MOBILNOST I BIODOSTUPNOST ODABRANIH ELEMENATA U POLJOPRIVREDNOM ZEMLJIŠTU ALUVIONA REKE IBAR

MOBILITY AND BIOAVAILABILITY OF SELECTED ELEMENTS IN AGRICULTURAL LAND OF THE IBAR RIVER ALLUVIUM

Podaci o mentoru i članovima komisije

Mentor:

_____

Članovi komisije:

_____

_____

_____

_____

Datum odbrane: _____

Doktorska disertacija predstavlja rezultat projekta "Industrija proizvodnje olova i cinka, posledice po stanovništvo i uređenje i zaštita ekosistema" iz programa tehnološkog razvoja i oblasti uređenja, zaštite i korišćenja voda, zemljišta i vazduha, ev. broj TR-37016 koji finansira Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije. Analiza uzoraka je vršena na Katedri za analitičku hemiju Hemijskog fakulteta Univerziteta u Beogradu i na Katedri za neorgansku hemijsku tehnologiju Tehnološko-metalurškog fakulteta Univerziteta u Beogradu.

Ovom prilikom bih želeo da se zahvalim rukovodiocu projekta prof. dr Aleksandru Ćorcu na svemu što je pratilo naš zajednički rad, korisnim savetima i svesrdnoj pomoći na koju sam mogao uvek da računam.

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Mobilnost i biodostupnost odabranih elemenata u poljoprivrednom zemljištu aluviona reke Ibar

Solanum tuberosum *Zea mays*

Principal

Component Analysis *Hierarhical Cluster*

Analysis

Bureau Communautaire de Référence

TF

HI

HI

HQ

HQ

Ključne reči:

Zea mays *Solanum tuberosum*

Naučna oblast:

UDK broj:

Mobility and Bioavailability of Selected Elements in Agricultural Land of the Ibar River Alluvium

ie

Solanum tuberosum *Zea mays*

TF

***Keywords**:* *Zea mays*

Solanum tuberosum

Scientific field:

UDC number:

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I_{geo}

RI

RAC

PLI

TF

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Principal Component Analysis

Cluster Analaysis

I_{geo}

PLI

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Spisak skraćenica i simbola:

Agricultural Development and Advisory Service

Analysis of Variance

Biologische Bundesanstalt für Land- und Forstwirtschaft

Bureau Communautaire de Référence

Charge-Coupled Device

C_d *Contamination Degree*

Centers for Disease Control and Prevention

CDI – *Chronic Daily Intake*

Cation Exchange Capacity

C_f^i *Contamination Factor*

Charge-Injection Device

Certified Reference Material

Charge-Transfer Device

Detection Limit

Diethylenetriamine-pentaacetic acid

European Commission

Ethylenediamine-tetraacetic acid

E_{r}^i *Potential Ecological Risk Factor*

EF *Enrichment Factor*

Error Sum of Squares

European Union

Food and Agriculture Organization of the United Nations

Geographic Information System

Global Positioning System

Target Value

Hierarhical Cluster Analysis

Hazard Quotient

Inductively Coupled Plasma Optical Emission Spectrometry

I_{geo} *Index of Geoaccumulation*

European Commission Institute for Reference Materials and Measurements

International Organization for Standardization

International Society of Soil Science

Kajzer-Mejer-Olkin

Kolmogorov-Smirnov

Md – Median

Maximal Permissible Limit

Organic Matter

p – Significance Level

Pro Analysis

Principal Component

Principal Component Analysis

Polychlorinated biphenyls

PLI Pollution Load Index

Particle Size Distribution

Polytetrafluoroethylene

QL *Quantification Limit*

r *Correlation Coefficient*

RAC *Risk Assessment Code*

RfDo *Reference Dose*

RI *Potential Ecological Risk Index*

RSD *Relative Standard Deviation*

Intervention Value

Sequential Chemical Extraction

SD *Standard Deviation*

Sequential Extraction Procedure

Sequential Extraction Scheme

Sequential Extraction Test

EU Standards Measurement and Testing Programm

Selective Sequential Dissolution

Selective Sequential Extraction

Short Sequential Extraction Procedure

Soil Science Society of America

Triethanolamine

TF *Transfer Factor*

T_f^i *Toxic Response Coefficient*

U *Mann-Whitney U*

United Nations Scientific Committee on the Effects of Atomic Radiation

United States Environmental Protection Agency

United States Department of Agriculture

Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer

World health organization

Z *Wilcoxon Signed-Rank*

λ *engl. Eigenvalue*

$\bar{x}$ *Mean Value*

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Solanum tuberosum

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RI

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n

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n =

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Zea mays *Solanum tuberosum*

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1. Uvod

et al *et al* *et al*

Trace

Elements

et al

et al

et al

et al

et al

et al

EU Standards Measurement and Testing Programme

Bureau Communautaire de Référence

et al *et al*

et al. *et al* *et al* *et al*

et al

et al

Solanum tuberosum

Zea mays

2. Teorijski deo

2.1. Kratak istorijat razvoja industrijske proizvodnje na području istraživanja i literaturni pregled dosadašnjih istraživanja

et al

et al

et al

et al

et al *et al*

et al *et al* *et al* *et al*

et al *et al* *et al*

et al

et

al

et al *et al*

et al

et al

et al

et al

et al

et al

et al *et al*

et al

et al

et al

et al

et al

et al

et al

et al

et al

et al

United Nations Scientific Committee on the Effects of Atomic Radiation *et al*

et al *et al* *et al*

et al

Centers for Disease Control and Prevention,

et al *et al*

et al

2.2. Zemljište, koncept i definicija

Upper Weathering Layer

Soil Science Society of America,

2.2.1. Faktori koji utiču na proces nastajanja zemljišta

Pedon - zemljište

et al

Klima

reljef

et al

Biosfera

čovek *et al*

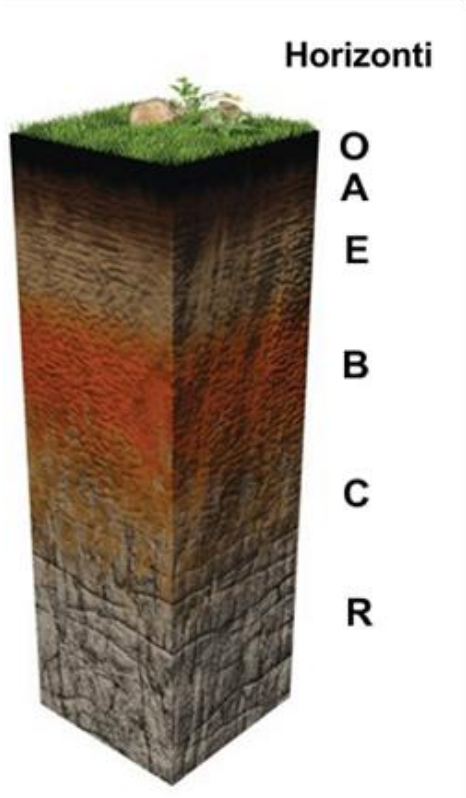
vreme

et al

2.2.2. Profil zemljišta

et al

Topsoil



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2.2.3. Sastav zemljišta

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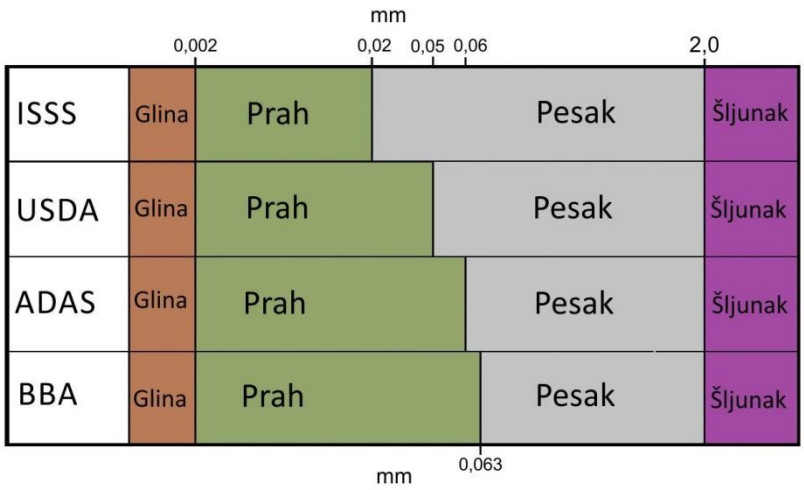
et al

2.2.4. Tekstura i klasifikacija zemljišta

et al

International Society of Soil Science, *United States Department of Agriculture,* *Agricultural Development and Advisory Service,* *Biologische Bundesanstalt für Land- und Forstwirtschaft*



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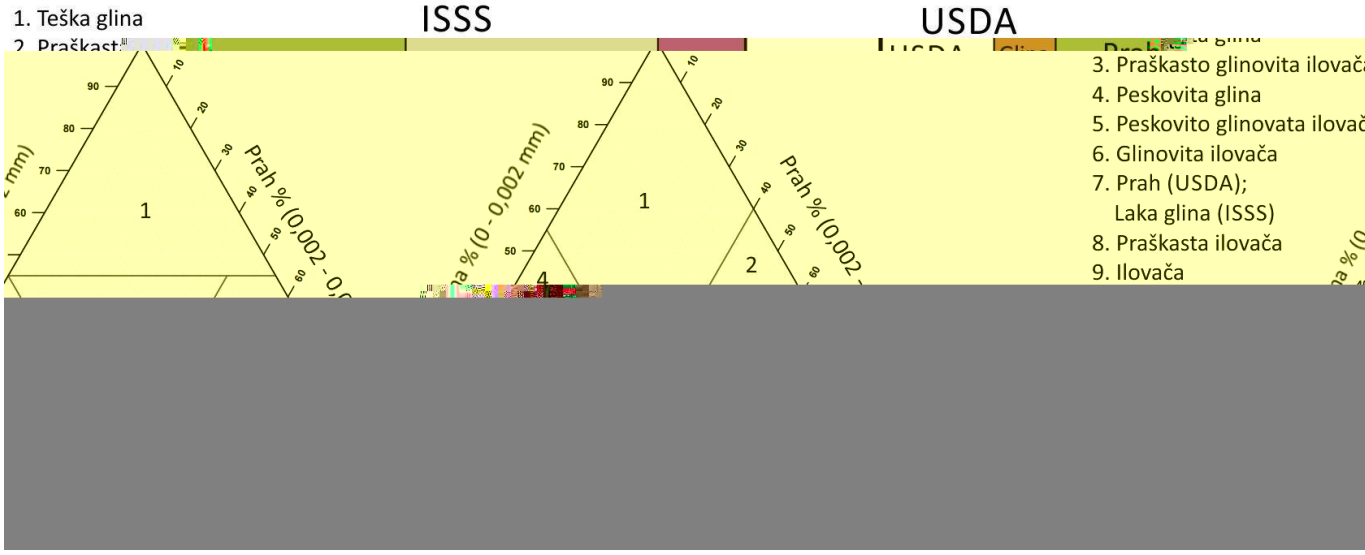

1. Teška glina
ISSS
USDA
3. Praškasto glinovita ilovača
4. Peskovita glina
5. Peskovito glinovata ilovača
6. Glinovita ilovača
7. Prah (USDA);
Laka glina (ISSS)
8. Praškasta ilovača
9. Ilovača
Prah % (0,002 - 0,0
Prah % (0,002 mm)
1
2
4

Slika 3.

2.3. Analiza hemijskih elemenata u zemljištu

2.3.1. Specijacija hemijskih elemenata

et al .

et al

Species

et al

Chemical Species

Speciation Analysis

Speciation

et al

et al

2.3.2. Sekvencijalna ekstrakcija – metoda za frakcionisanje hemijskih elemenata u životnoj sredini

et al

et al

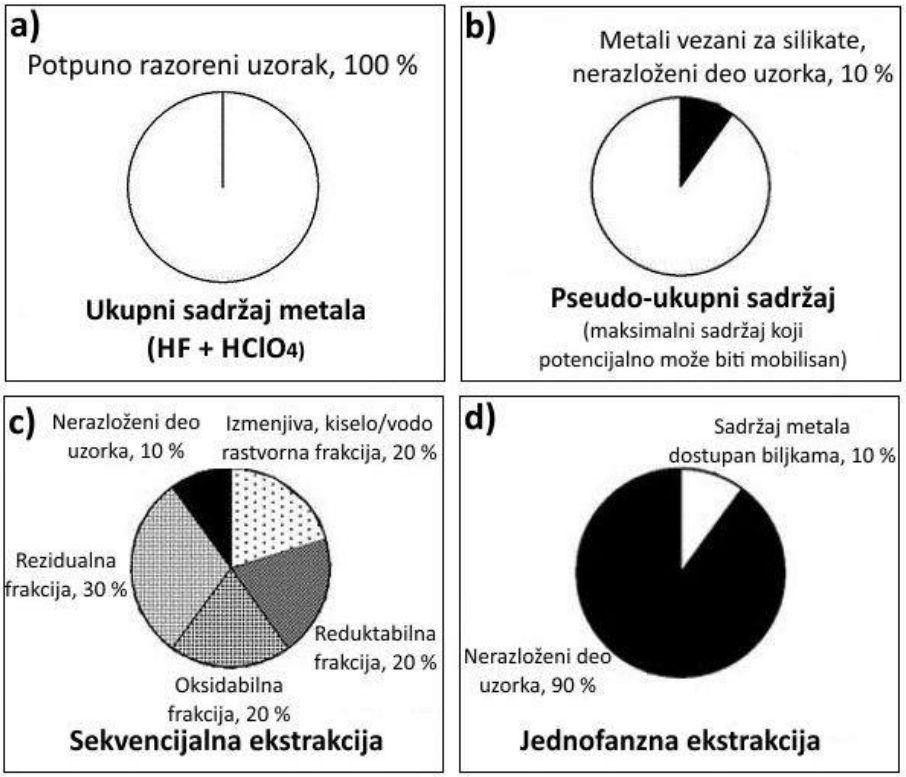
carskoj vodi

et al

et al *et al*

et al *et*

al *et al*



Slika 4.

et al

et al

et al

et al

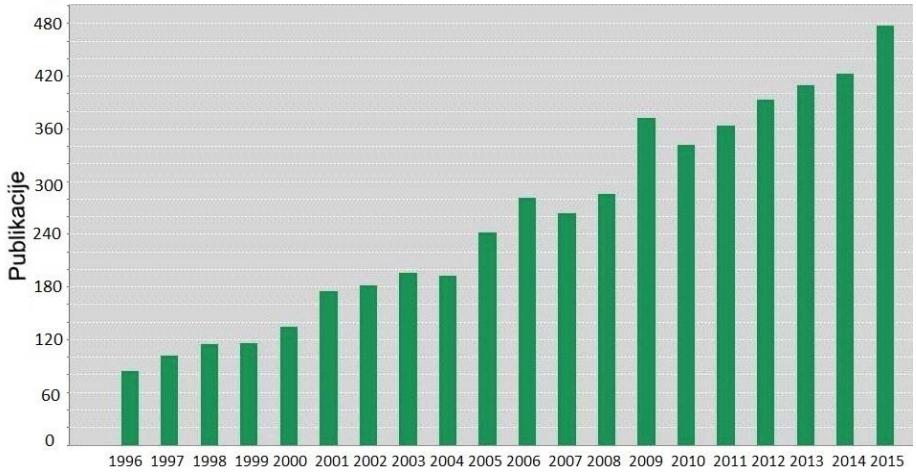
et al

et al

Tabela 1. *et al*

Tabela 2. *et al*

et al		
et al		
et al		
et al		
et al		
et al		
et al		
et al		
et al		



Slika 5.

Sequential Chemical Extraction *Sequential Extraction Procedure* *Sequential Extraction Scheme* *Sequential Extraction Test* *Selective Sequential Dissolution* *Selective Sequential Extraction,* *Sequential Selective Extraction* *Short Sequential Extraction Procedure*

2.3.2.1. Faze sekvencijalne ekstrakcije

Izmenjiva faza

et al

et al

et al

et al *et*

al *et al*

in situ

Kiselo-rastvorna faza

et al

et al

et al

Reduktabilna faza

et al

Nodules

et al

et al

et al

et al

Organsko-sulfidna faza

et al

et al

et al

et al *et al*

Rezidualna faza

et al

2.3.3. BCR sekvencijalna ekstrakcija

Certified Reference Material

Joint Research Centre-

Community Bureau of Reference *Bureau Communautaire de Référence*

framework

Measurements and Testing Programme

Standards, Measurements and Testing Programme

et al

et al

et al

et al

et al

et al

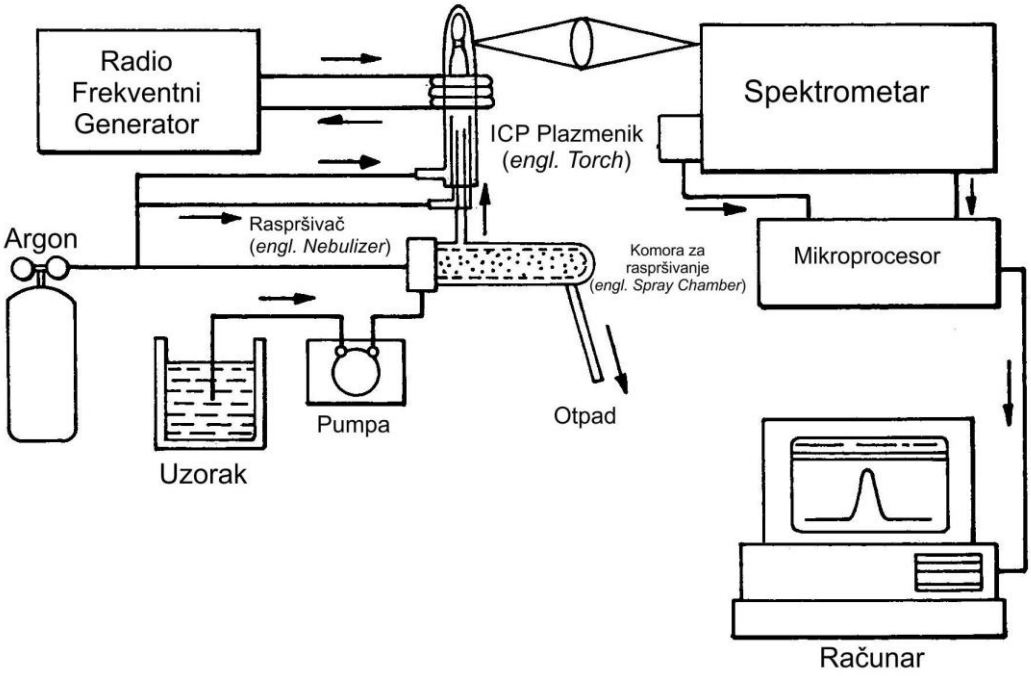
et al

Tabela 3. *et al*

	f		
I			
	f		
II			
	f		
III			
IV	*f*		

2.4. Indukovano spregnuta plazma sa optičkom emisionom spektrometrijom (ICP-OES)

Inductively Coupled Plasma Optical Emission Spectrometry,



Slika 6.

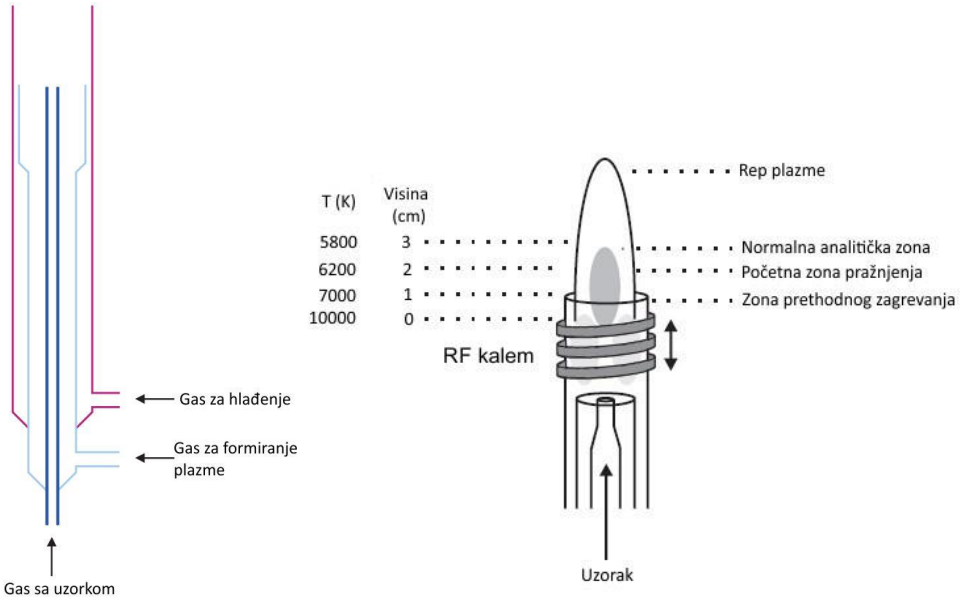
2.4.1. Indukovano spregnuta plazma (ICP)

Torch

Coolant or Plasma Gas

Auxiliary Gas

Nebulizer Gas



Slika 7.

