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The effect of trees on physical and chemical properties of substrata contaminated by gold mine waste disposal

Arendze, Shakera

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11 APPENDICES

APPENDIX A – Soil Photos

A.1 Vaal River West Complex

Control samples



Figure A1 Control sample from Vaal River West Complex (Sample name: CWC2)



Figure A2 Control sample from Vaal River West Complex (Sample name: CWC4)



Figure A3 Control sample from Vaal River West Complex (Sample name: CWC5)

Rhus lancea samples



Figure A4 Sample from Vaal River West Complex taken in the rooting zone of *Rhus lancea* (Sample name: RLWCP7T23)

Tamarix usneoides samples



Figure A5 Sample from Vaal River West Complex taken in the rooting zone of *Tamarix usneoides* (Sample name: TWCP8T3)



Figure A6 Sample from Vaal River West Complex taken in the rooting zone of *Tamarix usneoides* (Sample name: TWCP8T22)



Figure A7 Sample from Vaal River West Complex taken in the rooting zone of *Tamarix usneoides* (Sample name: TWCP8T26)

A.2 Vaal River Mispah

Control samples



Figure A8 Control sample from Vaal River Mispah (Sample name: CM1)



Figure A9 Control sample from Vaal River Mispah (Sample name: CM2)



Figure A10 Control sample from Vaal River Mispah (Sample name: CM3)

Rhus lancea samples



Figure A11 Sample from Vaal River Mispah in the rooting zone of *Rhus lancea* (Sample name: MRL12P16)



Figure A12 Sample from Vaal River Mispah in the rooting zone of *Rhus lancea* (Sample name: MRL51P16)



Figure A13 Sample from Vaal River Mispah in the rooting zone of *Rhus lancea* (Sample name: MRL30P16)

Tamarix usneoides samples



Figure A14 Sample from Vaal River Mispah in the rooting zone of *Tamarix usneoides* (Sample name: MT19P23)



Figure A15 Sample from Vaal River Mispah in the rooting zone of *Tamarix usneoides* (Sample name: MT17P23)



Figure A16 Sample from Vaal River Mispah in the rooting zone of *Tamarix usneoides* (Sample name: MT39P23)

APPENDIX B

B.1 NCS DC 73315 CRM Reference Sheet

Certificate of Certified Reference Materials

NCS DC 73313— NCS DC 73318

Stream Sediment

Issued in 2004

Approved by China National Analysis Centre for Iron and Steel

(Beijing, China)

Analytical Methods

Composition	Methods	Composition	Methods
Ag	AA; AAN; ES; NA	Pb	AA;ES;ICP;ID;POL;XRF
As	AAH; AF; COL; POL; ES;NA;XRF	Pr	ICP;MS;NA
Au	AAN; ES	Rb	AA;FP;NA;XRF
B	COL; ES; ICP	Sb	AA;AAH;AF;COL;POL;ES;NA
Ba	AA; AAN; ES; ICP; NA; MS; XRF	Sc	ES;ICP;NA;XRF
Be	AAN; COL; ES; ICP; POL	Se	AAN;AF;COL;ICP;POL
Bi	AAN;AAH;AF;COL;POL;MS; ES;ICP	Sm	AAN;ICP;ID;MS;NA
Br	COL;IC;NA	Sn	AAN;POL;COL;ES;MS;XRF
Cd	AAN;AAP;ES;ICP;POL	Sr	AA;AAN;ES;ICP;NA;XRF
Ce	ICP;ID;MS;NA;XRF	Ta	COL;ICP;NA
Cl	COL;IC;ISE;NA	Tb	AAN;ICP;MS;NA
Co	AA;AAN;COL;ES;ICP;NA;POL;XRF	Te	AAN;AF;COL;POL
Cr	AA;COL;ES;ICP;NA;XRF	Th	COL;ICP;MS;NA;POL;XRF
Cs	AA;FP;NA	Ti	COL;ICP;NA;XRF
Cu	AA;COL;ICP;POL;XRF	Tl	AAN;COL;POL;ES;MS
Dy	AAN;ICP;ID;MS;NA	Tm	AAN;ICP;MS;NA
Er	AAN;ICP;ID;MS;NA	U	COL;DNA;ID;MS;NA;POL;XRF
Eu	AAN;ICP;MS;NA	V	COL;ES;ICP;NA;POL;XRF
F	COL;ISE	W	COL;NA;MS;POL;XRF
Ga	AAN;COL;POL;ES;ICP;XRF	Y	AAN;ES;ICP;MS;XRF
Gd	ICP;MS;NA	Yb	AAN;ES;ICP;ID;MS;NA
Ge	AAN;COL;POL	Zn	AA;ICP;NA;POL;XRF
Hf	COL;MS;NA;XRF	Zr	COL;ES;ICP;MS;NA;POL;XRF
Hg	AA;AAP;AF	SiO_2	GR;ICP;VOL;XRF
Ho	AAN;ICP;MS;NA	Al_2O_3	COL;ICP;VOL;XRF
I	COL;ISE;NA;POL;VOL	TFe_2O_3	AA;COL;ICP;NA;VOL;XRF
In	AAN;ES;NA;POL	FeO	COL;VOL
La	ICP;MS;NA;XRF	MgO	AA;GR;ICP;VOL;XRF

Li	AA;FP;ICP	CaO	GR;ICP;VOL;XRF;AA
Lu	ICP;MS;NA	Na_2O	AA;FP;ICP;NA;XRF
Mn	AA;COL;ICP;NA;POL;XRF	K_2O	AA;FP;ICP;NA;XRF
Mo	COL;ES;NA;MS;POL;XRF	S	VOL;XRF
Nb	COL;ES;ICP;MS;XRF	H_2O^+	GR;EL
Nd	ICP;ID;MS;NA;XRF	CO_2	GR;VOL
Ni	AA;AAN;COL;ES;ICP;NA;POL;XRF	Org.C	GR;VOL
P	COL;ICP;XRF	L.O.I	GR

Note:

AA: Flame Atomic Absorption spectrometry

ES: Emission Spectrography

AAH: Atomic Absorption spectrometry with hydride generation

FP: Flame Photometry

AAN: Non-flame Atomic Absorption spectrometry

GR: Gravimetry

AF: Atomic Fluorescence spectrophotometry

IC: Ion Chromatography

COL: Colorimetry

ICP: Inductively Coupled Plasma spectrography

DNA: Delay Neutron Activation method

ID: Isotope Dilution spark source mass spectrometry

EL: Electrometric method

LF: Laser Fluorescence spectrometry

ISE: Ion Selective Electrode method

NA: Neutron Activation analysis

MS: Mass Spectrometry

VOL: Volumetry

POL: Polarography

XRF: X-Ray Fluorescence spectrometry

Professor Wang Haizhou, Chief

China National Analysis Center for Iron and Steel

CERTIFIED VALUES (Certification 1986, Revision 2003) OF STREAM SEDIMENT REFERENCE MATERIALS

