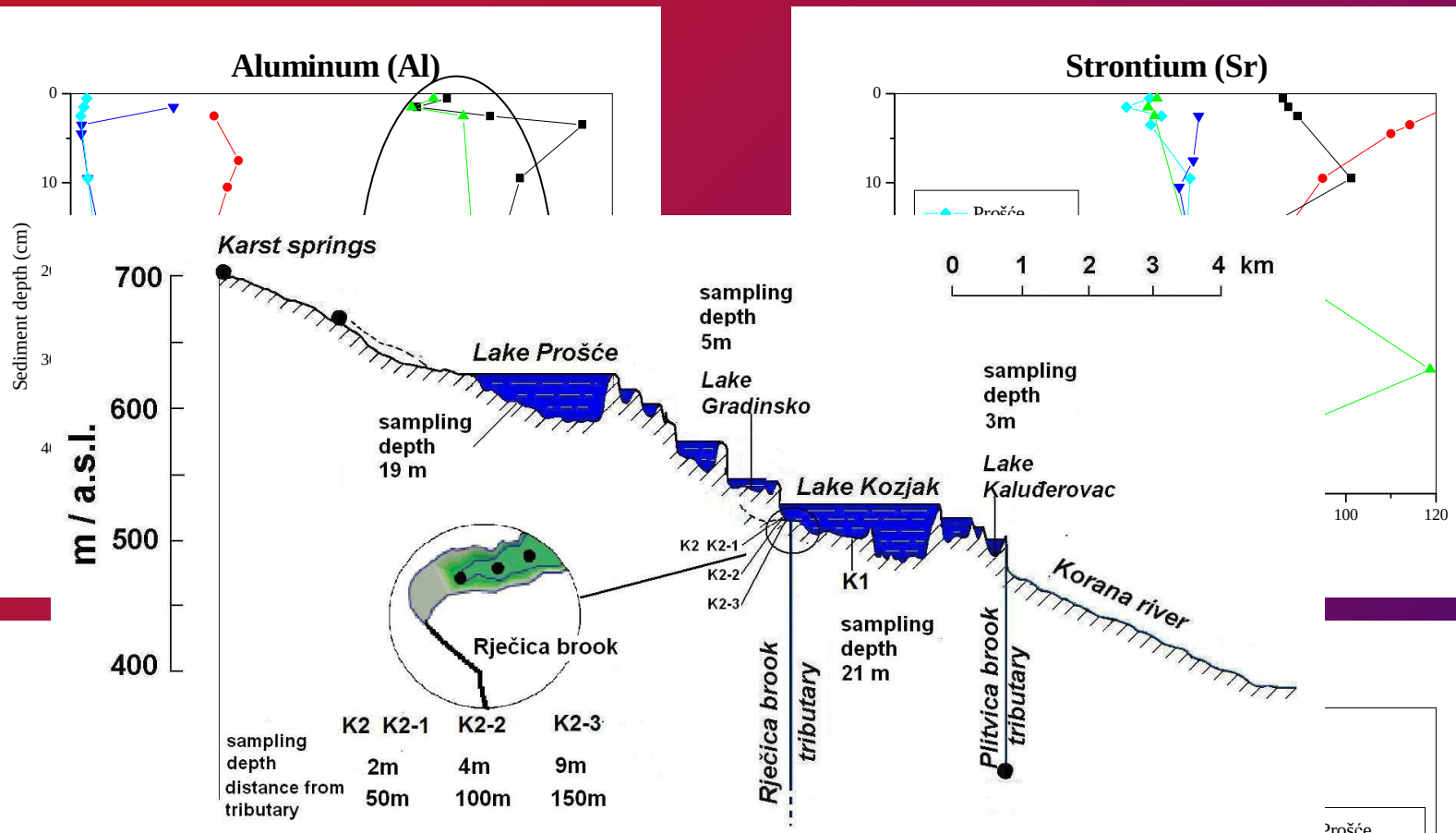
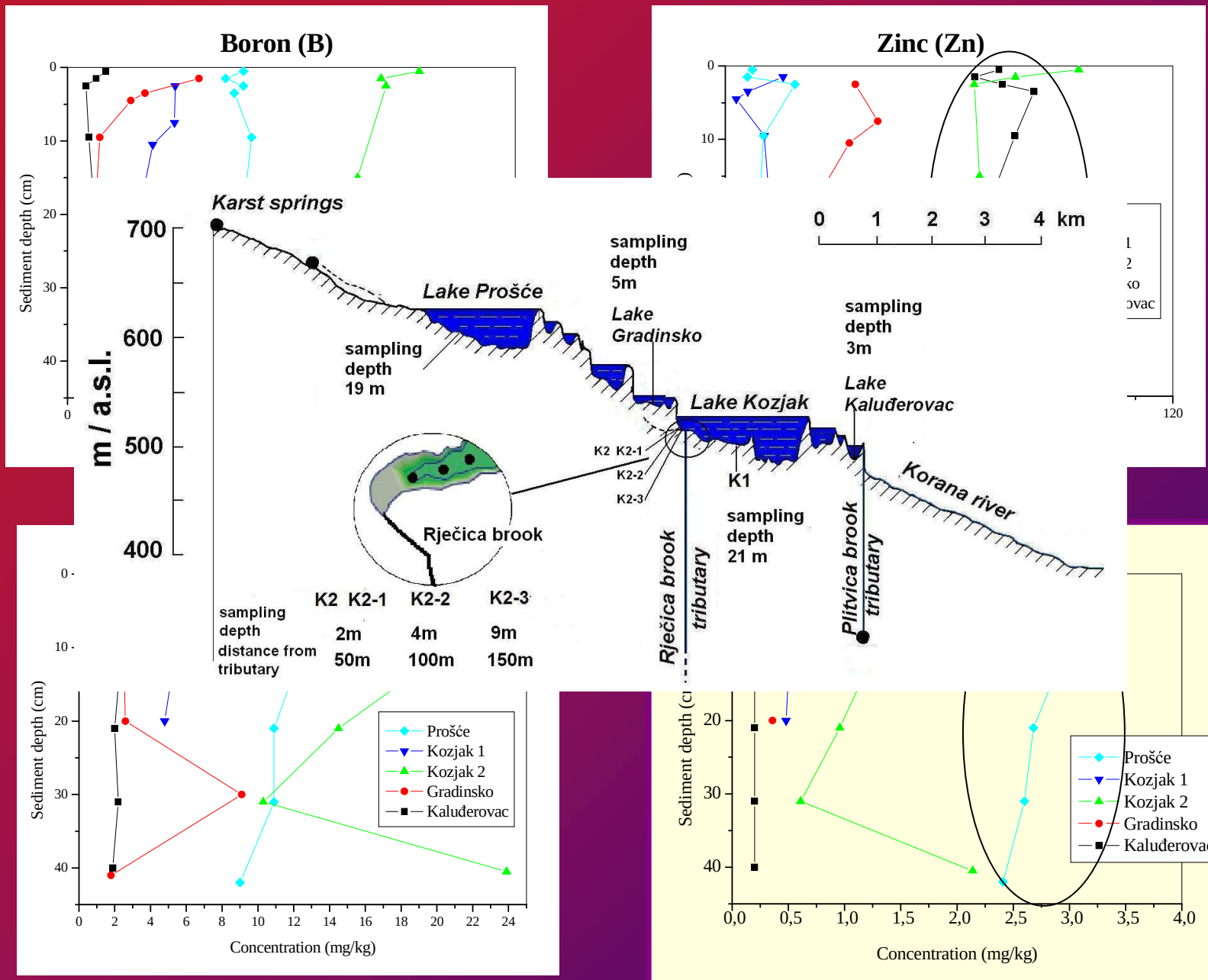
327