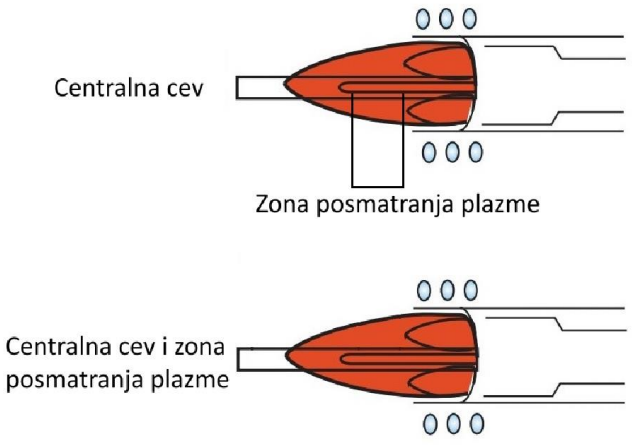
Preheating Zone

Initial Radiation Zone

Normal Analytical Zone),

Spray Chamber

et al


Centralna cev
Zona posmatranja plazme
Centralna cev i zona posmatranja plazme

Slika 8.

2.4.2. Spektrometri i detektori

franc. échelle

Charge-Coupled Device, *Charge-Injection Device,*

Charge-Transfer Device,

2.4.3. Merenje sadržaja elemenata

2.5. Hemometrijski pristup obrade podataka

et al

kemo *metri* *engl. Chemometrics = Chemo– –Metrics*

2.5.1. Testiranje statističkih hipoteza

Formulisanje nulte i alternativne hipoteze

nultu i alternativnu Nultom hipotezom H

$H \quad \bar{x} \qquad \bar{x}$

Alternativnom ili radnom hipotezom H

$H \quad \bar{x} \qquad \bar{x}$

Određivanje nivoa značajnosti (α nivo).

Tabela 4.

	H_o	H_o
H_o		
H_o		

Izbor statističkog testa

t

F *t* *B*

Bartlett *Levene*

Kolmogorov-Smirnov *Shapiro-*

Wilk *Skewness -*

Kurtosis –

p *α-* *p*

2.5.2. Korelaciona analiza

Tabela 5.

	Pearson	*Spearman*

Pearson-ovim koeficijentom korelacije

$$r_{(x,y)} = \frac{cov_{(x,y)}}{SD_x SD_y}$$

$$cov_{(x,y)} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1}$$

$$SD_x = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

x y

$\bar{x}$ $\bar{y}$ *i = 1 . . . n*

x y

Pearson

$r_{(x,y)}$ $r_{(x,y)}$

$r_{(x,y)}$ *t*

$$t = r_{(x,y)}\sqrt{\frac{n-2}{1-r_{(x,y)}^2}}$$

n

p

Spearman-ov koeficijent korelacije *Spearman*

Spearman-

$r_s = 1 - \frac{6 \sum_{i=1}^{n} d_i^2}{n(n^2-1)}$

d_i *x y n*

x y

t

et al

2.5.3. Analiza glavnih komponenti (*Principal Component Analysis*)

engl. Principal Component Analysis,

engl. Principal Components,

X *n*

p

Tabela 6.

	X_1	X_2	X_3		X_p
	x_{11}	x_{12}	x_{13}	...	x_{1p}
	x_{21}	x_{22}	x_{23}	...	x_{2p}
	...	...	...	...	.
	...	...	...	...	.
	x_{n1}	x_{n2}	x_{n3}	...	x_{np}

p

$PC_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + ... + a_{1p}X_p$

$PC_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + ... + a_{2p}X_p$

$PC_p = a_{p1}X_1 + a_{p2}X_2 + a_{p3}X_3 + ... + a_{pp}X_p$

$PC_1, PC_2, PC_3, . . . , PC_p$ a_{ij} $i = 1, 2, ..., p; j = 1, 2, ..., p$

j *i*

a_{ij}

$a_{i1}^2 + a_{i2}^2 + a_{i3}^2 + \cdots + a_{ip}^2 = 1$ *i* *p*

$a_{i1}a_{j1} + a_{i2}a_{j2} + a_{i3}a_{j3} + \cdots + a_{ip}a_{jp} = 0$ *i ≠j*

a_{ij} *Eigenvectors*

engl. Eigenvalue λ a_i

eigen-

eigen-

C

$$\begin{vmatrix} c_{11} & c_{12} & c_{13} & \dots & c_{1p} \\ c_{21} & c_{22} & c_{23} & \dots & c_{2p} \\ c_{31} & c_{32} & c_{33} & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ c_{p1} & c_{p2} & c_{p3} & \dots & c_{pp} \end{vmatrix}$$

c_{ii} X_i

X_i X_j. *Eigen*

λ_i PC_i λ_i PC_i

eigen-

C

$\lambda_1 + \lambda_2 + \lambda_3$ $\lambda_p = c_{11}$ c_{22} c_{33} c_{pp}

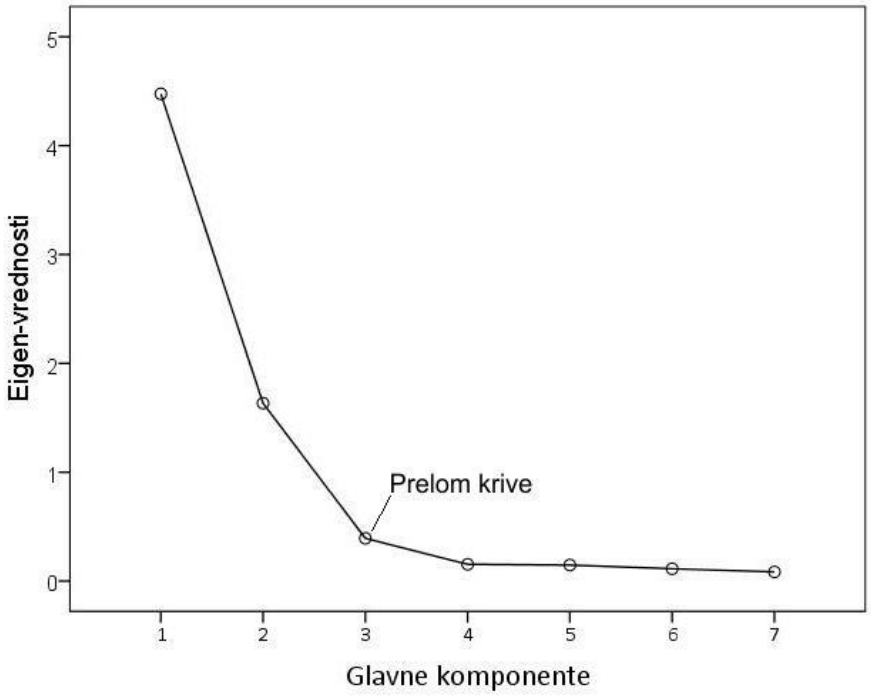
Kaiser

eigen

eigen

eigen

scree



Slika 9. *Cattell*

eigen

Kaiser-Meyer-Olkin

Bartlett *Bartlett's Sphericity test*

Kaiser-Meyer-Olkin

Bartlett

hi

Bartlett

p *p*

varimax *Variance Maximizing*

2.5.4. Analiza grupisanja (*Cluster Analysis*)

Cluster Analysis

Definisanje merila sličnosti

korelacijom, merom udruživanja i merom udaljenosti

Korelacione

Mere udruživanja

Mera udaljenosti

Euclidean

Euclidean d_{rs} *Euclidean Distance*

r

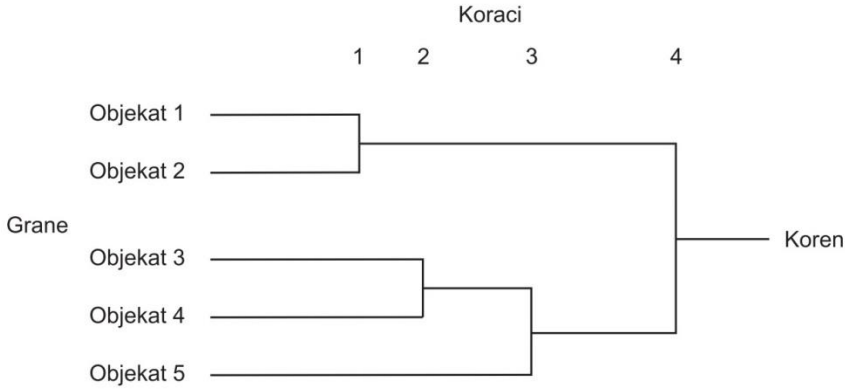
s X_1 X_2

Euclidean d_{rs}^2 *Squared Euclidean Distance* *j*

$$d_{rs}^2 = \sum_{j=1}^{p}(x_{rj} - x_{sj})^2$$

2.5.4.1. Hijerarhijsko i nehijerarhijsko povezivanje objekata u klastere

hijerarhijske metode *Hierarhical Cluster Analysis*



Slika 10.

Single Linkage or the

Nearest Neighbour Method

Complete Linkage or the

Farthest Neighbor Method

Average Linkage Between Groups

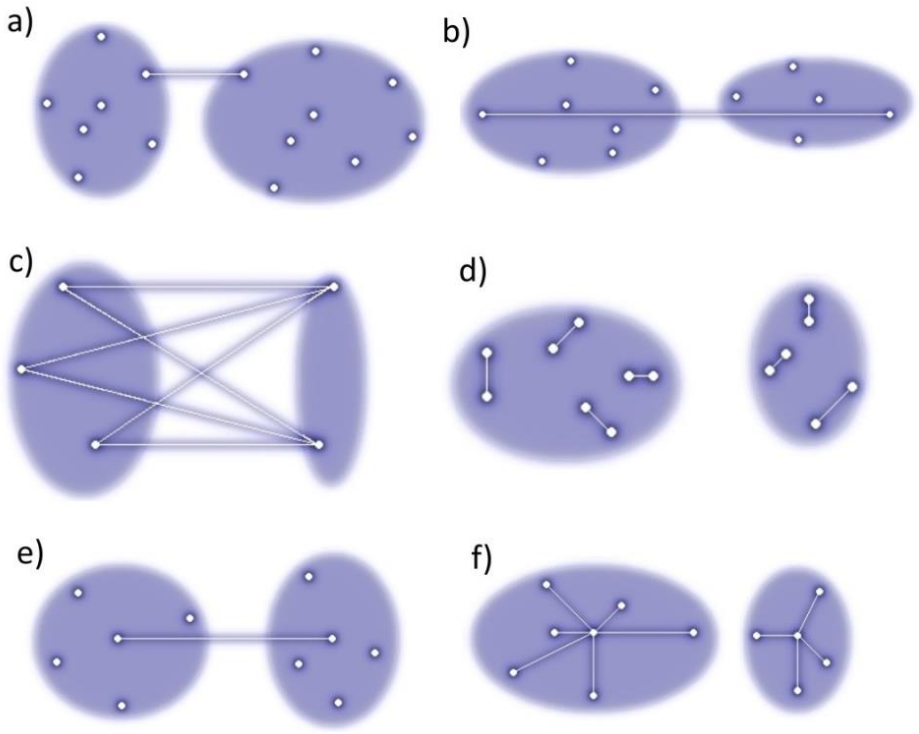
Average Linkage Within Groups

Euclidean

Euclidean

Ward

Error Sum of Squares



Slika 11.

Nehijerarhijska metoda *k* *k - Means Clustering Method*

outliers

2.5.5. Primena PCA i HCA u analizi zemljišta

et al *et al* *et al*

et al

Factor Loading

et al

et al

Total Organic Carbon

et al

et al

background

Factor

Loading

Factor Loading

background *et al*

et al.

Kaiser

eigen-

z *Euclidean*

Ward

et al.

et al

et

al

et al

et al

et al

f f f f et al

et al et al

et al

et al et al

et al et al

3. Eksperimentalni deo

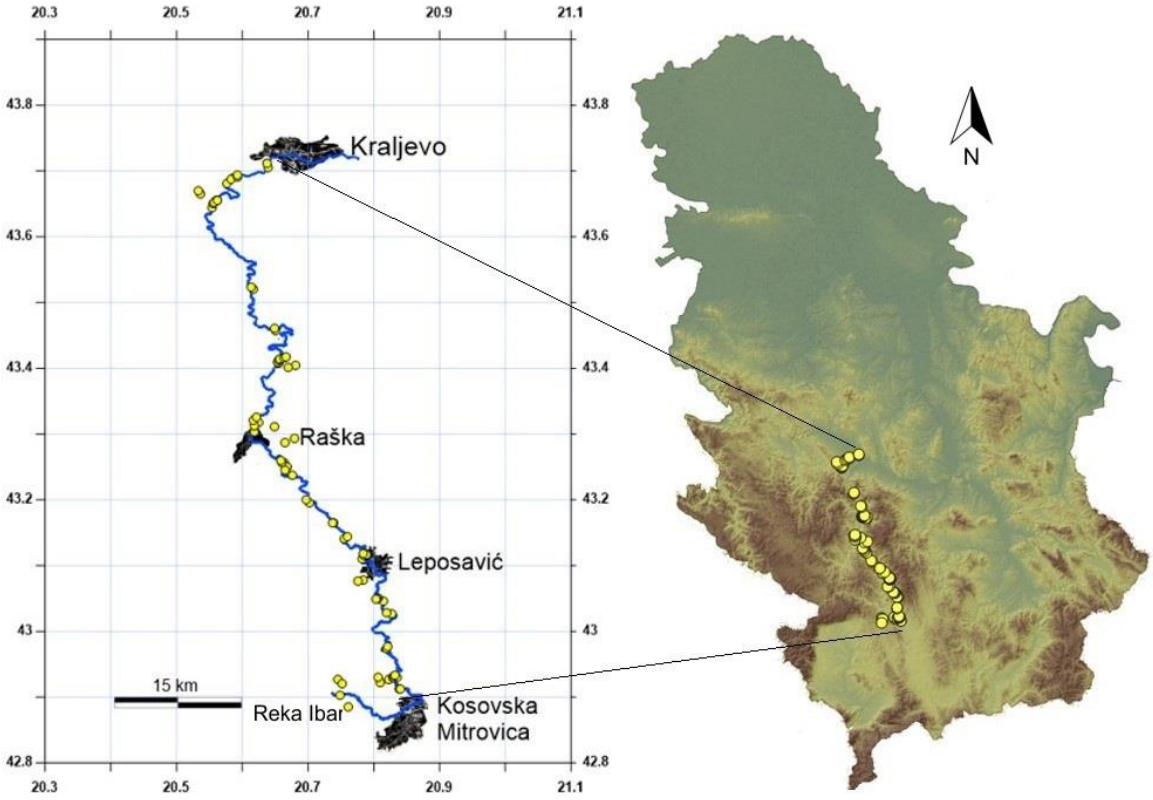
3.1. Plan rada

n

n *n* *n*

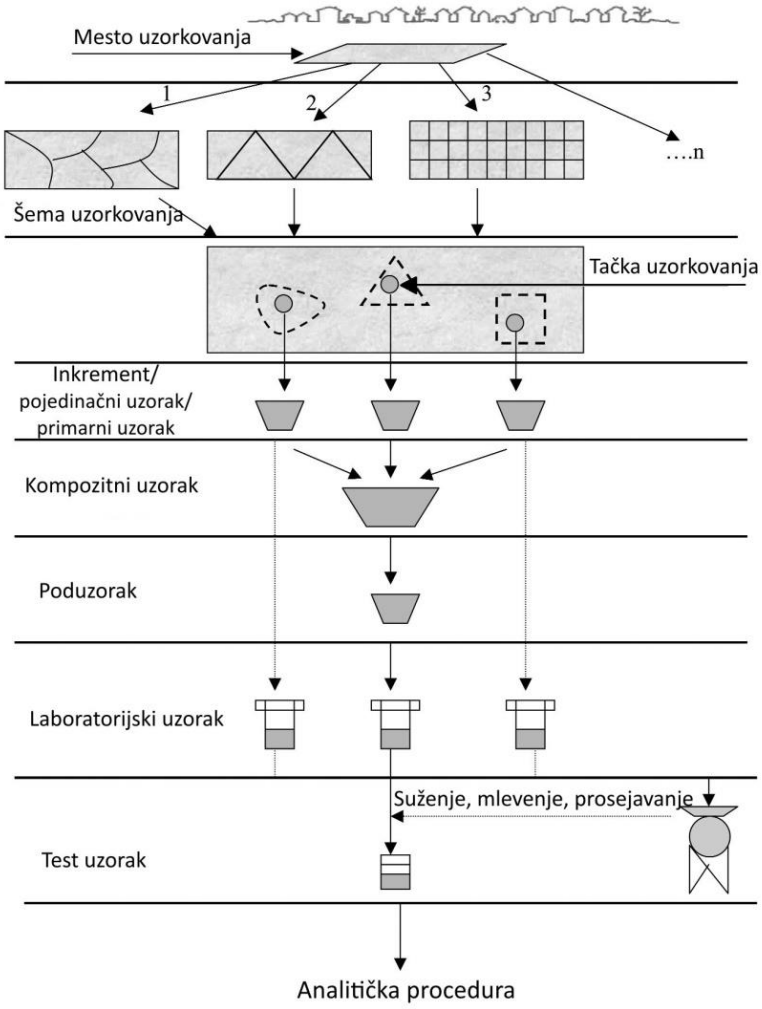
n

3.2. Uzorkovanje poljoprivrednog zemljišta i uzgajanih biljaka

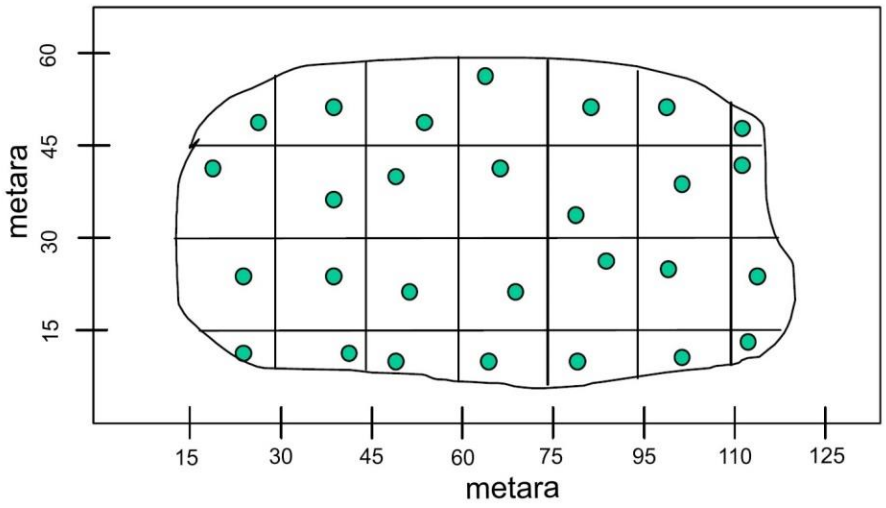


Slika 12.

et al



Slika 13. *et al*



Slika 14.

Slika 15.

3.3. Priprema uzoraka za analizu

3.4. Priprema laboratorijskog materijala i reagenasa

3.4.1. Priprema rastvora za ekstrakciju

et al

U prvom koraku sekvencijalne ekstrakcije

U drugom koraku sekvencijalne ekstrakcije,

trećem koraku sekvencijalne

U četvrtom koraku sekvencijalne ekstrakcije

3.5. Postupak BCR sekvencijalne ekstrakcione procedure

Prvi korak ekstrakcije:

Rotations per Minute

Drugi korak ekstrakcije:

Treći korak ekstrakcije:

Četvrti korak ekstrakcije:

3.6. Mikrotalasna digestija uzoraka krompira i kukuruza

3.7. Uređaji i oprema korišćeni u eksperimentalnom radu

Charge-Injection Device

matrix

match

signal to background ratio

3.8. Kontrola kvaliteta

Detection Limit

Quantification Limit,

SD *a* *SD/a*

SD/a

et al *et al*

r

Institute for Reference Materials and Measurements, Geel, Belgium

RSD *SD* $\bar{x}$

3.9. Fizičko-hemijska karakterizacija uzoraka zemljišta

3.9.1. Kapacitet izmene katjona

engl. Cation Exchange Capacity,

Milli-equivalents of Charge

per 100g of soil

et al

Postupak određivanja.

