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An Assessment of Nutrient Levels of Environmental Pollutant Elements in the Soils of Three Selected Rice Farms in Yola Metropolis, Adamawa State, Nigeria

[1]Abraham, E.A., [2]Osemeahon, S.A., [1]Bakari, A.B. and [1]Bawa, Abubakar

[1]The Federal Polytechnic Mubi, Adamawa State, Nigeria.

[2]Department of Chemistry, Modiboo Adama University of Technology Yola, Adamawa State, Nigeria.

ABSTRACT

Heavy metals environmental pollution is an age-long global problem bedeviling nations most especially the less developed ones due to the sacrificing of environmental monitoring and systematic information gathering on pollutants at the expense of quest for rapid industrialization and educational attainment. The study was undertaken in order to assess the status and distribution of molybdenum, zinc, chromium, organic carbon, lead and available phosphorus in five soil profiles each during the dry and rainy seasons in three selected rice farms in Yola metropolis, Adamawa State, Nigeria. EDXFR spectrometer (Mini pal version) and U.V-visblespectrometer, respectively were used to determine the environmental pollution load of the elements. Molybdenum and chromium showed marked variation within the same farm and other farms in different locations. The aforementioned elemental contents ranged from 2.42-0.75, 77.74-39.22mg/kg, respectively, while the mean concentrations of zinc, organic carbon and available phosphorus ranged from 101.19-58.22 mg/kg, 4.63-1.45% and 14.18-9.9mg/kg, respectively. The mean soil pH values ranged from 5-7-6.3 with the exception of dry-season Farm "A" and rainy-season Farm "B" and "C" values which were higher than the range recommended for rice plant cultivation. Molybdenum, chromium and organic carbon contents were higher in the topsoils (0-5 cm) than in the subsoils (5-20cm), while the reverse was the case for available phosphorus. On the whole, the distribution of zinc with soil depth, however did not show clear-cut pattern. Lead was not detected in any of the soils in the studied area. In comparison with authenticated critical levels for each element investigated, the area of interest was not contaminated by these elements, rather the soils would be suitable for high rice crop production with supplementarylime, mineral fertilizers and organic manure applications.

Keywords*:* Soil, Nutrients, Environmental Pollutant elements, critical level.

INTRODUCTION

Rice farming especially the irrigated variant has importance in several countries such as Brazil [1]. In Nigeria, rice is a staple food and delicacy and gets to the dining table in various forms [2]. Hence, it is the preferred meal of choice in social functions such as wedding. Soil, a dynamic medium is one of the primary recipients or sinks for heavy metals released into the environment by anthropogenic activities [3]. The rice plant absorbs its nutrients from the soil and finally to man via the food chain ([3], [4], [5].

The studied area encompassed three selected rice farms, viz Farm "A", "B" and "C" respectively, which received environmental pollutant elements from atmospheric deposition, run-offs, annual flooding, urban wastes and agro-allied activities. The pollutant load may contain different toxic elements which accumulate gradually in the soil are taken up by rice plants and ultimately to man via the food chain as noted earlier on. With time, the level of these toxic elements exceed the tolerable limits in the human body and may be responsible for some strange ailments that can bedevil the local communities that feed on this unsuspected rice produce as was the case in Tamayacity, Japan in 1965 [6]. The present study therefore, is aimed at determining zinc, molybdenum, available phosphorus, organic carbon, lead and chromium status and distribution at definite spots and specified depths in the soils of the study area in order to ascertain their pollution load.

MATERIALS AND METHODS

THE STUDY AREA

Abraham *et al*., (2014) [7] described the area of interest in detail with sketched maps in their report of the first phase of the project. Yola lies between latitude 9^0 13'48"N and 9.23^0N and longitude $12^0$27'36"E and 12.46^0E (http://www.en.wikipedia.org/wiki). The area has humid tropical climate coded Aw (http://www.en.m.wikipedia.org/...koppen) characterized by high temperature and sunshine from January – May and heavy rainfall in August. The annual temperature is between 20-41^0C, while the mean annual rainfall is about 500-1000mm.

Five soil profile representation of rice growing flood plain soils in Yola metropolis were investigated. The samples were collected in February during the dry season and July in the rainy season, respectively.

