GLOBAL JOURNAL OF ENVIRONMENTAL SCIENCES VOL. 6, NO. 1, 2007: 27 - 32
COPYRIGHT (C) BACHUDO SCIENCES CO. LTD. PRINTED IN NIGERIA. ISSN 1596 - 6194

ECOLOGICAL BASELINE STUDY OF HEAVY METAL BIOACCUMULATION IN A PROPOSED WETLAND FOR RIVGAS REFINERY PROJECT IN ASE-NDONI, RIVERS STATE

N. L. EDWIN-WOSU AND E. N. ELENWO

(Received 1 August 2006; Revision Accepted 9 January, 2007)

ABSTRACT

The present work involves the baseline study of heavy metal concentration in the wetland environment of a proposed refinery project site in Ase-Ndoni in Rivers State, Nigeria. Results of both wet and dry season samples showed that the element analyzed were those associated with bio indicator and occurred in the order of abundance: K+ > Mg^{2+} >Fe > P > Cu > Zn > A1 > Mn^{2+} > Ni > Cr > Ba >Cd and Mg^{2+} > K+ > Ba > Cr > Cu > Ni > P > Fe > Zn > A1 > Mn^{2+} > Cd for the rainy and dry seasons respectively and these are likely envisaged to be released into the environment through the hydrocarbon prospecting. The absence of the most common pollutants like lead (Pb), vanadium (v), mercury (Hg) arsenic (As), chromium (Cr) cadmium (Cd) and barium (Ba) in some plants sampled have indicated lack of any form of pollution by human influences. The plants are said to be in their natural state of tolerable metal accumulation even far below their normal concentration standard. Results depicted lower concentration levels of heavy metals (mg/g) in the project site and of tolerable standard (mg/g) when compared with other regulatory limit and standards. It is anticipated that these findings may be useful in interpreting wetland environments where hydrocarbon activities are being conducted.

KEYWORDS: Baseline study, Heavy metals, bioindicator, Rivgas Refinery, Ase-Ndoni.

INTRODUCTION.

Man's inability to handle the available natural resources sustainably has resulted in the fouling of the natural environment in recent years. The fouling substances may be untreated organic and inorganic substances from processing and manufacturing industries, oil exploration, exploitation and refining activities. Toxic and hazardous materials from these organic and inorganic wastes settle in the soil and get accumulated (particularly the metals) in plants growing in such environment thereby constituting environmental hazards to the dependent of such plant resources. Thus, in any development activity and ecological demand, it becomes imperative for a baseline investigation (a first hand information) of such project site to be carried out. Ecological baseline study is a sin-qua-non in environmental management. It provides a data base against which the extent and degree of impact are assessed, especially during any proposed project.

A baseline study gathers information early on an activity so that later judgment can be made about the quality and development resulting from the activity. It is an early element in the monitoring and evaluation plan using a long frame structure to systematically assess the circumstances in which an activity commences. It provides the basis for subsequent assessment of how efficiently an activity is being implemented and the eventual result achieved. Subsequent monitoring of activity progress also gathers and analyses data using the long frame, which is in consonance with the baseline study. On general *axion*, information from a baseline study offers a road map for a comparative progress judgment for mid-term reviews, project completion report and other evaluations.

A development activity entails change, so good monitoring and evaluation system will show whether change is occurring and indicate the results of the activity including eventual impacts and the extent of the desired results achieved and their sustainability (AUS AID, 2003).

