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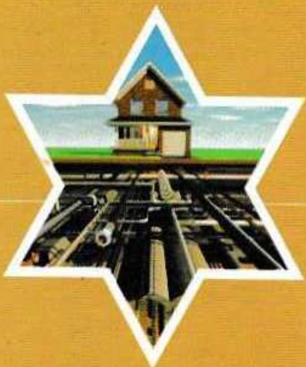




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Concentrations of Trace Metals in Axonopus Compressus Within an Abandoned Steel Industry Environment

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Abstract

This work is aimed at investigating the levels of some trace metals in Axonopus compressus within the abandoned Qua-Steel Industry environment. Ten metals (Fe, Ni, Mn, Zn, Al, Co, Pb, Cd, Cr, and Cu) were analyzed using Unicam Solar 969 Atomic Absorption Spectrophotometer (A.A.S). Levels of these trace metals in the industrial environment were generally higher than those from the control site, suggesting that the activities of steel production and other manufacturing processes which took place when the industry was operational, contributed to the observed higher levels in the industrial environment. The average concentrations of Fe, Ni, Mn, Zn, Al, Co, Pb, Cd, Cr and Cu, in the plant (Axonopus compressus) samples were 257.31±40.75 mg/kg; 8.53±3.62 mg/kg; 2.41±1.18 mg/kg; 60.80±19.18 mg/kg; 21.85±15.40 mg/kg; 1.73±1.20 mg/kg; 0.25±0.24 mg/kg; 2.39±2.01 mg/kg; 33.74±20.28 mg/kg; and 130.89±33.72 mg/kg, respectively. The concentrations of Cd, Co, Cr and Cu in the plant (Axonopus compressus) were significantly high to cause environmental concern as their concentrations exceeded the tolerable limits. Adverse effects of these trace metals in the environment are discussed. Remediation of the polluted environment and suspension of all agricultural activities in the abandoned Qua-Steel Industry environment are recommended

Keywords: axonopus compressus, trace metals, steel industry, pollution

INTRODUCTION

Plants can absorb heavy metals from soil, water and from air. The accumulation of heavy metals as well as metals predominantly toxic to plants in the soil can be a consequence of the natural lithogenic and pedogenic processes (Woolhouse, 1983), as well as anthropogenic factors which result in environmental pollution (Piperski and Radisic, 2003).Heavy metals uptake by plants is performed constantly during their vegetation period and during the year when they reach their highest value at the end of the vegetation period (Krstic et al., 2007; Stankovic, 2006).

Steel is an alloy that contains more than 50% of iron and 0.03-1.5% of carbon and to obtain the properties described for different purposes, other metals are usually added (Umland and Bellama, 1996). Some of these metals include; Manganese, Zinc, Nickel, Chromium, Tin, Tungsten, and Vanadium. Manganese is the only metal without any substitute that is used as a deoxidizing and desulfuring agent in the manufacture of steel. Zinc is used in galvanizing steel to give a protective coating against corrosion. Nickel is used in making stainless steel and high temperature alloys of steel. Chromium is used also for making stainless steel. Tin is used in protective coating for steel and tungsten is used to produce very tough steel (Leet *et al., 1982*). Vanadium used in the manufacture of steel makes the metal more ductile and resistant to shock (Anusiem, 2000). These metals can be accumulated in the soil through waste from steel production. According to Udosen *et al.*, (1990), heavy metals in soils are associated with geometrical cycles and biological processes and could be greatly influenced by industrial activities. Plants in turn are capable of absorbing these metals from the soil (Kalulu and Abdullahi, 2004). These metals could be leached into the soil when they undergo chemical reactions and could come in direct contact with roots of plants (Udosen, 1991). When these plants in the form of vegetables, are eaten by man, trace metals become bioaccumulated and eventually result in several ailments which may subsequently end up in death (Odiette, 1999; Udosen, 1998). Plants can accumulate some which are not injurious to them, but may be poisonous to animals grazing on the plants (Raven and Evert, 1976). *Axonopus compressus* plant was chosen for two main reasons. First, because of its abundance in the site and secondly because of it economic importance. Domestic animals feed on these plants on the site or when harvested by their owners to the domestic animals. These animals if eaten by humans, will introduce the trace elements to man through food chain. This could have adverse effect on man's health.