µg/g	NCS DC 73313	NCS DC 73314	NCS DC 73315	NCS DC 73316	NCS DC 73317	NCS DC 73318
Ag	0.59±0.05	0.084±0.017	0.36±0.03	0.36±0.03	1.05±0.06	0.062±0.009
As	18±2	19.7±1.7	75±8	13.6±1.0	84±6	2.4±0.4
B	33±4	52±6	51±6	50±7	143±16	3.6±0.7
Ba	615±41	470±37	440±30	330±24	720±45	480±32
Be	1.5±0.3	2.4±0.3	2.3±0.2	1.7±0.3	2.7±0.3	2.0±0.2
Bi	0.79±0.10	0.64±0.10	2.4±0.3	5.0±0.4	0.66±0.09	0.19±0.03
Br						(0.9)
Cd	0.10±0.02	0.19±0.02	0.82±0.05	0.43±0.03	1.05±0.06	0.081±0.012
Ce	64±5	78±4	89±7	68±7	78±6	54±5
Cl						(38)
Co	11.7±1.1	18±2	18.9±2.1	24.4±1.9	21±2	3.6±0.8
Cr	87±6	81±6	70±6	190±15	122±7	7.6±1.4
Cs	7.8±0.7	10±1	9.4±0.9	9.1±1.3	5.9±0.7	3.6±0.5
Cu	177±7	37±2	137±7	383±12	38±2	4.1±0.5
Dy	4.0±0.5	4.6±0.5	5.0±0.5	3.8±0.9	4.2±0.6	2.6±0.5

Er	2.3±0.4	2.5±0.4	2.8±0.5	2.2±0.5	2.3±0.3	1.8±0.3
Eu	1.3±0.1	1.31±0.13	1.4±0.3	1.50±0.13	1.3±0.2	0.56±0.07
F	345±22	740±37	585±36	690±35	890±52	204±28
Ga	15.9±1.0	20.5±1.2	20.3±0.9	16.7±0.7	17.7±1.0	10.8±0.7
Gd	4.7±0.3	5.0±0.8	6.4±1.1	5.5±0.9	5.8±0.8	3.5±0.6
Ge	1.3±0.3	1.4±0.3	1.4±0.3	1.3±0.3	1.4±0.3	0.94±0.21
Hf	6.0±1.9	5.8±1.7	6.5±1.9	4.9±1.4	4.9±1.4	14.5±2.3
Hg	0.048±0.007	0.044±0.008	0.10±0.02	0.045±0.008	0.053±0.013	0.042±0.005
Ho	(0.9)	1.0±0.2	0.95±0.15	0.76±0.10	0.96±0.20	0.7±0.2
I						(0.8)
In	0.09±0.03	0.085±0.022	0.13±0.03	0.14±0.03	0.081±0.015	(0.04)
La	39±5	40±6	46±5	39±6	45±5	30±4
Li	33±1	51±2	45±2	40±1	32±1	13.2±0.6
Lu	0.39±0.05	0.47±0.14	0.46±0.06	0.34±0.09	0.39±0.08	0.38±0.07
Mn	400±23	825±32	1160±38	970±37	690±33	335±16
Mo	92±5	0.86±0.18	1.2±0.2	7.7±0.8	1.4±0.2	0.54±0.13
N						(340)

Nb	16±2	18±3	19±3	12±3	17±2	35±3
Nd	30±4	32±3	35±4	33±6	37±5	21±2
Ni	26±3	40±4	34±3	78±5	53±4	(2.7)
P	630±39	470±37	630±25	1020±42	820±41	140±22
Pb	40±3	30±5	112±9	27±4	350±17	21±3
Pr	8.3±1.1	9.3±1.6	9.9±1.3	8.4±0.8	9.6±1.5	5.8±0.7
Rb	79±6	130±8	118±6	107±6	147±8	132±7
S	192±23	354±51	410±65	784±118	190±30	(80)
Sb	5.4±0.6	1.84±0.18	3.9±0.5	1.25±0.22	2.6±0.2	0.24±0.06
Sc	14.3±1.5	15.4±1.7	14.5±2.0	17±2	14.6±1.4	5.7±0.4
Se	1.0±0.2	0.29±0.08	0.40±0.10	0.30±0.08	0.30±0.08	(0.10)
Sm	5.3±0.4	6.2±0.5	6.6±0.5	5.6±0.6	6.1±0.5	3.8±0.3
Sn	3.4±0.6	4.0±0.7	4.6±0.8	2.8±0.7	5.4±0.9	9.4±1.0
Sr	90±8	142±12	204±12	266±18	220±15	52±6
Ta	(1.0)	1.4±0.2	1.4±0.2	0.75±0.09	1.35±0.16	3.7±0.7
Tb	0.70±0.09	0.90±0.19	0.89±0.19	0.69±0.17	0.76±0.16	0.54±0.10
Te	0.16±0.03	0.065±0.020	0.14±0.04	0.14±0.04	0.07±0.02	(0.01)

Th	9.2±0.7	14.6±1.0	15.2±1.2	9.0±1.4	12.6±1.0	13.4±0.8
Ti	6360±230	5340±160	5370±160	4640±120	4480±120	3640±110
Tl	0.58±0.13	1.2±0.2	1.16±0.19	1.08±0.15	0.93±0.16	0.78±0.18
Tm	0.39±0.08	0.46±0.05	0.46±0.07	0.35±0.06	0.44±0.12	0.33±0.06
U	1.9±0.3	2.6±0.4	2.6±0.4	2.4±0.4	3.5±0.4	3.0±0.2
V	120±7	118±6	109±6	142±8	96±6	26±3
W	4.9±0.5	2.5±0.5	3.2±0.4	25±2	5.5±0.6	2.0±0.3
Y	22±3	26±3	26±3	20±2	24±2	18±2
Yb	2.6±0.2	2.9±0.3	2.9±0.3	2.1±0.3	2.6±0.3	2.1±0.3
Zn	52±4	101±10	243±15	144±7	238±12	43±3
Zr	220±14	188±11	220±11	170±8	162±9	490±41
%						
SiO_2	71.29±0.29	52.59±0.26	56.44±0.24	61.24±0.13	64.70±0.18	82.89±0.27
Al2O3	12.04±0.11	15.69±0.13	15.37±0.14	14.16±0.09	13.41±0.09	7.70±0.09
TFe_2O_3	6.54±0.09	5.91±0.10	5.84±0.09	5.88±0.07	6.51±0.09	2.20±0.04
FeO	(0.72)	(0.91)	(0.94)	1.58±0.14	1.50±0.12	0.53±0.09
MgO	0.68±0.04	1.02±0.04	0.98±0.04	3.00±0.06	3.08±0.09	0.25±0.02

CaO	(0.22)	7.54±0.12	5.34±0.09	3.87±0.07	1.67±0.05	0.24±0.04
Na_2O	0.32±0.03	0.30±0.03	0.39±0.03	2.30±0.07	1.21±0.04	0.47±0.04
K_2O	2.46±0.06	2.23±0.06	2.11±0.07	2.43±0.05	3.54±0.08	2.84±0.08
H_{2O}^+	(4.1)	(6.6)	(6.7)	3.49±0.27	(3.6)	2.22±0.27
CO_2	(0.07)	5.48±0.19	3.56±0.08	2.03±0.12	(0.17)	(0.09)
C org.	(0.58)	(1.05)	(1.3)	(0.36)	(0.63)	(0.33)
TC	(0.60)	(2.6)	(2.3)	0.91±0.15	(0.68)	(0.35)

Note:

Data behind "±" are uncertainty; U = $t_\alpha \bullet s/\sqrt{N}$. α=0.01, S is standard deviation, N means number of data (N>8).

Data enclosed in brackets are reference values.

The certification will expire in Dec 2010, although we reserve the right to make change as issue revision.

The sample is packed in glass bottle with size less 0.074 mm. The minimum package is 70 g.

