FINAL REPORT

NKFIH OTKA SNN 118101

Modeling and risk analysis of transboundary PTE pollution for sustainable agriculture, food security and protection of natural riverine habitats on the example of the Drava floodplain

2020

The 3 years Slovenian-Hungarian Bilateral project has delivered 4 ISC publications (IF 3.57, 3.35, 0.73), 8 other publications, an outstanding 13 international and 5 national conference presentations, 3 theses: 1 BSc, 1 MSc, and 1 PhD theses (PhD on-going), seeded in EU Interreg project and 3 Stipendium Hungaricum Grant PhD projects. The project is proud for promoting the involvement of several young researchers (see theses, publications, conference presentations) form the BSc to the PhD and post-doc levels. Three extensive field observation campaigns have been caried out, followed by intensive geochemistry and microbiology laboratory measurements and tests. The project has developed the most detailed GIS database and sediment geochemistry dataset for the Drava floodplain. The project research emphasis has been shifted from PTE plan uptake towards the novel soil-sediment microbial investigations and digital spatial and temporal modelling as the research group's interest followed the most current research trends. The bilateral project has provided an outstanding opportunity for international research cooperation development with China, Vietnam, Cuba, and most notably with the Danube Convention Countries (ICPDR), in addition to various ERASMUS projects. Scientific results are presented below.

FINAL REPORT

NKFIH OTKA SNN 118101 Project

Modeling and risk analysis of transboundary PTE pollution for sustainable agriculture, food security and protection of natural riverine habitats on the example of the Drava floodplain

2020

Research background and Objectives

- Floodplains are the most fertile agricultural areas, with diverse riparian wildlife, as well as densely populated, industrialized areas
- Sensitive receptors for pollutants from the upper reaches of the river (e.g mining, metallurgy)
- Ecosystems sensitive to climate change
- Soil and river sediment samples from alluvial plains and river terraces: 1. chemistry, 2. microbiology
- Pollution distribution, dynamics and mobility in the floodplain
- Identification of potentially vulnerable and vulnerable areas

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Sampling and Laboratory Analyses

- Topsoil, Subsoil and River Sediment samples
- Alluvial plains and river terraces
- ICP-MS (Aqua Regia extraction)
- Mobility test: Distilled water leaching
- pH, LOI, carbonate content
- Grain size distribution, EC
- FDA (micorbial activity)
- FDA control, DHA, ß-glucosidase, phosphatase
- MALDI-TOF (microbial identification)

SAMPLING

topsoil & subsoil

2017

Sampling with the Slovenian colleagues

SAMPLING

sediment core sampling

2018

Sampling with the Slovenian and Croatian colleagues

SAMPLING

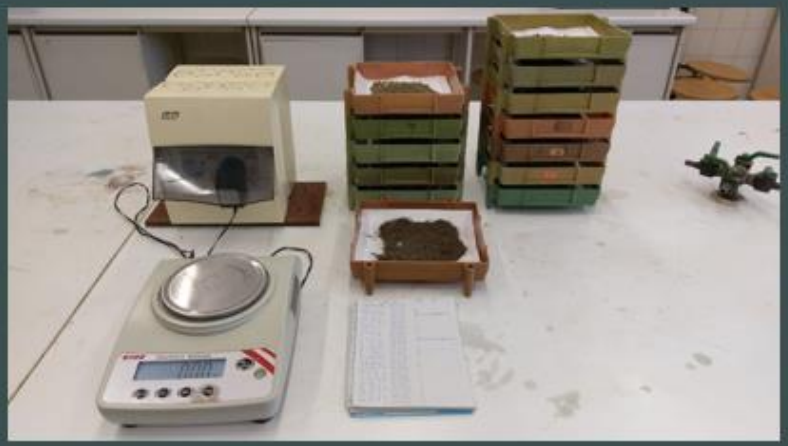
microbial activity

2019

Sampling with SZIE microbiologist colleague

LABORATORY ANALYSIS

sediment geochemistry



Sample preparation and measurements

DESCRIPTIVE STATISTICS

PTE total concentrations & EQS exceedance

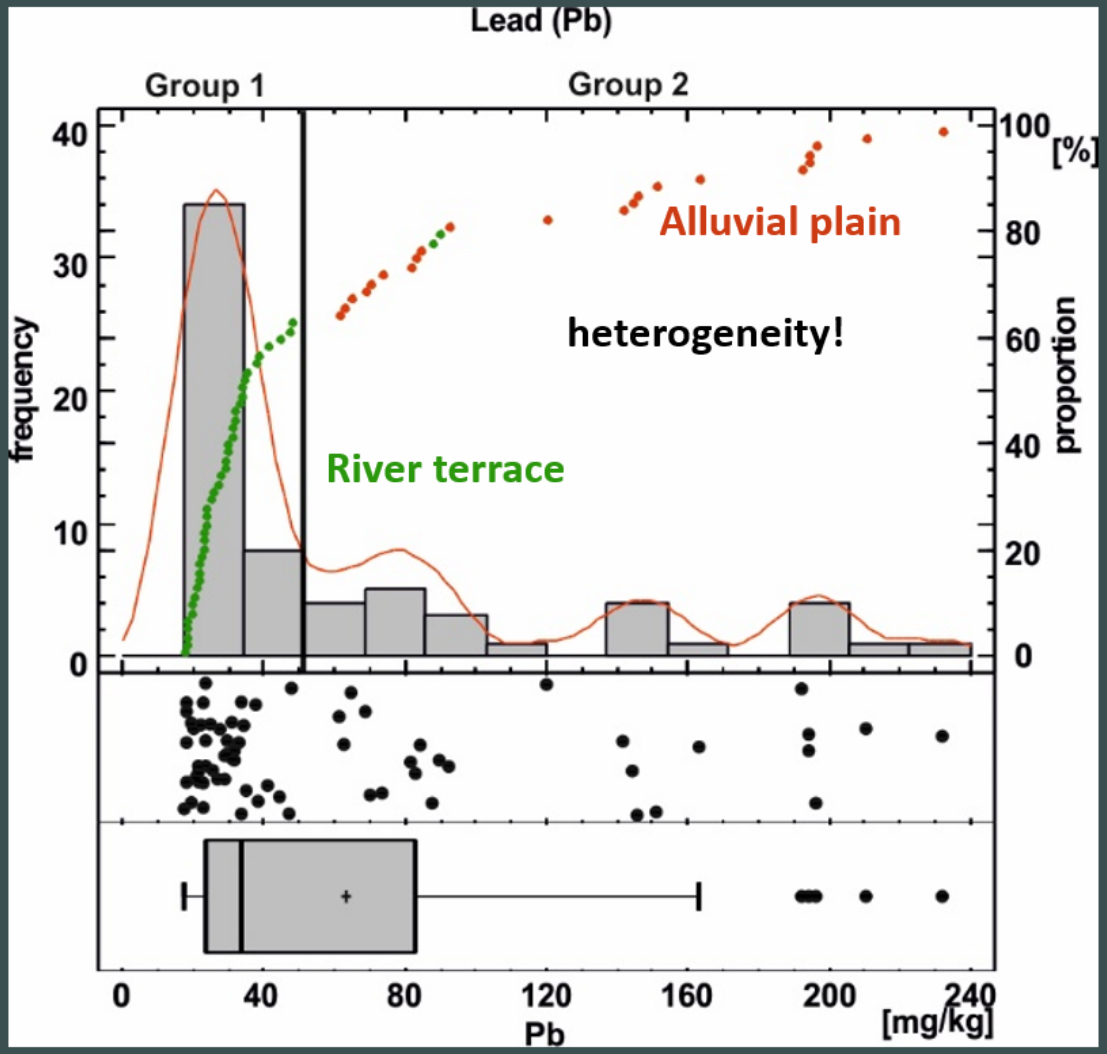
Chemical element	Statistical parameters									6/2009. (IV. 14.) KvVM-EüM-FVM
	Minimum	Lower quartile	Median	Upper quartile	Maximum	MAD	Average	Standard deviation	Relative standard deviation	
	mg/kg	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*		*mg/kg*
Cr	43.00	66.00	75.00	89.00	116.00	14.00	77.41	20.01	0.26	75
Ni	19.00	33.20	39.50	48.30	66.90	6.55	40.28	12.08	0.30	40
Cu	12.60	22.60	28.80	37.20	48.50	7.05	29.21	9.86	0.34	75
Zn	48.00	77.00	107.50	197.00	854.00	45.50	186.94	181.33	0.97	200
As	6.00	12.00	15.00	19.00	36.00	3.00	15.47	5.21	0.34	15
Mo	-0.10	0.40	0.60	0.80	1.10	0.20	0.60	0.28	0.47	7
Cd	-0.10	0.20	0.30	0.90	3.00	0.10	0.64	0.71	1.10	1
Sn	1.60	2.70	3.00	3.60	5.30	0.55	3.12	0.68	0.22	30
Ba	242.00	397.00	455.00	506.00	569.00	56.00	445.99	72.70	0.16	250
Pb	17.70	23.30	33.35	83.10	232.30	13.35	63.21	57.96	0.92	100
Al	4.57	5.94	6.40	7.27	8.79	0.80	6.52	0.95	0.15	n.a.
Ca	0.35	1.05	2.62	3.78	8.66	1.40	2.50	1.61	0.65	n.a.
Fe	2.27	3.04	3.47	4.04	4.97	0.46	3.53	0.70	0.20	n.a.
K	0.97	1.54	1.75	1.98	2.45	0.22	1.76	0.31	0.17	n.a.
Mg	0.44	0.97	1.49	1.99	2.69	0.51	1.50	0.61	0.41	n.a.
Mn	344.00	640.00	771.50	876.00	1067.00	107.00	753.00	159.74	0.21	n.a.
Na	0.42	1.00	1.09	1.21	1.54	0.11	1.08	0.18	0.17	n.a.
P	0.04	0.07	0.09	0.10	0.16	0.01	0.09	0.02	0.26	n.a.
Sb	0.60	0.80	1.00	1.20	2.20	0.20	1.06	0.32	0.30	n.a.
V	52.00	81.00	91.50	115.00	147.00	15.50	97.33	22.86	0.23	n.a.