Parnas-Vagner-

$$\mathrm{CEC} = \frac{(\mathrm{a}-\mathrm{b})\cdot 10}{\mathrm{m}-\mathrm{w}}\ (\mathrm{mmolM}^{+}(100\mathrm{g})^{-1}\ \text{zemljišta})$$

3.9.2. Određivanje teksture zemljišta

Particle Size Distribution,

et al *et al*

$$v = \frac{g d^2 (\rho_s - \rho_v)}{18\mu}$$

v g

d^2 ρ_s ρ_v

μ

3.9.3. Organska materija i pH

$$\text{OM}\ (\%) = \frac{(m_{PDS} - m_P) - (m_{PA} - m_P)}{(m_{PDS} - m_P)} \cdot 100$$

m_P m_{PDS}

m_{PA}

3.10. Procena zagađenja i rizika

Index of Geoaccumulation,

I_{geo} *Potential Ecological Risk Index, RI*

Risk Assessment Code, RAC *Pollution*

Load Index, PLI *Transfer Factor, TF*

Hazard Index, HI

3.10.1. Indeks geoakumulacije (I_{geo})

I

background

et al *et al* *et al* *et al*

et al *et al* *et al*

$$I_{geo} = \log_2 \frac{C_i}{1{,}5 C_{bcg}}$$

C_i C_{bcg}

background

background

et al.,

background

et

al

et al *background*

Tabela 7. *I*

I
I
I
I
I
I
I

3.10.2. Indeks potencijalnog ekološkog rizika (*RI*)

et al

et al *et al*

et al *et al*

C_f^i C_d

E_r *RI*

$$C_f^i = C_i / C_{\mathrm{bcg}}^i$$

$$C_d = \sum_{i=1}^{n} C_f^i$$

$$E_{\mathrm{r}}^i = C_f^i \cdot T_{\mathrm{f}}^i$$

$$RI = \sum_{i=1}^{n} E_{\mathrm{r}}^i$$

C_f^i *i*

background

background

et al

$C_i \geq C_{\mathrm{bcg}}^i$

$C_i \leq C_{\mathrm{bcg}}^i$

C_d

C_d

$n-$ n C_d $n-$ n C_d n

C_d $n-$

C_d

Tabela 8. (C_f^i) C_d n

C_f^i	C_d
C_f^i	C_d
C_f^i	C_d
C_f^i	C_d

$E_{\mathrm{r}}^i)$

C_f^i T_{f}^i

T_{f}^i

C_d *RI*

(E_{r}^i)

Tabela 9. E_{r}^{i}

RI

E_{r}^{i}	*RI*
E_{r}^{i}	*RI*
E_{r}^{i}	*RI*
E_{r}^{i}	*RI*
E_{r}^{i}	*RI*
E_{r}^{i}	

3.10.3. Kod procene rizika (*RAC*)

Risk Assessment Code, RAC

et al

et al *et al* *et al*

et al

Tabela 10 *RAC*

RAC
RAC
RAC
RAC
RAC
RAC

3.10.4. Indeks zagađenja (*PLI*)

engl. Pollution Load Index, PLI

et al

et al *et al*

et al *et al*

$$PLI_{merno\ mesto} = n\sqrt{C_{f1} \cdot C_{f2} \cdot C_{f3} \cdot \ldots \cdot C_{fn}}$$

$$PLI_{zona} = n\sqrt{mesto_1 \cdot mesto_2 \cdot mesto_3 \cdot \ldots \cdot mesto_n}$$

$$PLI_{područje} = n\sqrt{Zona_1 \cdot Zona_2 \cdot Zona_3 \cdot \ldots \cdot Zona_n}$$

C_f *n*

PLI *PLI*

PLI

et al

PLI *et al*

PLI *PLI*

PLI *PLI*

et al *PLI*

PLI *background”* *PLI*

PLI *PLI*

PLI *PLI* *PLI*

3.10.5. Transfer faktor (*TF*)

et al *TF*

$$TF = \frac{C_{biljka}}{C_{zemljiše}}$$

C_{biljka} $C_{zemljište}$

et al *et al*

3.10.6. Procena rizika po zdravlje ljudi

Hazard Quotient, HQ

$$HQ = \frac{CDI}{RfDo}$$

$$CDI = \frac{C \cdot IR \cdot EF \cdot ED}{BW \cdot AT}$$

CDI *C*

IR

et al *EF* *ED*

BW

AT

ED *RfDo*

RfDo *et al*

HQ

HQ

et al *et al* *et al*

Hazard Index, HI

et al

$$HI = HQ_1 \quad HQ_2 + HQ_3 + \cdots + HQ_n$$

HI

HI *et al*

et al

3.11. Statistička obrada podataka

Kolmogorov-Smirnov *Shapiro-Wilk*

Wilcoxon Signed-Rank ,

Mann-Whitney U *t–*

Pearson

Spearma

varimax

Kaiser

Euclidean *Ward*

log

4. Rezultati i diskusija

4.1. Sertifikovani referentni materijal

Recovery

f_1

f_2 f_3 *RSD*

Tabela 11.

	Recovery
f_1	
f_2	
f_3	

4.2. Fizičko-hemijska karakterizacija uzoraka zemljišta

Shapiro-Wilk

Spearman

r = *p* *r =*

p *r =*

p

r = *p*

Tabela 12.

	n	$\bar{x}$	*SD*	*Md*	*Minimum*	*Maksimum*	*Skewness*	*Kurtosis*	*S-W Test*[a]
									p =
									p =
									p =
									p =
									p =
									p =

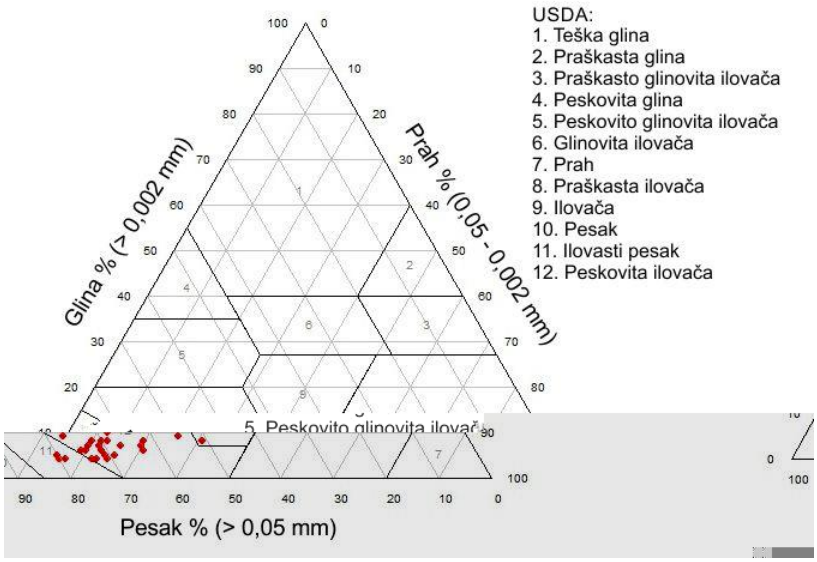
a - Shapiro – Wilk

p *n – broj uzoraka;* $\bar{x}$ *SD –* *Md*

Tabela 13. *Spearman*

	n

Spearman



Slika 16.

4.3. Pseudo-ukupni sadržaj odabranih elemenata u zemljištu

$$c_{pseudo-uk.} = \sum_{i=1}^{4} f_i$$

background”

et al

the New Dutch

List

background”

background”

$$(\mathrm{SW},\ \mathrm{IW})_{\mathrm{b}} = (\mathrm{SW},\ \mathrm{IW})_{\mathrm{sb}} \cdot \frac{\mathrm{A} + (\mathrm{B} \cdot \%\ \mathrm{gline}) + (\mathrm{C} \cdot \%\ \mathrm{OM})}{\mathrm{A} + (\mathrm{B} \cdot 25) + (\mathrm{C} \cdot 10)}$$

gline

OM

Tabela 14.

Tabela 15.

$\bar{x}$									
SD									
Md									
Minimum									
Maksimum									
Skewness									
Kurtosis									
K-S Test[a]	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*

bcg

p Kolmogorov-Smirnov

p n $\bar{x}$ *SD Md –*

Target Value *Intervention Value*

bcg

background” *et al*

background”

Md

et al

et al

background”

Md

Md

Md

Md

Md

Md

Md

Md

4.3.1. Hemometrijska analiza pseudo-ukupnog sadržaja odabranih elemenata u zemljištu

Kolmogorov-Smirnov-

Wilcoxon Signed-Rank *t*

Md *Md*

Md *Md* *Md*

Md *Md* *Md*

Md *Md* *Md*

Md *Md* *Md*

Md *Md* *Md*

Md

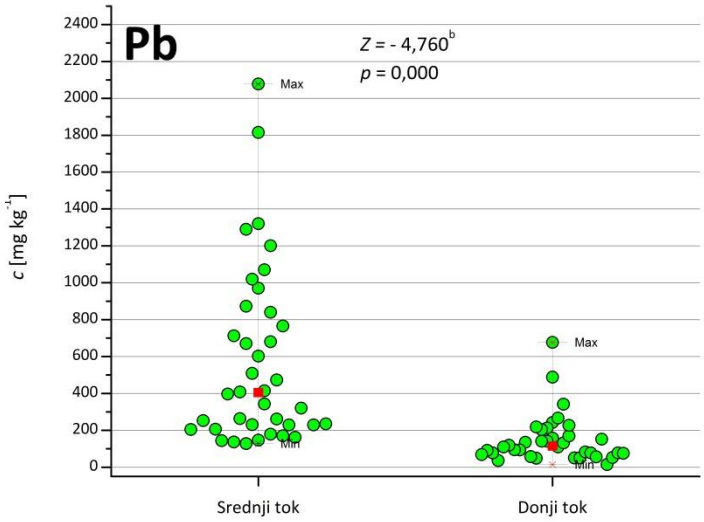
One Sample

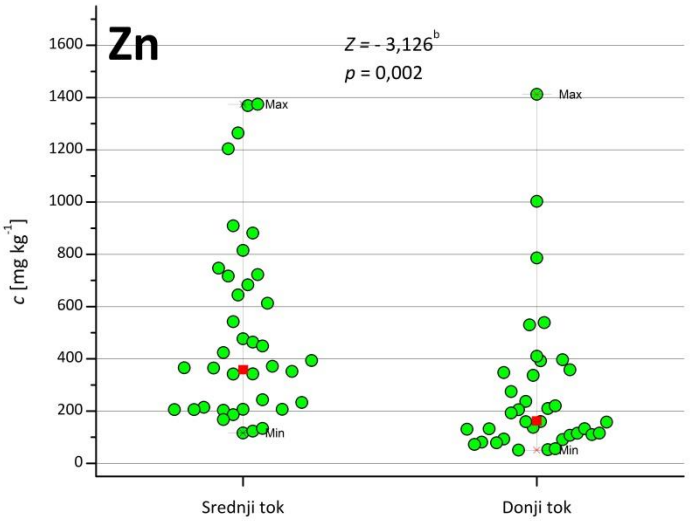
$\bar{x}$ *t*

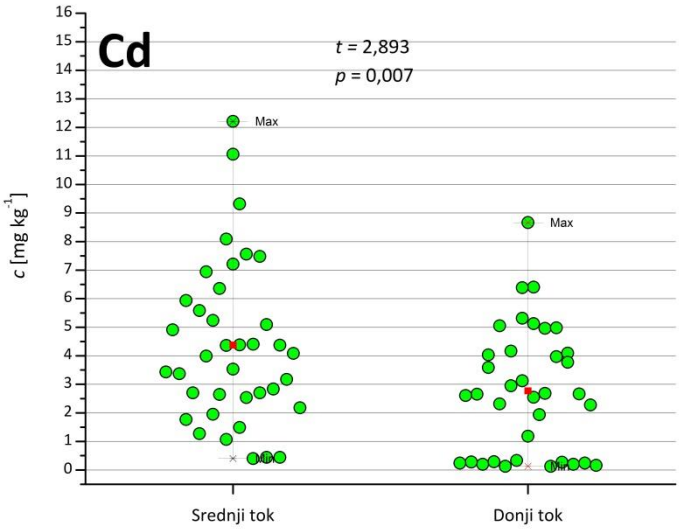
p $\bar{x}$ *t* *p*

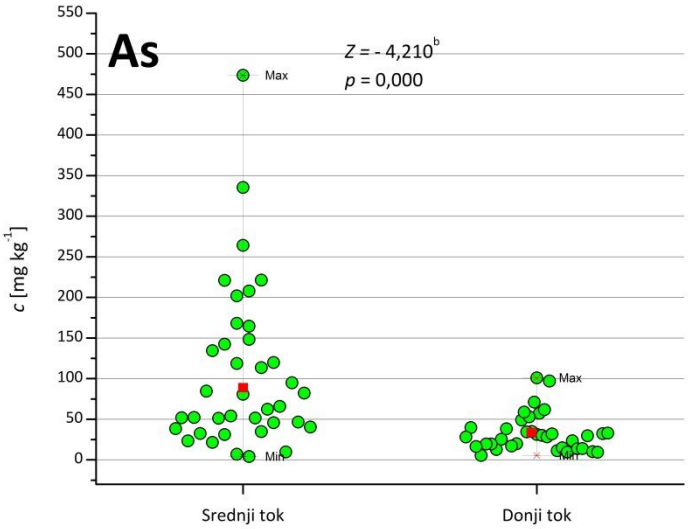
$\bar{x}$ *t* *p*

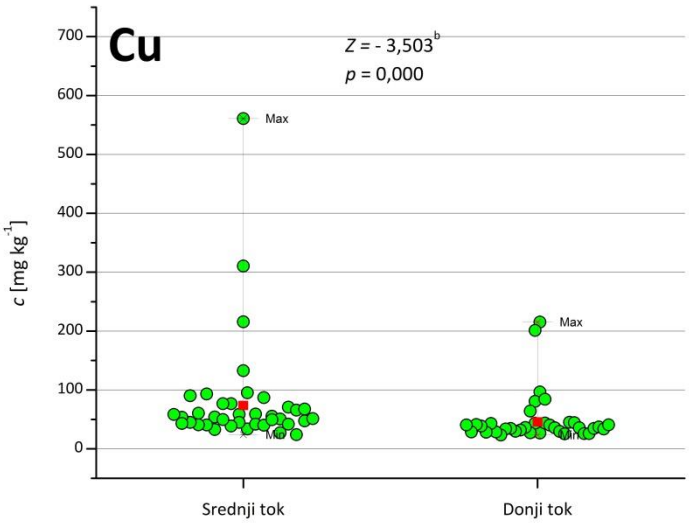
$\bar{x}$ *t* *p*

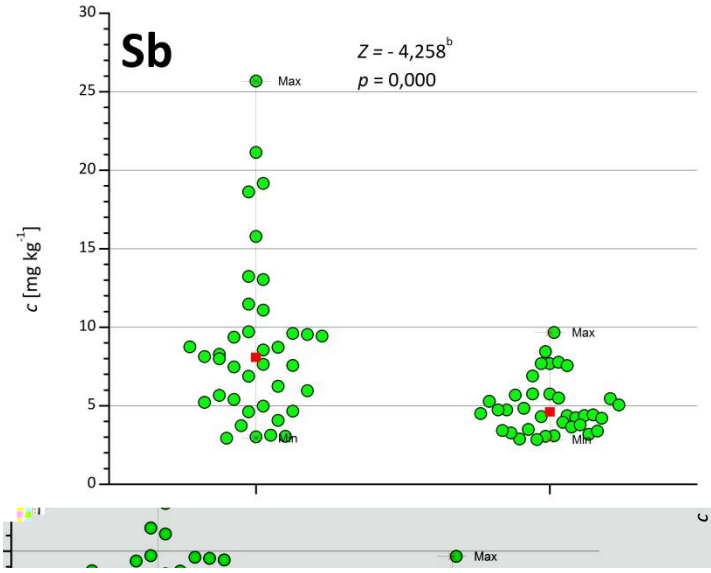

Pb
Z = - 4,760b
p = 0,000
c [mg kg-1]
Max
Min
Srednji tok
Donji tok


Zn
Z = - 3,126b
p = 0,002
c [mg kg-1]
Max
Min
Srednji tok
Donji tok


Cd
t = 2,893
p = 0,007
c [mg kg-1]
Max
Min
Srednji tok
Donji tok


As
Z = - 4,210b
p = 0,000
c [mg kg-1]
Max
Min
Srednji tok
Donji tok


Cu
Z = - 3,503b
p = 0,000
c [mg kg-1]
Max
Min
Srednji tok
Donji tok


Sb
Z = - 4,258b
p = 0,000
c [mg kg-1]
Max
Min

Slika 17.

n

n

4.3.1.1. Korelaciona analiza

et al *et al* *et al*

Spearman

Tabela 16. *Spearman*

n =

r

p

r = *p* *r =*

p *r =* *p* *r =* *p*

r = *p*

r = *p* *r =*

p

et al

r = *p*

et al

et al

et al

et al

et al

Tabela 18. *Kajzer-Majer-Olkin-*
Bartlett

Bartlett	
	p

Cattell *scree*

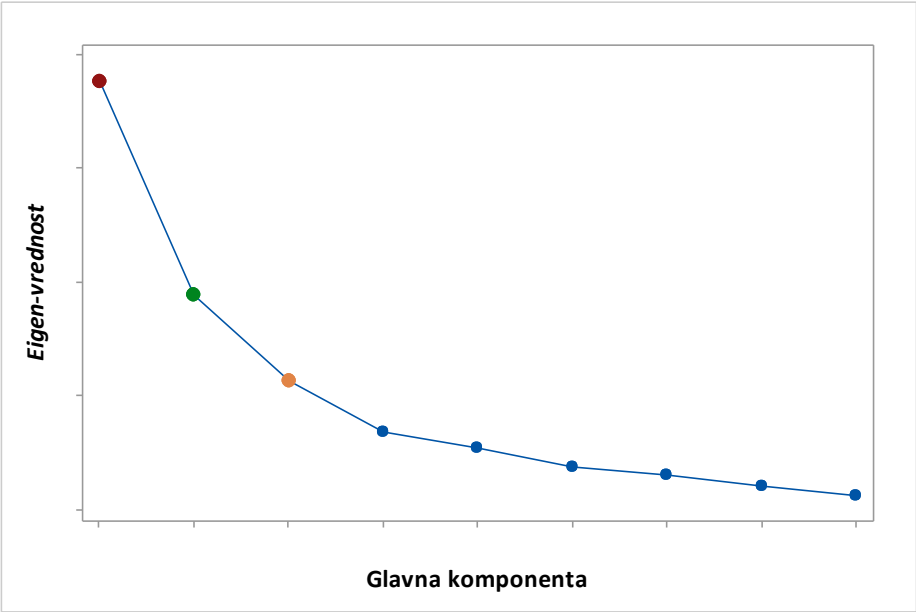
Cattell

Kaiser-

Morrison

Kaiser

eigen



Slika 18. *eigen*
Scree plot

Tabela 19.

	eigen

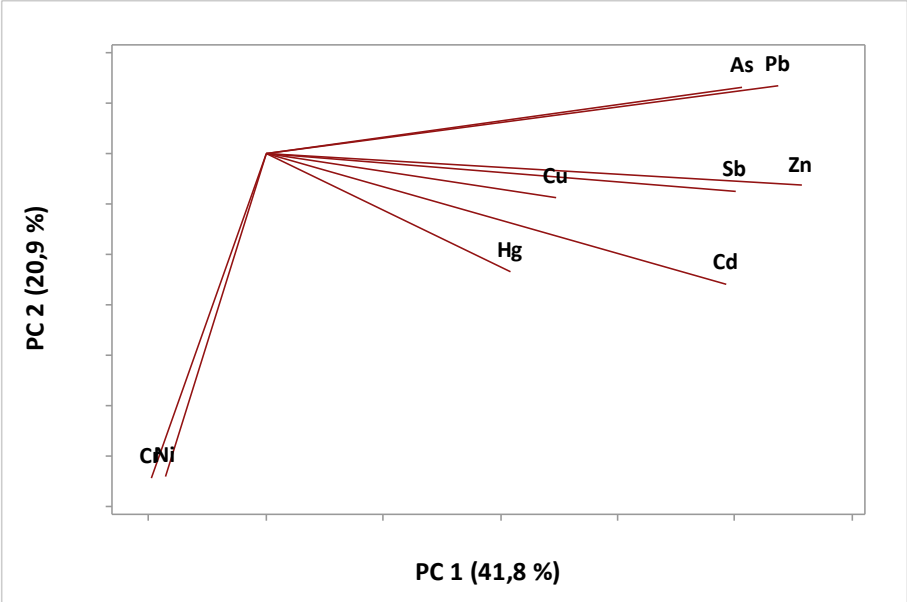
Communalities

Tabela 20.