ANALYTICAL PROCEDURES

Pretreated composite soil samples were air-dried, pulverized, sieved through a 2mm-aluminium sieve, pelletized an analyzed for total elements contents by EDXFR spectrometry (Mini pal version), while available phosphorus content was by Bray P-I method [8]. The organic carbon was determined by dichoromate wet-oxidation method of Agarwala and Sharma, (1979) [9] as outlined by ITTA (2006). And the pH of aqueous suspension (1:10) was measured by a digital pH meter.

RESULTS AND DISCUSSION

Total molybdenum, chromium, Zinc, organic carbon contents and available phosphorus are given in Tables (1-5).

MOLYBDENUM (Mo)

Molybdenum was detected in all the soils of the studied area, with the range of 0.54 - 4.05mg/kg (Table 1). With the exception of dry-season Farm "C", its availability, unlike Zinc and most other heavy metals increases with soil pH (Table 7). Furthermore, it is less available and less mobile in acidic environment, (Table 7). The concentration of Mo in the topsoil was higher than that of the subsoil (Table 6). These facts above support the report by Hodges (2002)[10] that under acidic conditions Mo is less available and less mobile. Moreover, the Mo content in the soils of the study area was within the range' of 20-100 mg/kg of threshold toxicity for plants growth reported by Agarwala and Sharma (1979)[9].

CHROMIUM (Cr)

Farm "C" was the poorest in Cr content, with mean values of 41.45 ± 13.61 and 41.74 ± 11.34 mg/kg of the dry and rainy season soil samples, respectively (Table 2).

Cr concentration in the topsoil was higher than that of the subsoil with the exception of rainy-season Farm "B" where 25.83 and 41.51 mg/kg were detected in former and latter soil types, respectively.

The higher Cr content in the topsoil is an indication of the slow rate of movement in the soil. This slow movement may be attributed to complexation of Crwith organic matter. Adriano (1986)[11] reported that most chromium was organically complexed in the upper horizon (topsoil) rich in organic matter. The mean value of Cr concentrations were within the range of 49-74 mg/kg. recommended by IAEA (2000)[12].

ZINC (Zn)

Zinc contents of the Farms "A", "B" and "C" ranged from 29.20-102.20, 23.090-163.30; 56.94-127.00, 67,16 - 163.30; 61.52-97.82 and 68.00-129.94 mg/kg, respectively of the dry and rainy season samples[Table 3).

On the whole, the distribution of this metal with soil depth, however did not show any district pattern.

Zn contents in the soils were within the range of 5-100 mg/kg reported by Alloway (1990)[13] with the exception of the rainy season Farm "A", but within the recommended range of 101-113mg/kg reported by IAEA (2000)[12].

LEAD (Pb)

Lead was not detected in any of the soils of the area studied. This might either be due to their low natural abundance, scavenging capacities of manganese and iron in the soils [Alloway, 1990)[13] or its concentration was below the detection limit of the EDXRF instrument used for their determination or extensive leaching of this metal of interest in the soils below the sampling depth.

AVAILABLE PHOSPHORUS (P)

Table 4 shows the extractable content in the soils of the studied area. Generally, available P content increases with soil depth in accordance with the opinion proffered by Banerji and Samir, (2005)[14] that soluble organic-phosphorus compound may move down the profile to some extent and get subsequently decomposed. The mean values were 7.21, 10.10; 12.84, 12.57; 14.56 and 13.07 mg/kg for the dry and rainy season soil samples of Farms "A", "B" and "C', respectively. These values were rated low in comparison with those obtained by Ibanga (1992)[15] from soil plains of South -Eastern Nigeria. Nevertheless, the values were well above the lower critical limit of P (6 mg/kg) in soils required by rice plant reported by the University of International Institute Of Tropical Agriculture (UTA). (2006)[16].

The per cent mean values of organic C decrease with soil depth (Table 5). Organic C was rated medium for Farms "A", dry-season Farms "B" and "C" and high for rainy- season Farms "B" and "C" soil samples in accordance with the figures adopted by Ibanga and Armon,(1992)[15] in their report on fertility status of selected soils in Akamkpa Local Government Area, Cross River State.