Karst springs
Lake Prošće
sampling depth 19 m
Lake Gradinsko
sampling depth 5m
Lake Kozjak
Lake Kaluđerovac
sampling depth 3m
K2 K2-1
K2-2
K2-3
K1
sampling depth 21 m
Korana river
Rječica brook
Rječica brook tributary
Plitvica brook tributary
m / a.s.l.
700
600
500
400
0 1 2 3 4 km
sampling depth distance from tributary
K2 K2-1 K2-2 K2-3
2m 4m 9m
50m 100m 150m

Aluminum (Al)
Sediment depth (cm)
Prošće
Kozjak 1
Kozjak 2
Gradinsko
Kaluđerovac
Concentration (mg/kg)

Strontium (Sr)
Sediment depth (cm)
Prošće
Kozjak 1
Kozjak 2
Gradinsko
Kaluđerovac
Concentration (mg/kg)


Boron (B)
Zinc (Zn)
Sediment depth (cm)
Concentration (mg/kg)
Karst springs
Lake Prošće
Lake Gradinsko
Lake Kozjak
Lake Kaluđerovac
Rječica brook
Korana river
Rječica brook tributary
Plitvica brook tributary
m / a.s.l.
700
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0 1 2 3 4 km
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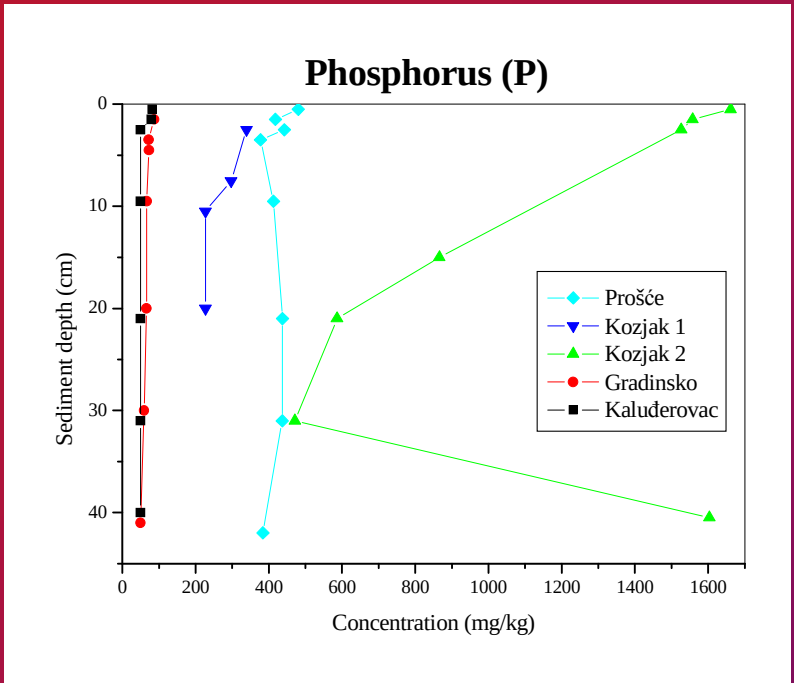
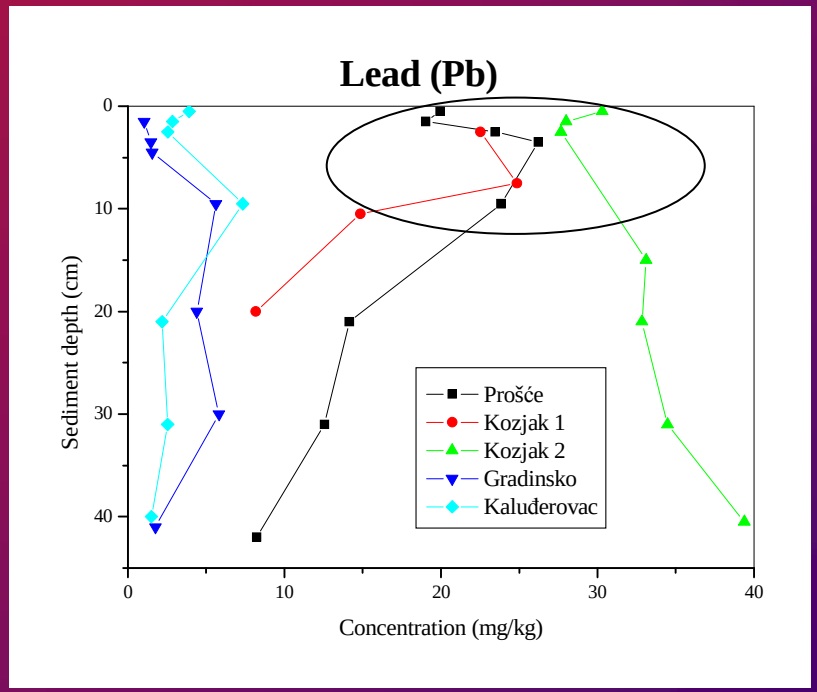
K1
sampling depth
distance from tributary
2m 4m 9m
50m 100m 150m
Prošće
Kozjak 1
Kozjak 2
Gradinsko
Kaluđerovac

Downstream deacreasing, sedimentation, selfpurification!
Source: influence of Rječica Brook, forest! – P
Rječica, road - Pb