On a parallel *maxim*, baseline study ensures that the proposed activities of Rivgas project are executed in accordance with statutory requirements without much damage to the environment. To date, no report of baseline study of heavy metal concentration level in that area (Ase-Ndoni) have been published. Therefore from the above consideration, it is pertinent that knowledge of the heavy metal status of the project site in its natural state be obtained for effective management of its envisaged associated problems during the refinery operations. In order to assess the levels of impacts envisaged to emanate due to the project on the ecology of the environment and the people of Ndoni in Rivers State, baseline ecology of heavy metal concentration status of the study area was carried out using vegetation as bio indicator and accumulator for analysis. Thus the study was aimed at unveiling the metal concentration status of the project sites with the objectives of: i Evaluating the bio-ecological indicators as accumulators used in assessing the level of metal concentration. ii Providing and establishing through the bio indicators appropriate ecobaseline data on the existing status of the environment, aimed at optimum facility plan and guidelines for its timely implementation against which long-term monitoring program can be developed for sustainable development. iii Above all proposing appropriate mitigation measures to minimize negative environmental impact that may arise from the project, besides positive impact on the environment, which will aid in suggesting and developing an environmental management plan (EMP) in all phases of the project development.

MATERIALS AND METHODS.

The Project Area.

The study area is a portion of the marshy tropical rainforest sandwiched between the Rivers Orashi and Niger in ASE, Ogba Egbema Ndoni Local Governemtn Area (located between latitude 5° 25' N and 5° 35' N and longitude 6° 31'E and 6°40' E), (Fig. 1).

N. L. Edwin-wosu, Department of Plant Science and Biotechnology; University of Port Harcourt, Choba, P. M. B. 5323, Nigeria.
E. N. Elenwo, Department of Plant Science and Biotechnology; University of Port Harcourt, Choba, P. M. B. 5323, Nigeria.