The minimum weight for analysis is 0.1.

B.2 CRM BCR 701 Reference Sheet

EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

Institute for Reference Materials and Measurements (Geel)

CERTIFIED REFERENCE MATERIAL
BCR® – 701

CERTIFICATE OF ANALYSIS

SEDIMENT

		Extractable mass fraction based on dry mass		Number of accepted sets of data p
		Certified value [1] [mg/kg]	Uncertainty [2] [mg/kg]	
Step 1:	Cd	7.3	0.4	14
	Cr	2.26	0.16	14
	Cu	49.3	1.7	14
	Ni	15.4	0.9	13
	Pb	3.18	0.21	14
	Zn	205	6	14
Step 2:	Cd	3.77	0.28	14
	Cr	45.7	2.0	12
	Cu	124	3	14
	Ni	26.6	1.3	12
	Pb	126	3	11
	Zn	114	5	12
Step 3:	Cd	0.27	0.06	13
	Cr	143	7	12
	Cu	55	4	13
	Ni	15.3	0.9	13
	Pb	9.3	2.0	12
	Zn	46	4	11

[1] Unweighted mean value of the means of p accepted sets of data, each set being obtained in a different laboratory and/or with a different method of determination. The certified value is traceable to sequential extraction procedure as described in the certification report.
[2] Half-width of the 95 % confidence interval of the mean defined in [1].

This certificate is valid for one year after purchase.

Sales date:

The minimum amount of sample to be used is 1 g.

NOTE

This material has been certified by BCR (Community Bureau of Reference, the former reference materials programme of the European Commission). The certificate has been revised under the responsibility of IRMM.

Brussels, January 2001
Latest revision: August 2012

Signed:

Prof. Dr. Hendrik Emons
Unit for Reference Materials
EC-JRC-IRMM
Retieseweg 111
2440 Geel, Belgium

Page 1 of 3

Indicative Values		
	Mass fraction based on dry mass	
	Indicative value [1] [mg/kg]	Uncertainty [2] [mg/kg]
Cd	0.13	0.08
Cr	63	8
Cu	39	12
Ni	41	4
Pb	11	6
Zn	95	13

[1] Unweighted mean value of the means of p accepted sets of data, each set being obtained in a different laboratory and/or with a different method of determination. The indicative value is traceable to determinations following ISO 11466.
[2] Half-width of the 95 % confidence interval of the mean defined in [1].

DESCRIPTION OF THE SAMPLE

The material consists of a sediment sample in a glass bottle containing about 20 g of powder.

ANALYTICAL METHOD USED FOR CERTIFICATION

- Electrothermal atomic absorption spectrometry
- Flame atomic absorption spectrometry
- Inductively coupled plasma emission spectrometry
- Inductively coupled plasma mass spectrometry

PARTICIPANTS

- Joint Research Centre, Environment Institute, Ispra (IT)
- Agricultural Research Centre, Environmental Resources, Jokioinen (FI)
- Federal Research Centre for Materials and Testing (BAM), Berlin (DE)
- Agriculture and Food Development Authority, TEAGASC, Wexford (IE)
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- University of Huelva, Dept. Chemistry and Material Sciences, Huelva (ES)
- University of Ghent, Lab. of Analytical and Agro-Chemistry, Gent (BE)
- University of Reading, Dept. of Soil Science, Reading (GB)

SAFETY INFORMATION

The usual laboratory safety precautions apply.

INSTRUCTIONS FOR USE

The material is intended for the verification or validation of an analytical procedure. This material is not intended for use as a calibrant.
Before a bottle is opened, it should be shaken manually so that the material is re-homogenised. The sample must be used as it is from the bottle. The correction to dry mass should be made on a separate portion of 1 g which should be dried in an oven at (105 ± 2) °C for 2-3 h until constant mass is attained. The analysis must be carried out following strictly the sequential extraction protocol given in the certification report.

STORAGE

The tightly closed bottles should be kept at 4 °C in the dark.
However, the European Commission cannot be held responsible for changes that happen during storage of the material at the customer's premises, especially of opened samples.

LEGAL NOTICE

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or
(b) assume any liability with respect to, or for damages resulting from, the use of any information, material, apparatus, method or process disclosed in this document save for loss or damage arising solely and directly from the negligence of IRMM or any of its subsidiaries.

NOTE

A technical report on the production of BCR-701 is supplied on the internet (http://www.irmm.jrc.be/).
A paper copy can be obtained from IRMM on request.

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APPENDIX C – Data from Statistical Analysis

C.1 Principle components analysis (PCA)

Table C1 The PCA of the initial soil solution measurements for the soil core samples at the Vaal River sites

	Component	
	1	2
Soil pH	.965	.041
pH in KCl	.964	-.096
Redox potential (mV)	-.953	.205
Conductivity (uS/cm)	.126	-.776
Soil moisture content (%)	-.007	.662
Total variance explained: 77.5%		

Table C2 The PCA of the soil texture data for the soil core samples at the Vaal River sites

	Component	
	1	2
% Clay	.980	.073
Bulk density (g/cubic cm)	-.969	.132
% Silt	.912	-.074
% Sand	-.046	.999
Total variance explained: 94.0%		

Table C3 The PCA of the soil fertility data for the soil core samples at the Vaal River sites

	Component
	1
Total cations (cmol L^{-1})	.962
Cation exchange capacity (cmol kg^{-1})	.958
% Organic carbon	.622

Total variance explained: 74.3%

Table C4 The PCA of the CHNS data for the soil core samples at the Vaal River sites

	Component	
	1	2
% Carbon	.975	.101
% Hydrogen	.927	.251
% Sulphur	.063	.886
% Nitrogen	.255	.774
Total variance explained: 83.40%		

Table C5 The PCA of the major nutrients for the soil core samples at the Vaal River sites

	Component	
	1	2
Calcium - Ca (mg kg^{-1})	.959	.042
Magnesium - Mg (mg kg^{-1})	.899	.091
Sulphur - S (mg kg^{-1})	.796	-.080
Phosphorous - P (mg kg^{-1})	-.241	.909
Potassium - K (mg kg^{-1})	.291	.901
Total variance explained: 83.18%		

Table C6 The PCA of the trace metals for the soil core samples at the Vaal River sites

	Component		
	1	2	3
Mercury - Hg (mg kg^{-1})	.950	.197	-.045
Vanadium - V (mg kg^{-1})	-.943	-.177	.095
Chromium - Cr (mg kg^{-1})	.939	.268	-.003
Copper - Cu (mg kg^{-1})	.916	.136	.312
Arsenic - As (mg kg^{-1})	.889	.322	-.076
Titanium - Ti (mg kg^{-1})	.795	.224	.354
Nickel - Ni (mg kg^{-1})	.747	.286	-.151

Zinc - Zn (mg kg^{-1})	-.609	-.056	.142
Aluminium - Al (mg kg^{-1})	.185	.962	-.037
Manganese - Mn (mg kg^{-1})	.342	.895	-.256
Iron - Fe (mg kg^{-1})	.580	.765	.178
Uranium - U (mg kg^{-1})	.254	-.370	.788
Gold - Au (mg kg^{-1})	.388	.354	-.727
Lead - Pb (mg kg^{-1})	-.019	.218	.664
Total variance explained: 82.56%			