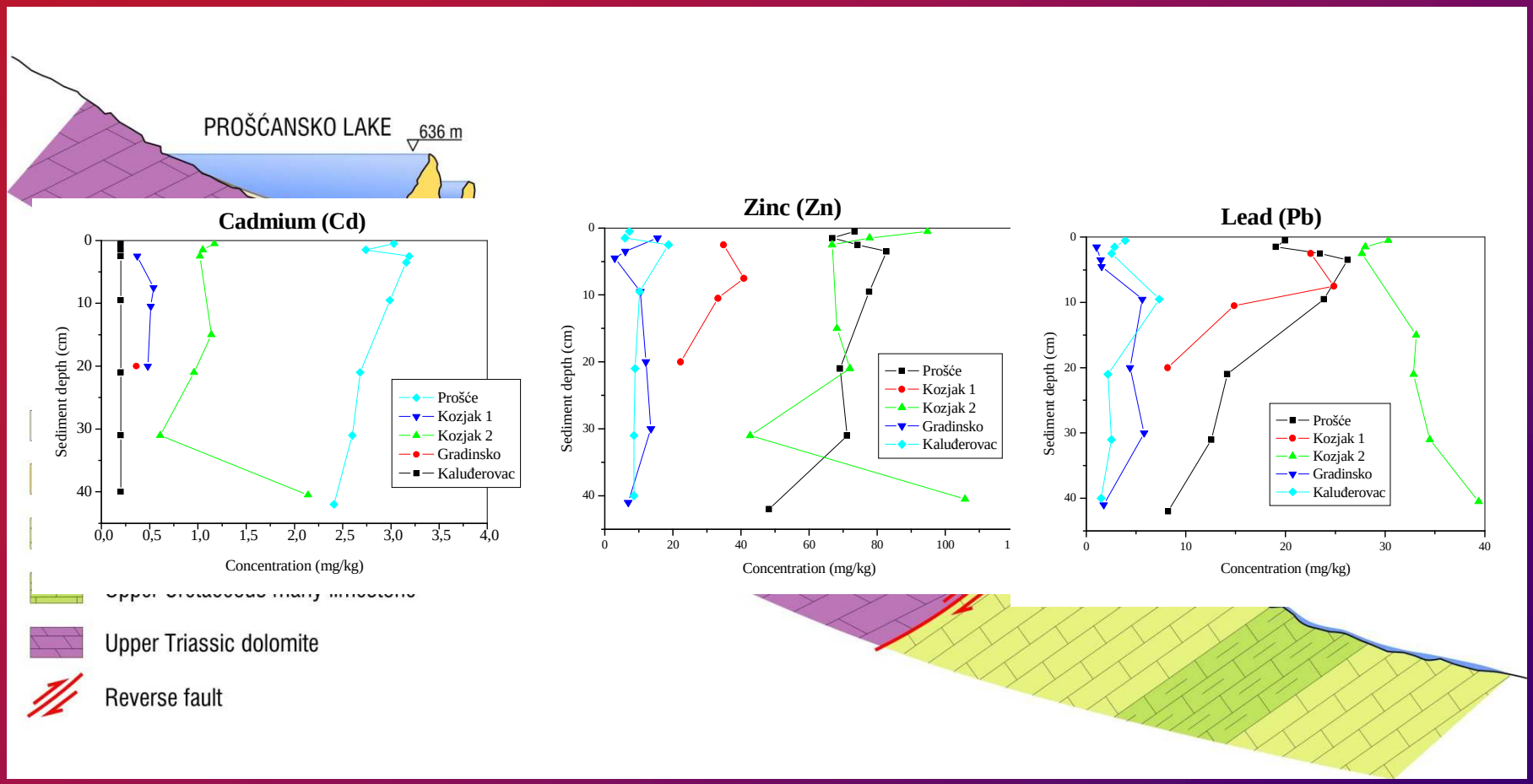




Horvatinčić et al. 2006.
Barešić 2009.
Barešić et al. 2011.

More detail Rječica Brook confluence investigation!

Cd, increased concentration, natural, geological setting of upppermost lake!
Downstream deacreasing, sedimentation, selfpurification!



Mikac et al. 2011.