DESCRIPTIVE STATISTICS

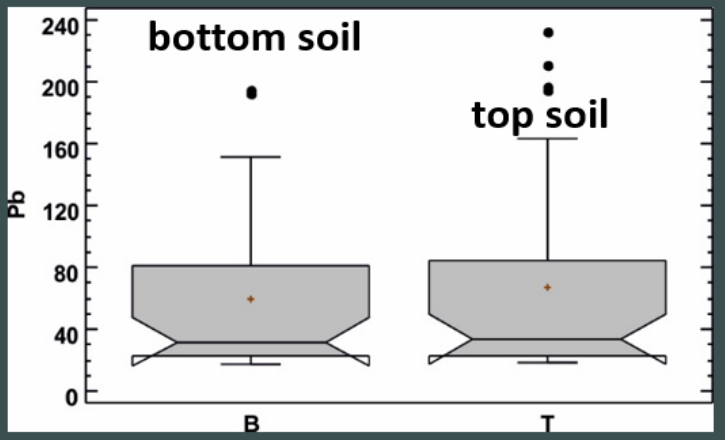
Chemical element	Min	LQ	Median	UQ	Max	MAD	Avg	SD	FOREGS	HRGB	EF	Decree 6/2009
	mg/kg	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*		*mg/kg*
As	7	*12*	***15***	***17***	***25***	3	14.9	4.2	6	7.3	2.1	15
Ba	***297***	***391***	***460***	***479***	***560***	56	440.4	68.0	65	95	4.8	250
Cd	0.1	0.2	0.3	*0.9*	***3***	0.1	0.8	0.8	0.145	<0.5	0.6	1
Cr	*43*	*66*	***78***	***89***	***113***	12	77.6	19.1	22	21	3.7	75
Cu	13.1	*22.8*	*30.8*	*35.9*	*48.5*	6.4	29.5	9.3	12	19	1.6	75
Ni	19	*33.2*	*37.7*	***46.1***	***63.1***	7.4	39.6	11.6	14	22	1.7	40
Pb	*18.3*	*23.4*	*33.4*	*84.5*	***232.3***	12.5	67.2	64.4	15	17	2.0	100
Zn	48	*82*	*106*	*196*	***854***	49	199.8	201.9	48	65	1.6	200

Min-minimum, **LQ**-lower quartile, **UQ**-upper quartile, **Max**-maximum, **MAD**-Median Absoulute Deviation, **Avg**-average, **SD**-standard deviation, **FOREGS**-European mean topsoil value, **HRGB**-Hungarian regional background value (**italics if exceeded**), **EF**-enrichment factor (Median/HRGB), **Decree 6/2009**-Limit values in the Hungarian Joint Government Decree for the protection of geological medium and groundwater against pollution (**bold if exceeded**)

UNIVARIATE ANALYSIS - Pb



DEPTH



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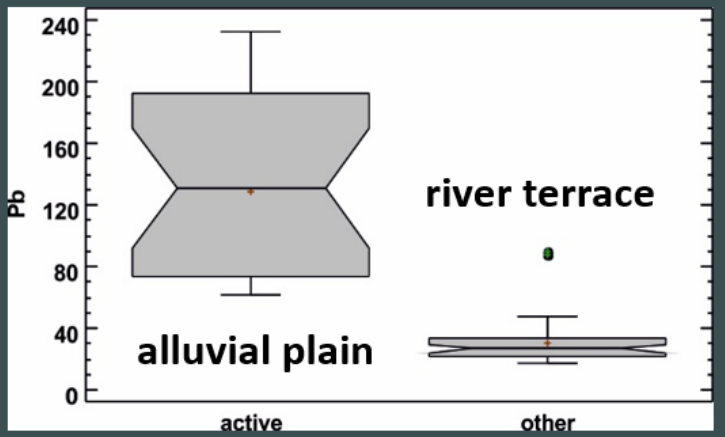
REGIME



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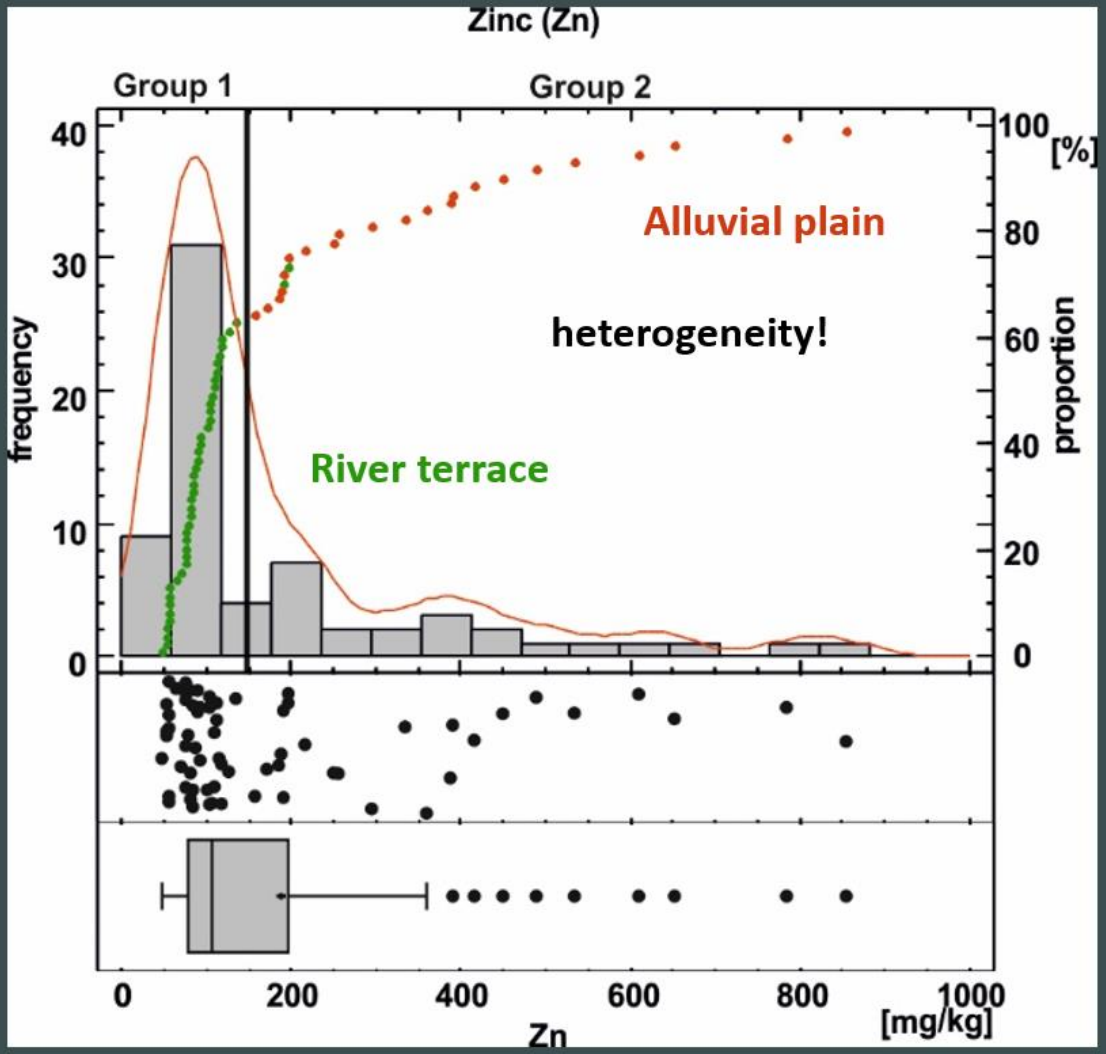
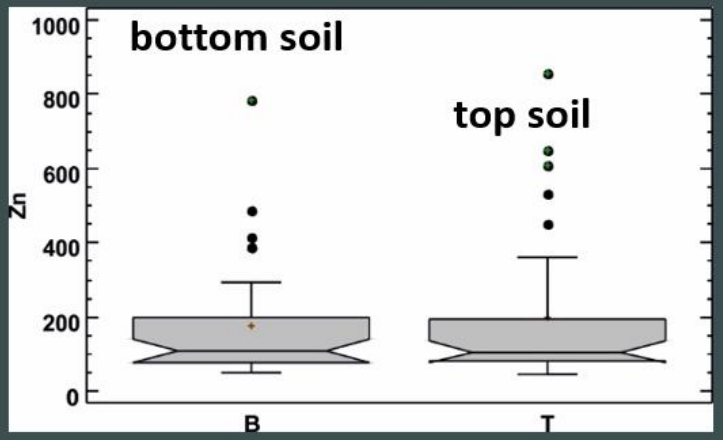
UNIVARIATE ANALYSIS - Zn