C.2 Histograms

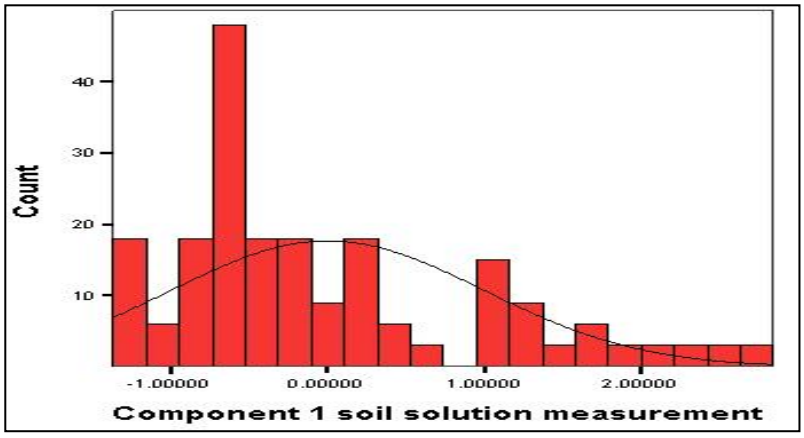

Figure C1 The histogram for component 1 of the initial soil solution measurements of the soil core samples at the Vaal River sites

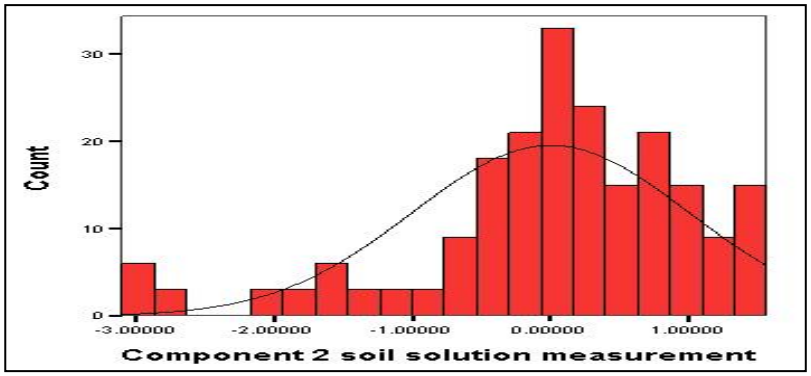

Figure C2 The histogram for component 2 of the initial soil solution measurements of the soil core samples at the Vaal River sites

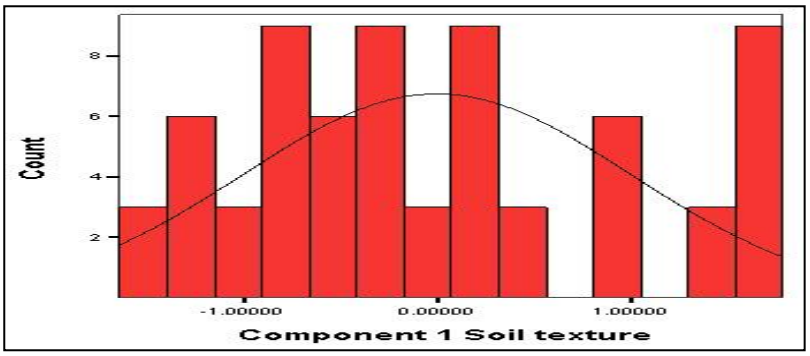

Figure C3 The histogram for component 1 of the soil texture measurements of the soil core samples at the Vaal River sites

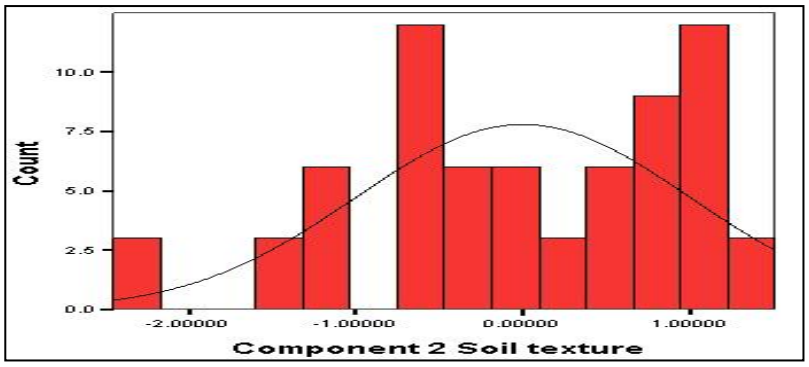

Figure C4 The histogram for component 2 of the soil texture measurements of the soil core samples at the Vaal River sites

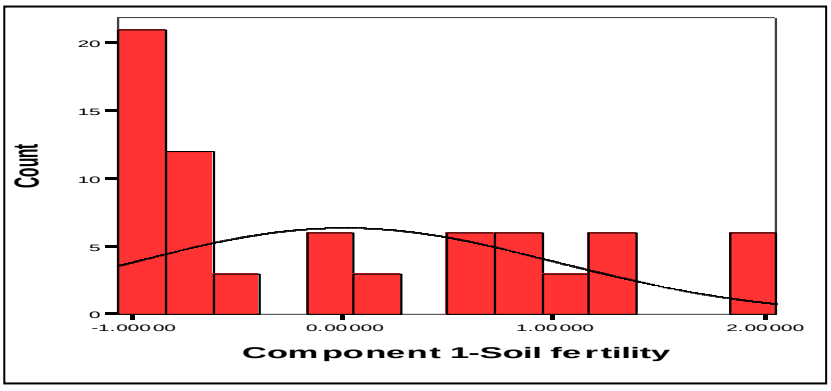

Figure C5 The histogram for component 1 of the soil fertility measurements of the soil core samples at the Vaal River sites

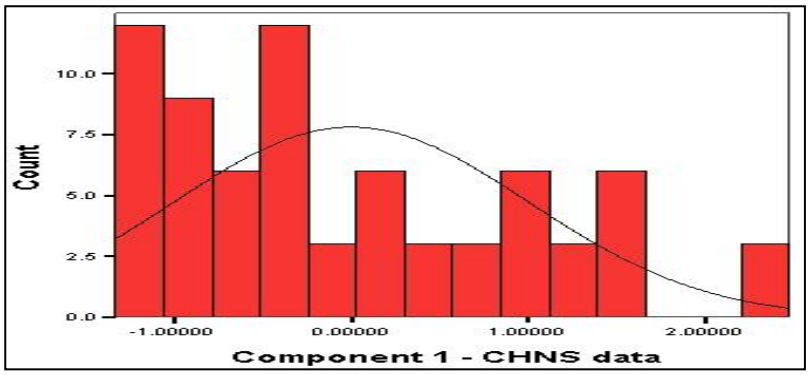

Figure C6 The histogram for component 1 of the CHNS data of the soil core samples at the Vaal River sites

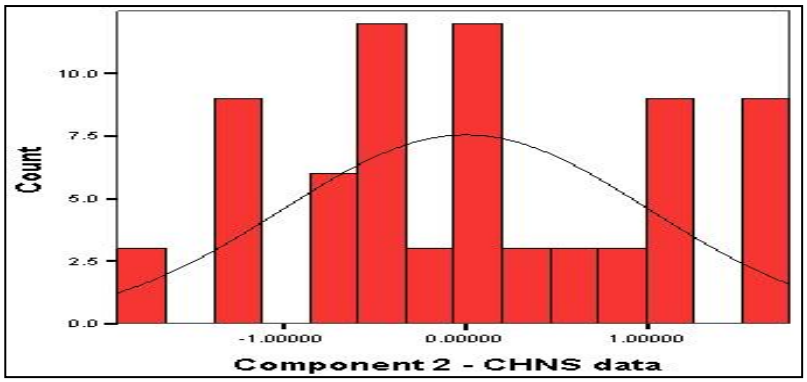

Figure C7 The histogram for component 2 of the CHNS data of the soil core samples at the Vaal River sites