Apart from the building and cemented areas, all other areas are now used for agricultural purposes. Some of the wastes emanating from steel production are spread over some parts of the environment particularly on water-logged soil. Trace metals present in the waste may therefore accumulate in plants in this environment. Hence, plants in this environment are presumed to be polluted with trace metals. This study is therefore to assess the trace metal levels in the plant *Axonopus compressus* within the abandoned steel industry environment. Ten metals (Fe, Ni, Mn, Zn, Al, Co, Pb, Cd, Cr, and Cu) were analyzed using Unicam Solar 969 Atomic Absorption Spectrophotometer (A.A.S).

Measurement of the levels of metals in plants can be useful in establishing trends in abundance and other consequences (Kalulu and Abdullahi, 2004). Again, heavy metals discharged into our environment including their distribution, reaction in the ecosystem and subsequent uptake and distribution in plants are of great concern for human health, (Udosen *et al.*, 2007). Specifically, the aims of the study are: (i) to determine the levels of some trace metals in *Axonopus compressus* in the abandoned steel company environment. (iii) to ascertain the pollution status and the effect of the trace metals in the environment . (iv) to recommend some remedies to the pollution problem of the environment.

MATERIALS AND METHODS

Study Area

Qua-Steel Products Limited was one of the major Steel producing industries in the South-South zone of Nigeria located along Ibeno road in Eket Local Government Area of Akwa Ibom State. The industry was commissioned in 1978, and was known for the production of steel and also for other manufacturing businesses. The major raw material used by this steel industry was steel billets. Some of the wastes generated by this industry were spread in some parts of the environment to check water-logging within the premises. Because of the lack of raw materials due to the closure of Delta Steel Company (DSC) Aladja – Warri in June 1996, as a result of the non-functionality of the major plants and machineries in the industry, Qua-Steel products Limited was closed down in 1996 and has remained abandoned till now. The premises of the abandoned industry is now used for agricultural purposes.

Sample Collection

The plant samples (*Axonopus compressus*) commonly called carpet grass from the Qua-Steel Industry environment were harvested. The samples were put into polyethylene bags, labeled and taken to the laboratory for treatment and analysis. Sampling was carried out within the Qua-Steel Products Limited environment from three different locations (A, B and C) for three consecutive months (September to November). Samples of plants (*Axonopus compressus*) were collected in triplicate from each location. Control samples were also collected about 10 km away from the industry.

Sample Treatment and Analysis

Each plant sample was oven-dried at 50°C - 60 °C. The dry sample was ground into powder and stored. The powdered plant sample (1g) was weighed into a crucible and ashed in a furnace at 500 °C-700 °C for 4 hours. It was removed after ashing from the furnace and cooled. The sample (ash) was leached with 5 cm^3 of 6 MHCl and was made to 50 cm^3 of volume of deionized water. Blank determination was also carried out as in a similar way as described above except for the omission of the sample. The solutions were analyzed for metals using A. A. S (Unicam Solaar A.A.S 969 model). A calibration graph was plotted for each element using measured absorbance and the corresponding concentration. The calibration curve was used to determine the concentration of the metal.

RESULTS AND DISCUSSION

Table 1: Concentrations of metals in *Axonopus compressus* samples from Qua-Steel Industry environment and control site (mg/kg) in September