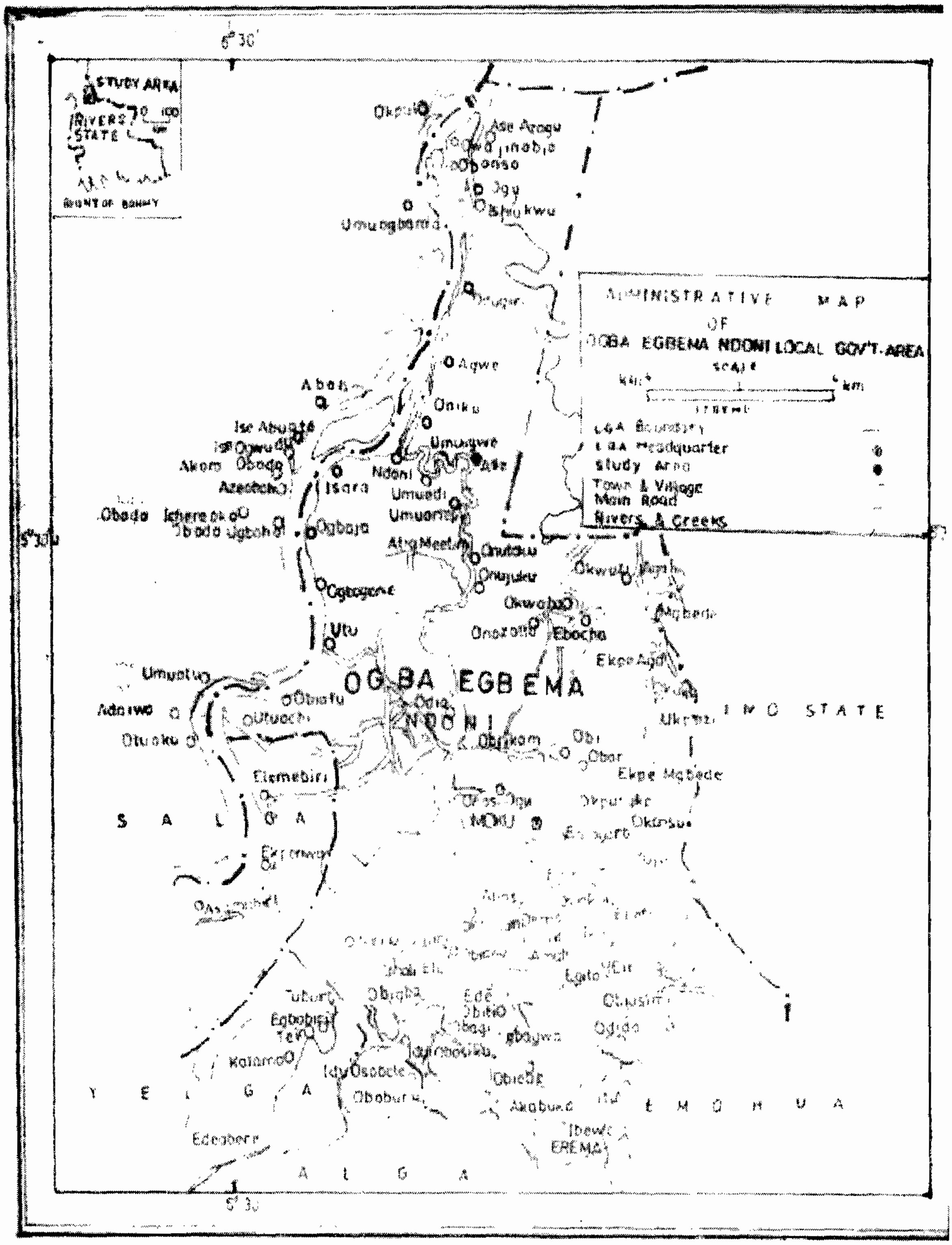

Fig. 1: Map of Ogba/Egbema/Ndoni Local Government Area Showing Ase-Study Area.

The project area is located in the rainforest belt in Rivers State, Nigeria within the equatorial climate region, characterized by high rainfall, high relative humidity and maximum temperature. The area is in the heart of one of the agricultural zones of Rivers State. By its edaphic and topographic status, the site is ecologically characterized by silty-clay soil, with narrow strips and pockets of fresh water ponds among the vegetation array. The vegetation is a typical virgin rainforest with its prevalent species of shrubs, trees, herbs, wood, climbers, lianers and mainly members of the poaceae, cyperaceae and fabaceae plant families, typical of fallowed farm and marshy land. The area is a typical fresh water ecological zone with prevalence of aquatic flora like *Nymphaea maculata, Nymhaea lotus, Eichornea crassipes* and associated pteridophyte (ferns) of the wetland habitat. Though primarily a virgin forest of various vegetation strata, the effects of various forms of anthropogenic activities such as farming, logging and domestic firewood fetching have consequently left it with some form of irregular vegetation features, which thus can best be categorized as a lowland secondary agricultural mosaic forest as described by Hopkins (1968). Despite such ecological succession seen to be engendered by anthropogenic influences, the vegetation can be described as rainforest vegetation in relation to similar views of vegetation analysis by SAF (1954).

Vegetation Sampling and Analysis.

This study was carried out between July 2004 and Feb 2005 reflecting the rainy and dry season sampling respectively. The sampling method engaged in the study of vegetation was simple random sampling based on standard procedures (Kinako, 1988) for ecological assessment studies along specific transect of distance of 100m interval up to 1200m for each transect giving a total of 15 sampling locations for the 5 transect directions. Representative specimens were collected from the study transect, using shears, with their frequency of distribution and abundance estimated using the method of Kershaw (1975) and Austin and Greigsmith (1968). The samples were analyzed for the presence of heavy metal, which could also reflect the soil concentration status. The analysis entails the mixed acid (nitric / perchloric acid) digestion method of International Institute of Tropical Agriculture (IITA) (1979) and using the Perkins-Elmer (1968) Atomic Absorption spectrophotometer, (AAS).

RESULT

The results of this study have indicated that plant species within the project site vegetation have not been impacted by heavy metals, which may have emanated as a result of intensive hydrocarbon activities. Tables 1 & 2 show the concentration of heavy metals (mg/kg) in plant samples from wet and dry seasons sampling respectively. The reports show that the plant species have relatively lows level of heavy metal content.