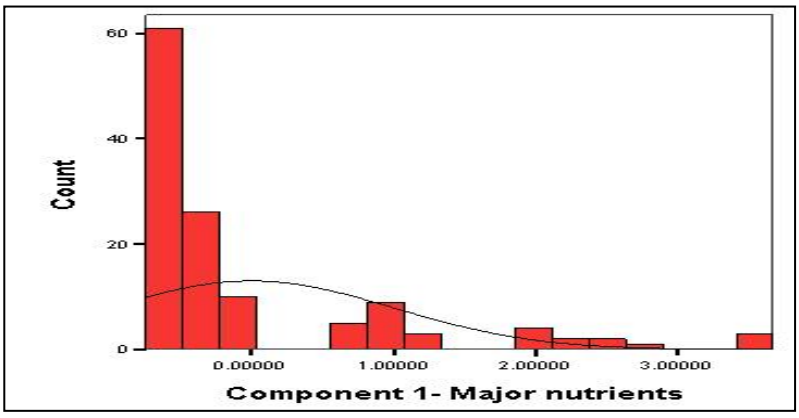

Figure C8 The histogram for component 1 of the major nutrients of the soil core samples at the Vaal River sites

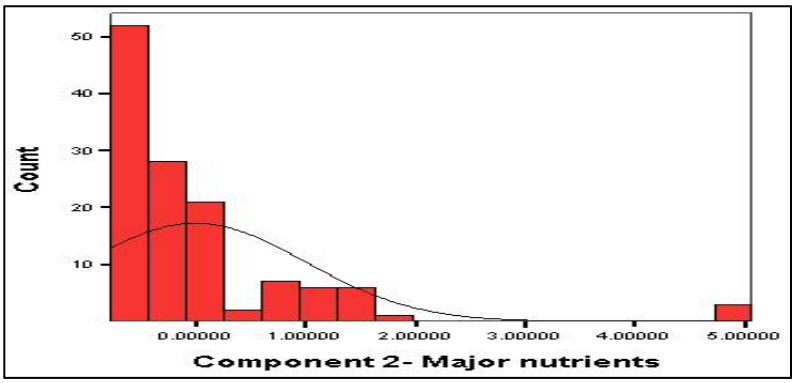

Figure C9 The histogram for component 2 of the major nutrients of the soil core samples at the Vaal River sites

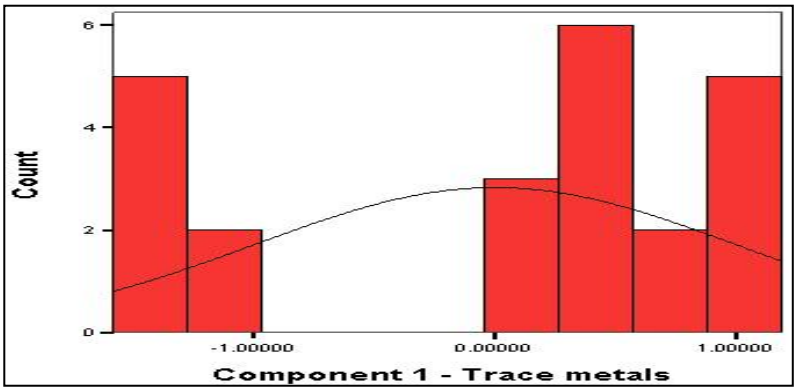

Figure C10 The histogram for component 1 of the trace metals of the soil core samples at the Vaal River sites

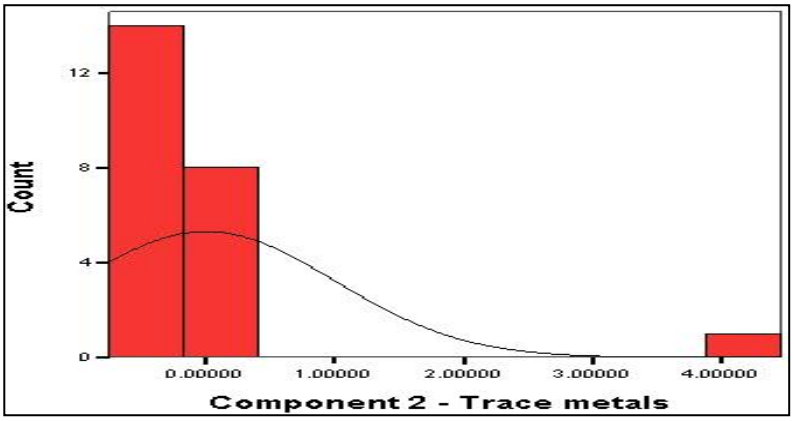

Figure C11 The histogram for component 2 of the trace metals of the soil core samples at the Vaal River sites

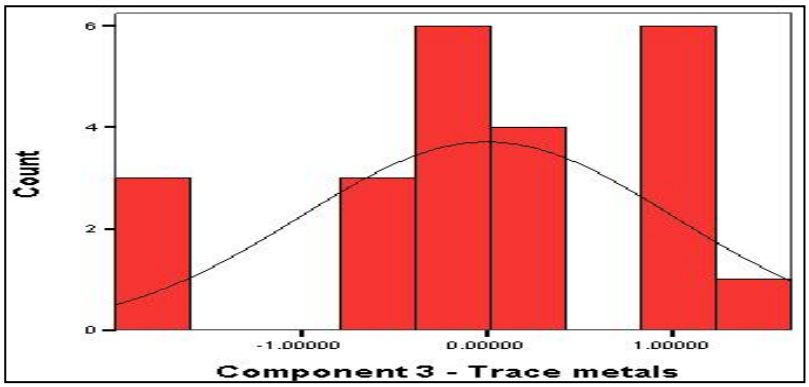

Figure C12 The histogram for component 3 of the trace metals of the soil core samples at the Vaal River sites

C.3 ANOVA tables

Table C7 ANOVA (one-way) descriptive statistics table for component 1 and 2 of the major nutrients by site, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Component 1- Major nutrients	VRWC	59	.537830	1.2482203	0.000	.2125428	.8631187	-.73836	3.66704
	VRMB	66	-.489796	.14568243		-.5256094	-.4539830	-.63807	-.00676
	Total	125	-.004756	1.00259221		-.1822474	.1727348	-.73836	3.66704
Component 2- Major nutrients	VRWC	59	.549028	1.21139970	0.000	.2333360	.8647210	-.76190	5.06422
	VRMB	66	-.493012	.30477441		-.5679358	-.4180900	-.75635	.75541
	Total	125	-.001169	1.00393766		-.1788986	.1765599	-.76190	5.06422

Table C8 ANOVA (one-way) test statistics table using the non-parametric Mann-Whitney test for component 1 and 2 of the major nutrients by site, for the soil core samples at the Vaal River sites

	Component 1- Major nutrients	Component 2- Major nutrients
Mann-Whitney U	961.000	415.000
Wilcoxon W	3172.000	2626.000

Z	-4.876	-7.576
Asymp. Sig. (2-tailed)	.000	.000
Exact Sig. [2*(1-tailed Sig.)]		
a Not corrected for ties.		
b Grouping Variable: Sites		