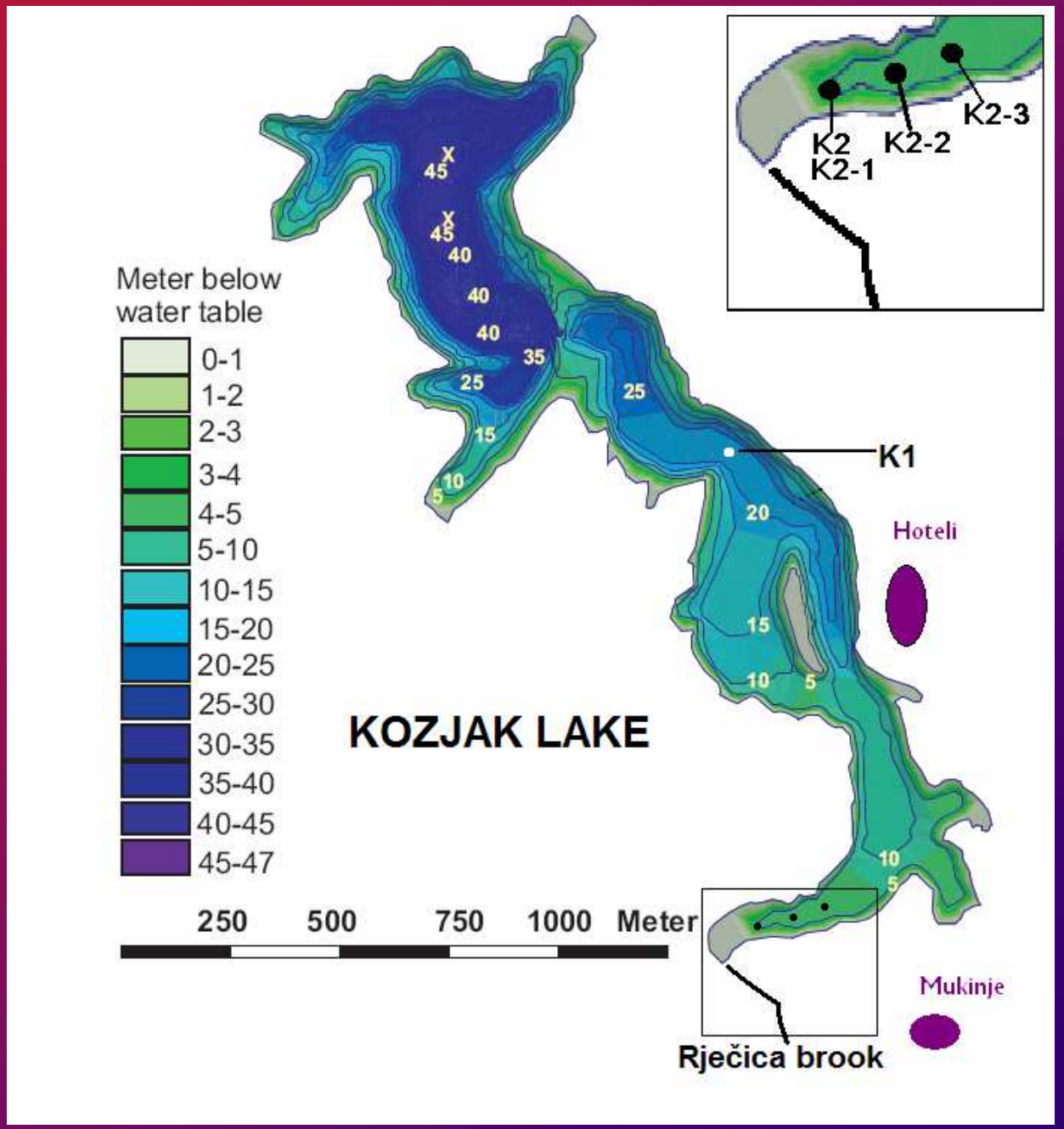
Kozja

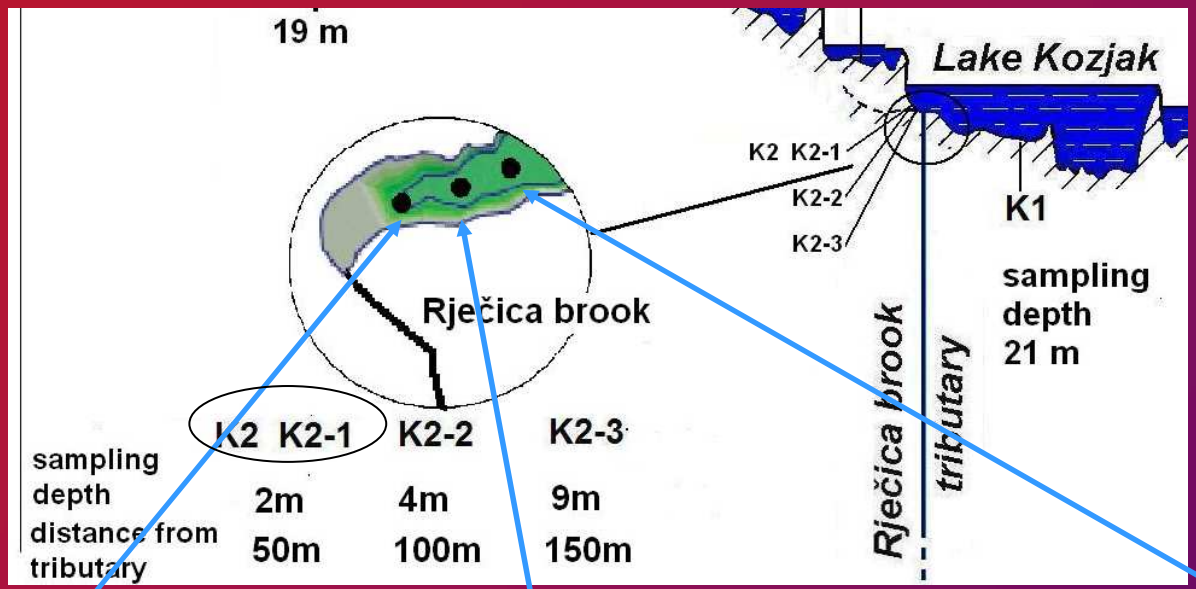
Rječi … st lake

Incre … at the R… confl…

Hotel…

Fores… Vicini…



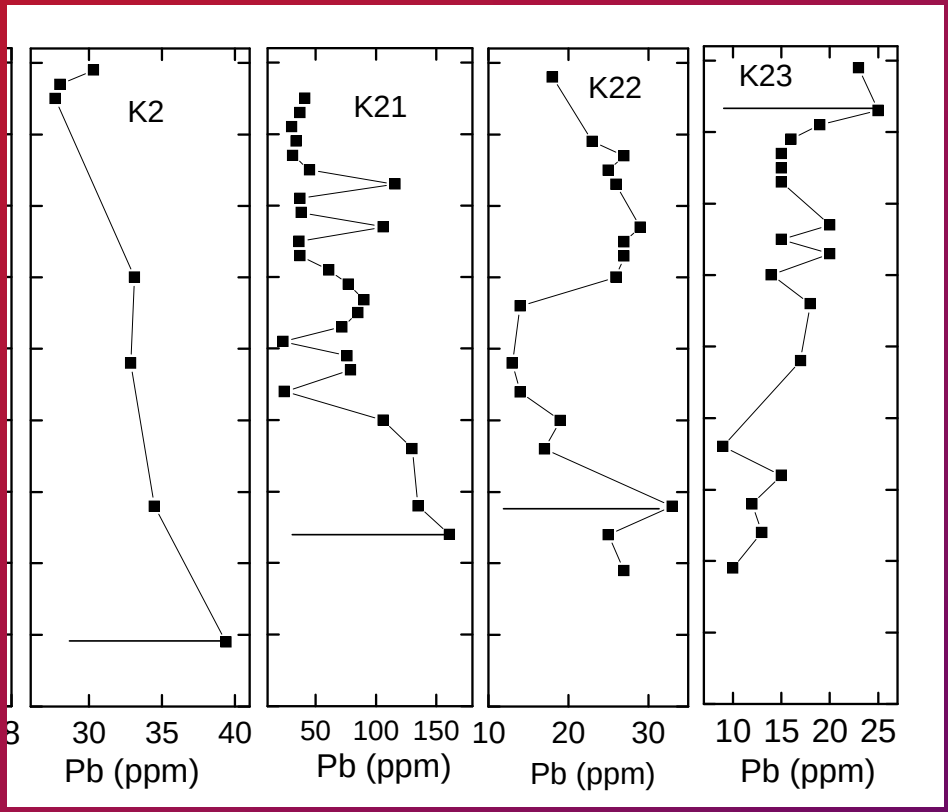


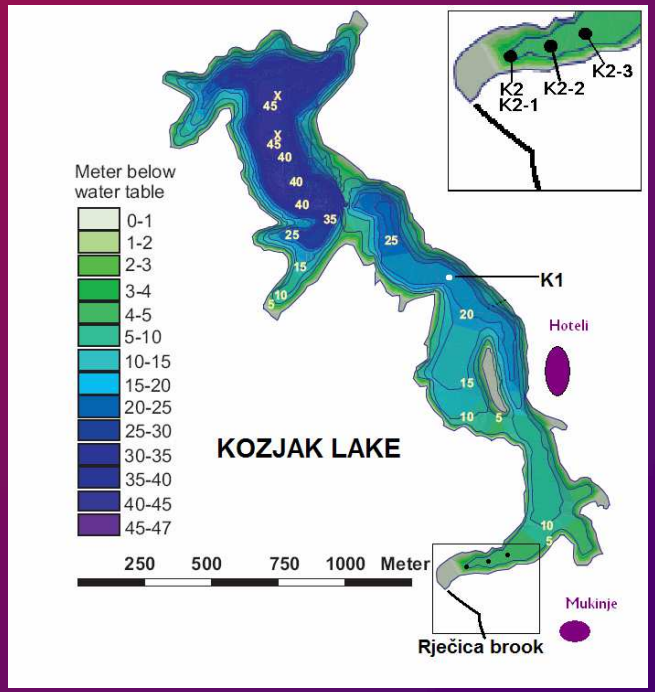
Near the confluence