	0,847		
	0,887		
	0,761		
		0,880	
		0,883	
			0,758
	0,789		
	0,777		

Eigen

Factor Loadings



Slika 19.

varimax

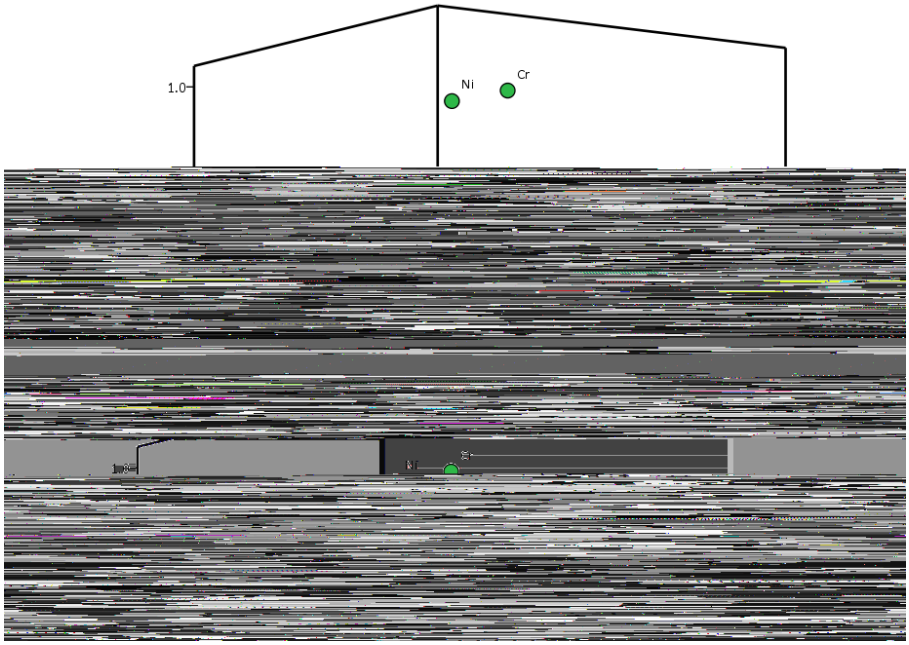
varimax

varimax

varimax

Tabela 21 *Varimax*

	0,832		
	0,824		
	0,764		
		0,895	
		0,899	
			0,849
	0,764		
	0,564		
	0,802		
Eigen			



Slika 20.

Factor Loading)

varimax

varimax

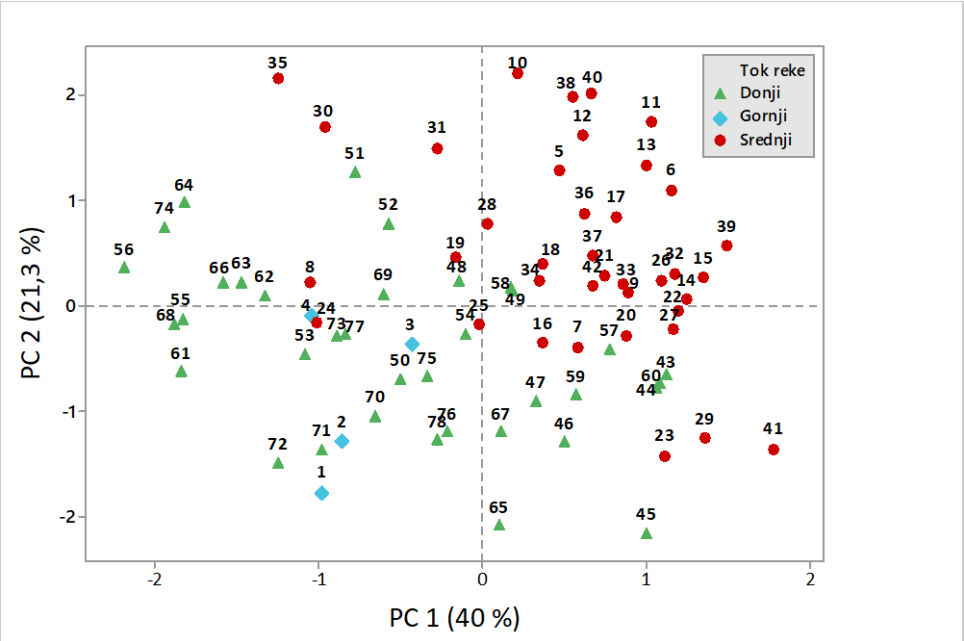
log

varimax

et al *et al*

varimax

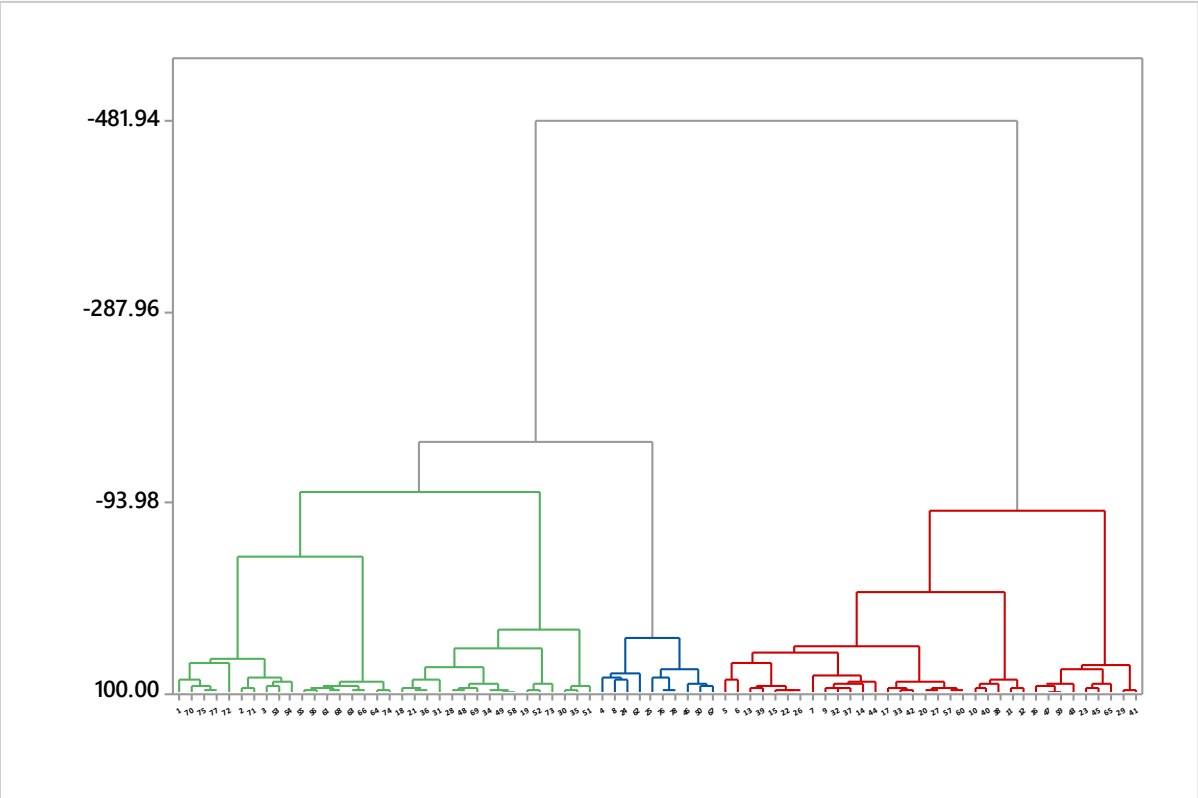
n



Slika 21.

4.3.1.3. Analiza grupisanja (Cluster Analaysis)

Ward- *Euclidean*



Slika 22.

Ward Linkage

Md

Md *Md* *Md* *Md*

Md

Md *Md* *Md*

Md *Md* *Md*

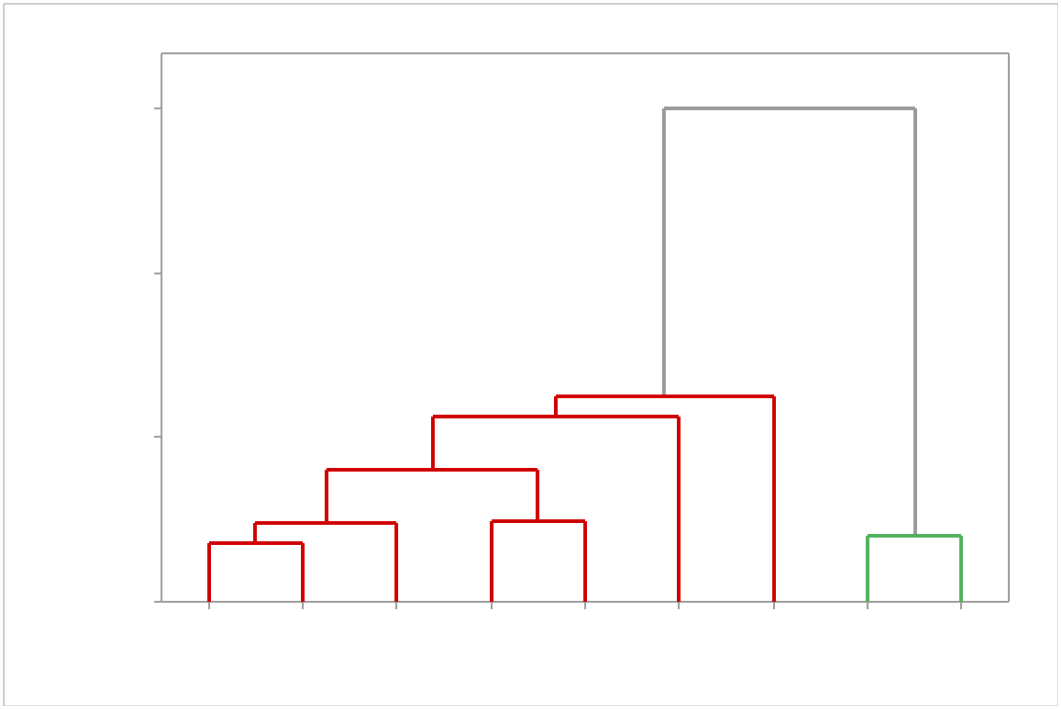
Md *Md*

Md

Md

Md *Md* *Md* *Md*

Md



Slika 23.

4.3.2. Procena zagađenja i rizika

4.3.2.1. Indeks geoakumulacije (I_{geo})

Muller *I* *I*

I

I

I

I

I

I

I

I

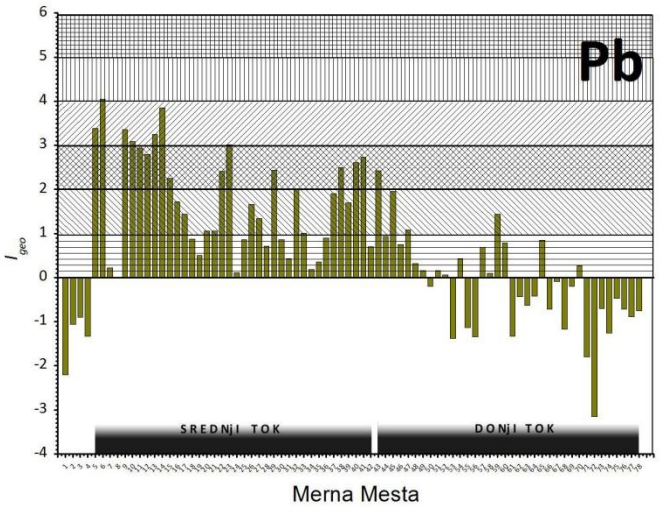
I

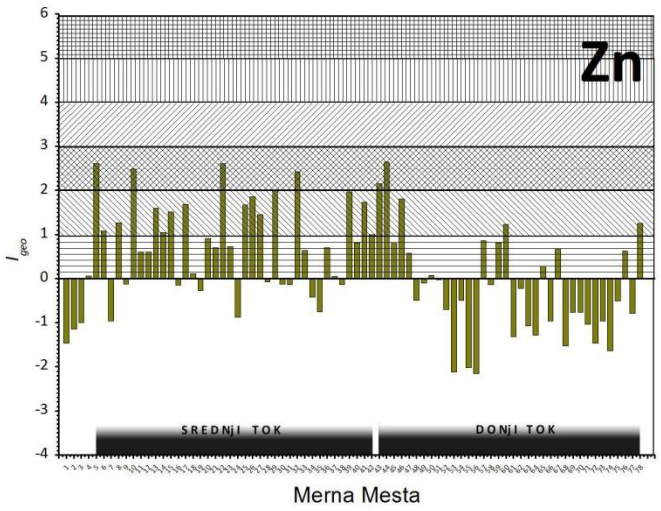
I

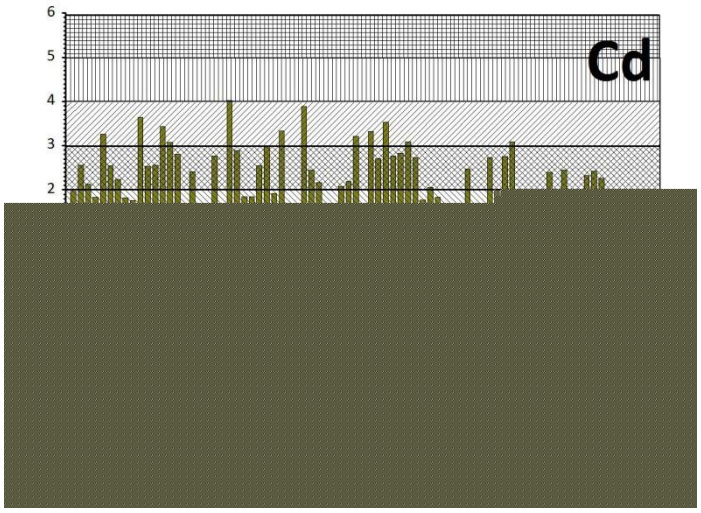
I

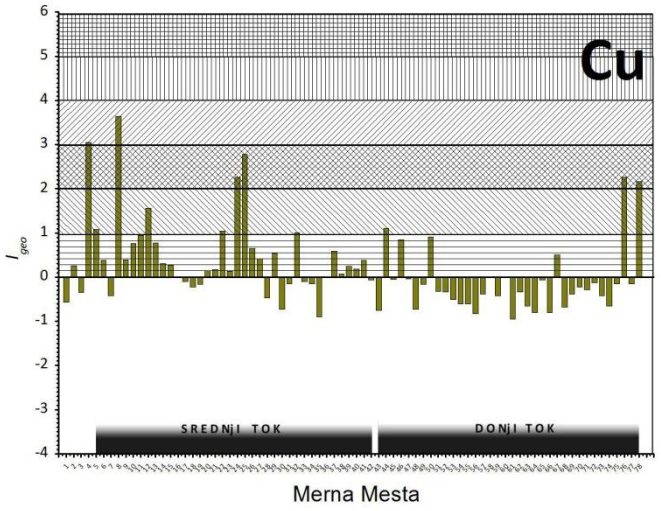
I_{geo} klasifikacija zemljišta:

Klasa 6	Ekstremno zagađeno
Klasa 5	Veoma do ekstremno zagađeno
Klasa 4	Veoma zagađeno
Klasa 3	Umereno do veoma zagađeno
Klasa 2	Umereno zagađeno
Klasa 1	Nezagadjeno do umereno zagađeno
Klasa 0	Nezagađeno

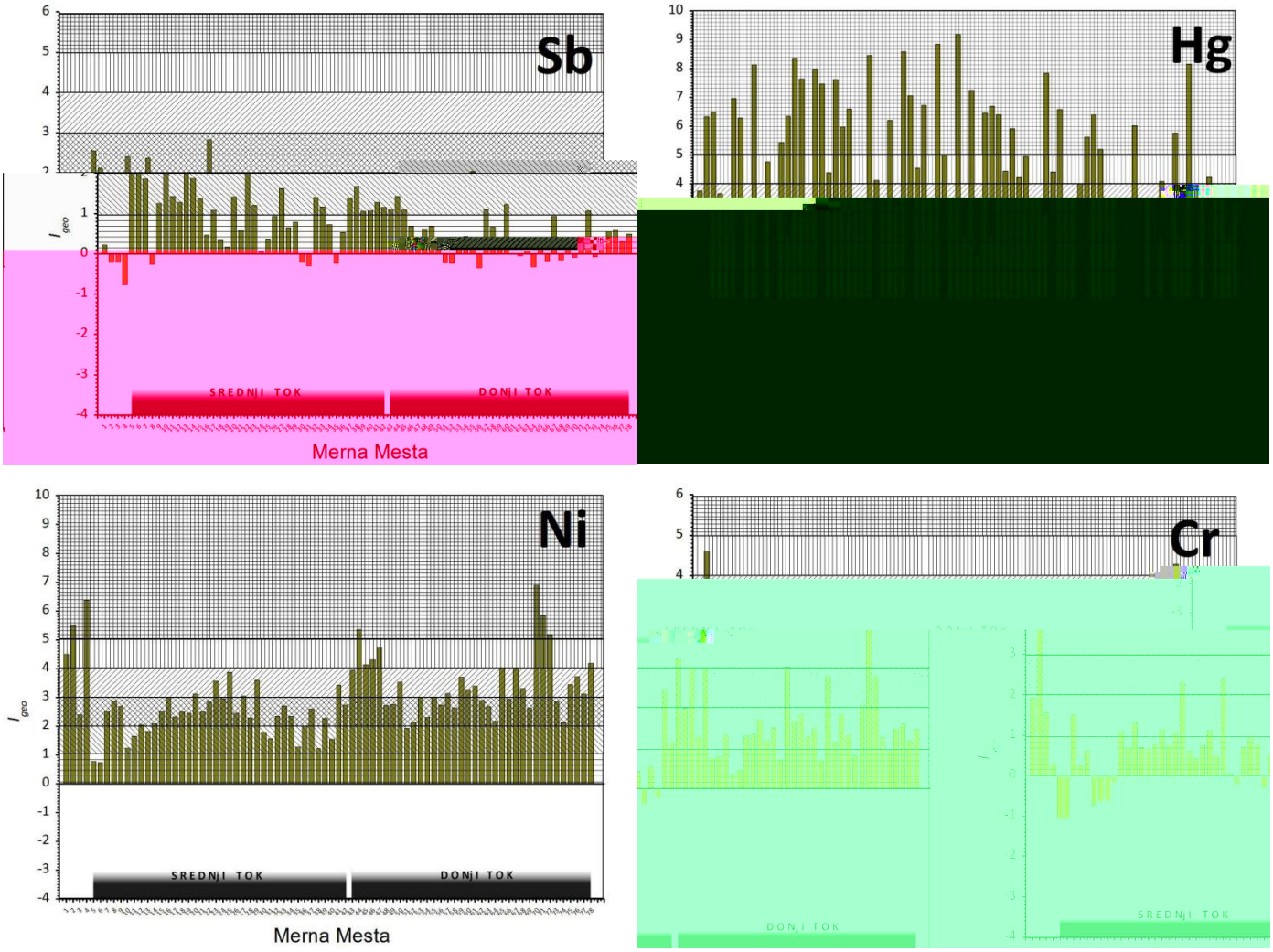








Slika 24. *I*



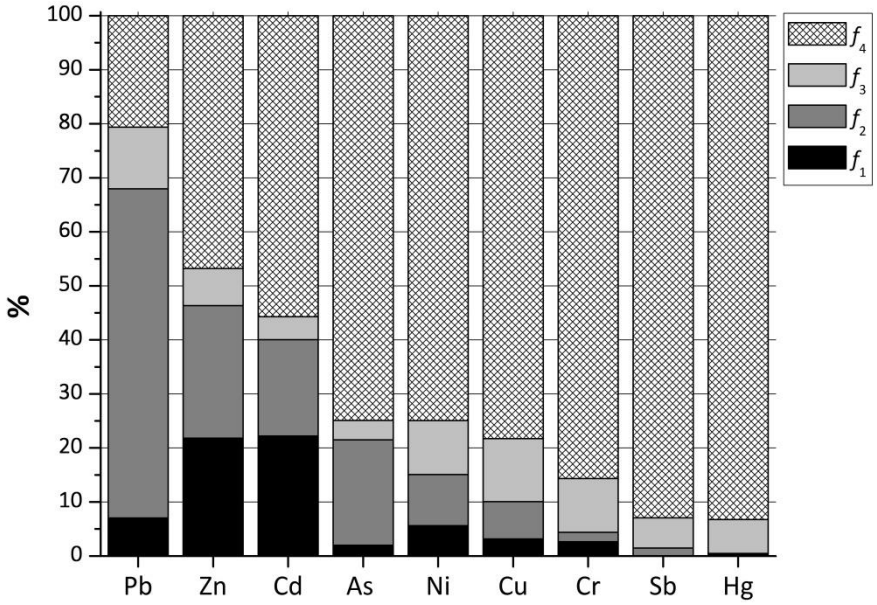
Slika 24. *Nastavak*

PLI

PLI *n* *PLI* *n* *PLI* *n*

PLI

4.4. Frakcionisanje odabranih elemenata u poljoprivrednom zemljištu



Slika 26.