Table C9 ANOVA (one-way) descriptive statistics table for component 1 and 2 of the major nutrients by treatment, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Component 1- Major nutrients	Grassland	45	-.166496	.61059992	0.388	-.3499410	.0169480	-.67035	1.17030
	Woodland	81	.092498	1.15463687		-.1628131	.3478092	-.73836	3.66704
	Total	126	.000000	1.00000000		-.1763144	.1763144	-.73836	3.66704
Component 2- Major nutrients	Grassland	45	-.075913	.60205775	0.405	-.2567916	.1049647	-.73806	1.54011
	Woodland	81	.0421741	1.16537422		-.2155113	.2998595	-.76190	5.06422
	Total	126	.0000000	1.00000000		-.1763144	.1763144	-.76190	5.06422

Table C10 ANOVA (one-way) test statistics table using the non-parametric Mann-Whitney test for component 1 and 2 of the major nutrients by treatment, for the soil core samples at the Vaal River sites

	Component 1- Major nutrients	Component 2- Major nutrients
Mann-Whitney U	1653.000	1659.000
Wilcoxon W	2688.000	4980.000
Z	-.863	-.832
Asymp. Sig. (2-tailed)	.388	.405
Exact Sig. [2*(1-tailed Sig.)]		
a Not corrected for ties.		
b Grouping Variable: Treatment or groups		

Table C11 ANOVA (one-way) descriptive statistics table for component 1 and 2 of the major nutrients by tree, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean	Minimum	Maximum

						Lower Bound	Upper Bound		
Component 1- Major nutrients	Tamarix usneoides	47	.102068	1.25189561	0.665	-.2655022	.4696385	-.73836	3.66704
	Rhus lancea	34	.079268	1.02323742		-.2777556	.4362932	-.60486	2.14611
	None	45	-.166496	.61059992		-.3499410	.0169480	-.67035	1.17030
	Total	126	.000000	1.00000000		-.1763144	.1763144	-.73836	3.66704
Component 2- Major nutrients	Tamarix usneoides	47	.271425	1.40308753	0.123	-.1405361	.6833877	-.75635	5.06422
	Rhus lancea	34	-.274732	.60814894		-.4869258	-.0625394	-.76190	1.35942
	None	45	-.075913	.60205775		-.2567916	.1049647	-.73806	1.54011
	Total	126	.000000	1.00000000		-.1763144	.1763144	-.76190	5.06422

Table C12 ANOVA (one-way) test statistics table using the non-parametric Kruskal-Wallis test for component 1 and 2 of the major nutrients by tree, for the soil core samples at the Vaal River sites

	Component 1- Major nutrients	Component 2- Major nutrients
Chi-Square	.815	4.191
df	2	2
Asymp. Sig.	.665	.123
a Kruskal Wallis Test		
b Grouping Variable: Types of trees		

Table C13 ANOVA (one-way) descriptive statistics table for component 1, 2 and 3 of the trace metals by site, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Component 1 - Trace metals	VRWC	16	.6111457	.38789933	0.000	.4044488	.8178427	-.02806	1.19329
	VRMB	7	-1.3969046	.13393341		-1.5207723	-1.2730368	-1.58171	-1.25128
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.58171	1.19329
Component 2 - Trace metals	VRWC	16	.1175622	1.16575102	0.423	-.5036226	.7387471	-.33884	4.46075
	VRMB	7	-.2687137	.38487768		-.6246662	.0872388	-.74355	.32380
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-.74355	4.46075
Component 3 -	VRWC	16	-.0612006	1.10900145	0.668	-.6521458	.5297445	-1.99629	1.14278

Trace metals	VRMB	7	.1398871	.74775549		-.5516714	.8314456	-.50077	1.64230
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.99629	1.64230

Table C14 ANOVA (one-way) test statistics table using the non-parametric Mann-Whitney test for component 2 of the trace metals by site, for the soil core samples at the Vaal River sites

	Component 2 - Trace metals
Mann-Whitney U	44.000
Wilcoxon W	72.000
Z	-.802
Asymp. Sig. (2-tailed)	.423
Exact Sig. [2*(1-tailed Sig.)]	.452(a)
a Not corrected for ties.	
b Grouping Variable: Sites	

Table C15 ANOVA (one-way) analysis table for component 1 and 3 of the trace metals by site, for the soil core samples at the Vaal River sites

By sites						
		Sum of Squares	df	Mean Square	F	Sig.
Component 1 - Trace metals	Between Groups	19.635	1	19.635	174.380	.000
	Within Groups	2.365	21	.113		
	Total	22.000	22			
Component 3 - Trace metals	Between Groups	.197	1	.197	.190	.668
	Within Groups	21.803	21	1.038		
	Total	22.000	22			

Table C16 ANOVA (one-way) descriptive statistics table for component 1, 2 and 3 of the trace metals by treatment, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Component 1 - Trace metals	Grassland	16	-.1198519	1.18403128	0.397	-.7507776	.5110739	-1.58171	1.19329
	Woodland	7	.2739471	.18968754		.0985154	.4493789	-.02806	.51834
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.58171	1.19329

Component 2 - Trace metals	Grassland	16	-.2641302	.24784151	0.004	-.3961957	-.1320648	-.74355	.32380
	Woodland	7	.6037262	1.70347608		-.9717264	2.1791789	-.20032	4.46075
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-.74355	4.46075
Component 3 - Trace metals	Grassland	16	.1794227	.63617139	0.200	-.1595691	.5184145	-.53845	1.64230
	Woodland	7	-.4101091	1.54039405		-1.8347360	1.0145178	-1.99629	1.14278
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.99629	1.64230

Table C17 ANOVA (one-way) test statistics table using the non-parametric Mann-Whitney test for component 2 of the trace metals by treatment, for the soil core samples at the Vaal River sites

	Component 2 - Trace metals
Mann-Whitney U	13.000
Wilcoxon W	149.000
Z	-2.873
Asymp. Sig. (2-tailed)	.004
Exact Sig. [2*(1-tailed Sig.)]	.003(a)
a Not corrected for ties.	
b Grouping Variable: Treatment or groups	

Table C18 ANOVA (one-way) analysis table for component 1 and 3 of the trace metals by treatment, for the soil core samples at the Vaal River sites

By treatment						
		Sum of Squares	df	Mean Square	F	Sig.
Component 1 - Trace metals	Between Groups	.755	1	.755	.746	.397
	Within Groups	21.245	21	1.012		
	Total	22.000	22			
Component 3 - Trace metals	Between Groups	1.692	1	1.692	1.750	.200
	Within Groups	20.308	21	.967		
	Total	22.000	22			

Table C19 ANOVA (one-way) descriptive statistics table for component 1, 2 and 3 of the trace metals by tree, for the soil core samples at the Vaal River sites

		N	Mean	Std. Deviation	P-value	95% Confidence Interval for Mean		Minimum	Maximum
						Lower	Upper		