50 m downstream

100 m downstream

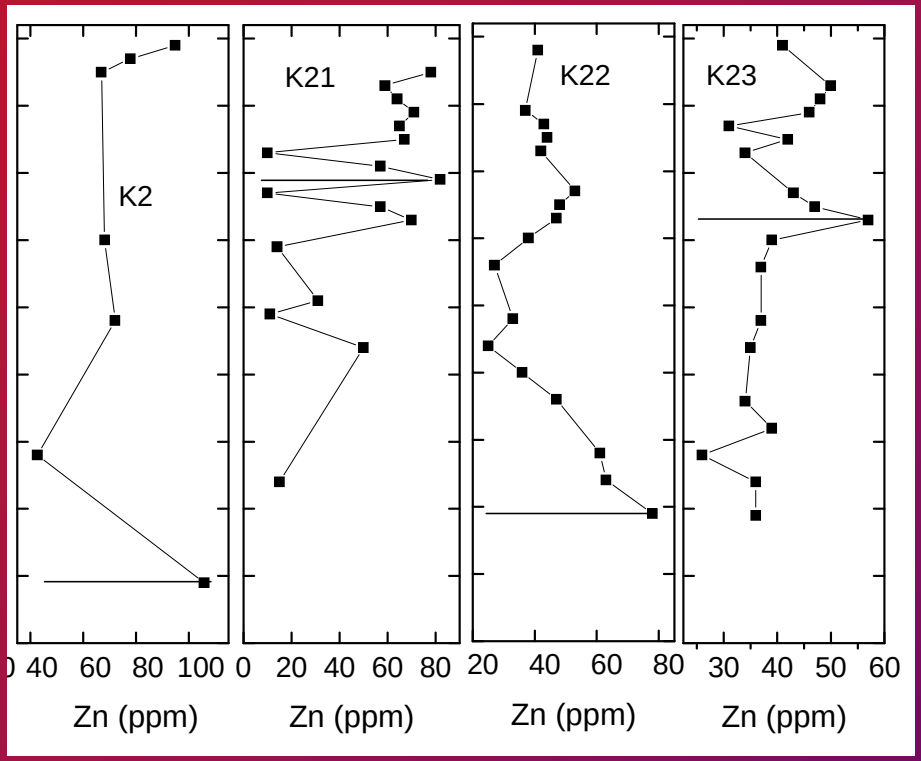
Rječica Brook (Pb)



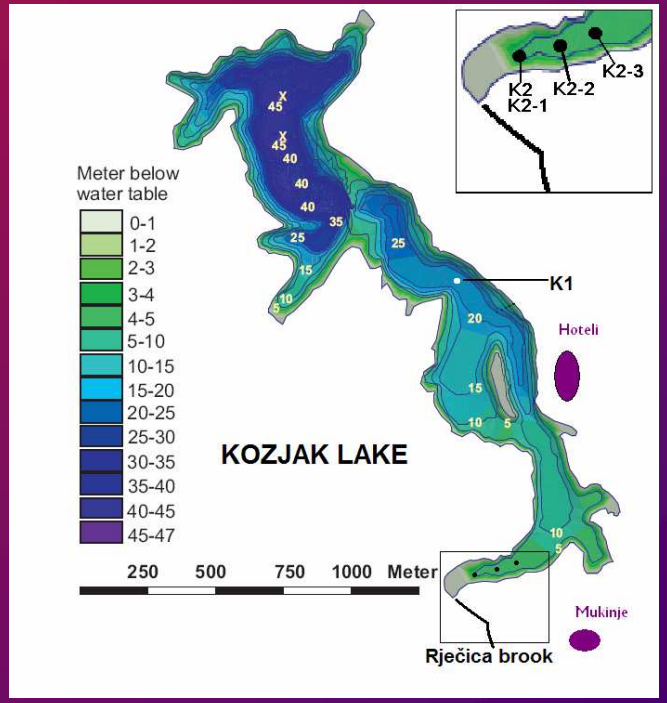


Aver	32.264	**68.28**	**22.94**	**16.17**

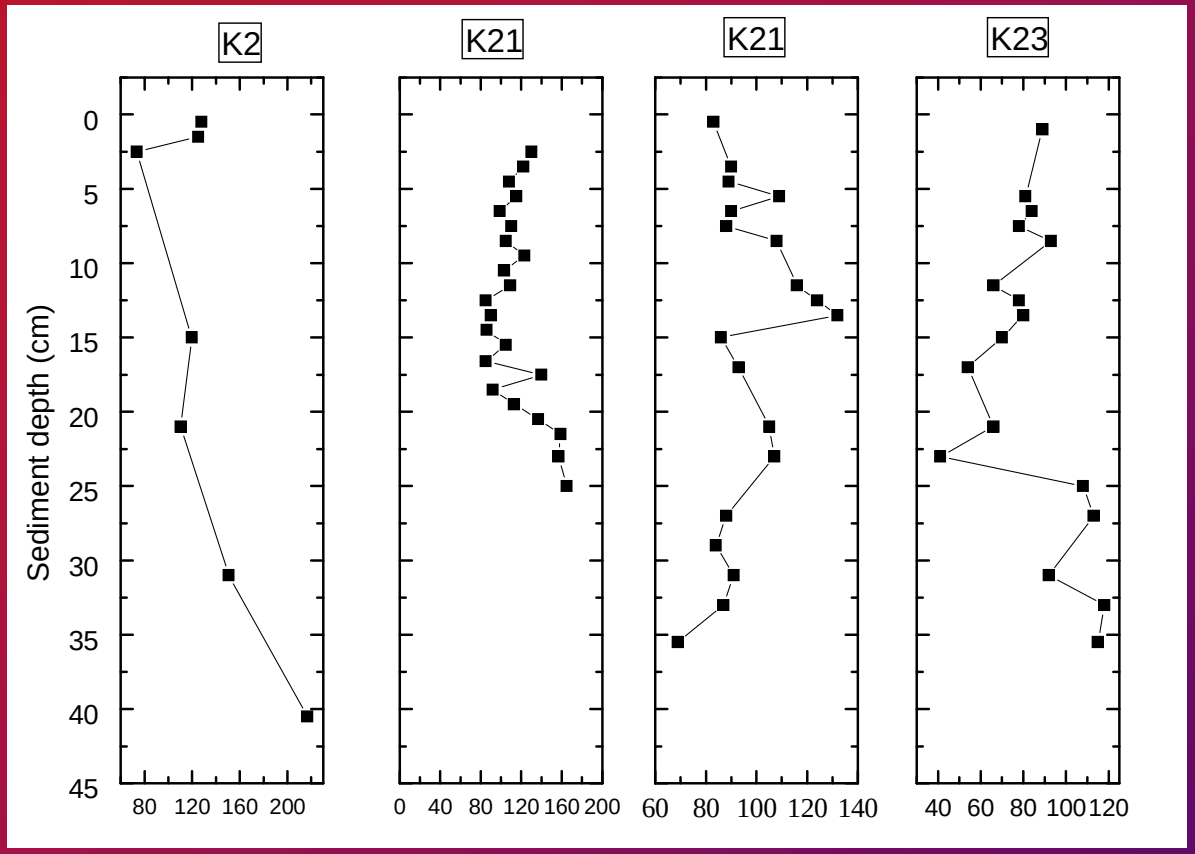
Rječica Brook sediments (Zn)