n

f_1

et al

f_2

et al *et al*

f_3

et al

et al f_4

et al *et al*

et al *et al* *al* *et al*

f *f* *f*

Tabela 24.

n	$\bar{x}$	*SD*	*Md*	*Minimum*	*Maksimum*	*Skewness*	*Kurtosis*	*K-S Test*[a]
f								*p*
f								*p*
f								*p*

4.4.1. Hemometrijska analiza frakcionisanja elemenata u zemljištu

Kolmogorov-Smirnov-

Wilcoxon Signed-Rank *t*

Olovo

$\bar{x}$

RAC

f

$\bar{x}$

$\bar{x}$

t *p*

f

f

et al

$\bar{x}$

f $\bar{x}$

$\bar{x}$

f

Wilcoxon Signed-Rank test: Z *p*

f

f

et al *et al*

f

et al *et*

al *et al* *f*

et al *f*

f

$\bar{x}$

f

$\bar{x}$

$\bar{x}$

f

f

f

f

f f

et al

Cink i kadmijum

f

$\bar{x}$ $\bar{x}$

RAC

et al

et al

et al *f*

f

f

f

f $\bar{x}$

$\bar{x}$

t *p*

f $\bar{x}$

$\bar{x}$

Z

p

r = *p*

f

$\bar{x}$

f $\bar{x}$

$\bar{x}$

f

Z p

f

$\bar{x}$

$\bar{x}$

$\bar{x}$ Z p

f_3

f f

f

f f f

Arsen

f $\bar{x}$

$\bar{x}$

et al

f

$\bar{x}$ $\bar{x}$

Z *p*

f

f

f *Z* *p*

f *Z* *p*

f

> f f f *RAC*

Bakar

f

$\bar{x}$

f f f

f

f

f

RAC

f

Antimon i živa

f

f₂ *f*

f *f₂* *f*

f

f

et al *f*

et

al *f*

f

f

et al *et al*

et al *et al*

f

Hrom i nikal

f

$\bar{x}$

f

$\bar{x}$

f

Z p f $\bar{x}$

$\bar{x}$

f

f

$\bar{x}$

$\bar{x}$ $\bar{x}$

f f

$\bar{x}$

Z *p*

$\bar{x}$

4.4.1.1. Identifikacija osnovnih supstrata odabranih elemenata u zemljištu

f *f* *f*

f

f *f* *f*

f

f *f*

f *f* *f* *r*

p

f

f *f*

f f r p

f f

f

f r p

f

f f r p

Tabela 25. *Spearman*

	Fe				Mn				Mg				Ca				Si				Al			
	f	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*
f																								
f					0,644*											0,534*								
f					0,613*																			
f					0,591*										0,270	0,591*								
f					0,697**							0,636*												
f					0,657*							0,552*												
f					0,662**							0,532*												
f					0,666**							0,568*												
f					0,635*							0,559*												
f					0,657*							0,596*												
f					0,662**							0,587*												
f					0,530			0,600*																
f				0,670**					0,982**								0,574*	0,622*	0,688**					
f				0,653*					0,908**								0,749**	0,789**	0,793**					
f				0,653*					0,908**								0,749**	0,789**	0,793**					
f				0,552*					0,873**		0,644*						0,552*	0,613*	0,591*					
f				0,644*					0,925**	0,596*	0,591*						0,600*	0,648*	0,714**					
f				0,538*					0,763**								0,780**	0,776**	0,701**					
f				0,565*					0,789**								0,776**	0,785**	0,705**					
f				0,591*					0,798**	0,604*	0,596*						0,560*	0,591*	0,534*					
f	0,616*										-0,539*													
f										-0,543*	-0,607*													
f										-0,543*	-0,607*													
f																								
f																								
f												0,577*												
f												0,577*												
f												0,537*												
f																								
f																								
f																								
f																								0,736**
f																								
f																								
f																								
f																0,670**								

4.4.1.2. Analiza glavnih komponenti (Principal Component Analysis)

outlier f_1, f_2 *i* f_3

f_1, f_2 *i* f_3 f_1

f_4

Kajzer-Mejer-Olkin *Bartlett*

p

Kaiser-

eigen

varimax

Tabela 26 *Pearson* *n*

	f	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*
f																				
f																				
f																				
f																				
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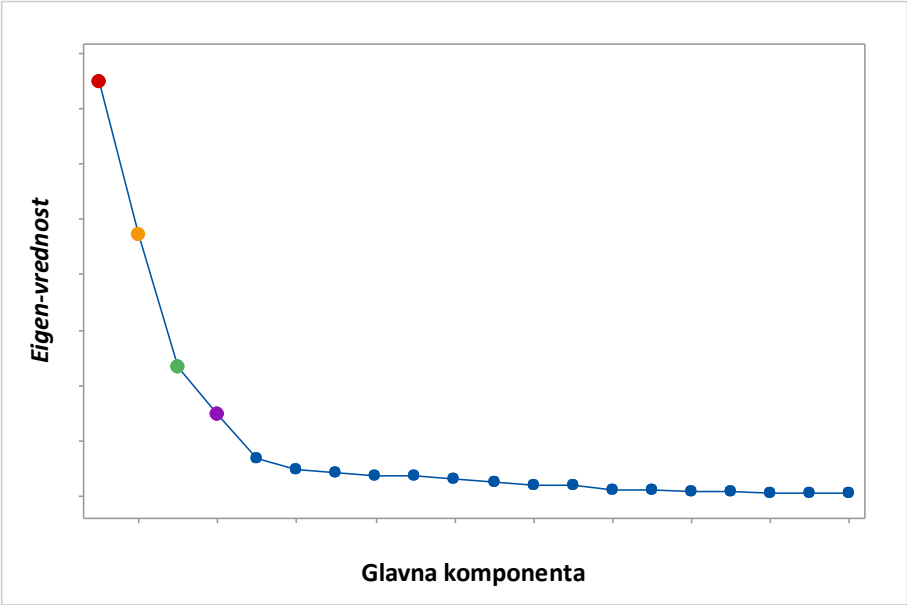
Tabela 27. *Kajzer-Majer-Olkin-*
Bartlett

Bartlett

p



Slika 27. *eigen*
Scree plot

Tabela 28. *Varimax*

frakcija
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
f
Eigen

Factor loadings

varimax

f f f f f

f f f f

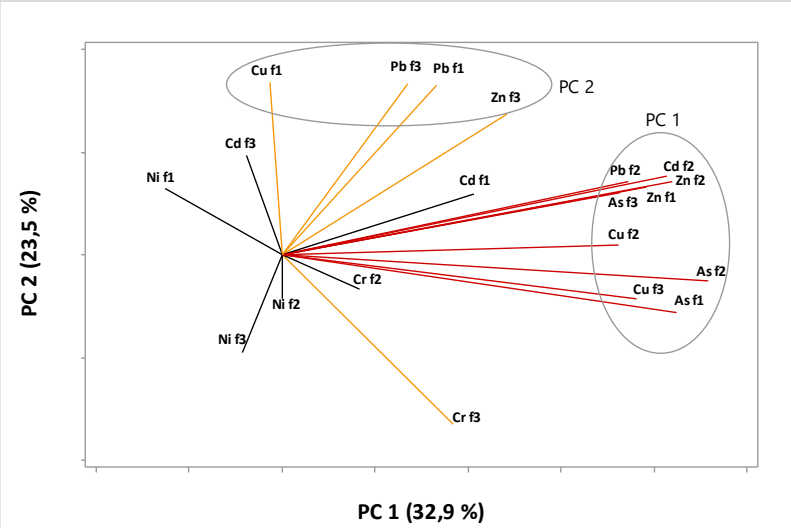
f f

f f f f

f

f

f



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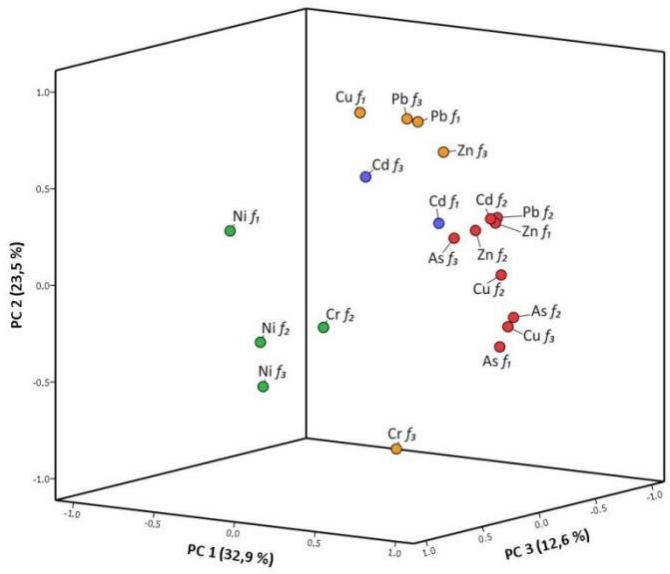


Slika 29.

f f f f

et al

f

f

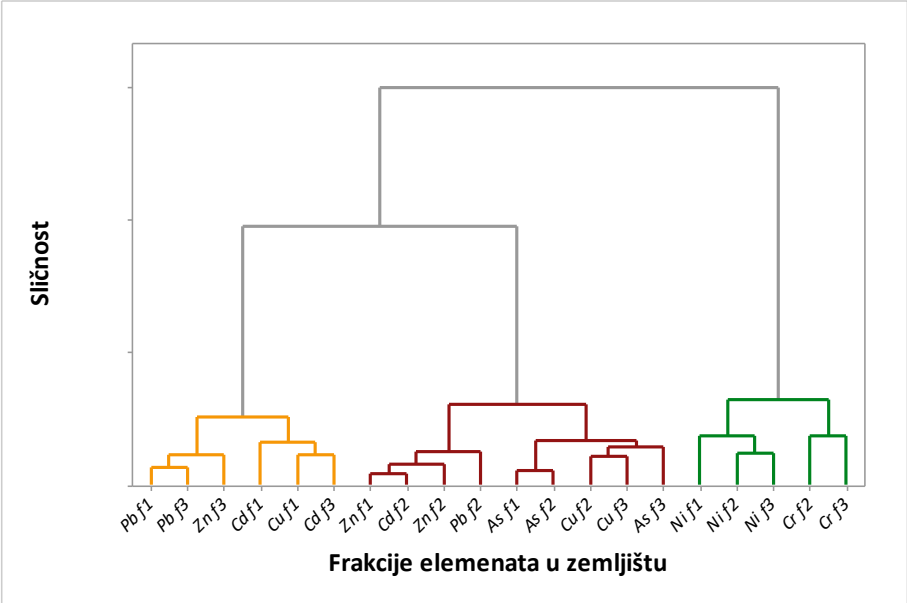
f f f

f f

4.4.1.3. Analiza grupisanja (Cluster Analaysis)

Ward-

Euclidean



Slika 30.

et al

et al *et al*

f f f f f f

f

4.5. Sadržaj odabranih elemenata u analiziranim biljkama

Zea mays *Solanum tuberosum*

Mann-Whitney U

Wilcoxon Signed-Rank

4.5.1. Transfer odabranih elemenata iz zemljišta

TF

et al

Md *Md*

Md *Md*

Md *Md*

Md *Md*

Md

TF *Md*

Md *Md*

Md *Md*

Md *Md*

Md *Md*

TF

et al

et al *et al* *et al* *et al*

et al *et al*

TF

TF

TF

TF

TF

et al

TF

TF

TF

Tabela 29. *Zea mays*

Solanum tuberosum

	n	$\bar{x}$	*SD*	*Md*	*Minimum*	*Maksimum*	*Skewness*	*Kurtosis*	*K-S Test*[a]
									p
									p
									p