						Bound	Bound		
Component 1 - Trace metals	Tamarix usneoides	4	.2419449	.22645828	0.702	-.1184007	.6022906	-.02806	.51834
	Rhus lancea	3	.3166168	.16198685		-.0857809	.7190144	.15364	.47760
	None	16	-.1198519	1.18403128		-.7507776	.5110739	-1.58171	1.19329
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.58171	1.19329
Component 2 - Trace metals	Tamarix usneoides	4	1.0292866	2.28844418	0.015	-2.6121388	4.6707119	-.20032	4.46075
	Rhus lancea	3	.0363125	.06990277		-.1373356	.2099606	-.02945	.10973
	None	16	-.2641302	.24784151		-.3961957	-.1320648	-.74355	.32380
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-.74355	4.46075
Component 3 - Trace metals	Tamarix usneoides	4	-1.5570874	.80761494	0.000	-2.8421830	-.2719918	-1.99629	-.34648
	Rhus lancea	3	1.1191953	.02832543		1.0488310	1.1895596	1.08778	1.14278
	None	16	.1794227	.63617139		-.1595691	.5184145	-.53845	1.64230
	Total	23	.0000000	1.00000000		-.4324324	.4324324	-1.99629	1.64230

Table C20 ANOVA (one-way) test statistics table using the non-parametric Kruskal-Wallis test for component 2 of the trace metals by tree, for the soil core samples at the Vaal River sites

	Component 2 - Trace metals
Chi-Square	8.338
df	2
Asymp. Sig.	.015
a Kruskal Wallis Test	
b Grouping Variable: Types of trees	

Table C21 ANOVA (one-way) analysis table for component 1 and 3 of the trace metals by tree, for the soil core samples at the Vaal River sites

By types of trees						
		Sum of Squares	df	Mean Square	F	Sig.
Component 1 - Trace metals	Between Groups	.765	2	.382	.360	.702
	Within Groups	21.235	20	1.062		
	Total	22.000	22			
Component 3 - Trace metals	Between Groups	13.971	2	6.985	17.401	.000
	Within Groups	8.029	20	.401		
	Total	22.000	22			

C.4 Linear regression analysis

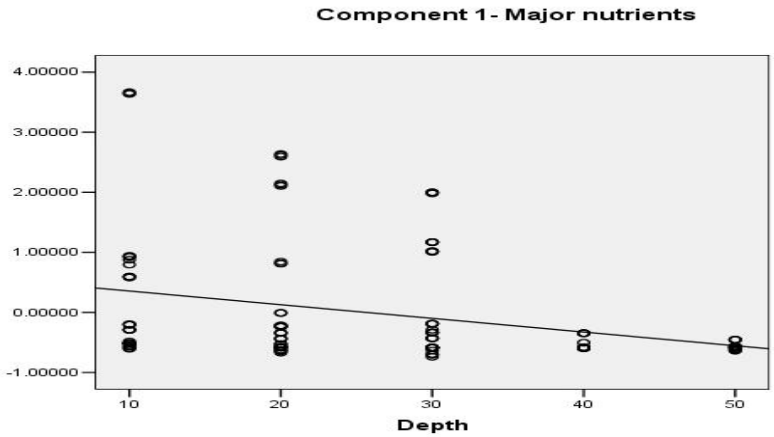

Figure C13 The linear regression histogram for component 1 of the major nutrients for the soil core samples at the Vaal River sites

Table C22 The model summary table for the linear regression analysis of component 1 of the major nutrients with depth, for the soil core samples at the Vaal River sites

Model Summary		
R	R Square	Std. Error of the Estimate
.287	.082	.962
The independent variable is Depth.		

Table C23 The ANOVA table for the linear regression analysis of component 1 of the major nutrients with depth, for the soil core samples at the Vaal River sites

ANOVA					
	Sum of Squares	df	Mean Square	F	P-value
Regression	10.306	1	10.306	11.143	.001
Residual	114.694	124	.925		
Total	125.000	125			
The independent variable is Depth.					

Table C24 The coefficient table for the linear regression analysis of component 1 of the major nutrients with depth, for the soil core samples at the Vaal River sites

Coefficients				
	Coefficients		t	P-value
	B	Std. Error		
Depth	-.023	.007	-3.338	.001
(Constant)	.583	.195	2.997	.003

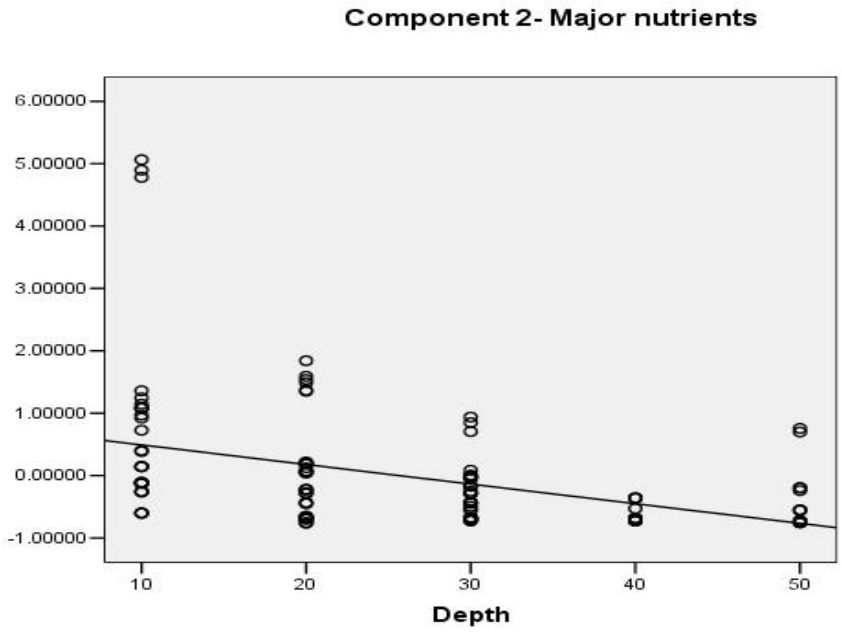

Figure C14 The linear regression histogram for component 2 of the major nutrients for the soil core samples at the Vaal River sites

Table C25 The model summary table for the linear regression analysis of component 2 of the major nutrients with depth, for the soil core samples at the Vaal River sites

Model Summary		
R	R Square	Std. Error of the Estimate
.396	.157	.922
The independent variable is Depth.		

Table C26 The ANOVA table for the linear regression analysis of component 2 of the major nutrients with depth, for the soil core samples at the Vaal River sites

ANOVA					
	Sum of Squares	df	Mean Square	F	P-value
Regression	19.646	1	19.646	23.123	.000

Residual	105.354	124	.850		
Total	125.000	125			
The independent variable is Depth.					

Table C27 The coefficient table for the linear regression analysis of component 2 of the major nutrients with depth, for the soil core samples at the Vaal River sites

Coefficients				
	Coefficients		t	P-value
	B	Std. Error		
Depth	-.031	.007	-4.809	.000
(Constant)	.805	.187	4.318	.000