DEPTH



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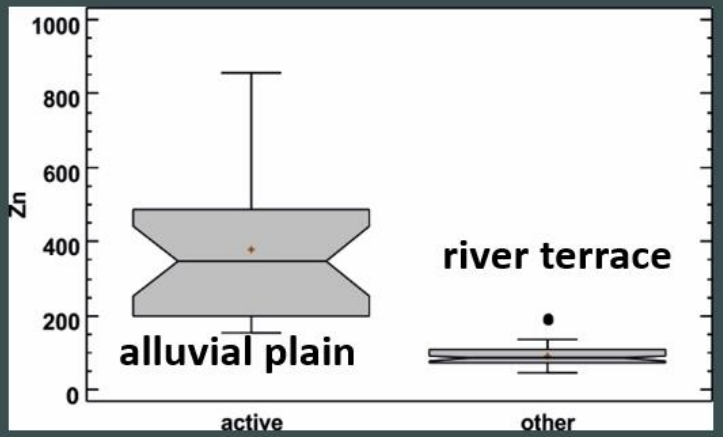
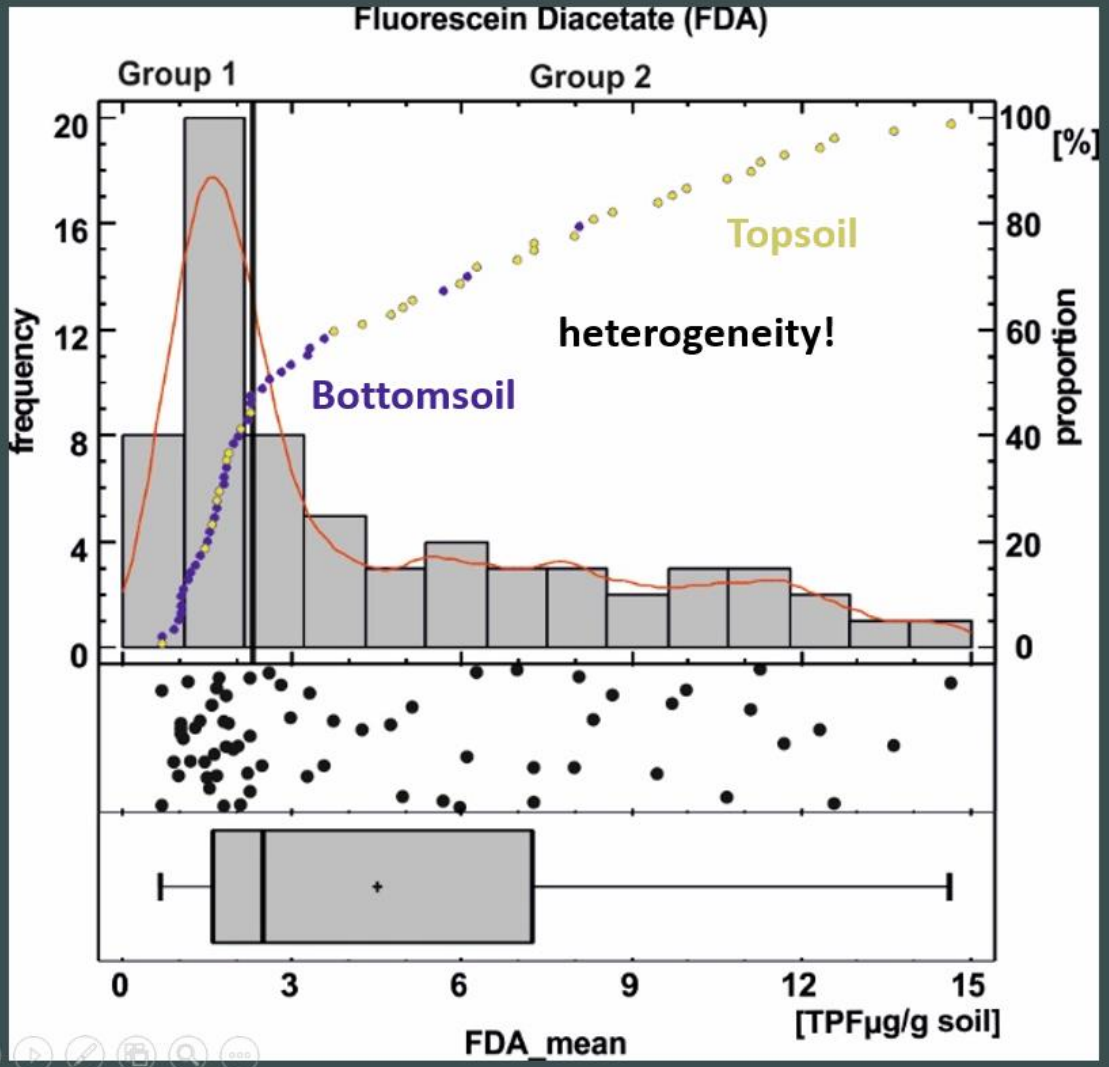
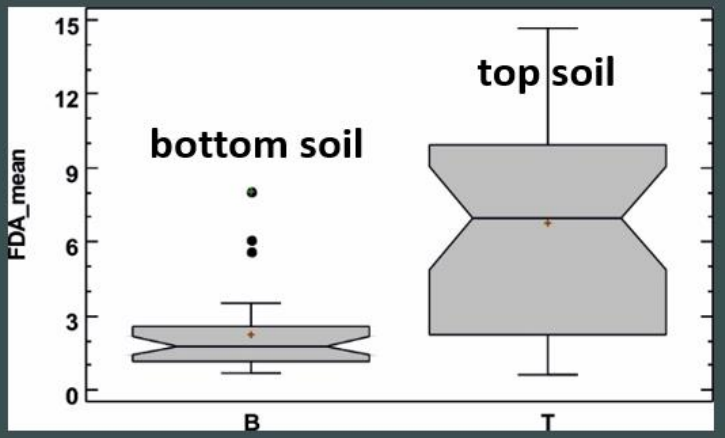