4.5.2. Koncentracije odabranih elemenata u analiziranim biljkama

Md

Md

Mann-Whitney U

U *p*

et al

Md =

Md =

U *p*

Md =

Md =

U p

et al

root barrier effect

et al *et al*

Md =

Md =

U p

et al

et al

Food Standards Program

Md =

Md =

U p

f

background

hot-spot

Md =

Md =

n n

U p

et al

Md =

Md =

U

p

U *p*

Md

Md =

p

Z *p*

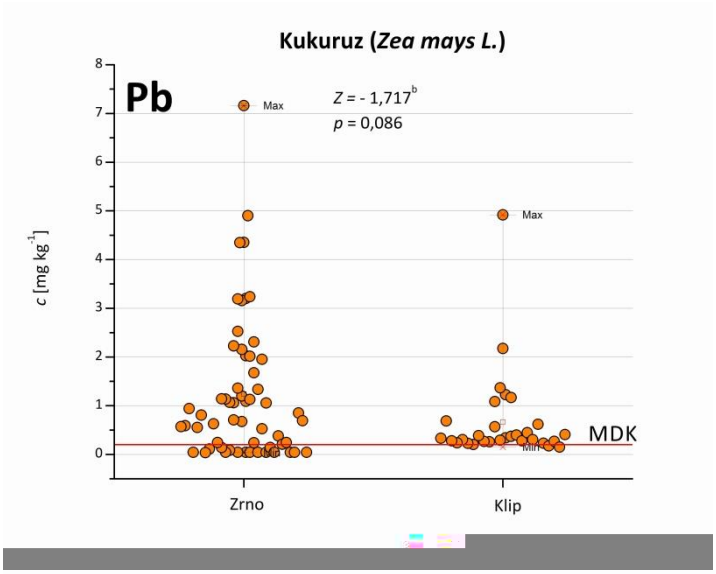
Z *p*

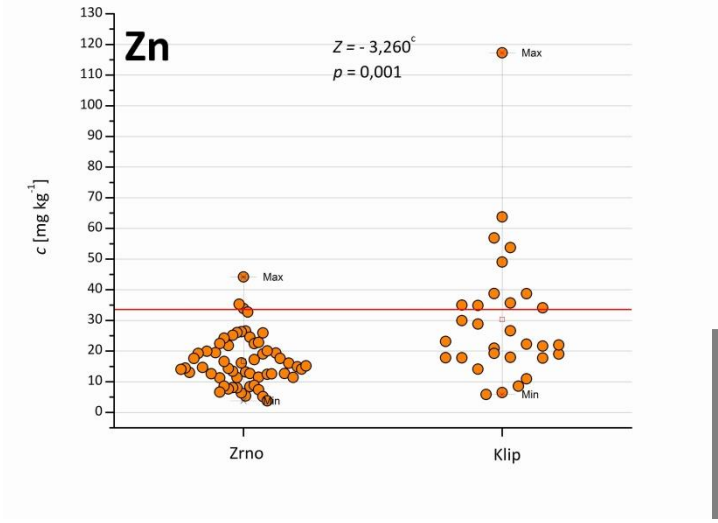
Wilcoxon

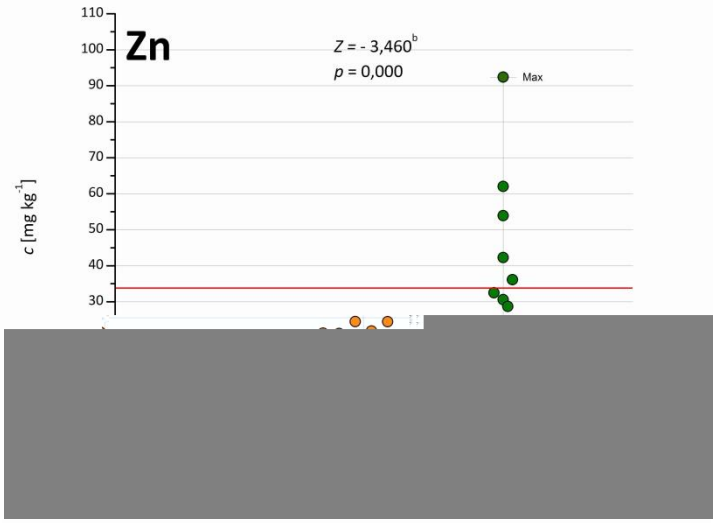
Signed-Rank

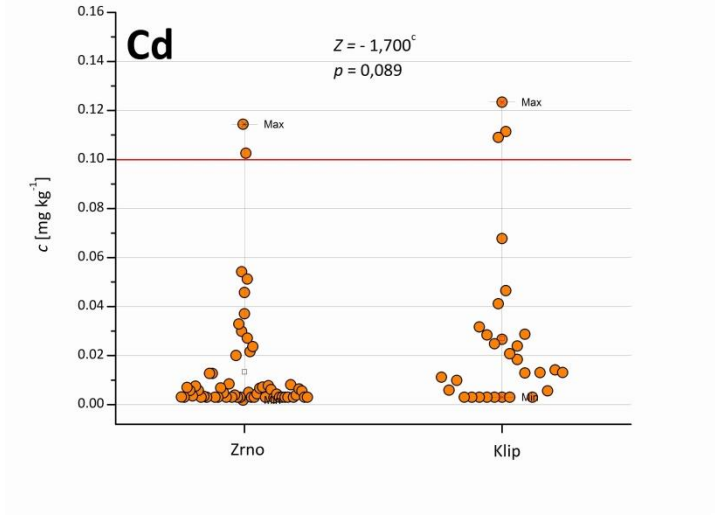
Wilcoxon Signed-Rank

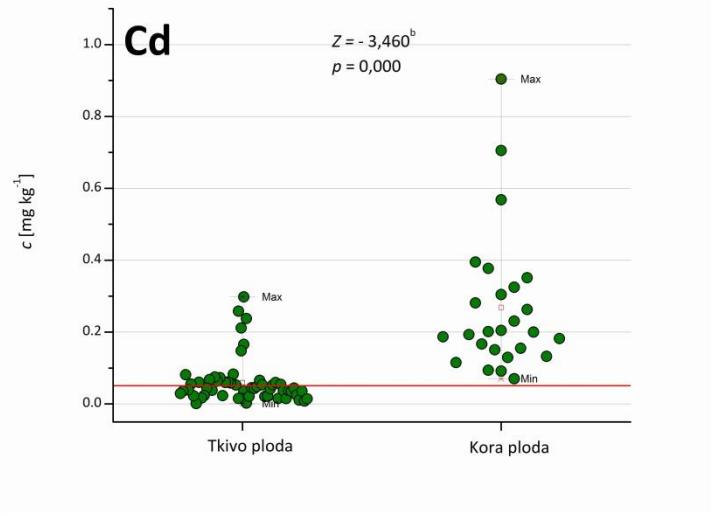
p



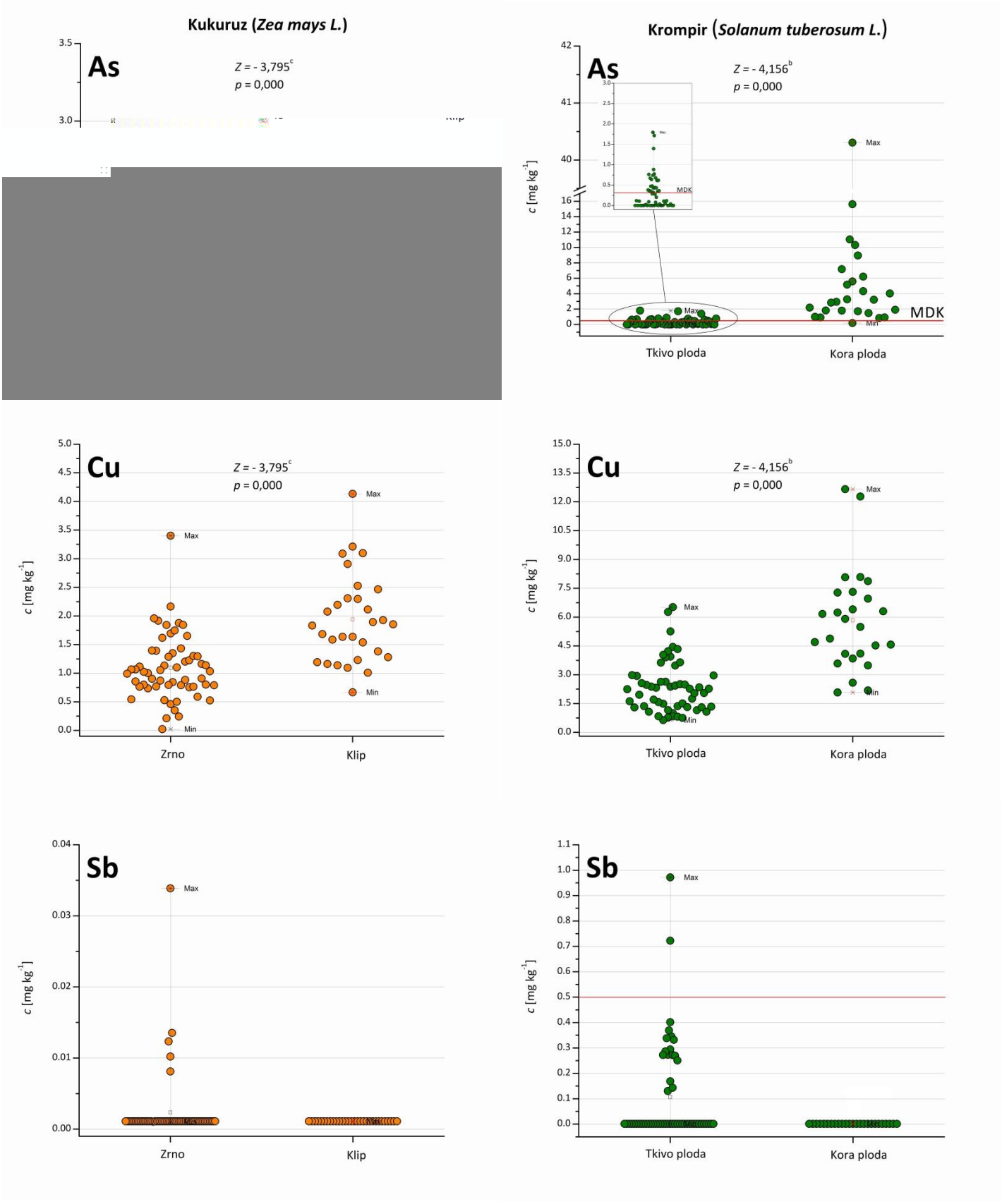




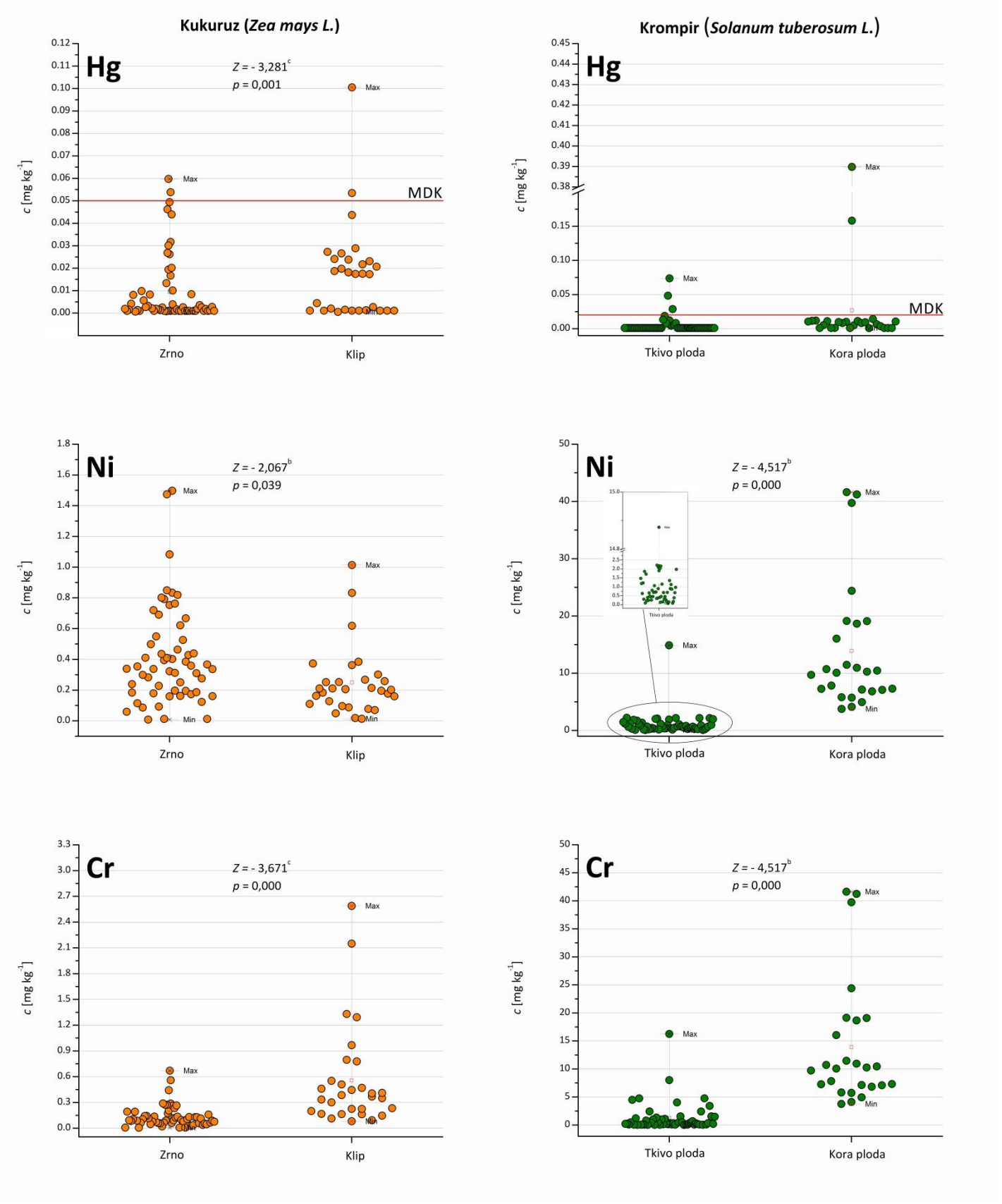




Slika 31. *Zea mays* *Solanum tuberosum*



Slika 31. *Nastavak*



Slika 31. *Nastavak*

4.5.3. Korelaciona analiza

Speraman

p

f f

f *f*

f

f

f

f

f f f

Tabela 30. *Spearman*

	f	*f*	*f*	*f*

p

f

f *f* *f*

r *p* *r*

p

f *r* *p*

f

p

r *p*

et al

et al

4.5.4. Zdravstveni aspekti konzumiranja *Zea mays* L. i *Solanum tuberosum* L.

Tabela 31.

	RfDo	*CDI*	*HQ*

HI

RfDo

CDI

HI

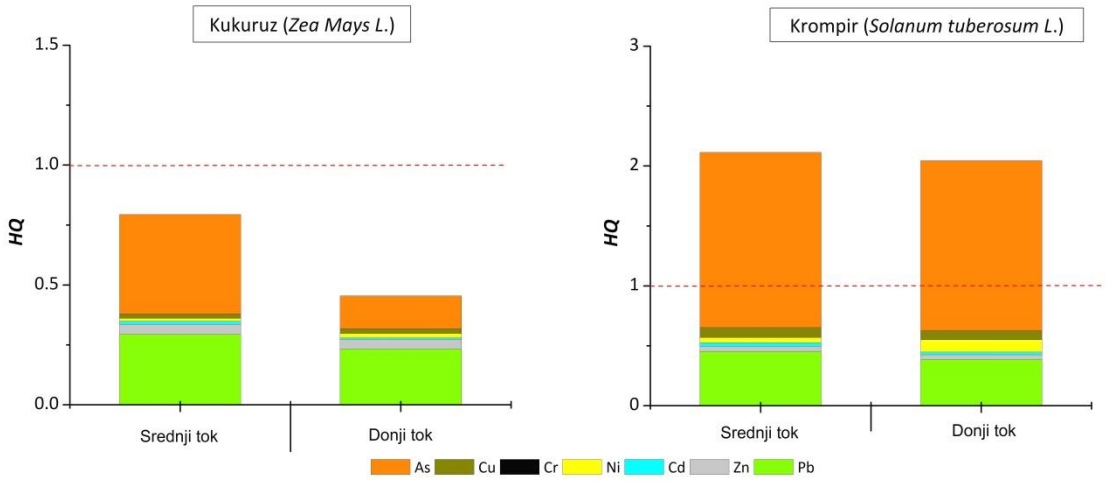
HQ

HI *HQ*

HQ

HQ

HI



Slika 32.

5. Zaključak

I

RI *PLI* *I*

C_d

RI *RI*

PLI

TF

HI

HI

HQ

HQ

6. Literatura

Zea mays *Solanum tuberosum*

Zea mays

Solanum tuberosum

Triticum aestivum *Zea mays*

PRILOZI

Tabela P1.

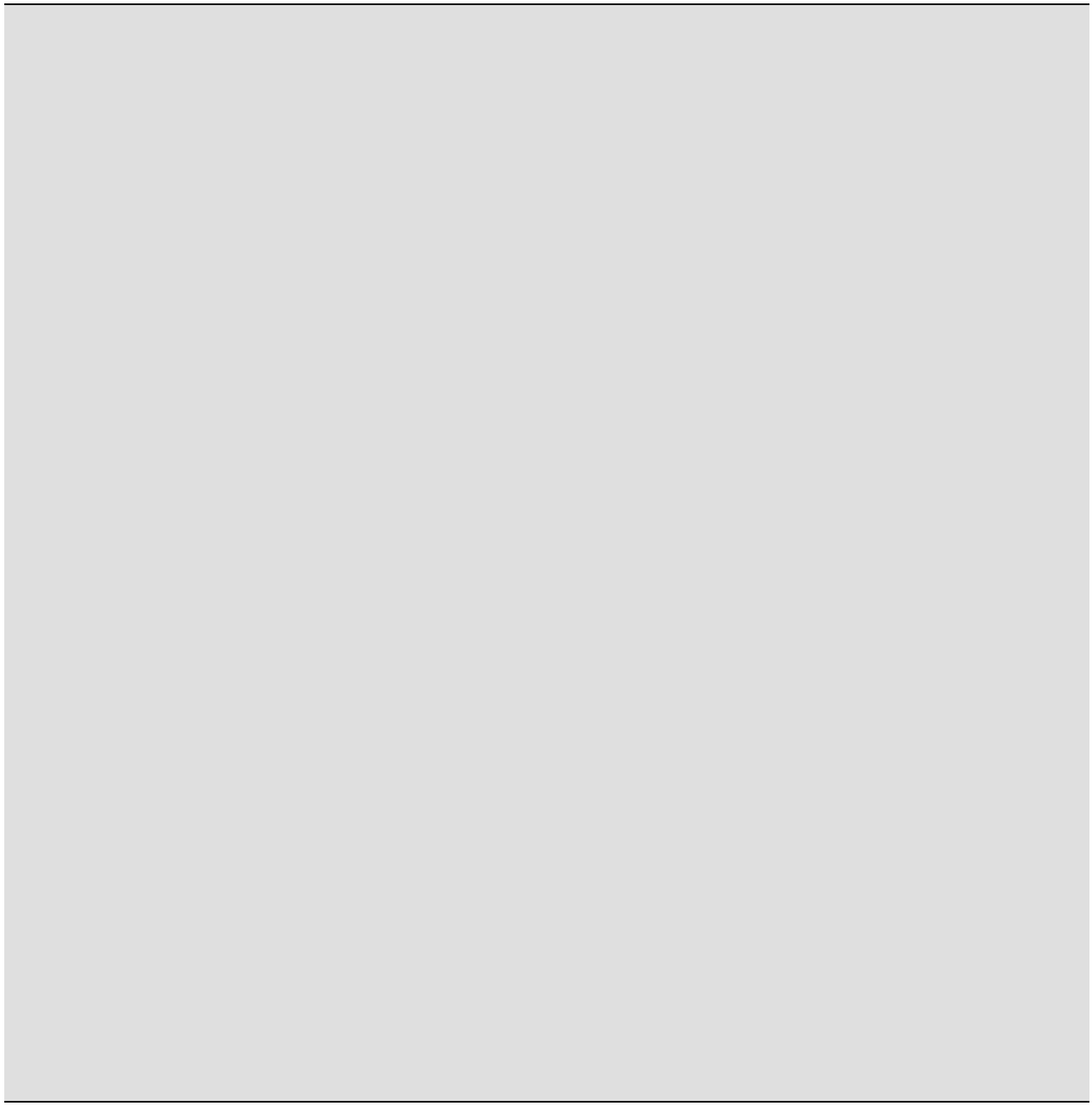
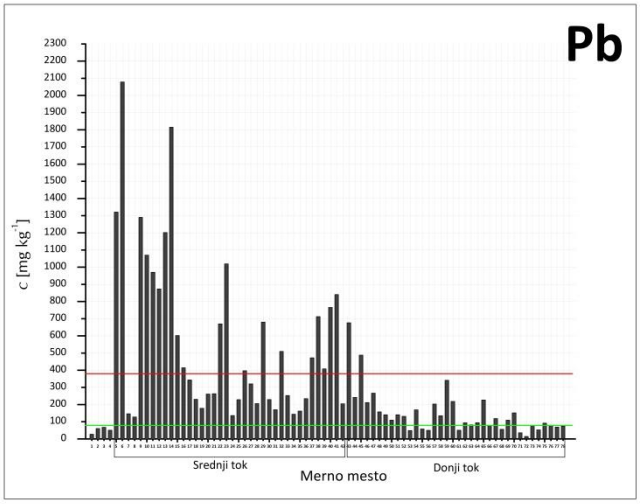
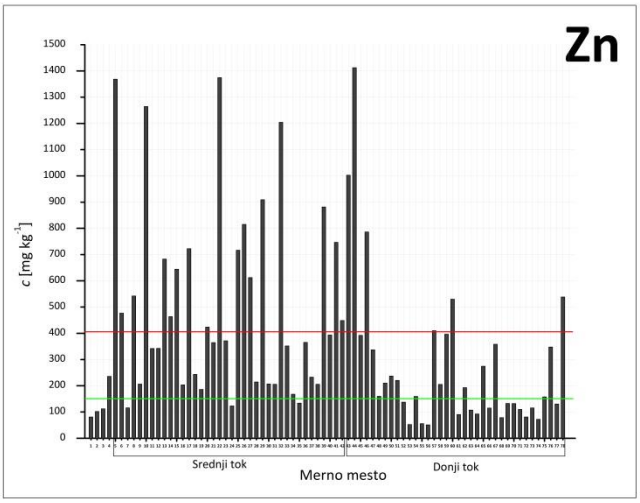
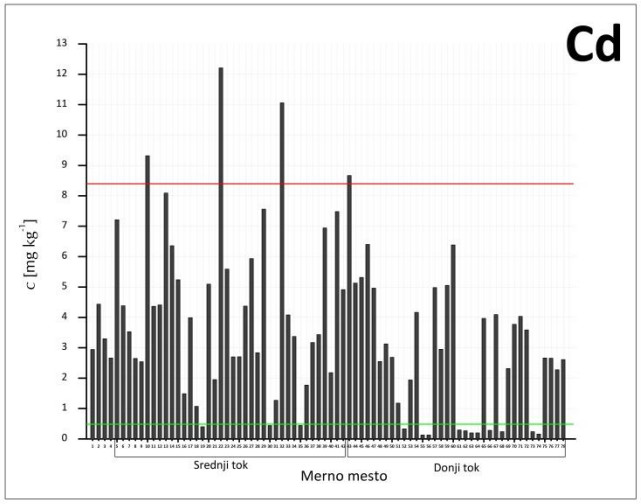
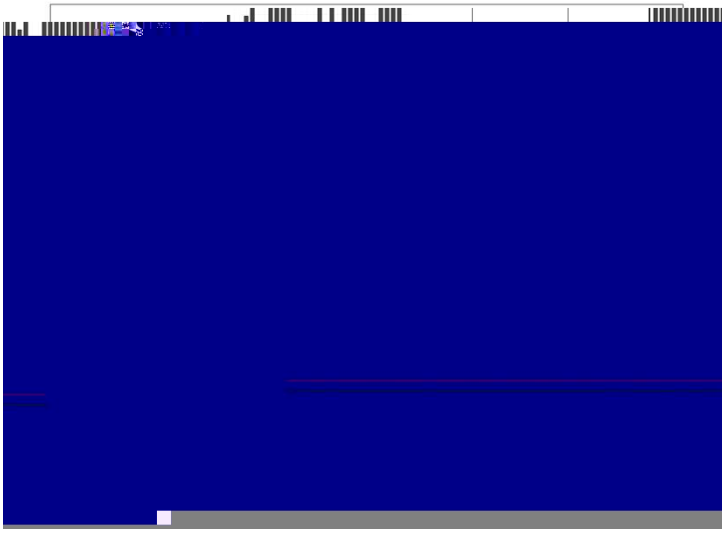


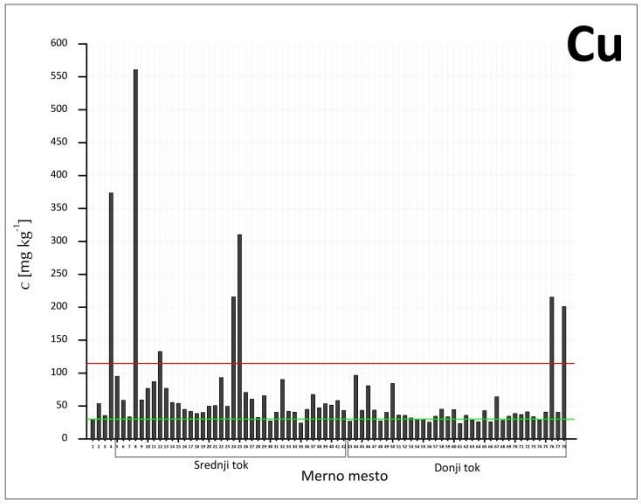
Tabela P1. *Nastavak*

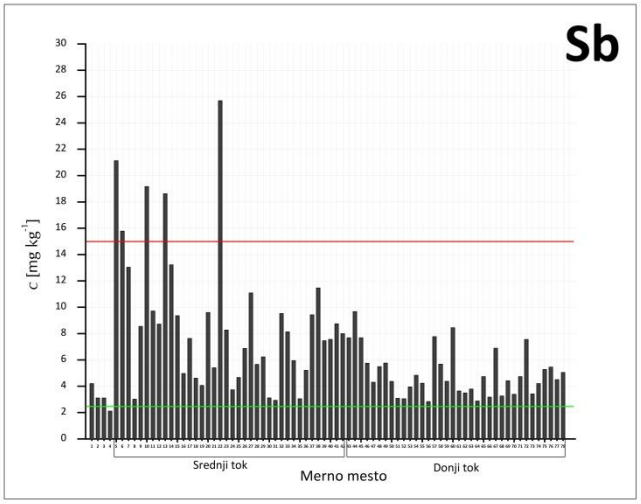

Pb
c [mg kg-1]
Srednji tok
Donji tok
Merno mesto


Zn
c [mg kg-1]
Srednji tok
Donji tok
Merno mesto

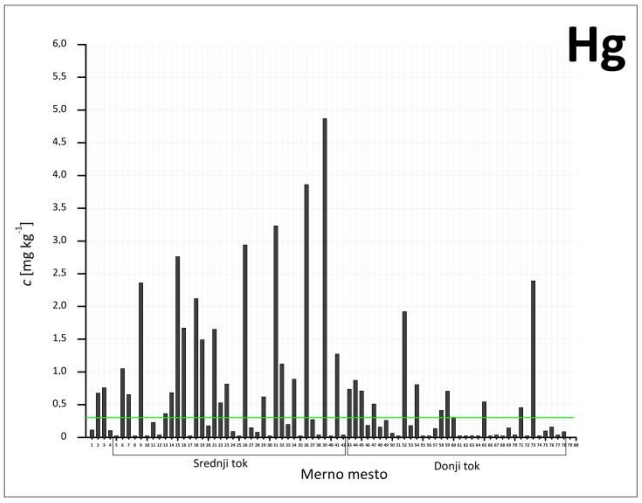

Cd
c [mg kg-1]
Srednji tok
Donji tok
Merno mesto

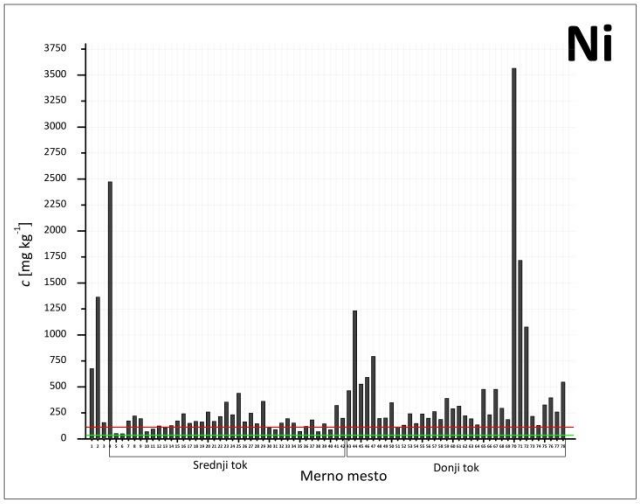


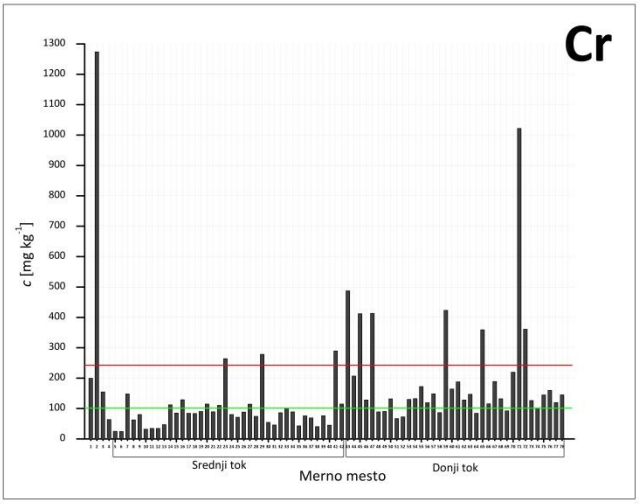

Cu
c [mg kg-1]
Srednji tok
Donji tok
Merno mesto


Sb
c [mg kg-1]
Srednji tok
Donji tok
Merno mesto

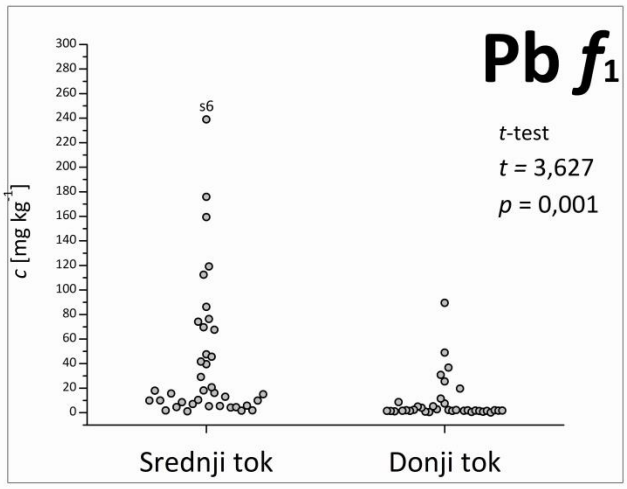
Slika P1.