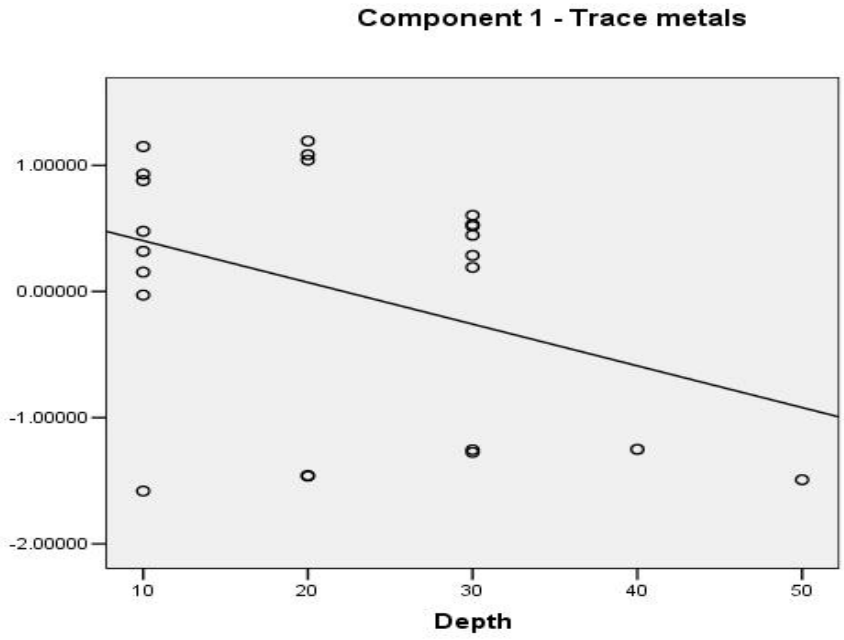

Figure C15 The linear regression histogram for component 1 of the trace metals of the soil core samples at the Vaal River sites

Table C28 The model summary table for the linear regression analysis of component 1 of the trace metals with depth, for the soil core samples at the Vaal River sites

Model Summary		
R	R Square	Std. Error of the Estimate
.373	.139	.950
The independent variable is Depth.		

Table C29 The ANOVA table for the linear regression analysis of component 1 of the trace metals with depth, for the soil core samples at the Vaal River sites

ANOVA					
	Sum of Squares	df	Mean Square	F	P-value
Regression	3.053	1	3.053	3.384	.080
Residual	18.947	21	.902		
Total	22.000	22			
The independent variable is Depth.					

Table C30 The coefficient table for the linear regression analysis of component 1 of the trace metals with depth, for the soil core samples at the Vaal River sites

Coefficients				
	Coefficients		t	Sig.
	B	Std. Error		
Depth	-.033	.018	-1.840	.080
(Constant)	.733	.445	1.647	.114

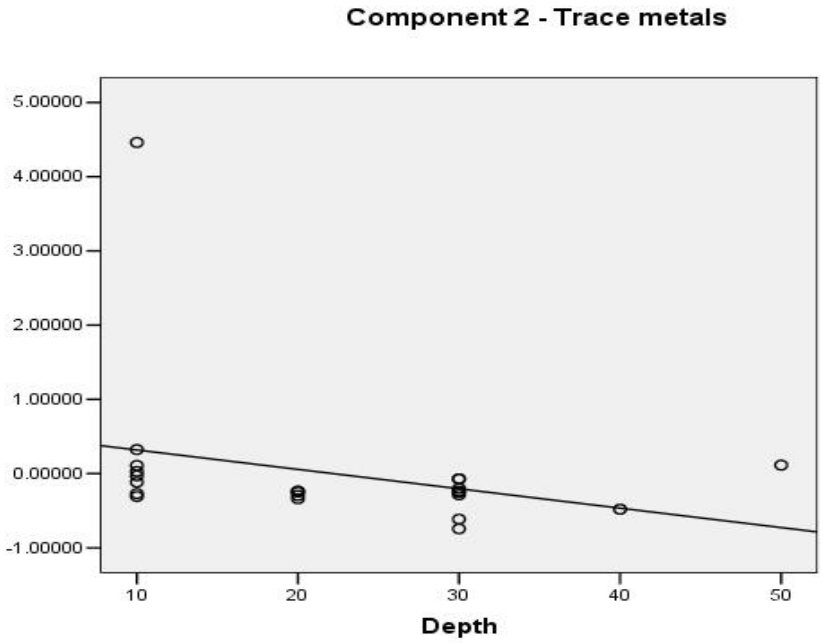

Figure C16 The linear regression histogram for component 2 of the trace metals of the soil core samples at the Vaal River sites

Table C31 The model summary table for the linear regression analysis of component 2 of the trace metals with depth, for the soil core samples at the Vaal River sites

Model Summary		
R	R Square	Std. Error of the Estimate
.294	.087	.978
The independent variable is Depth.		

Table C32 The ANOVA table for the linear regression analysis of component 2 of the trace metals with depth, for the soil core samples at the Vaal River sites

ANOVA					
	Sum of Squares	df	Mean Square	F	P-value
Regression	1.906	1	1.906	1.992	.173
Residual	20.094	21	.957		
Total	22.000	22			
The independent variable is Depth.					

Table C33 The coefficient table for the linear regression analysis of component 2 of the trace metals with depth, for the soil core samples at the Vaal River sites

Coefficients				
	Coefficients		t	P-value
	B	Std. Error		
Depth	-.026	.019	-1.411	.173
(Constant)	.579	.458	1.264	.220

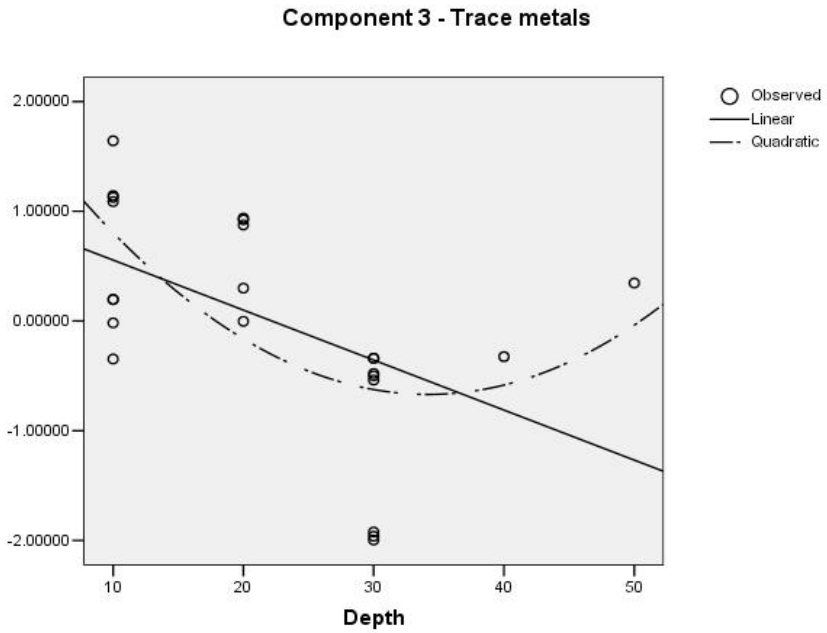

Figure C17 The linear regression histogram for component 3 of the trace metals of the soil core samples at the Vaal River sites

Table C34 The model summary table for the linear regression analysis of component 3 of the trace metals with depth, for the soil core samples at the Vaal River sites

Model Summary					
Linear			Quadratic		
R	R Square	Std. Error of the Estimate	R	R Square	Std. Error of the Estimate
.513	.264	.878	0.632	0.399	0.813
The independent variable is Depth.					

Table C35 The ANOVA table for the linear regression analysis of component 3 of the trace metals with depth, for the soil core samples at the Vaal River sites

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	8.782	2	4.391	6.644	.006
Residual	13.218	20	.661		
Total	22.000	22			
The independent variable is Depth.					

Table C36 The coefficient table for the linear regression analysis of component 3 of the trace metals with depth, for the soil core samples at the Vaal River sites

Coefficients				
	Coefficients		t	Sig.
	B	Std. Error		
Depth	-.172	.062	-2.797	.011
Depth ** 2	.003	.001	2.125	.046
(Constant)	2.276	.707	3.220	.004