p-value = 0.00

UNIVARIATE ANALYSIS - FDA



DEPTH



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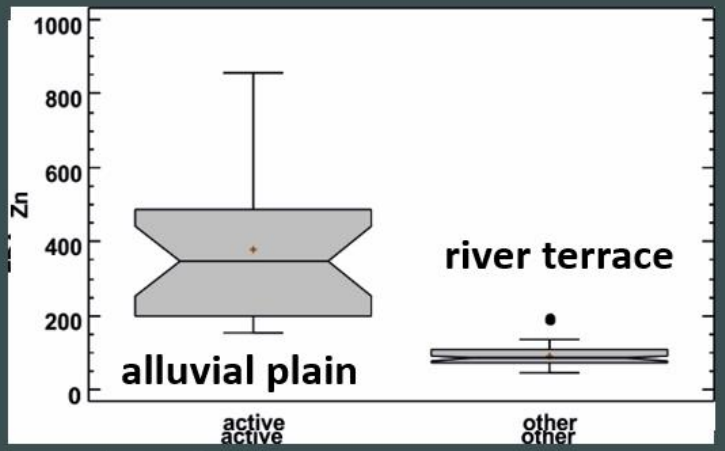
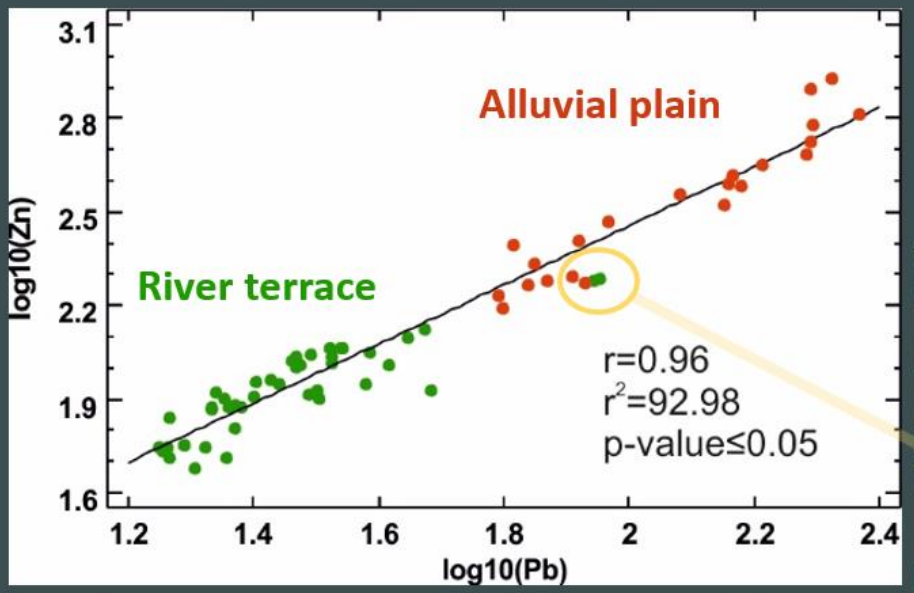
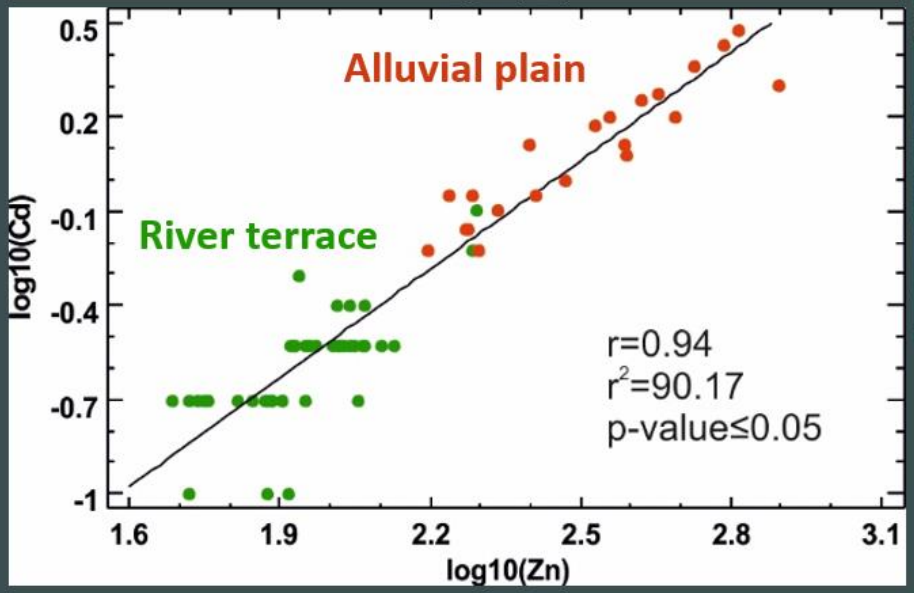


p-value = 0.22

REGRESSION ANALISYS – Zn-Pb; Zn-Cd

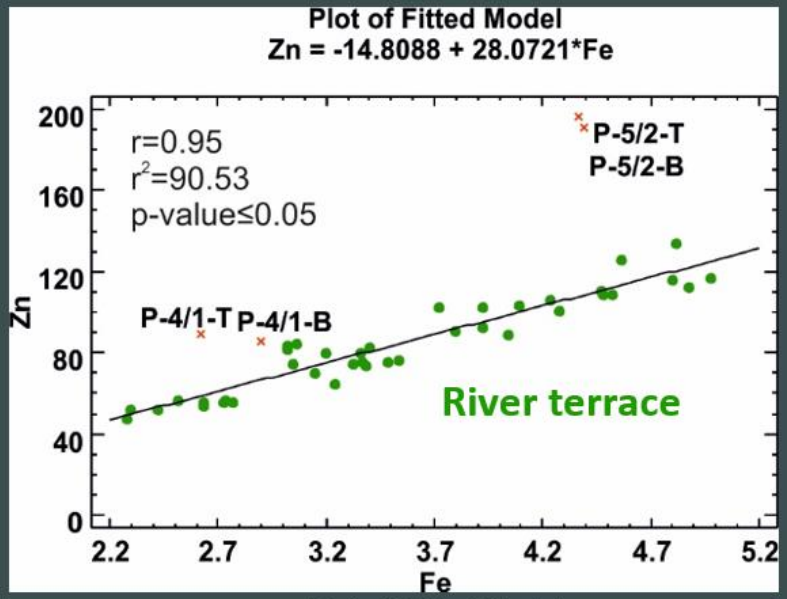


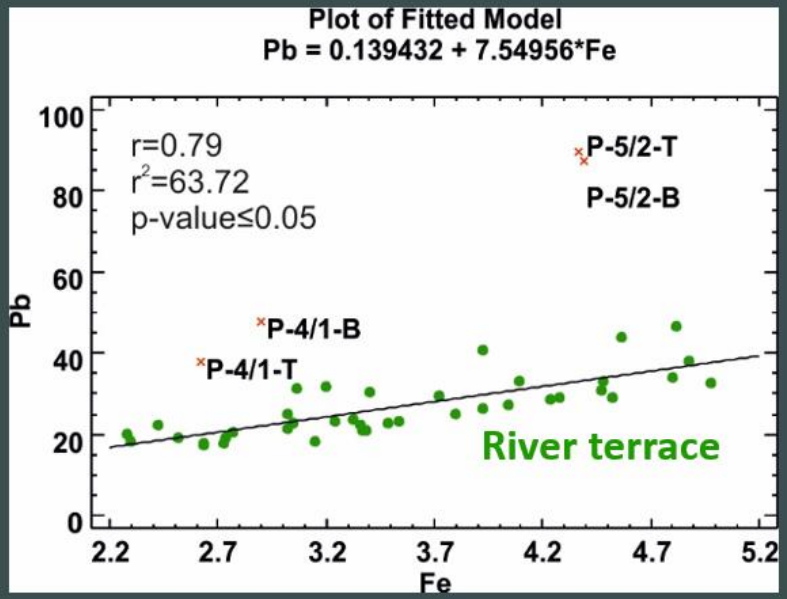


Oxbow!

Heterogeneity!