Table 1: Wet Season concentration of Heavy Metals (mg/kg) in plant Samples from Rivgas Refinery Baseline Project

S/N	SPECIES	% f	FAMILY	Pb	Zn	Cu	Al	Ni	V	Fe	Cr	Cd	Ba	Hg	Mn^{2}	K^{+}	Mg^{2+}	As	P
1	*Cola accuminata* (P.Beauv) Schott & Endl	13.4	STERCULIACEAE	ND	0.034	0.013	0.0175	0.014	ND	0.347	0.011	ND	ND	ND	0.013	10.09	9.7	ND	0.039
2	*Citrus sineensis (L.)* Osbeck	13.4	RUTACEAE	-	0.05	0.047	0.035	0.017	-	0.225	0.009	-	-	-	0.0.32	25.175	10..347	-	0.017
3	*Elaeis guineensis* Jacq	80	ARECACEAE	-	0.039	0.135	0.023	0.023	-	0.107	1.001	-	-	-	0.045	4.176	2..24	-	0.032
4	*Laccosperma opacum* Drude	40	ARECACEAE	-	0.08	0.049	0.008	0.027	-	0.115	0.006	-	-	-	0.036	4.377	1.774	-	0.064
5	*Newbouldia laevis* Seem	13.4	BIGNONIACEAE	-	0.031	0.038	0.013	0.036	-	1.007	0.004	-	-	-	0.017	8.334	3.64	-	0.234
6	*Senna occidentails* (Linn) Link	13.4	FABACEAE - CAESAL	-	0.049	0.137	0.36	0.014	-	0.336	0.002	-	-	-	0.015	6.374	2.641	-	0.367
7	*Bulbophyllum barbigerum* (Lindl)	26.6	ORCHIDACEAE	-	0.05	0.455	0.011	0.013	-	0.774	ND	-	-	-	0.024	4.334	1.006	-	0.076
8	*Zea mays* Linn	13.4	POACEAE	-	0.04	0.093	0,008	0.027	-	0.344	ND	ND	0.002	-	0.077	5.77	2.403	-	0.135
9	*Crinum jagus* (Thomps) Dandy	53.4	AMARYLLIDACEAE	-	0.01	0.036	0.011	0.034	-	0.145	0.01	-	ND	-	0.036	4.335	1.014	-	0.084
10	*Luffa cylindrica* (Linn) M.J Roem	26.6	CUCURBITACEAE	-	0.034	0.025	0.017	0.028	-	0.336	0.012	-	-	-	0.044	17.704	9.773	-	0.036
11	*Pentaclethra macrophylla* Benth	26.6	FABACEAE-MIMO	-	0.08	0.047	0.02	0.033	-	0.771	ND	-	0.008	-	0.033	9.31	2.004	-	0.187
12	*Laccosperma accutiflora* Drans	93.4	ARECACEAE	-	0.121	0.038	0.011	0.027	-	0.225	ND	0.009	ND	-	0.045	4.761	1.342	-	0.086
13	*Funtumia africana* (Benth)	26.6	ARECACEAE	-	0.07	0.104	0.035	0.035	-	0.314	0.009	ND	-	-	0.017	3.454	0.309	-	0.074
14	*Psidium guajava* Linn	40	MYRTACEAE	-	0.04	0.067	0.018	0.077	-	0.271	ND	-	-	-	0.036	12.41	6..33	-	0.13
15	*Pterocarpus santalinoides* Linn	40	FABACEAE	-	0.08	0.084	0.027	0.038	-	0.671	ND	-	-	-	0.054	8.761	3..36	-	0.73
16	*Vernona cinera* (Linn). Less	13.4	ASTERACEAE	-	0.03	0.047	0.036	0.014	-	0.032	ND	-	-	-	0.025	4.76	1.34	-	0.064
17	*Hypolytrum heterophorphum* Nelmes	13.4	CYPERACEAE	-	0.024	0.063	0.011	0.053	-	0.471	ND	-	0.007	-	0.01	3.101	0.885	-	0.082
18	*Manihot esculenta* Crantz	40	EUPHORBIACEAE	-	0.07	0.086	0.016	0.043	-	0.325	ND	-	ND	-	0.036	4.14	1.1062	-	0.066
19	*Dacryodes edulis* (G.Don) H.J.Lam	53.4	BURSERACEAE	-	0.05	0.077	0.018	0.068	-	0.225	0.023	-	-	-	0.015	3.37	0.931	-	0.134
20	*Chromolaena odorata* (Linn.) king and Robinson	40	ASTERACEAE	-	0.037	0.032	0.013	0.024	-	0.134	ND	-	-	-	0.027	8.371	3.004	-	0.116
21	*Musa paradisiaca* Linn	66.6	MUSACEAE	-	0.024	0.066	0.024	0.013	-	0.225	ND	-	0.004	-	0.036	11.031	7.761	-	0.088
22	*Elaphoglossum barteri* (Bak) C. Chr	26.6	LOMARIOPSIDACEAE	-	0.04	0.059	0.011	0.024	-	0.177	0.034	-	ND	-	0.074	12.12	13.34	-	0.071
23	*Anthocleista nobilis* G Don	60	LOGANNIACEAE	-	0.13	0.103	0.047	0.017	-	0.348	0.014	-	-	-	0.144	6.895	2.76	-	0.134
24	*Rhipsalis cassutha* Gaertn	13.4	CACTACEAE	-	0.04	0.025	0.022	0.034	-	0.665	0.025	0.003		-	0.117	8.761	3.86	-	0.072
25	*Senna alata* (Linn). Roxb	26.6	FABACEAE - CAESAL		0.031	0.091	0.018	0.023	-	0.118	0.01	0.001	-	-	0.097	7.445	2.48	-	0.09
	TOTAL				**1..284**	**2.017**	**0.988**	**0.756**		**8.708**	**0.17**	**0.013**	**0.021**		**1.105**	**199..359**	**95.35**		**3..208**
	X				**0.05**	**0.08**	**004**	**0.03**		**0..35**	**0.01**	**0.001**	**0.001**		**0.04**	**7..97**	**3.81**		**0.13**