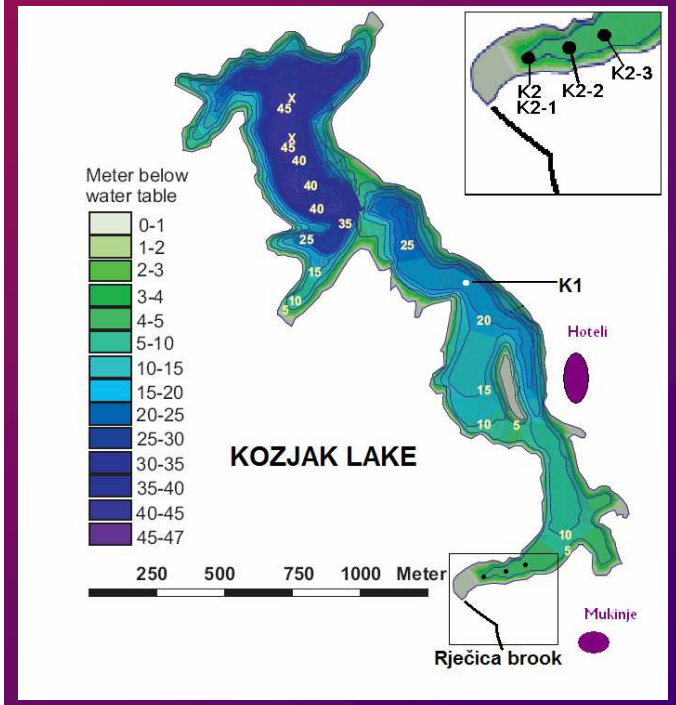


105.8 **47.71** **44.88** **39.89**



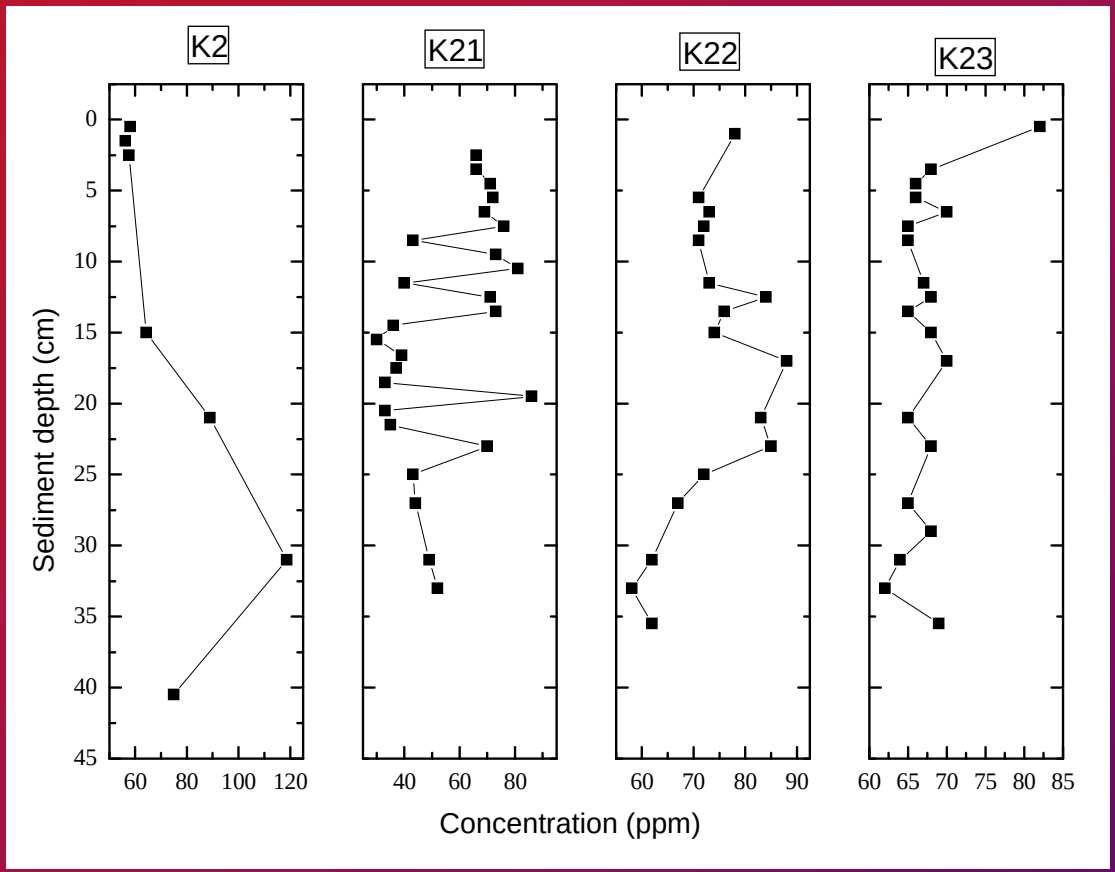
Mn

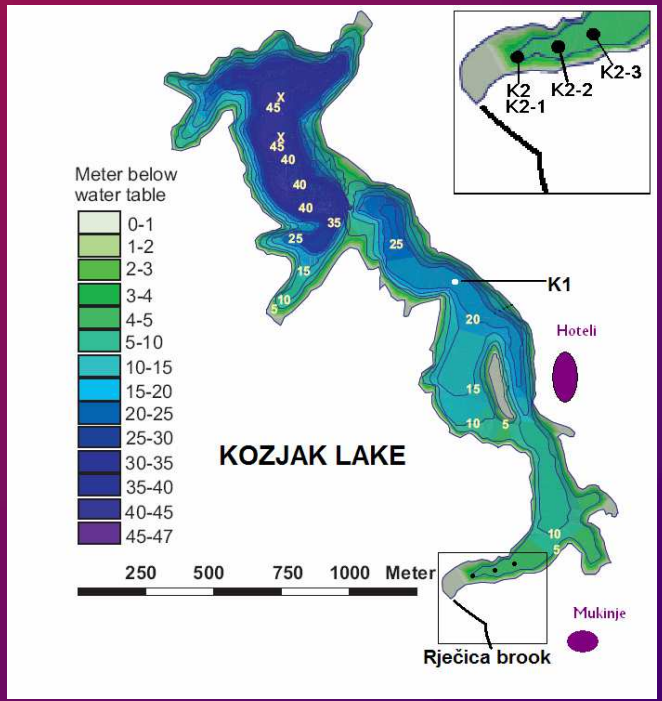




131,9 115,4 88 96,7

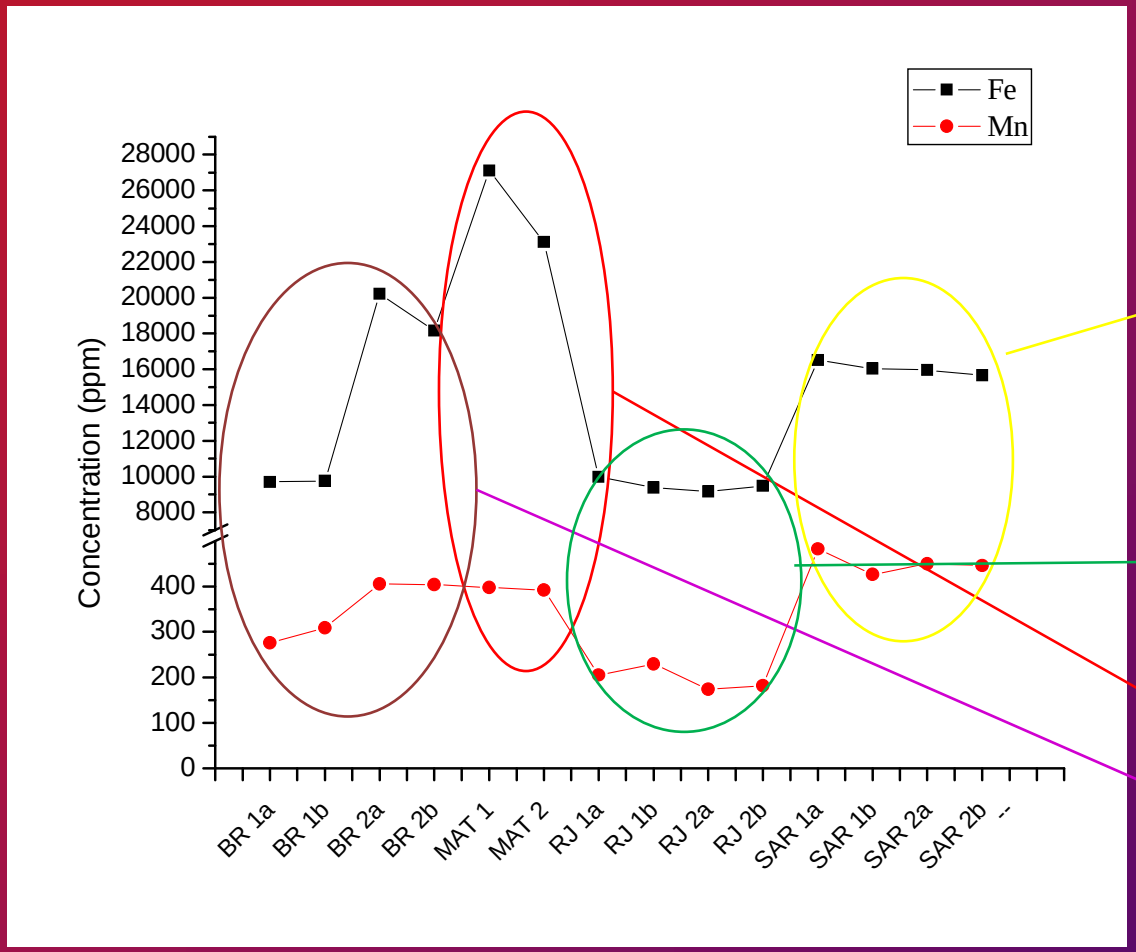
Sr

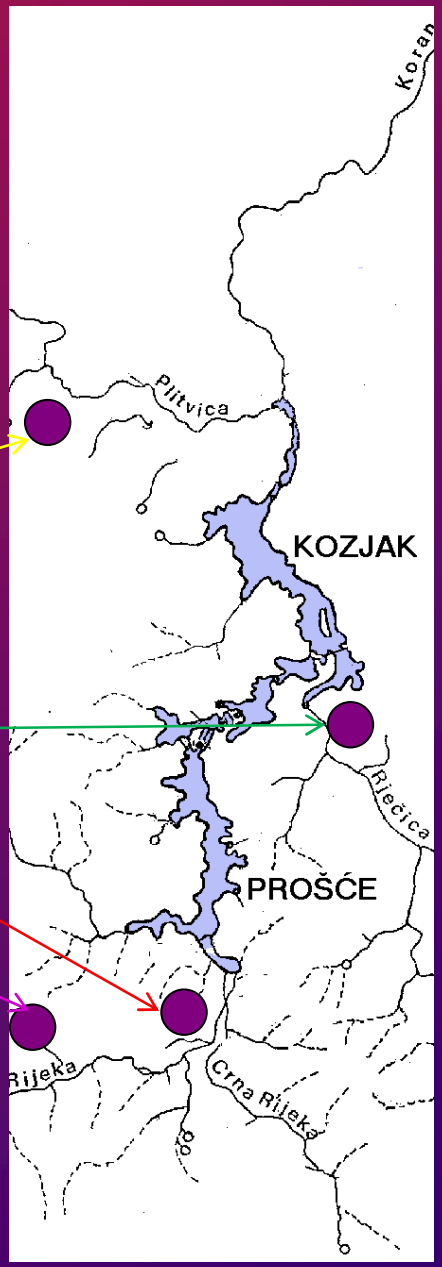


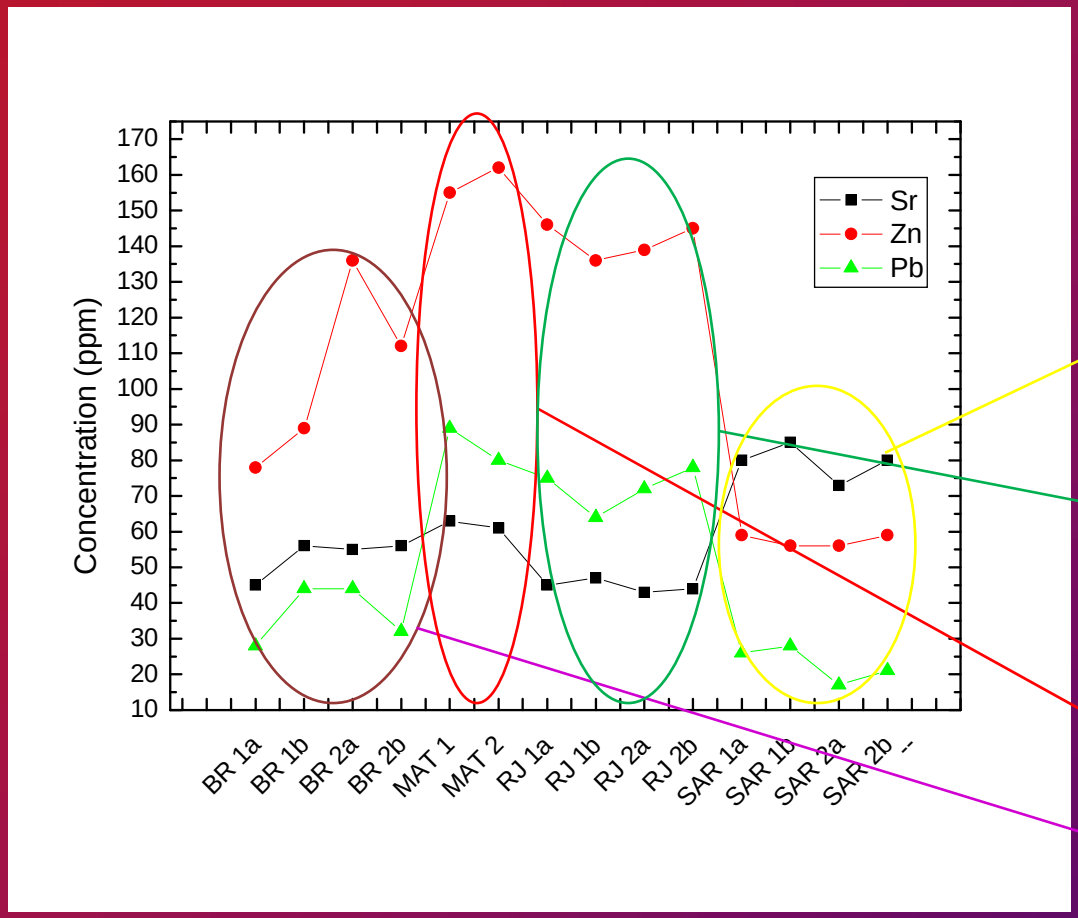


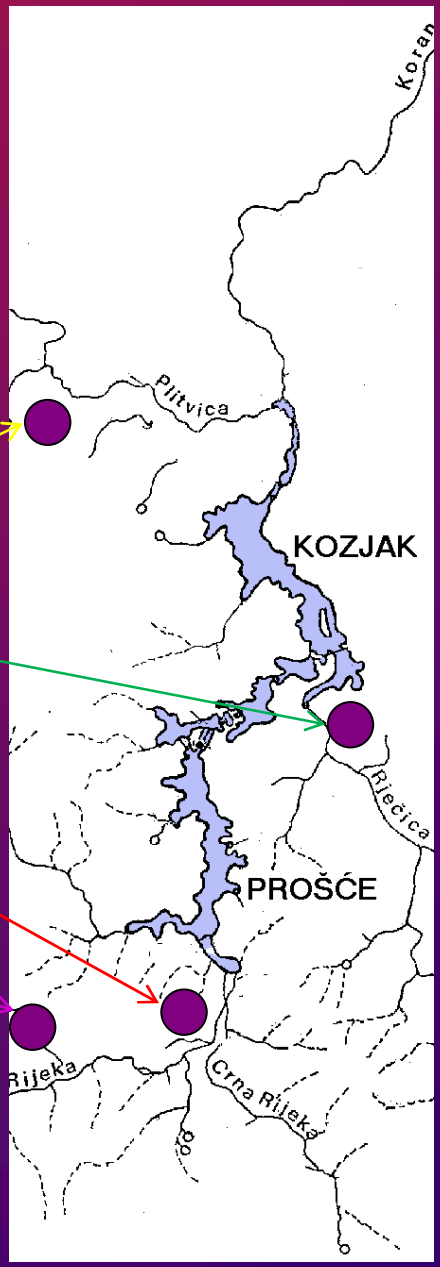
74,2 78 73,2 69,8

Soil samples (xrf)






Concentration (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Sr
Zn
Pb
BR 1a
BR 1b
BR 2a
BR 2b
MAT 1
MAT 2
RJ 1a
RJ 1b
RJ 2a
RJ 2b
SAR 1a
SAR 1b
SAR 2a
SAR 2b


Korana
Plitvica
KOZJAK
Rječica
PROŠĆE
Rijeka
Crna Rijeka

$$CER_n = [(C_n/C_n\,Backg)/(C_{Fe}/C_{Fe}backg)]$$

Anthropogenic influence

Soil		
Location	**CER Pb**	**CER Zn**
Matica 1	2.95275284	1.6138282
Matica 2	3.02991639	1.78980893
Sartuk 1a	1.22625575	0.92739598
Sartuk 1b	1.47949455	0.9292693
Sartuk 2a	1	1
Sartuk 2b	1.31830132	0.98226373
Bijela R 1a	2.620055	1.97743954
Bijela R 1b	3.83153915	2.50452905
Bijela R 2a	1.80961829	1.72452652
Bijela R 2b	1.51647544	1.57801737
Rječica 1a	**5.96170746**	**3.69289465**
Rječica 1b	**5.28079272**	**3.74174876**
Rječica 2a	**6.40240535**	**3.96587868**
Rječica 2b	**6.50399419**	**4.04483936**

Conclusions

- TE conc. are getting lower in downstream direction: from Prošće to lake Kaluđerovac, as from K21 (K2) core to K23, and K1 (Lake Kozjak centre)