SAMPLE-ID	Fe	Ni	Mn	Zn	Al	Co	Pb	Cd	Cr	Cu
PA 1	275.35	9.01	2.78	57.88	40.53	1.02	0.20	0.87	57.08	150.25
PA 2	261.70	7.45	1.95	65.77	27.89	1.55	0.15	1,02	53.58	147.05
PA 3	203.50	6.76	2.15	63.81	35.08	1.16	0.34	0.86	55.76	135.32
PB 1	304.26	14.26	3.50	93.30	4.46	3.48	0.04	5.10	35.42	155.63
PB 2	300.58	10.47	3.29	99.55	5.11	2.75	0.00	4.45	27.80	152.69
PB 3	301.98	12.70	4.13	81.84	4.43	3.03	0.00	4.50	28.03	159.42
PC 1	215.01	5.20	1.00	55.45	23.23	1.05	0.55	1.24	16.50	83.10
PC 2	212.42	4.47	1.25	35.99	30.18	0.54	0.44	1.87	15.51	102.20
PC 3	241.00	6.40	1.61	56.60	25.60	0.97	0.52	1.64	13.96	92.33
PCTL 1	90.23	0.65	0.55	38.92	1.70	0.52	0.00	0.35	5.51	17.69
PCTL 2	69.76	1.00	0.57	43.25	2.64	0.49	0.00	0.33	7.52	23.03

Table 2: Concentrations of metals in Axonopus compressus samples from Qua-Steel Industry environment and control site (mg/kg) in October

SAMPLE-ID	Fe	Ni	Mn	Zn	Al	Co	Pb	Cd	Cr	Cu
PA 1	276.39	9.10	2.79	57.95	40.55	1.03	0.22	0.89	57.09	149.30
PA 2	260.87	8.36	1.92	65.69	27.87	1.55	0.15	1.03	53.60	148.03
PA 3	203.30	5.76	2.17	63.84	35.08	1.15	0.32	0.84	55.71	135.30
PB 1	305.00	14.50	3.53	93.25	4.57	3.49	0.05	5.11	35.40	155.64
PB 2	300.12	10.77	3.25	99.56	5.11	2.77	0.00	4.43	27.82	152.68
PB 3	301.70	12.16	4.14	81.88	4.42	3.00	0.00	4.52	28.03	159.40
PC 1	216.97	5.25	1.01	55.44	23.24	1.06	0.55	1.25	16.51	83.09
PC 2	210.39	4.49	1.26	54.01	30.17	0.55	0.45	1.87	15.50	102.22
PC 3	241.07	6.32	1.60	56.59	25.60	0.95	0.51	1.62	13.95	92.31
PCTL 1	91.16	0.62	0.55	38.94	1.73	0.53	0.00	0.35	5.53	17.72
PCTL 2	68.83	1.03	0.55	43.23	2.61	0.48	0.00	0.32	7.50	23.00

Table 3: Concentrations of metals in Axonopus compressus samples from Qua-Steel Industry environment and control site (mg/kg) in November.

SAMPLE-ID	Fe	Ni	Mn	Zn	Al	Co	Pb	Cd	Cr	Cu
PA 1	276.37	9.11	2.80	57.99	40.56	1.04	0.21	0.89	57.10	150.26
PA 2	260.85	8.34	1.93	65.67	27.87	1.56	0.16	1.04	53.59	147.03
PA 3	203.33	5.77	2.15	63.82	35.07	1.13	0.32	0.82	55.72	135.34
PB 1	306.56	14.16	3.57	93.20	4.58	3.49	0.05	5.11	35.41	155.64
PB 2	299.27	10.50	3.23	99.55	5.10	2.76	0.00	4.42	27.80	152.70
PB 3	300.99	12.77	4.12	81.94	4.42	3.01	0.00	4.52	28.04	159.40
PC 1	217.06	5.31	1.02	55.43	23.25	1.07	0.56	1.26	16.53	83.10
PC 2	210.40	4.40	1.27	54.00	30.17	0.56	0.44	1.88	15.52	102.21
PC 3	240.97	6.38	1.59	56.61	25.59	0.93	0.51	1.61	13.92	92.32
PCTL 1	93.13	0.61	0.54	38.95	1.74	0.53	0.00	0.36	5.52	17.71
PCTL 2	66.86	1.04	0.56	43.22	2.60	0.48	0.00	0.31	7.51	23.01

For sample ID see Appendix

TABLE 4: Mean concentrations of Fe, Ni, Mn, Zn, Al, Co, Pb, Cd, Cr and Cu in *Axonopus compressus* from Qua-Steel Industry Environment and control site (Mg/Kg)