ND: Not detected.

Table 2: A dry Season Concentration of Heavy Metals (Mg/Kg) in Plant Samples from Rivgtas Refinery Baseline Project.

%F	FAMILY	Pb	Zn	Cu	Al	Ni	V	Fe	Cr	Cd	Ba	Hg	Mn2+	K+	Mn2+	As	P
40	ARECACEAE	ND	0.046	0.01	0.01	0.017	ND	0.08	0.027	ND	ND	ND	0.027	17.346	23.074	ND	0.04
26.6	ASTERACEAE	ND	0.036	0.013	0.01	0.018	ND	0.09	0.012	ND	ND	ND	0.061	27.74	34.038	ND	0.24
7	MORACEAE	ND	0.03	0.012	0.02	0.013	ND	0.07	0.024	ND	ND	ND	0.022	21.48	33.664	ND	0.23
33.3	BOMBACACEAE	ND	0.061	0.011	0.01	0.016	ND	0.11	0.021	ND	ND	ND	0.021	22.274	20.736	ND	0.09
13.3	LOGANIACEAE	ND	0.131	0.014	0.01	0.013	ND	0.37	0.018	ND	ND	ND	0.073	13.364	18.864	ND	0.14
7	COSTACEAE	ND	0.047	0.013	0.02	0.011	ND	0.08	0.027	0.013	0.003	ND	0.014	21.77	22.874	ND	0.08
20	FABACEAE-MIMO	ND	0.063	0.011	0.01	0.013	ND	0.04	0.036	0.017	0.005	ND	0.038	11.35	14.436	ND	0.25
13.3	CYPERACEAE	ND	0.054	0.017	0.01	0.011	ND	0.04	0.012	0.09	ND	ND	0.02	21.37	18.732	ND	0.35
13.3	AMARYLLIDACEAE	ND	0.077	0.012	0.02	0.015	ND	0.06	0.022	ND	ND	ND	0.053	22.24	31.145	ND	0.07
7	SAPOTACEAE	ND	0.068	0.013	0.01	0.017	ND	0.07	0.024	ND	ND	ND	0.036	21.335	27.73	ND	0.05
7	ZINGIBERACEAE	ND	0.054	0.017	0.01	0.016	ND	0.05	0.021	0.011	ND	ND	0.038	24.667	31.447	ND	0.04
20	ARECACEAE	ND	0.046	0.011	0.02	0.011	ND	0.08	0.016	ND	ND	ND	0.028	18.803	24.38	ND	0.06
13.3	DELLENIACEAE	ND	0.053	0.013	0.02	0.018	ND	0.1	0.018	ND	ND	ND	0.053	22.236	23.388	ND	0.08
7	POLYGALACEAE	ND	0.077	0.021	0.01	0.011	ND	0.1	0.009	ND	ND	ND	0.048	21.0996	13.875	ND	0.24
7	CYPERACEAE	ND	0.84	0.018	0.02	0.022	ND	0.09	0.021	ND	0.003	ND	0.037	24.47	23.784	ND	0.15
26.6	EUPHORBIACEAE	ND	0.136	0.016	0.02	0.013	ND	0.08	0.027	0.017	ND	ND	0.028	18.336	11.442	ND	0.43
33.3	RUBIACEAE	ND	0.044	0.02	0.02	0.016	ND	0.05	0.011	0.019	ND	ND	0.063	21.136	31.138	ND	0.18
13.3	ARECACEAE	ND	0.038	0.023	0.01	0.018	ND	0.18	0.013	0.014	0.002	ND	0.048	21.138	24.017	ND	0.07
7	MUSACEAE	ND	0.056	0.031	0.02	0.013	ND	0.07	0.017	0.011	ND	ND	0.104	20.936	23.77	ND	0.21
7	BURSERACEAE	ND	0.036	0.021	0.01	0.015	ND	0.13	0.019	ND	0.009	ND	0.077	11.448	40.384	ND	0.14
7	MYRTACEAE	ND	0.067	0	0.01	0.011	ND	0.09	0.023	ND	ND	ND	0.043	17.887	21.136	ND	0.09
7	RUTACEAE	ND	0.038	0	0.02	0.012	ND	0.07	0.013	ND	ND	ND	0.023	21.136	31.041	ND	0.25
7	FABACEAE CAESAL	ND	0.048	0	0.01	0.014	ND	0.09	0.02	ND	ND	ND	0.038	24.66	22.443	ND	0.09
7	STERCULIACEAE	ND	0.033	0.013	0.01	0.012	ND	0.1	0.022	0.013	ND	ND	0.044	25.66	27.387	ND	0.04
	BIGNONIACEAE	ND	0.020	0.011	0.01	0.013	ND	0.06	0.016	ND	ND	ND	0.036	23.37	30.118	ND	0.38
7	MORACEAE	ND	0.01	0.01	0.02	0.013	ND	0.1	0.026	0.011	ND	ND	0.033	21.04	20.036	ND	0.14
7	FABACEAE-CAESAL	ND	0.024	0.013	0.02	0.017	ND	0.05	0.028	ND	ND	ND	0.067	18.877	11.335	ND	0.03
7	SPHENOCLEACEAE	ND	0.033	0.017	0.02	0.016	ND	0.05	0.029	ND	ND	ND	0.024	12.238	17.738	ND	0.46
7	FABACEAE-PAPI	ND	0.033	0.013	0.02	0.018	ND	0.14	0.022	ND	ND	ND	0.028	17.78	21.134	ND	0.15
20	POACEAE	ND	0.035	0.014	0.01	0.011	ND	0.08	0.015	ND	ND	ND	0.041	21.38	22.247	ND	0.23
			2.32	0.45	0.5	0.44		2.4	0.72	0.02	0.024		1.27	689.5	717.6		5
			0.08	1.51	0	1.45		0.1	2.39	0.01	0.0008		0.04	22.1	23.9		0.2