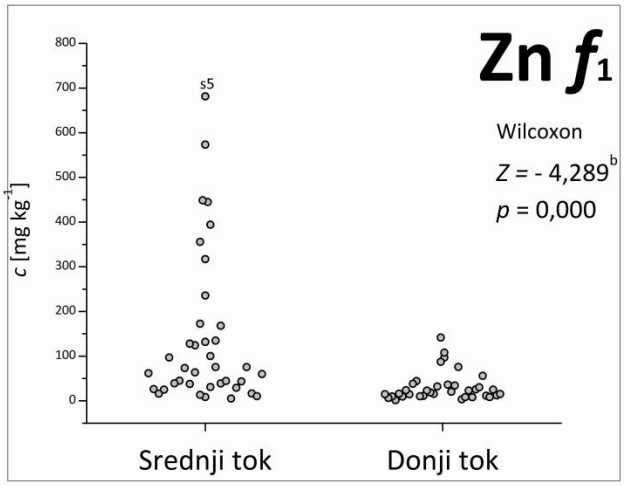


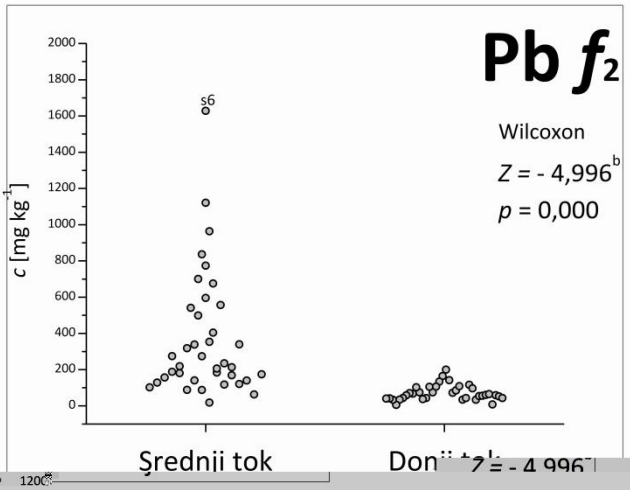


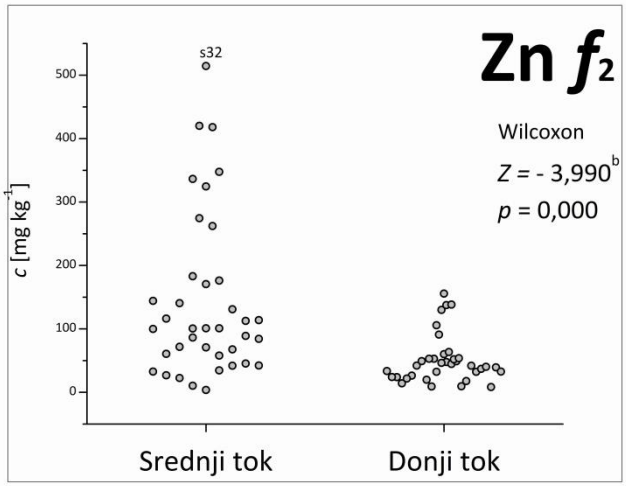


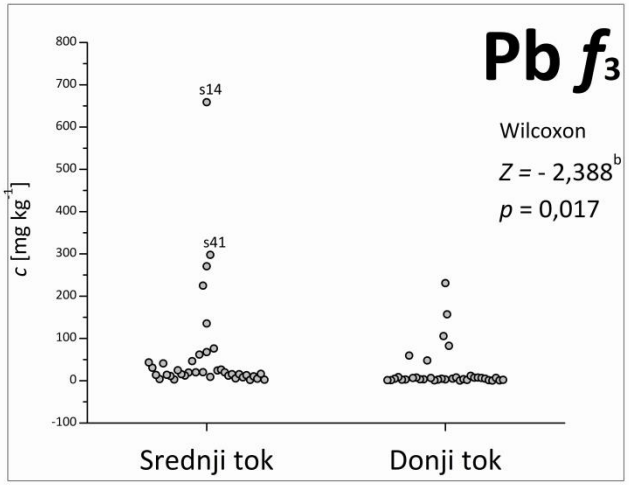
Slika P1. *Nastavak*

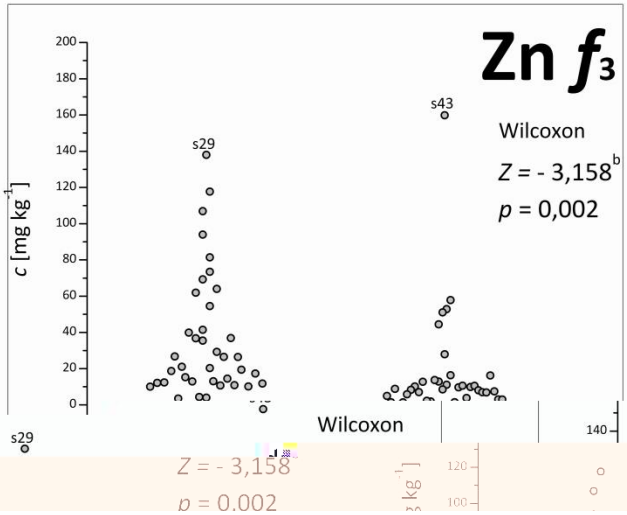








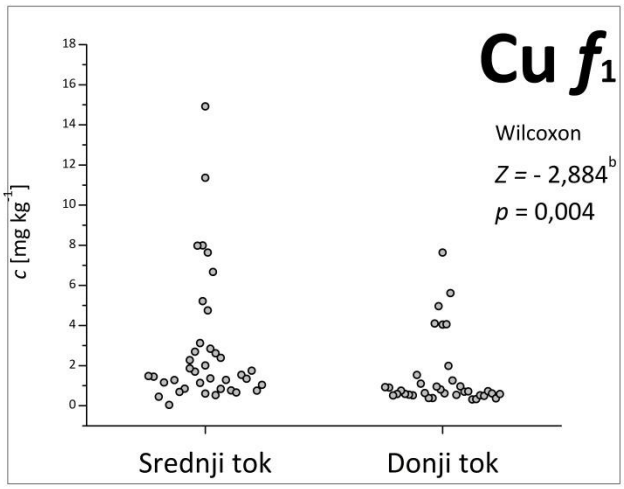


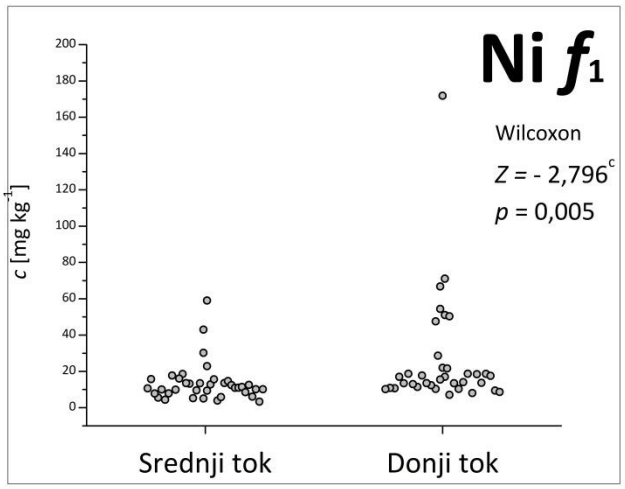


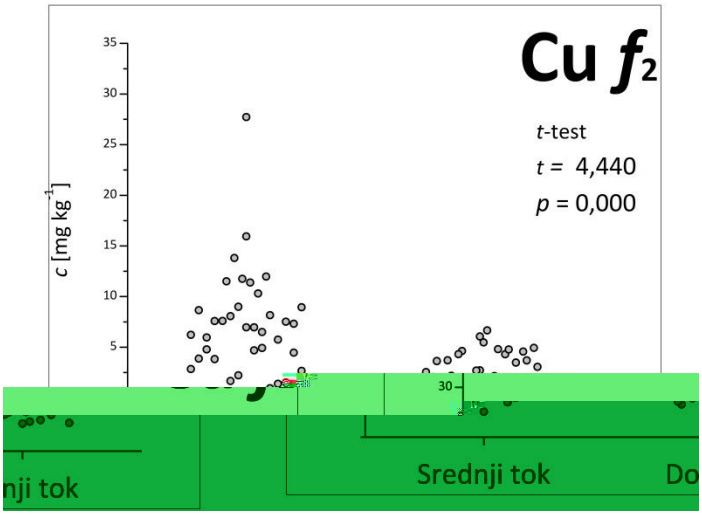
Slika P2.

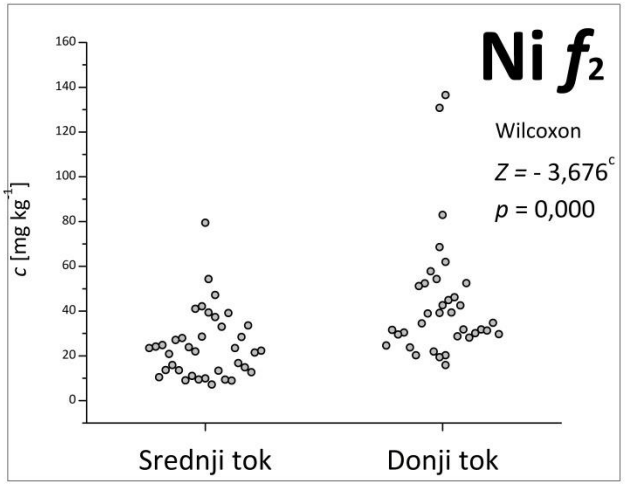
n *n*

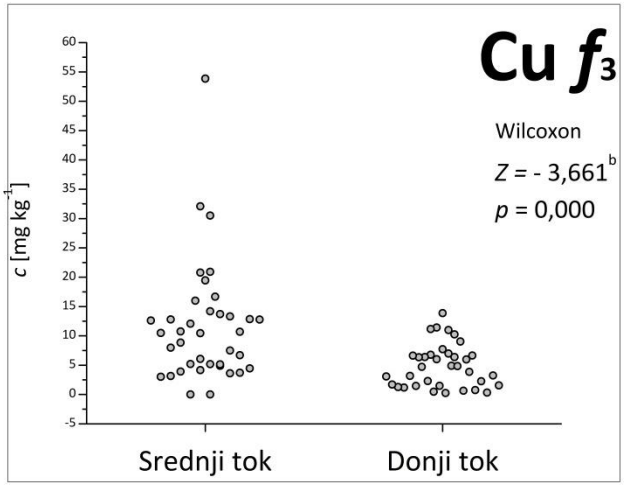
f *f* *f*

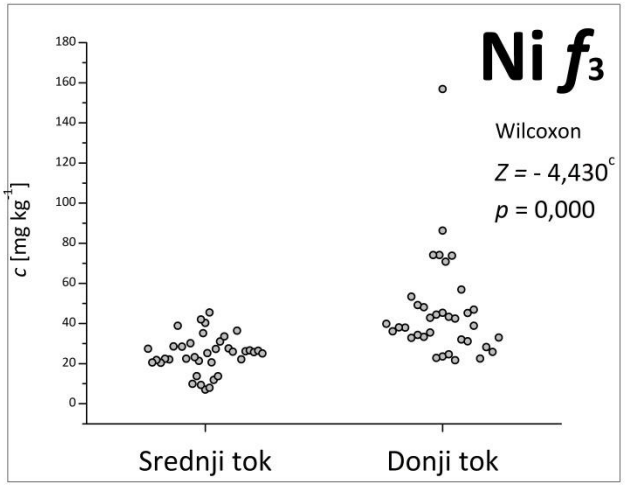












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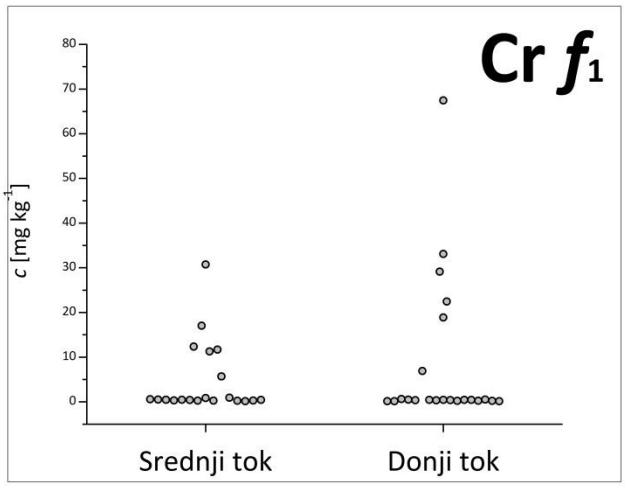
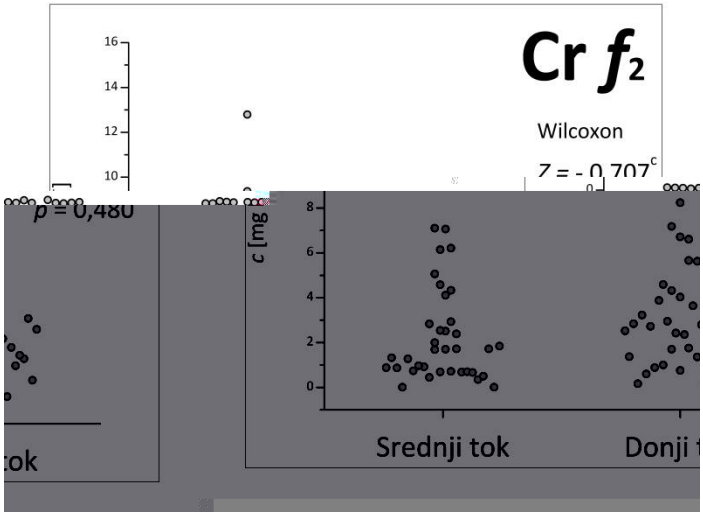
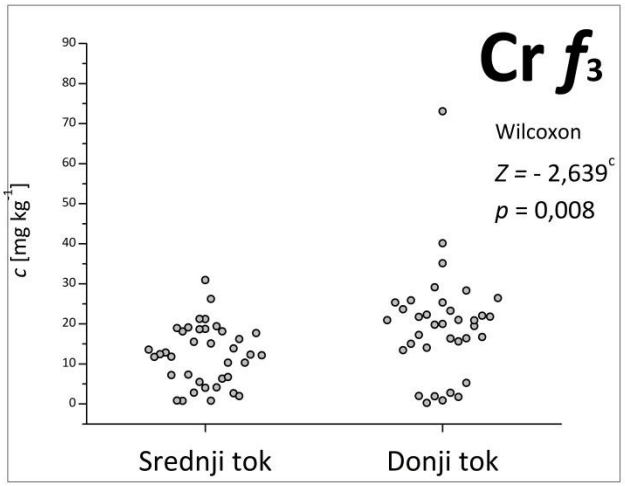
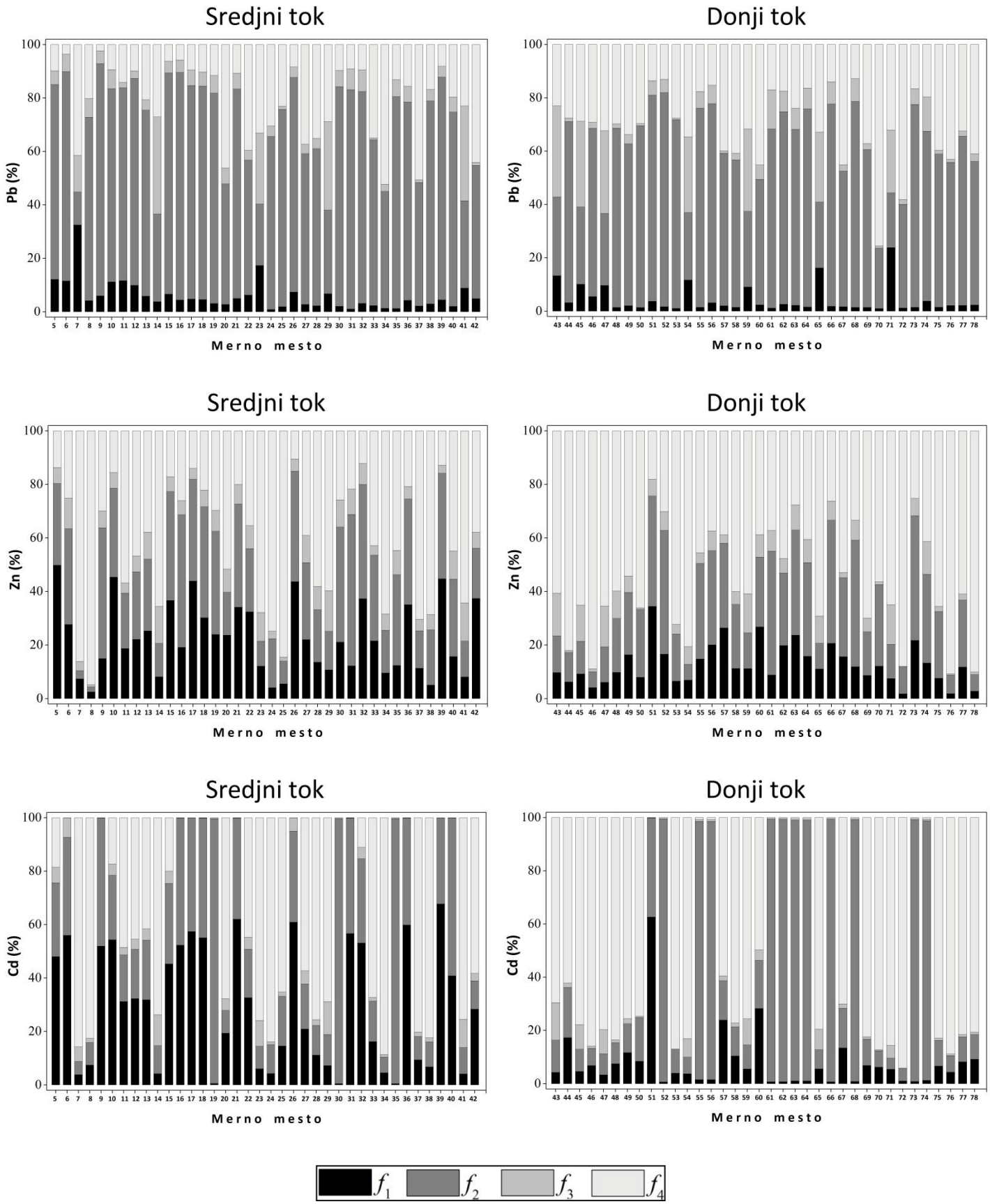