REGRESSION ANALISYS – Zn, Pb - Fe

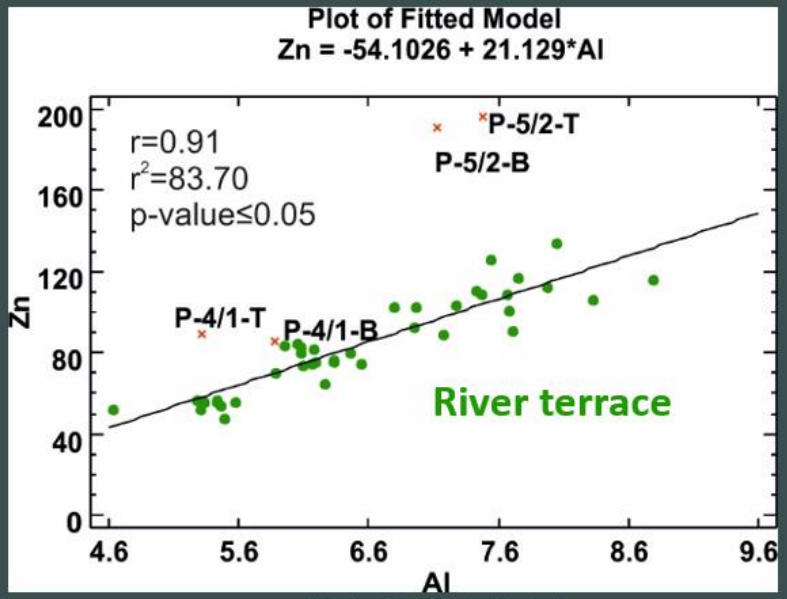


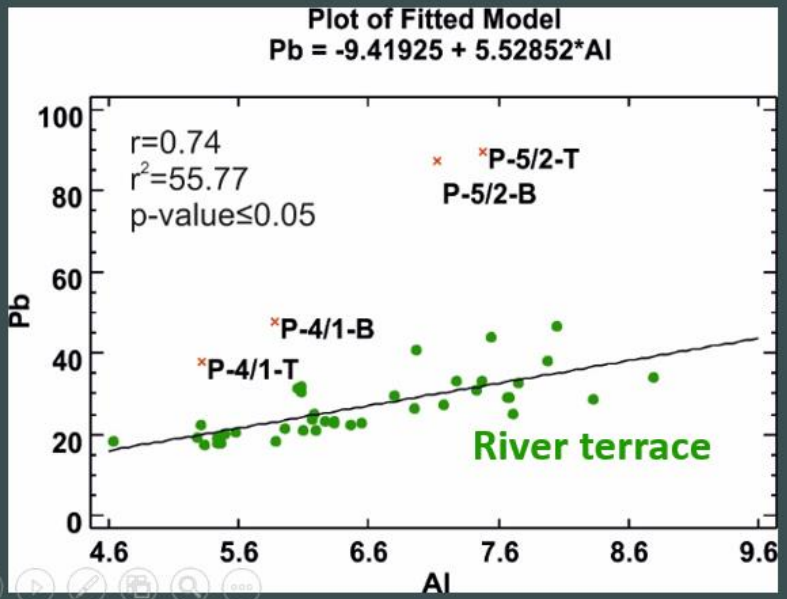


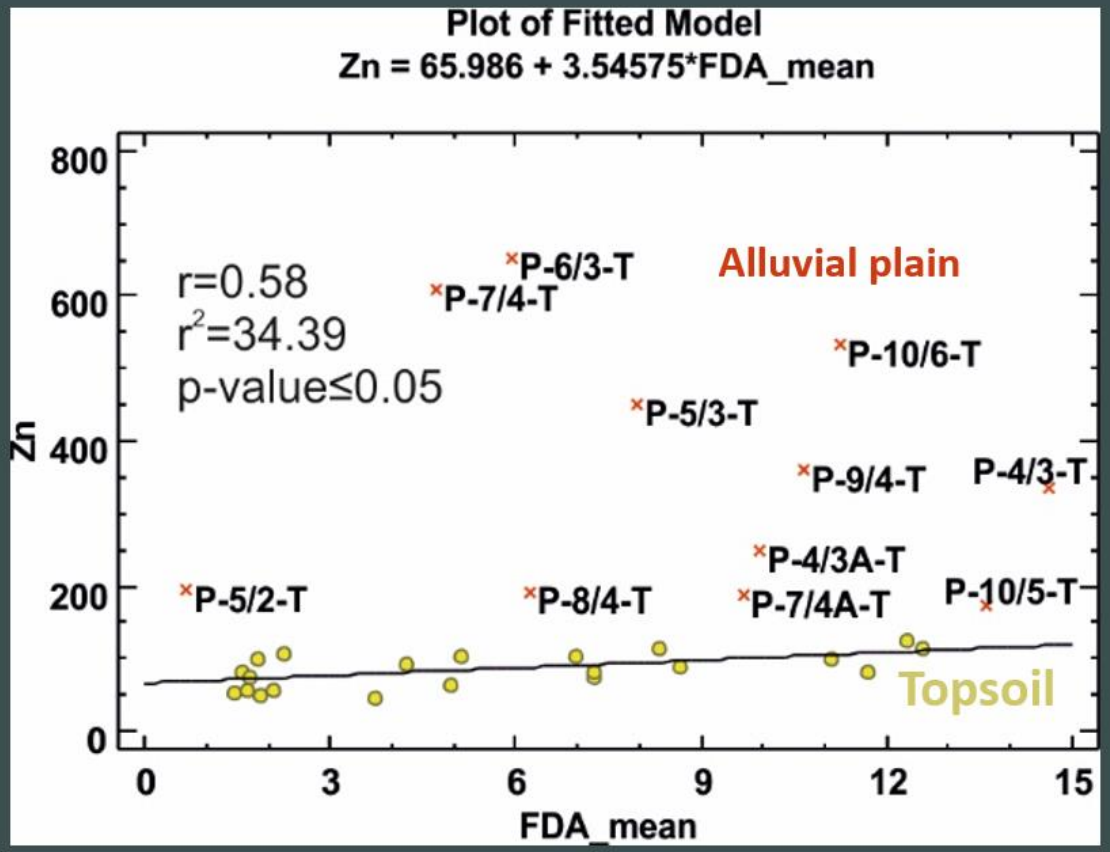
Oxbow!