Discussion

The results observed in Tables 1 & 2 represent the wet and dry season metal concentration levels respectively. The plant species have relatively low heavy metal content. The absence of the most common pollutants like lead (Pb), vanadium (v), mercury (Hg) and arsenic (As) coupled with the absence of chromium (cr), cadmium (cd) and barium (Ba) in some plants sampled have indicated lack of any form of pollution by human influences. The plants are said to be as in their natural state with a tolerable metal accumulation even far below the normal concentration standards of metals (mg/g). In order to interpret the level of heavy metal contents in soils, their concentration have to be analytically determined in normal soil, unaffected by anthropic impact and in affected soils. Also the evaluation of soil pollution level could be reflected by the quantitative and / or qualitative decrease of negative yield in a polluted soil when compared to a similar yield on conditions of practically unpolluted soil (Rauta and Carstea, 1983). There has been reflection between determining the comparison between the level of soil loading (concentration standard) with heavy metals as well as the severity with which each measured element contribute to one or other condition (Lacatusu *et al,* 1992).Similar trend could also take effect in the ecology of the project site. The quality of the environment through the introduction of different types of contaminant may be affected. This study attempted to consolidate this hypothesis by investigating the heavy metal chemistry of the flora around the project site. Plant often absorbs many poisonous substances in a concentrated form hence eating plant or any other food from such site may even be more hazardous than drinking the water. Thus analysis of plant could be valuable source of information in the evaluation of the concentration and effects of heavy metals in the environments. Plant take up metals and other contaminants through their body surface by evapotranspiration and phytoextraction mechanism in the environment. The excess of thes contanminants may affect not only the productivity of the plants but may ultimately pose a health risk to man that directly depend on them as their major source of protein and energy.

The present study examines the variation of heavy metals (Tables 1 & 2) in plant from the study area located in Ase Ndoni Rivers state. Seasonal variation in the trace metal concentrations were evident in all the metals.The level of the metals obtained in he dry season were relatively higher when compared with those of the rainy season. The high level of these metals in the plants in the dry season could be attributed to excessive evapotranspiration of water due to the intense heat prevalent in this period, which could enhance the ironic uptake of these metals from the soil solution by transpiration pull mechanism.

Similarly study has shown that the amounts of metal absorbed by a plant could be predicated on certain determining factors that control the concentrations and speciation of metal from the bulk soil to root surface, its transport from the surface into the root and it translocation from the root to the short (Chaney & Giordano, 1977; Wild, 1988). Similarly plants may accumulate trace metals and thus according to Rao (1980) is dependent on the inherent qualities of the plant, the content of the trace metal in the soil and location.

Averagely, the trace metals content of the natural environment occur in the order of abundance (in mg/g): K+ > Mg^{2+} >Fe > P > Cu > Zn > A1 > Mn^{2+} > Ni > Cr > Ba >Cd and Mg^{2+} > K+ > Ba > Cr > Cu > Ni > P > Fe > Zn > A1 > Mn^{2+} > Cd for the rainy and dry seasons respectively. The absence of the most common metals pollutants like lead (Pb), vanadium (V), mercury (Hg), and Arsenic (As) in the plant in both season is a reflection of little of no homogenic influence. Generally, the average levels of the metals in the project site are low when compared with some standards in Table 3. Thus reliable environmental management plan requires comprehensive information on the basic concentration level of metals in an area of activity such as the refinery operations.

Table 3: Metal Concentration (Mg/Kg) In Plants of Baseline Study of a Refinery Project and Concentration Standard.