SAMPLE	Fe	Ni	Mn	Zn	Al	Co	Pb	Cd	Cr	Cu
1	246.85± 33.24	7.74±1. 37	2.29±0. 39	62.49±3.5 1	34.50±5.5 0	1.24±0.2 4	0.23±0.0 8	0.92±0.0 9	55.47±1.5 3	144.21±6.7 7
2	302.27±2. 46	12.48± 1.63	3.46± 0.39	91.56± 7.75	4.70± 0.31	3.09± 0.32	0.02± 0.02	4.68± 0.32	30.42± 3.75	155.91± 2.92
3	222.81± 13.87	5.36± 0.83	1.29± 0.26	55.35± 1.31	26.34± 3.05	0.85± 0.23	0.50± 0.05	1.58± 0.27	15.32± 1.12	92.54± 8.28
Control	80.00± 12.68	0.83± 0.23	0.55± 0.00	41.09± 2.35	2.17± 0.49	0.51± 0.02	0.00±0.0 0	0.34± 0.02	6.52± 1.09	20.36± 2.91
Mean	257.31	8.53	2.41	69.80	21.85	1.73	0.25	2.39	33.74	130.89
S. D	40.75	3.62	1.18	19.18	15.40	1.20	0.24	2.01	20.28	33.72
C. V (%)	15.84	42.44	48.96	27.48	70.48	69.36	96.00	84.10	60.11	25.76

Table 5: Correlation Matrix between Heavy Metals in plant (Axonopus compressus) samples from Qua-Steel Industry Environment (r at $p<0.05$).

	Fe	Ni	Mn	Zn	Al	Co	Pb	Cd	Cr	Cu
Fe	1.000									
Ni	0.999	1.000								
Mn	0.990	0.995	1.000							
Zn	0.998	0.995	0.979	1.000						
Al	-0.843	0.824	-0.761	-0.878	1.000					
Co	0.991	0.985	0.963	-0.998	-0.908	1.000				
Pb	-0.956	-0.966	-0.988	-0.934	0.650	-0.908	1.000			
Cd	0.894	0.878	0.824	0.923	-0.995	0.946	-0.724	1.000		
Cr	0.157	0.191	0.291	0.089	0.399	0.022	-0.438	-0.302	1.000	
Cu	0.840	0.859	0.907	0.801	-0.417	0.759	-0.962	0.508	0.667	1.000

The results obtained from this study show variations in the concentrations of heavy metals in soils and the plant *Axonopus compressus*. The levels of these heavy metals were remarkably higher in soil samples than in the plant except for iron (Fe), zinc (Zn) and copper (Cu) which had higher concentrations in *Axonopus compressus* in some locations of the industrial environment than in soil. Similar results were also obtained by Kalulu and Abdullahi (2004), when they investigated the impact of municipal solid waste on trace metal concentration in herbage and in soil samples in Abuja Municipality. Udosen et al., (2007) also observed higher concentrations of some heavy metals in *Sporobulus pyramidalis* in abandoned battery industry environment and attributed it to bioaccumulation.

The mean level of Fe in the plant from all the locations of the study area was 257.32±40.75 mg/kg. Of all the metals analyzed for this study, Fe shows the highest concentration. This could be attributed to the fact that Fe was the major raw material used in the manufacture of steel, as observed by Joesten *et al.*, (1991) that steel is an alloy of iron. The high concentration of Fe in the plant shows the high uptake of Fe by *Axonopus compressus* from the soil. The high level of Fe in the plant species may also be due to Fe abundance or availability in the soil of this study area and biomagnifications (Botkin and Keller, 1998). Although Fe is not generally considered as soil pollutant because of its high background levels (Huamain et al., 1999), the relatively higher Fe concentration observed in plant samples from this study area calls for concern. The low coefficient of variation of Fe in *Axonopus compressus*, 15.84% shows that this metal is stable and will still be present in this environment for a long time. High concentrations of copper were also obtained in the plant samples with a mean value of 130.89±33.72 mg/kg. The high levels of Cu in the plant species could be as result of high uptake of Cu by *Axonopus compressus*, due to Cu availability in the soil. The reduced level of Cu in the soil might be due to leaching. The level of Cu observed in the plant species in this study area is above the natural limit in plant (4-15 mg/kg) (Vecera et al., 1999). The coefficient of variation of Cu observed for the plant samples (25.675 mg/kg) from this study area is evidence that Cu will persist in this environment. Excessive amount of Cu in an environment as indicated in this study area might be toxic to man and other organisms. Raven and Evert (1976) observed that high concentration of Cu is highly toxic to plants. Excess of copper in the body has been found to cause Wilson's disease (Moore et al., 2005).