Adsorption on Fe-oxihydroxides

REGRESSION ANALISYS – Zn, Pb - Al

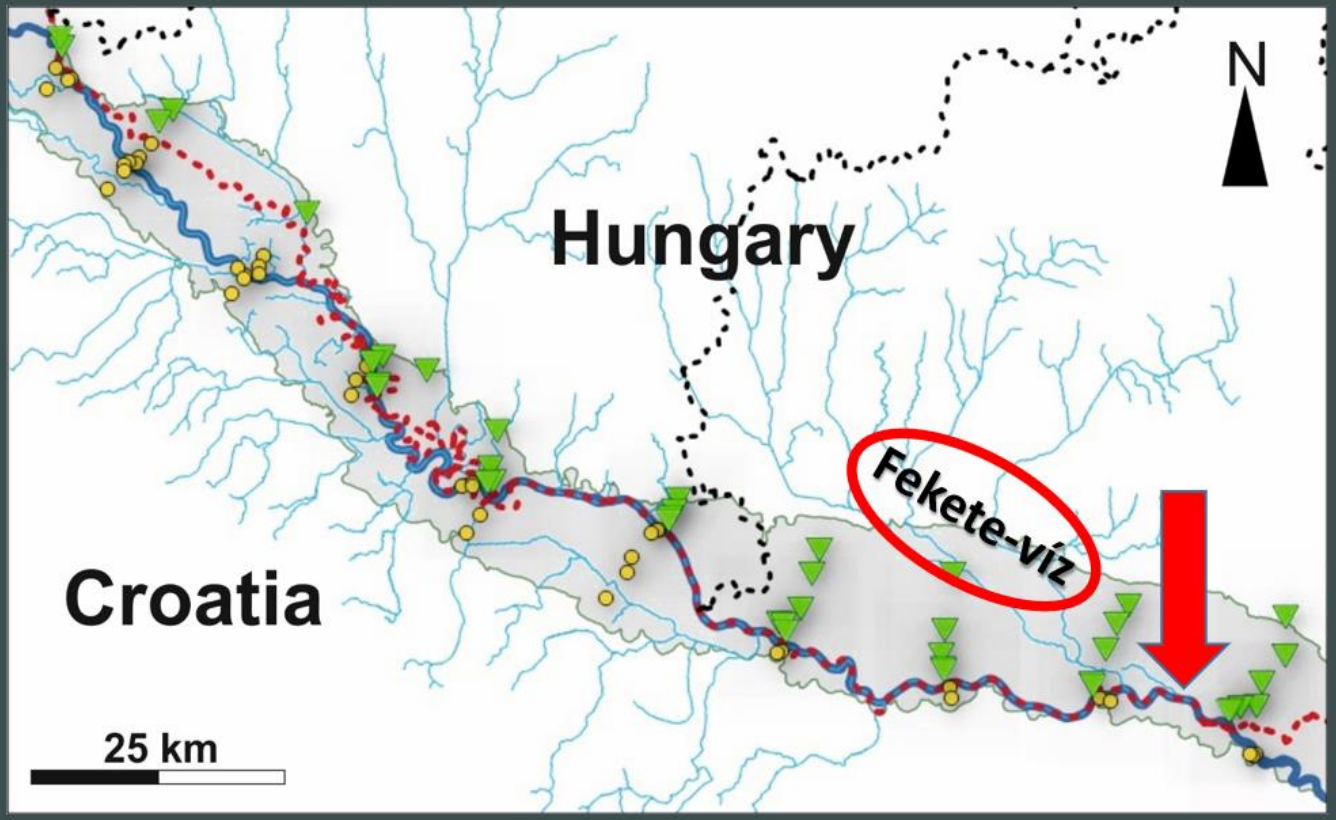


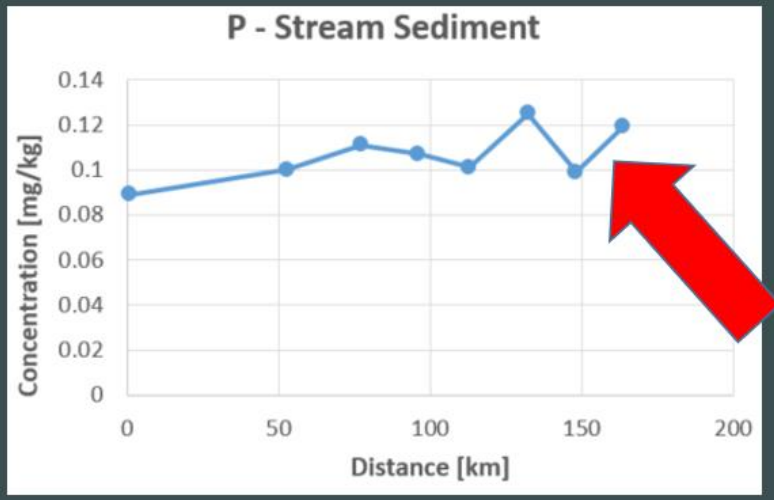


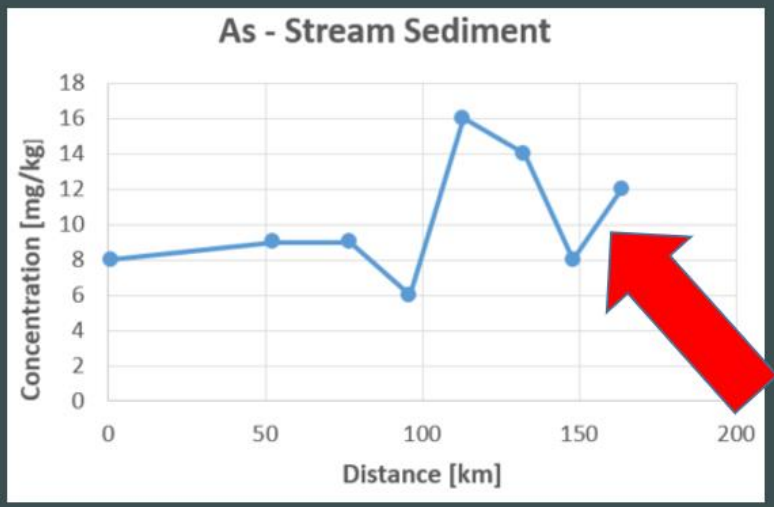


Adsorption on clay minerals

EFFECT OF TRIBUTARIES

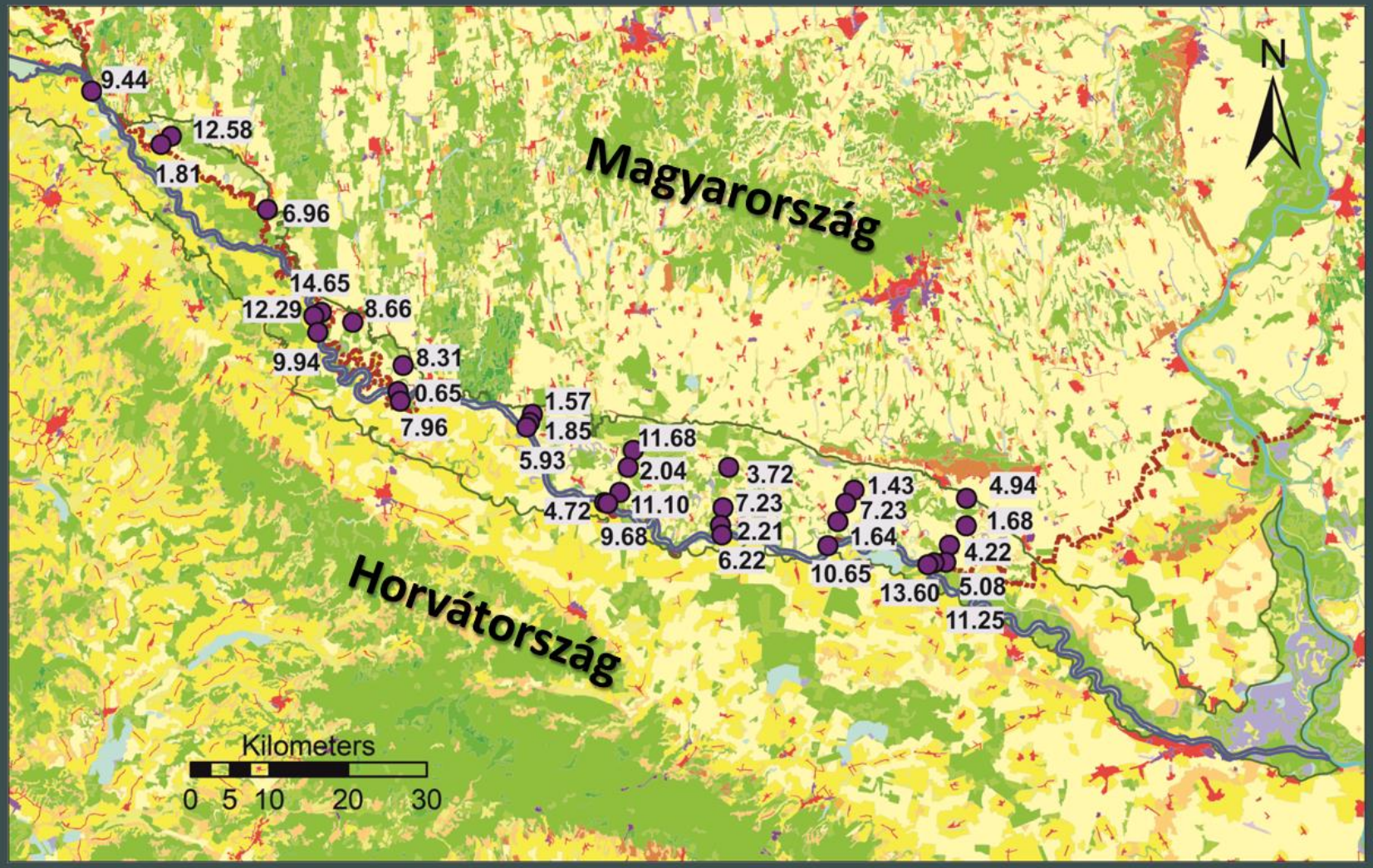






Sudden increase in P and As concentrations after the confluence of Drava and Fekete-víz