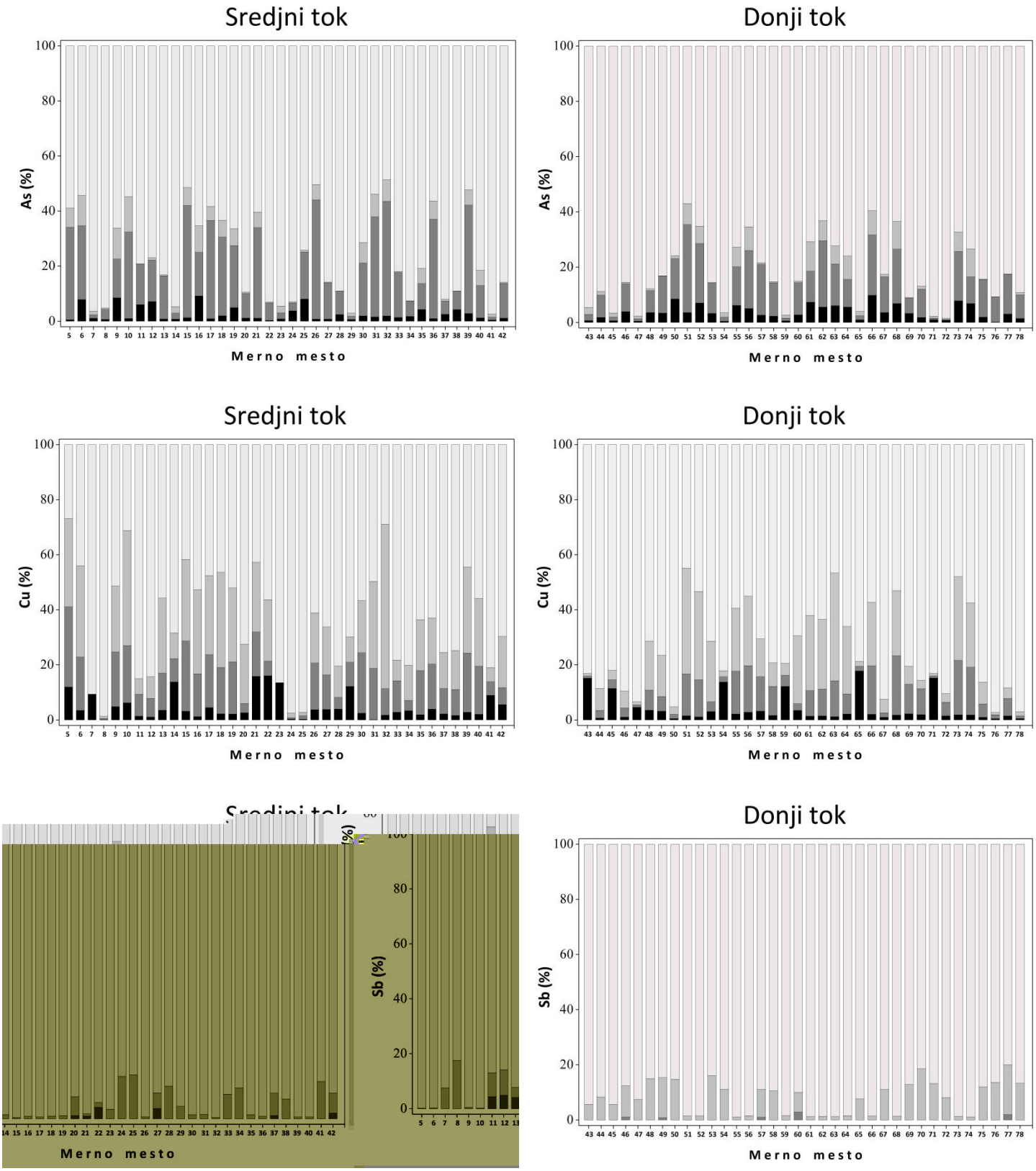


Slika P2 *Nastavak*

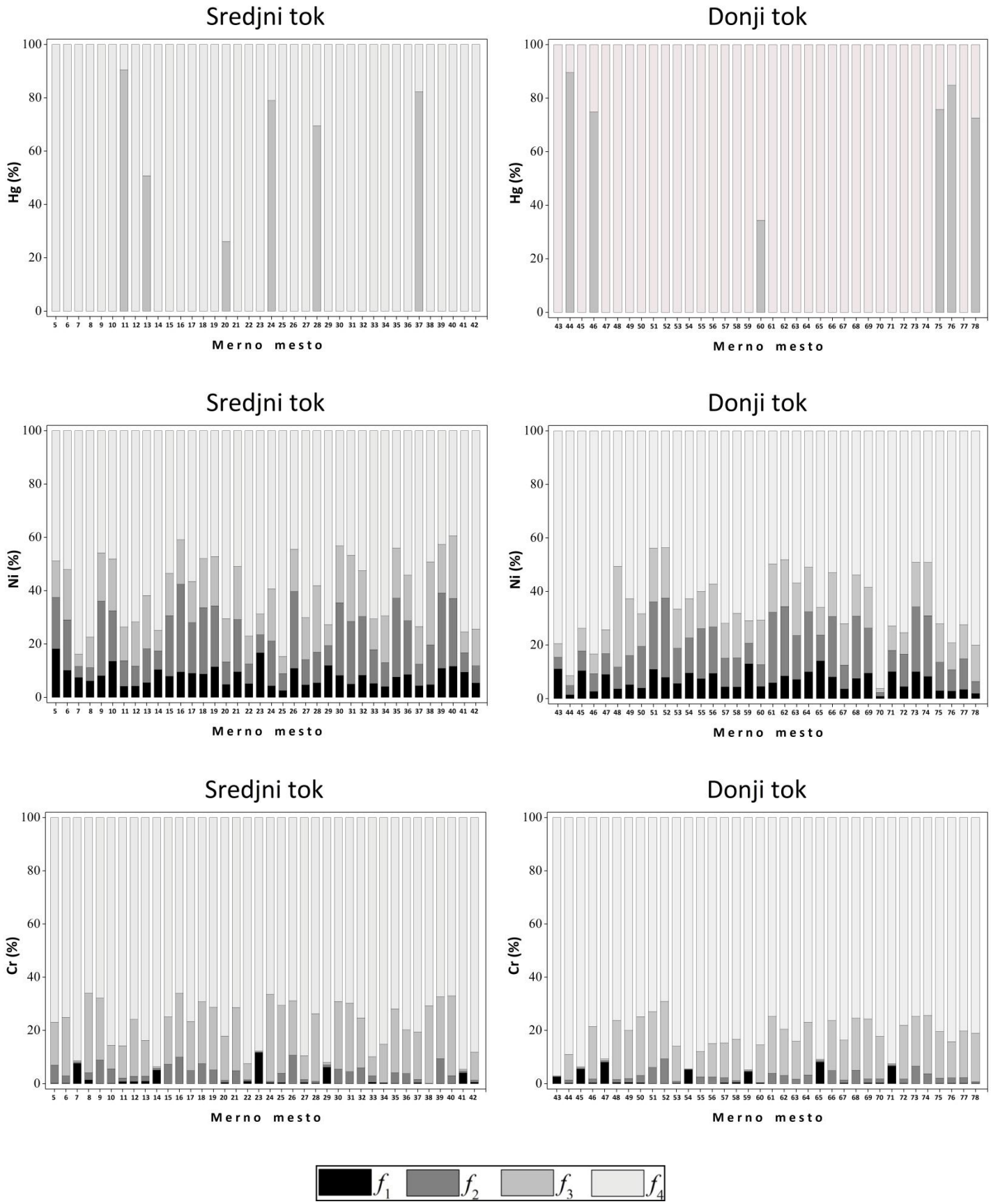


Slika P3.

n *f* *f* *f* *f* *n*

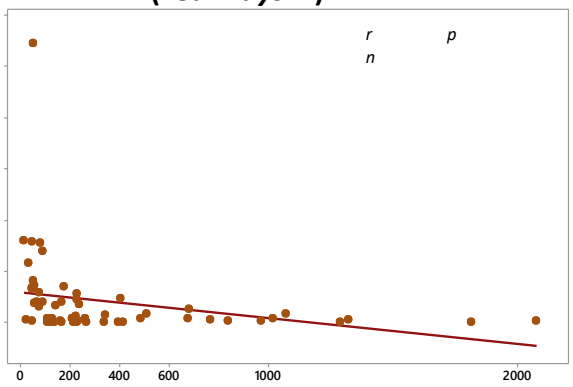


Slika P3 *Nastavak*

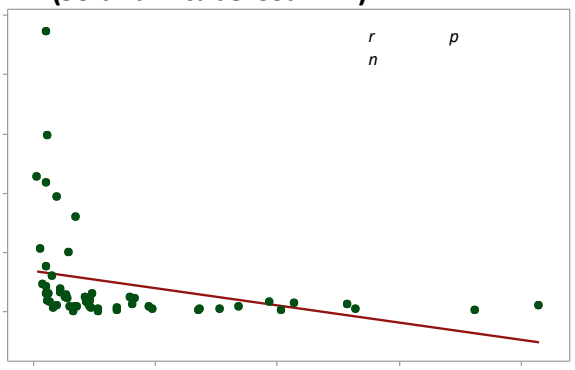


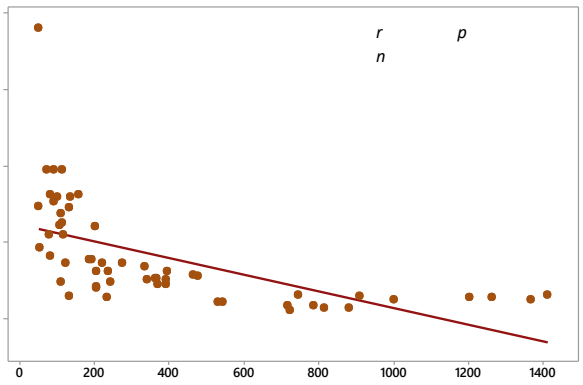
Slika P3. *Nastavak*

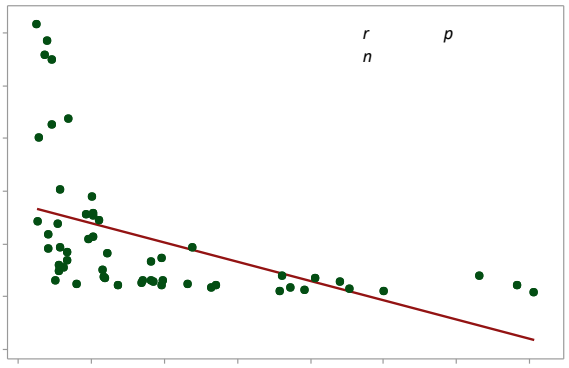
Zrno kukuruza
(*Zea mays* L.)

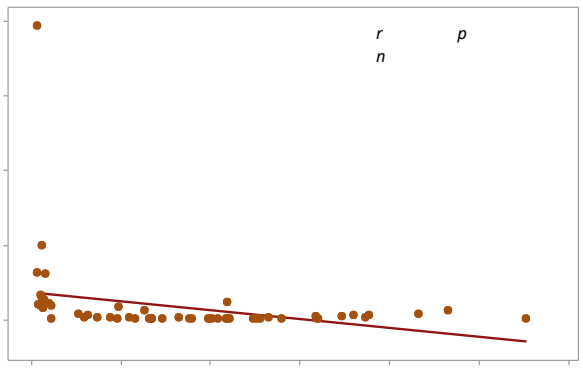


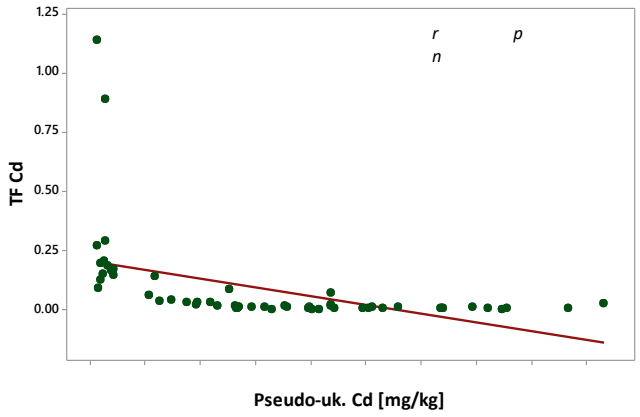
Krtola krompira
(*Solanum tuberosum* L.)









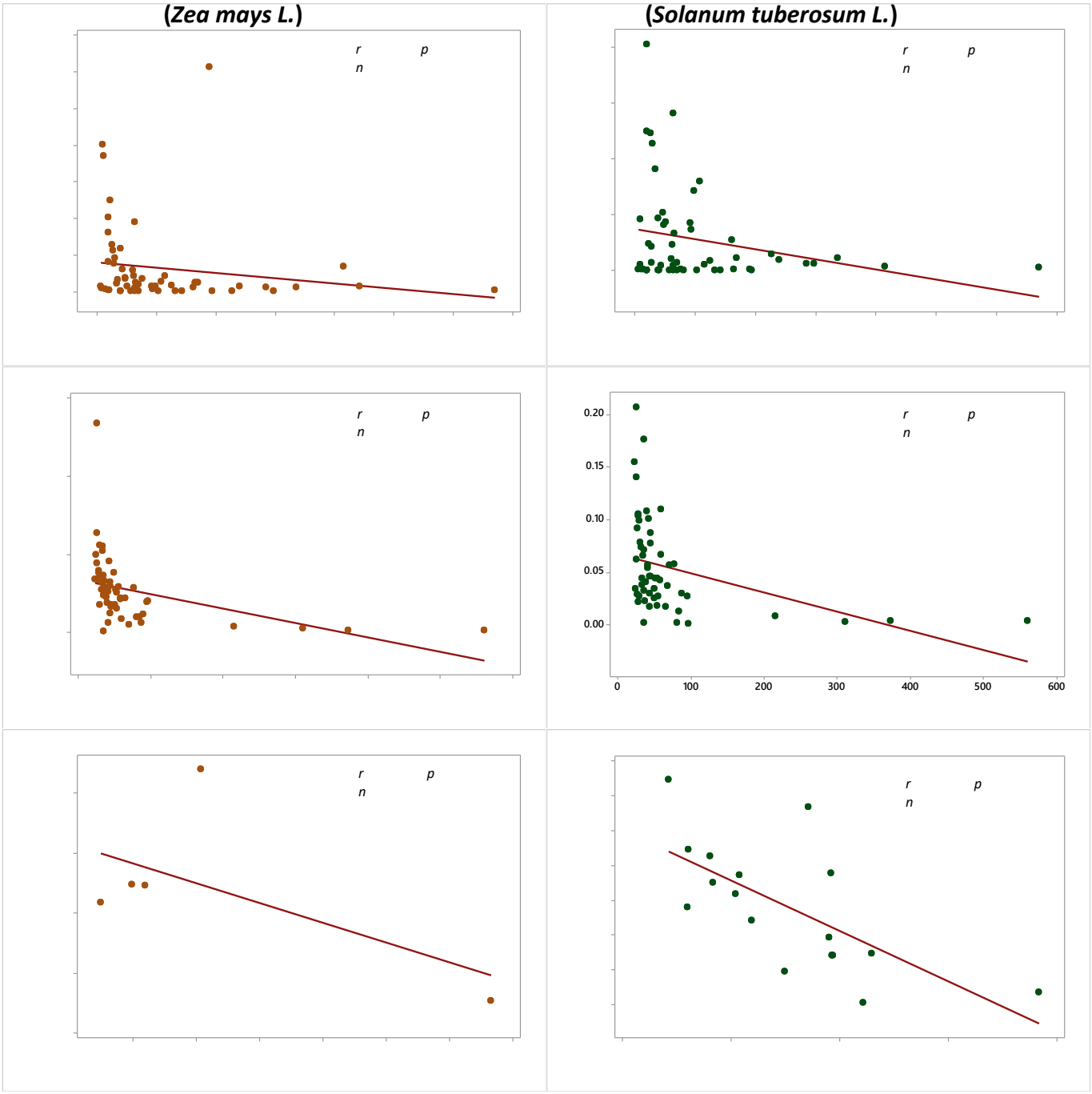


Slika P4. *TF*

r *p*

Zrno kukuruza
(*Zea mays L.*)

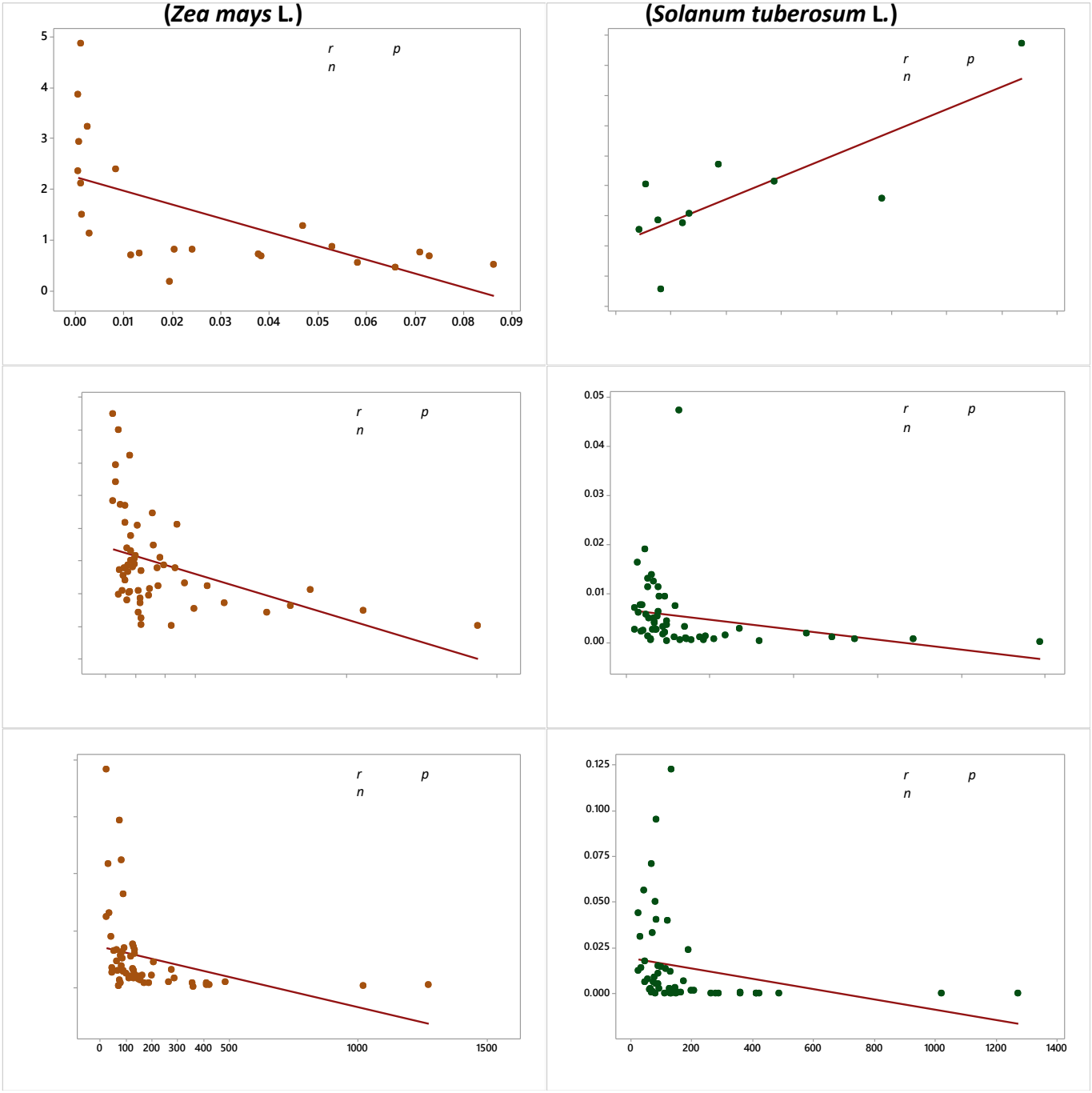
Krtola krompira
(*Solanum tuberosum L.*)



Slika P4. *Nastavak*

Zrno kukuruza
(*Zea mays* L.)

Krtola krompira
(*Solanum tuberosum* L.)



Slika P4. *Nastavak*

Biografija autora

Izjava o autorstvu

Nemanja Barać

4043/2009

Izjavljujem

Mobilnost i biodostupnost odabranih elemenata u poljoprivrednom zemljištu aluviona reke Ibar

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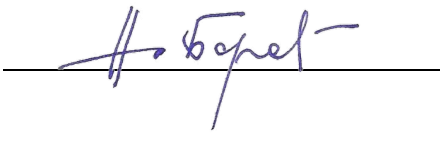
Potpis doktoranda



Izjava o istovetnosti štampane i elektronske verzije doktorskog rada

Nemanja Barać

4043/2009

Inženjerstvo zaštite životne sredine

Mobilnost i biodostupnost odabranih elemenata u poljoprivrednom zemljištu aluviona reke Ibar

dr Rada Petrović, redovni profesor

Nemanja Barać

Digitalnom repozitorijumu Univerziteta u Beogradu.

Potpis doktoranda

Izjava o korišćenju

Mobilnost i biodostupnost odabranih elemenata u poljoprivrednom zemljištu aluviona reke Ibar

3. Autorstvo – nekomercijalno – bez prerada

Potpis doktoranda

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