Zinc was also found in high levels in the plant samples with a mean level of 69.80±19.18 mg/kg. The high level of Zinc observed in this environment than in control site might be due to the use of Zinc in galvanizing steel (Leet et al., 1982). Zinc although being an essential trace element in low concentration, is toxic in high concentration (Oborn et al., 2005). Ingestion of Zinc in excess of 12 mg per day may cause lung disturbance (Eka and Udotong, 2003). Apart from the use of zinc in galvanizing steel, its use as an additive in lubricating oil (Ayodele and Gaya, 1998) may also be responsible for the observed level of Zn in this environment.

The mean level of chromium in the plant samples was 33.74±20.28 mg/kg. The observed level of Cr in plant samples is higher than the natural limit of 0.1-1 mg/kg. The presence of chromium in this environment under study might be due to its use in the steel industry. Dudka and Andiano (1997) reported high concentrations of chromium (30-4560 mg/kg) in soil from chromium smelting industry in Japan. Exposure to chromium has been found to cause dermatitis (Ayodele and Gaya, 1998), perforation of nasal septa and kidney damage among other diseases (Vincoli, 1995).

The mean level of Al in the plant samples of this study area was 21.85±15.40 mg/kg. The low coefficient of variation of aluminum (19.735 mg/kg) in the soil shows that Al will persist in this environment. Exposure to high concentrations of Al through repeated inhalation may result in aluminosis or lung fibrosis. Other hazards associated with exposure to Al are accumulation of aluminum particles in the kidney and Alzheimer's disease (Vincoli, 1995).

The recorded mean level of manganese obtained in this study in the plant samples was 2.41±1.18 mg/kg. This level of Mn is within the permissible limit (Vecera et al., 1999). The presence of Mn in this environment might be as a result of its use in the steel industry. Exposure to manganese has been indicated to cause lack of control of the bladder (Ayodele and Gaya, 1998) and transient psychiatric disturbances, among other effects (Nelson et al., 1993)

The mean nickel level in the plant samples of the study area was 8.53±3.62 mg/kg. This level of nickel observed was above the natural limit of 0-1-5 mg/kg for plant (Vecera et al., 1999). Ingestion of nickel may cause hyperglyanemia, depression of the central nervous system and kidney damage (Vincoli, 1995). The presence of nicked in this study area might be due to its use in the steel industry.

The mean concentrations of cobalt, lead and cadmium were quite low in the plant samples. The mean concentrations of Co, Cd and Pb in the plant samples were 1.73±1.20, 2.39±2.01 and 0.25±0.24 mg/kg respectively. Cobalt level in the plant was higher than the natural limit of 0.05-0.5 mg/k(Vecera et al., 1999). Exposure to Co may cause dermatitis and diseases of the red blood cell (Avila, 1992). The mean concentrations of Pb were within the natural limits in both soil and plant samples. The presence of Pb in this environment may have been due to automobile emission and industrial emission (Joesten et al., 1991). Chronic exposure to lead can lead to chronic lead poisoning, which will result in memory loss and restlessness. Lead has been found to inhibit enzymatic activity (Vincoli, 1995). Cadmium level in the plant samples higher than the natural limits of

0.1-1 mg/kg in plant(Vecera et al., 1999). Cadmium is therefore considered to be toxic to plants. Exposure to high cadmium levels may result in a disease known as osteoporosis (Akesson et al., 2006).