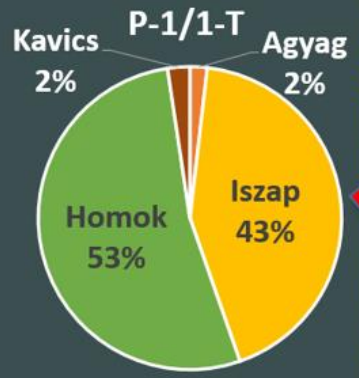
MICROBIAL ACTIVITY DISTRIBUTION

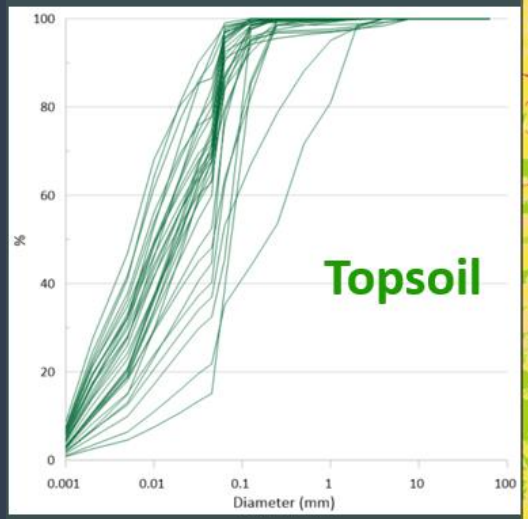


- No upstream / downstream trend
- Local processes
- Variable levels of activity

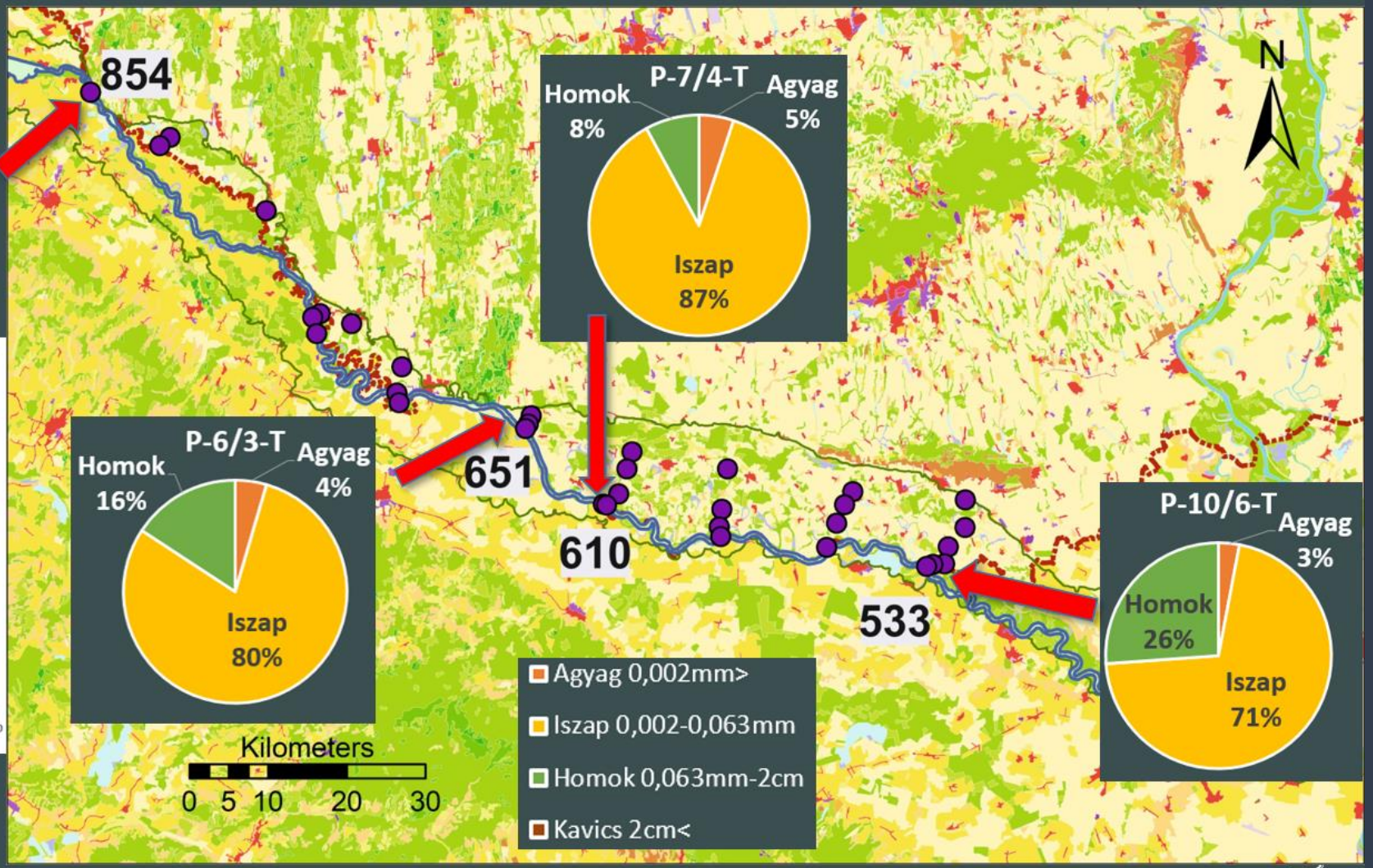
CORINE Landcover 2012

GRAIN SIZE DISTRIBUTION





2-3 types of granulometry



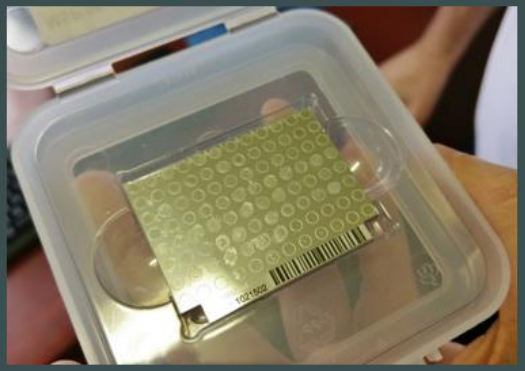
CORINE Landcover 2012

MICROBIAL DIVERSITY

	Σ = 82
Bacillus	17
Pseudomonas	13
Lactobacillus	10
Arthrobacter	4
Pseudarthrobacter	3
Streptomyces	3

Leggyakoribb fajok	Mintaszám (Σn=10)
Bacillus mycoides	8
Bacillus cereus	6
Bacillus megaterium	6
Bacillus weihenstephanensis	6
Bacillus thuringiensis	5
Bacillus simplex	4
Bacillus muralis	3
Bacillus pseudomycoides	3

MALDI-TOF műszer



- A total of 82 identified species
- Most diverse genera: Bacillus, Pseudomonas and Lactobacillus
- The most common species is from the genus Bacillus

Summary

1. Signs of historical mining in soils, river sediments (pollution).
2. High element concentrations in both topsoil and subsoil.
3. Element concentrations are different: active alluvial plain and inactive river terrace.
4. The tributaries can also have a large geochemical impact on the sediment quality.
5. The highest element concentration is in the fine fractions.
6. In terms of microbial activity, there is a difference between topsoil and subsoil.
7. Potentially toxic elements do not necessarily inhibit / reduce activity.
8. The FDA test can be used with limitations only to understand the dynamics of floodplain pollution. Microbial diversity testing (MALDI-TOF) complements FDA testing.

04 GIS – Digital maps & database

DRAVA GIS DATABASE:

Contains the following map data:

- Topographic map with borders, roads, railways, rivers, facilities, settlements, lakes
- Map of CORINE 2012 Landcover
- Soil Agrotopo map
- Geology of the whole area (1: 100 000)
- Pretercier Geology (1: 500 000)
- Drava polygon in the "kml" format
- Sampling points
- Excel spreadsheet with concentrations, separate for Topsoil and Bottomsoil

DATA COLLECTED FOR THE DRAVA SAMPLE AREA:

- 01 Surface water quality (water chemistry)
- 02 Water flow
- 02 Water level
- 02 Temperature
- 03 Population
- 04 Air pollution

CONFERENCE PRESENTATIONS – National

01 MOSONMAGYARÓVÁR *(Szlepák Emőke)*

- XXXV. Országos Hidrológiai Vándorgyűlés
- *http://www.hidrologia.hu/mht/letoltes/programfuzet_ovgy_2017.pdf*
- 2017 07 05-07
- OTKA kutatás megvalósításához szükséges know-how prezentálása szakmai konferencián.
- szóbeli előadás

PUBLICATION: *Szlepák E., Jordán Gy., Heltai Gy., Bardóczyné Sz. E. 2017. Kis vízfolyások komplex monitoringrendszerének kidolgozása a VKI ajánlása szerint, nehézfémszennyezés szállításának modellezése a Galga patakon, XXXV. Országos Hidrológiai Vándorgyűlés, 2017, Mosonmagyaróvár, Hungary. (CD) (in Hungarian) (HU)*

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02 DEBRECEN *(Szlepák Emőke)*

- XIII. Környezetvédelmi Analitikai és Technológiai Konferencia és 60. Magyar Spektrokémiai Vándorgyűlés
- *https://maszesz.hu/hireink/aktualis-hirek/xiii-kornyezetvedelmi-analitikai-es-technologiai-konferencia*
- 2017 08 21-26
- OTKA kutatás megvalósításához szükséges know-how prezentálása szakmai konferencián
- poszter + bemutatása szóban

PUBLICATION : *Szlepák E., Jordán Gy., Heltai Gy., Bardóczyné Sz. E. 2017. Komplex monitoring rendszer kidolgozása a Galga patak vízgyűjtő területén a VKI ajánlása szerint, XIII. Környezetvédelmi Analitikai és Technológiai Konferencia, 2017, Debrecen, Hungary. pp 142. (ISBN: 978 963 9970 77 9) (in Hungarian) (HU)*

CONFERENCE PRESENTATIONS – National

03 PÉCS *(Jordán Győző)*

- 20th HU and 9th HR-HU Geomathematical Congress “Geomathematics in multidisciplinary science - The new frontier?”
- *http://midra.uni-miskolc.hu/document/28201/23868.pdf*
- Pécs, Hungary, 11-13. May 2017
- OTKA kutatás megvalósításához szükséges know-how megtekintése szakmai konferencián.

04 RÁCKEVE *(Szabó Péter)*

- L. Ifjú Szakemberek Ankétja
- Ráckeve, Hungary, 29-30. March 2019
- Potenciálisan Toxikus Elemek környezetgeokémiai vizsgálata

PUBLICATION: *Péter Szabó, Győző Jordán, Gábor Földing, Imre Gaburi, Csaba Alföldi, István Kiss, Margit Balázs, Ildikó Kovács, Csaba Szabó, Jun Yao:*
Heterogeneous geochemical processes in mine waste dumps – Assessing the behaviour of potentially toxic elements (PTEs) in mine waste dumps and tailings in the Recsk mining area In: Magyar, Geofizikusok Egyesülete; Magyarhoni, Földtani Társulat 50. Ifjú Szakemberek Ankétja programfüzet Budapest, Magyarország : Magyar Geofizikusok Egyesülete, Magyarhoni Földtani Társulat, (2019) p. 53 , 1 p.

CONFERENCE PRESENTATIONS – National

05 MÁTRAHÁZA *(Szabó Péter)*

- 10. Kőzettani és Geokémiai Vándorgyűlés
- Mátraháza, Hungary, 05-07. September 2019
- Geokémiai és mikrobiológiai folyamatok a Dráva folyó árterén

PUBLICATION: *Szabó Péter, Jordán Győző, Kocsis Tamás, Šajn Robert, Alijagić Jasminka:*
A történelmi bányászat hatása a geokémiai és mikrobiológiai folyamatokra a Dráva folyó árterén In: Pál-Molnár, Elemér; H., Lukács Réka; Harangi, Szabolcs; Szemerédi, Máté; Németh, Bianka; Molnár, Kata; Jankovics, Mária Éva (szerk.) Saxa Loquuntur - Kőbe zárt történetek : 10. Kőzettani és Geokémiai Vándorgyűlés Budapest, Magyarország (2019) pp. 78-78. , 1 p.