Elements	Wet season	Dry season	Normal range in plants (1)	Critical concentration in plants (3) a	b	Normal range in plants (2)
Pb	-	-	0.2-20	30-300	-	0.05-3
Zn	0.05	0.08	1-400	100-400	100-900	15-100
Cu	0.08	1.51	5-20	20-100	5-64	2.5-25
A1	0.04	0.02	-	-	-	0.01-01
N1	0.03	1.45	0 02-5	10-100	8-220	0 5-5
V	-	-	0.001-1-5	5-10	1-13	-
Fe	0.35	0.08	-	-	-	40.500
Cr	0.01	2.39	0.03-14	5-30	2-18	0.05-0.5
Cd	0.001	0.01	0.1-2.4	5-30	4-200	0 01-0 3
Ba	0.001	0.001	-	-	-	-
Hg	-	-	0.005-0.17	1-3	1-8	0.05-0.1
Mn^{2+}	0.04	0.04	20-100	300-500	100-700	50-1000
Kt	7.97	22.10	-	-	-	-
Mg^{2+}	3.81	23.9	-	-	-	-
As	-	-	0.0-7	5-20	1-20	0.1-1.0
P	0.13	0.17	-	-	-	-

1. Source: Bowen, (1979).
2. Stewarte (1974).
3. The critical concentration in plant is the level above which toxicity effects are likely.

a. Kabata – pendias and pendias (1984) b Mc Nichol and Beckett (1985)

REFERENCES

AUS AID, 2003. *Baseline study guidelines.* Australian AID Knowledge Warehouse.

Austin, M. P and Greeg-Smith, P., 1968. The application of quantitative method to Vegetation survey *J. Ecol.* 56:851-884.

Bowen, H. J. M., 1979. *Environment chemistry of the elements* Academic Press, London

Chaney, R. L. and Giordano, P. M., 1977. Soils for the management of organic water and waste water Soil Sci. *Sol. AM. AM. Soc. Agron and Crop Sci. Soc. AM* Madison.

Hopkin, B., 1968. Vegetation of the Olakemeji Forest Reserve, *Nigeia J. Ecol.* 56:97 – 115.

International Institute of Tropical Agriculture, 1979. Selected methods for plant and soil analysis. (11TA) Ibadan.

Kabata-pendias, A. and Pendias, H., 1984. *Trace elements in soils and plants.* CRC Press, Boca Raton Fla.

Kinako, P.D.S., 1988. *Fundamentals of Quantitative and Applied Plant Ecology.* Belk Publishers Port Harcourt.

Kershaw, K.A., 1975. *Quantitative and Dynamic plant Ecology* 2nd Edition, Edward Arnold, London PP305.

Lacatusu, R., Rauta C., P, Blanaru, V., Toti, M., Dumitru, M., Iieana, G., 1992. Poluarea Solului Cu Emisii Industrial Si prin aplicarea technoligii lor Umane si gradul de poluare a alimenteler 110-112

Mc Nichol, R.D. and Bectett, P.H.T., 1985. Plant and soil. 85: 1.07-129

Perkin-Elmer Corporation, 1968. *Analytical procedure for Atomic Absorption spectrophotometr* Perken-Elmer Corporation, Norwalk, Connecticut.

Rao, M. N., 1980. *The need for more information on trace elements of food for improving human nutrition.* International Atomic Energy Agency Vienna. Technical Report series 197; PP 29 – 37.

Rauta, C and Carstea. St. 1954. Prevenirea si combatera poluarii solului. Editura ceres, Bucuresti Society of American Foresters (1954). *Forest Cover Types of North America.* Washington, D. C. SAF.

Stewarte, A. H., Max, G., John, A. P and Christopher Q. 1974. *Chemical analysis of ecological materials.* Blackwell Scientific Publications, Oxford. London.

Wild, B., 1988. *Russell's soil conditions and plant growth.* Longman London.