A correlation study between the metals in the plant samples studied is shown in Table 5. From the result, some metals were strongly correlated while some showed negative correlation. For example, there were strong correlations between Fe and Ni ($r=0.999$ $p,<0.05$), Fe and Mn ($r=0.990$, $p<0.05$), Fe and Zn ($r=0.998$, $p<0.05$), Fe and Co ($r=0.991$, $p<0.05$), Ni and Zn ($r=0.995$, $p<0.05$), Ni and Mn ($r=0.995$, $p<0.05$). Among the pairs of metals that were negatively correlated were Fe and Pb ($r=0.956$, $p<0.05$), Ni and Pb ($r=0.966$, $p<0.05$), Al and Cd ($r=0.995$, $p<0.05$), Mn and Pb ($r=0.988$, $p<0.05$).

CONCLUSION

The findings of this study show that steel production contributed to the levels of trace metals as depicted by the higher trace metal concentrations in the plant samples within the abandoned Qua-Steel industry environment than at the control site. The concentrations of cobalt, chromium and copper in the plant samples were above permissible limits, thus the level of environmental pollution by these metals are high in this study area. The levels of trace metal obtained in this environment may affect human health since the crops grown in this environment are continuously consumed. Thus, there is need for bioremediation of this environment and the suspension of all agricultural activities in this environment to avoid transmission of these heavy metals to man through food chain.

REFERENCES

Akesson, A., Bjellerup, P., Lundh, T., Lidfeldt, J., Nerbrand, C., Samsioe G.,Skerfving, S. and Vahter M. (2006). Cadmium – Induced Effects on Bone in a population – Based study of Women. Environmental Health Perspectives 114 (6) 830 – 835

Anusiem, A.C.I. (2000). Principles of General Chemistry. A Programme Approach. Versatile Publishers, Umuahia. P. 628

Avila, V.L. (1992). Biology. A Human Endeavor. Bookmark publishers, Califonia pp. 138, 563.

Ayodele, J.T. and Gaya, U.M. (1998). Chromium, Maganese and Zinc in Kano Municipality Street Dust. J. Chem. Soc. Of Nig. 23: 24 – 31

Botkin, D.B. and Keller, E.A. (1998). Environmental Science. Earth as a living Planet. 2nd ed. John Wiley and Sons, Inc. Canada. P.291

Dudka, S. and Adriano, D.C. (1997). Environmental Impacts of Metal Ore Mining and Processing; A Review. J. Environmental Quat. 26:590 – 602

Eka, O. U. and Udotong. I. R. (2003). A case study of Effects of Incessant Oil Spills from Mobil Producing Nigeria Unlimited on Human Health in Akwa Ibom State. In: Adinna, E. N., Ekpo, O. B. and Attah, V. I. (Eds), Environmental Pollution and Management in the Tropics. Snaap Press Ltd. Enugu. P219.

Huamain, C., Chungrong, Z., Cong, T. and Yongguan, Z. (1999). Heavy Metal Pollution in Soils in China: Status and Countermeasures. Ambio 28(2):130-134

Joesten, M.D., Johnston, D.O., Netterville, J. and Wood, J.L. (1991). World of Chemistry. Saunders College Publishing, Florida. Pp 301, 502.

Kalulu, S.E. and Abdullahi, N.K. (2004). Impact of Municipal Solid Waste on Trace Metal Concentrations in Herbage and Soil Samples of the Abuja Municipality. Global J. Environmental Sci. 3 (1 and 2): 65-69.

Krstic B, Stankovi_ D, Igi_ R, Nikoli_ N (2007). The potential of different plant species for nickel accumulation. J. Biotechnol. Biotechnol. Equip. 21: 431-436, Sofia, Bulgaria.