CONFERENCES PRESENTATIONS – International

01 SOFIA *(Jordán Győző)*

- 25th Meeting of the ICPDR Pressures and Measures Expert Group
- 28-29 September 2016 in Sofia, Bulgaria
- OTKA kutatási téma – EU perspektívája: fluviális üledékek monitoringja
- szóbeli előadás & megbeszélés

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02 SERBIA *(Jordán Győző)*

- 26th Meeting of the ICPDR Pressures and Measures Expert Group
- 21-23 March 2017, Fruška Gora, Serbia
- OTKA kutatási téma – EU perspektívája: fluviális üledékek monitoringja
- szóbeli előadás & megbeszélés

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03 VIENNA *(Jordán Győző)*

- 30 years EuroGeoSurveys Geochemistry Expert Group and 20 years IUGS Commission on Global Geochemical Baselines
- 20-21 April 2017, Vienna, Austria
- OTKA kutatási téma – elemek geokémiai eloszlásának térbeli vizsgálata
- szóbeli előadás & megbeszélés

CONFERENCES PRESENTATIONS – International

04 NAPOLI *(Jordán Győző)*
- 26th Meeting of the ICPDR Pressures and Measures Expert Group
- 17-18 May 2017, Napoli, Italy
- OTKA kutatási téma – környezetgeokémiai adatok térbeli modellezése
- szóbeli előadás & megbeszélés

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05 GUIYANG *(Jordán Győző)*
- 11th International Symposium on Geochemistry of the Earth's Surface (GES-11)
- 11-16 June 2017, Guiyang, China
- OTKA kutatási téma – fluviális talajok szennyezettségének vizsgálata
- szóbeli előadás

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06 BEIJING *(Jordán Győző)*
- Hungarian-Chinese Agro-technology Workshop, Embassy of Hungary in Beijing & China Technology Exchange
- 30-31 March 2017, Beijing, China
- OTKA kutatási téma – bányászati eredetű szennyeződés környezetgeokémiai vizsgálata
- szóbeli előadás

CONFERENCES PRESENTATIONS – International

07 VIETNAM *(Bartha András)*
- Szakmai látogatás és megbeszélések
- 26 May-03 June 2017, Ho Chi Minh City, Vietnam
- OTKA kutatási téma – toxikus elemek környezeti kockázatvizsgálata, As geokémiája
- szóbeli előadás & megbeszélés

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08 CUBA *(Jordán Győző)*
- Szakmai látogatás és megbeszélések
- 11-16 June 2018, Havanna & Moa, Cuba
- OTKA kutatási téma – nehézfémek viselkedésének vizsgálata különös tekintettel az élelmiszerbiztonságra
- szóbeli előadás, MSc kurzus & megbeszélés, MoU aláírás, EU ERASMUS projekt indítás

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09 BEIJING *(Jordán Győző)*
- Szakmai látogatás, konferencia előadás, kurzus tartása és megbeszélések
- 20-28 August, 22 September-22 October 2017, China
- OTKA kutatási téma – PTE (Potenciálisan Toxikus Elemek) szennyeződés környezetgeokémiai vizsgálata
- szóbeli előadás, terepbejárás, mintavétel, megbeszélés

CONFERENCES PRESENTATIONS – International

10 VIENNA *(Szabó Péter)*

- European Geosciences Union General Assembly 2019
- Szakmai konferencia
- 07-12 April 2019, Vienna, Austria
- OTKA kutatási téma – PTE (Potenciálisan Toxikus Elemek) szennyeződés környezetgeokémiai vizsgálata
- Interaktív poszter prezentáció

PUBLICATION: *Péter Szabó, Győző Jordán, Gábor Földing, Imre Gaburi, Csaba Alföldi, István Kiss, Margit Balázs, Ildikó Kovács, Jun Yao: Heterogeneous geochemical processes in mine waste dumps – Assessing the behaviour of potentially toxic elements (PTEs) in mine waste dumps and tailings in a historic copper mining area In: EGU General Assembly 2019, (2019) Paper: EGU2019-6123, 1 p.*

---

11 PÉCS *(Szabó Péter)*

- International Congress on Geomathematics in Earth- & Environmental Sciences and the 21th Congress of Hungarian Geomathematicians, Pécs, Magyarország, 2019.05.16-18.
- Szakmai konferencia
- 16-18 May 2019, Pécs, Hungary
- OTKA kutatási téma – PTE (Potenciálisan Toxikus Elemek) környezetgeokémiai vizsgálata ártéri talajokban
- szóbeli előadás

PUBLICATION: *Péter Szabó, Gyozo Jordan, Tamás Kocsis, Robert Šajn, Jasminka Alijagić*
Investigation of geochemical-microbiological processes in the Drava River floodplain based on environmental geochemical data
In: Hatvani, IG; Tanos, P; Fedor, F (szerk.) GEOMATES 2019. International Congress on Geomathematics in Earth-& Environmental Sciences Pécs, Magyarország : Regional Committee of the Hungarian Academy of Sciences at Pécs, (2019) pp. 22-22. , 1 p.

CONFERENCES PRESENTATIONS – International

12 BUDAPEST *(Kocsis Tamás)*
- 18th International Congress of the Hungarian Society for Microbiology
- Szakmai konferencia
- 03-05 July 2019, Budapest, Hungary
- OTKA kutatási téma – ártéri talajok mikrobiológiai aktivitása
- Poszter prezentáció

PUBLICATION: *Tamás Kocsis, Győző Jordán, Péter Szabó, Katalin Posta: Determinate the soil biological activity of Drava floodplain by fluorescein diacetate (FDA)*
ACTA MICROBIOLOGICA ET IMMUNOLOGICA HUNGARICA 66 : Supplement 1 p. 155 (2019)

---

13 *(Szabó Péter)*
- European Geosciences Union, General Assembly 2020
- Szakmai konferencia
- 04-08 May 2020, Vienna, Austria
- OTKA kutatási téma – PTE (Potenciálisan Toxikus Elemek) szennyeződés környezetgeokémiai vizsgálata
- Online prezentáció

PUBLICATION: *Péter Szabó, Gyozo Jordan, Tamás Kocsis, Robert Šajn, Jasminka Alijagić*
Assessing the impact of fluvial dynamics on floodplain soil contamination and microbiota in the transboundary Drava River Floodplain, In: EGU General Assembly 2020, (2020) Paper: EGU2020-18996 , 1 p.

THESES

01 BSc thesis

- Bartus Annamária Barbara: Élelmiszer eredetvédelem geokémiai-alapú nyomkövetéssel, **2017**
- Supervisor: Dr. Jordán Győző

---

02 MSc thesis

- Lőrincz Dalma Veronika: Az ártéri talajokban és folyami üledékekben található nehézfémszennyezések vizsgálata a Dráva árterén, **2020**
- Supervisor: Dr. Jordán Győző

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03 PhD thesis

- Szabó Péter: A Dráva folyó ártéri üledékeinek és talajainak környezetgeokémiai vizsgálata
- Várható befejezés: **2022**
- Supervisor: Dr. Jordán Győző

PUBLICATIONS - ISC

Carpathian Journal of Earth and Environmental Sciences, August 2020, Vol. 15, No. 2, p. 533 – 546; Doi:10.26471/cjees/2020/015/150

MULTI-SCALE TEMPORAL PATTERNS IN SOIL RADON GAS DATA SERIES

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[2] Institute *for Geological and Geochemical Research, Hungarian Academy of Sciences, Budaörsi út 45, H-1112 Budapest, Hungary, corresponding author: gyozojordan@gmail.com, silvanybel@gmail.com*

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Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Spatial relationship between the field-measured ambient gamma dose equivalent rate and geological conditions in a granitic area, Velence Hills, Hungary: An application of digital spatial analysis methods

Silvana Beltrán Torres[a], Attila Petrik[b], Katalin Zsuzsanna Szabó[c,*], Gyozo Jordan[d,e], Jun Yao[f], Csaba Szabó[a]

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PUBLICATIONS - ISC

Carpathian Journal of Earth and Environmental Sciences, February 2017, Vol. 12, No. 1, p. 207 - 224

SYSTEMATIC DIGITAL TERRAIN MODEL CONSTRUCTION AND MODEL VERIFICATION WITH MULTI-SOURCE FIELD DATA. MORPHOTECTONIC ANALYSIS IN THE VILLANY HILLS AND ITS SURROUNDINGS, SW HUNGARY

Attila PETRIK[1] & Gyozo JORDAN[2]

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Contents lists available at ScienceDirect

Journal of Geochemical Exploration

journal homepage: www.elsevier.com/locate/gexplo

GEMAS: Spatial analysis of the Ni distribution on a continental-scale using digital image processing techniques on European agricultural soil data

Gyozo Jordan[a,b,*], Attila Petrik[c,**], Benedetto De Vivo[c], Stefano Albanese[c], Alecos Demetriades[d], Martiya Sadeghi[e], The GEMAS Project Team[1]

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+8 other publications

FOLLOW UP PROJECTS

01 EU INTERREG DTP - SIMONA

Sediment-quality Information, Monitoring and Assessment System to support transnational cooperation for joint Danube Basin water management

- Scientific coordinator: Dr. Győző Jordán

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02 Stipendium Hungaricum PhD Grant (Supervisor: Dr. Győző Jordán)

- Malek Abidi (Tunesia)
- Omar Saeed (Yemen)
- Naji Alwani (Syria)