- Cr, Cd and Cu are not detected by XRF in sediment and soil samples indicating sediments and soil are not polluted
- Pb and Zn are detected in sediments, but CERs do not indicate pollution of the sediments. Higher Pb and Zn concentrations are measured in K2-1, point nearest to the Rječica Brook confluence, indicating input of elements by Rječica (CERs<5).
- In soil samples CERs values are enlarged for site Rječica (distance from the road 10 m) and indicate anthropogenic Pb input due to traffic, and possibility of Pb leaching to the Lake Kozjak by Rječica stream.
- Lowering of Pb and Zn concentrations (average values) with increasing distance from Rječica Brook confluence indicate that majority of Pb and Zn introduced by Rječica Brook precipitate at the place of input and does not reach the lake centre.

References:

Horvatinčić, N., Brianso, J.L., Obelić, B., Barešić, J., Krajcar Bronić, I., 2006. Study of pollution of the Plitvice lakes by water and sediment analyses, *Water Air Soil Pollut. Focus* 6, 475-485.

Barešić, J. 2009. Application of isotopic and geochemical methods in the study of global and local changes in ecological system of Plitvice Lakes, PhD thesis, University of Zagreb, (in Croatian).

Mikac, I., Fiket, Ž.,Terzić, S., Barešić, J., Mikac, N., Ahel, M., 2011. Chemical indicators of anthropogenic impacts in sediments of the pristine karst lakes, *Chemoshere* 84, 1140–1149.

Horvatinčić, N., Barešić, J., Babinka, S., Obelić, B., Krajcar-Bronić, I., Vreča, P., Suckow, A., 2008. Towards a deeper understanding of how carbonate isotopes (^{14}C, ^{13}C, ^{18}O) reflect environmental changes: A study with recent 210Pb dated sediments of the Plitvice Lakes, Croatia. *Radiocarbon*, 50, 233-253.

Barešić, J., Horvatinčić, N., Vreča, P., Sironić, A., 2011. Distribution of authigenic and allogenic fractions in recent lake sediment: isotopic and chemical compositions. *Acta Carsologica* 40/2: 293-305.

Acknowledgment

Minstry of scienece, education and sport, R Croatia

Plitvice Lakes National park

FP5 Project *"**ANTHROPOL.PROT** - Study of anthropogenic influence after the war and establishing of protection measures of National Park Plitvice and Bihać Region at the border area between Croatia and Bosnia-Herzegovina"*

FP7 Project "SOWAEUMED - Network in Solid Waste and Water Treatment between Europe and Mediterranean Countries"

FP7 Project "STRAVAL Studies, training, socio-economical valorisation and management of natural, cultural and monumental property for the promotion of the local societis in Latin America (Argentina, Brazil and Mexico)