Leet, L. D., Judson, S. and Kauffman, M.E. (1982). Physical Geology. 6th ed. Prentice – Hall Inc. New Jersey. pp 389 – 393

Moore, J.W. Stanitski, C.L., Jurs, P.C. (2005). Chemistry. The Molecular Science. 2nd ed. Brooks/cole – Thomson Learning, Inc. U.S.A. p. 1075.

Nelson, J.S., Parisi, J.E. and Schochet, S.S. Jnr. (1993). Principles and Practice of Neuropathology. Mobsy – year book Inc. St. Louis. Mo. P 317.

Oborn, I., Modin – Edman, A. Bengtsson, H., Gustafson, G. M., Solomon, E., Nilssons, S.I., Holmqvist, J., S. and Sverdrup, H. (2005). A Systems Approach to Assess Farm – Scale Nutrient and Trace Element Dynamics: A Case Study of the Ojebyn Dairy Farm. Ambio 34 (4 – 5): 301 – 310.

Odiette, W.O. (1999). Environmental Physiology of Animals and Pollution. Diversified Resources Ltd. Lagos. pp 171-185.

Piperski J, and Radiši_ A (2003). Kvalitet ambijentalnog vazduha: Zakonska regulativa EU I Republike Srbije. Eko konferencija 2003, 24-27 septembra, Novi Sad 251-255.

Raven, P.H. abd Evert, R.F. (1976). Biology of Plants. 2nd ed. Worth Publishers, Inc. New York p. 544.

Stankovic D (2006). Istraživanje uticaja saobra_aja na koncentraciju polutanata ušumskim ekosistemima NP Fruška gora, u funkciji zaštite i unapre_ivanja ivotne sredine. Doktorska disertacija., PMF, Univerzitet u Novom Sadu, Novi Sad, 1-141.

Udosen, E. D., Udoessien, E.I. and Ibok, U.J. (1990). Evaluation of Some Metals in the Industrial Wastes from a Paint Industry and their Environmental Pollution Implications. Nigerian J. Technol. Res., 2:71-77.

Udosen, E. D. (1991). Aquo – Terrestrial Environmental Pollution Studies of Inorganic Substances from two Industries Firms in Akwa Ibom State, Ph.D. Thesis, 575 pp.

Udosen, E. D. (1998). Trace Metal Levels in Arthropteris Orientalis from Battery Industry Environment. Global J. of Pure and Applied Sciences 4 (1): 35 – 42.

Udosen, E. D., Obot, N.U., Bassey, D.E. and Benson, N.U. (2007). Phytoextraction Potential of Sporrobulus Pyramidalis found in an Abandoned battery Industry Environment in Nigeria. Tech. and Environ. Chem. 89 (3): 499 – 506.

Umland, J.B. and Bellama, J.M. (1996). General Chemistry. 2nd ed. West Publishing Company, Minneapolis pp. 400-402, 740, 962.

Vecera, Z. P., Mikuska, Z., Zdrahal, B., Docekal, M., Buckova, Z., Tynova, R., Parizek, J. and Mosna, J. M. (1999). Environmental Analytical Chemistry Department, Institute of Analytical Chemistry, Academy of Sciences of the Czech Republic, Veveri 97, 61142.

Vincoli, J. W. (1995). Basic Guide to Industrial Hygiene. John Wiley and Sons. Inc. Canada. Pp. 140 – 142.

Woolhouse HW (1983). Toxicity and tolerance in the response of plants to metals. In: Encyclopedia of Plant Phisiol., New Series, Vol. 12 C, Springer-Verlag, New York, Heidelberg, Berlin, pp. 246-289.

APPENDIX

Description of samples

Symbol	Description
PA 1	First plant sample at location A
PA 2	Second plant sample at location A
PA 3	Third plant sample at location B
PB 1	First plant sample at location B
PB 2	Second plant sample at location B
PB 3	Third plant sample at location B
PC 1	First plant sample at location C
PC 2	Second plant sample at location C
PC 3	Third plant sample at location C
PCLT 1	First plant sample at control site
PCLT 2	Second plant sample at control site
PA	Average plant sample at location A
PB	Average plant sample at location B
PC	Average plant sample at location C
PCLT	Average plant sample at control site