CONCLUSION

Based on the results of this study and relying heavily on the established critical levels of each element determined, the soils of the three selected rice farms in Yola metropolis were not contaminated by the elements being examined.

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Table 1: Molybdenum content (in mg/kg) in the soil of the studied area

	Farm "A"				Farm "C"				Farm "C"			
Horizon (cm)	**Sample**	**Mo**	**Sample**	**Mo**	**Sample**	**Mo**	**Sample**	**Mo**	**Sample**	**Mo**	**Sample**	**Mo**
0 - 5	DABY 11	2.92	RABY 11	0.93	DWTP 11	2.08	RWTP 11	2.31	DCLG 11	3.47	RCLG 11	2.62
5 - 10	DABY 12	2.90	RABY 12	1.29	DWTP 12	1.86	RWTP 12	1.86	DCLG 12	2.40	RCLG 12	2.47
10 - 20	DABY 13	2.77	RABY 13	0.94	DWTP 13	2.64	RWTP 13	2.08	DCLG 13	2.70	RCLG 13	2.85
0 - 5	DABY 21	2.13	RABY 21	1.20	DWTP 21	2.63	RWTP 21	1.84	DCLG 21	2.49	RCLG 21	2.43
5 - 10	DABY 22	1.87	RABY 22	1.40	DWTP 22	2.81	RWTP 22	2.63	DCLG 22	2.34	RCLG 22	1.03
10 - 20	DABY 23	2.25	RABY 23	1.58	DWTP 23	2.84	RWTP 23	2.71	DCLG 23	2.90	RCLG 23	1.12
0 - 5	DABY 31	2.30	RABY 31	1.35	DWTP 31	2.61	RWTP 31	2.53	DCLG 31	1.80	RCLG 31	1.05
5 - 10	DABY 32	1.05	RABY 32	1.90	DWTP 32	4.05	RWTP 32	2.05	DCLG 32	1.21	RCLG 32	2.78
10 - 20	DABY 33	2.89	RABY 33	2.20	DWTP 33	3.40	RWTP 33	1.56	DCLG 33	2.50	RCLG 33	3.13
0 - 5	DABY 41	2.96	RABY 41	2.10	DWTP 41	2.23	RWTP 41	1.17	DABY 41	2.64	RABY 41	2.90
5 - 10	DABY 42	1.81	RABY 42	1.61	DWTP 42	2.79	RWTP 42	1.41	DABY 42	2.96	RABY 42	2.79
10 - 20	DABY 43	2.86	RABY 43	1.36	DWTP 43	2.30	RWTP 43	1.37	DCLG 43	1.04	RCLG 43	2.27
0 - 5	DABY 51	2.02	RABY 51	1.52	DWTP 51	1.06	RWTP 51	1.27	DCLG 51	2.28	RCLG 51	2.78
5 - 10	DABY 52	2.75	RABY 52	1.27	DWTP 52	0.98	RWTP 52	1.28	DCLG 52	2.67	RCLG 52	2.60
10 - 20	DABY 53	1.92	RABY 53	0.54	DWTP 53	2.80	RWTP 53	0.53	DCLG 53	2.86	RCLG 53	2.12
RANGE		1.05-2.96		0.54-2.20		0.90-4.05		0.53-2.71		1.04-3.47		1.03-3.13
MEAN		2.29± 0.57		1.27±0.49		2.12±0.87		1.75±0.63		2.42±0.52		2.33±0.52

Table 2: Chromium Content (in mg/kg) in the Soil of the Studied Area

	Farm "A"				Farm "C"				Farm "C"			
Horizon (cm)	**Sample**	**Cr**	**Sample**	**Cr**	**Sample**	**Cr**	**Sample**	**Cr**	**Sample**	**Cr**	**Sample**	**Cr**
0 - 5	DABY 11	55.94	RABY 11	93.28	DWTP 11	50.62	RWTP 11	25.38	DCLG 11	36.63	RCLG 11	50.62
5 - 10	DABY 12	62.60	RABY 12	64.56	DWTP 12	59.27	RWTP 12	57.80	DCLG 12	45.95	RCLG 12	41.96
10 - 20	DABY 13	52.61	RABY 13	80.75	DWTP 13	42.62	RWTP 13	75.42	DCLG 13	55.88	RCLG 13	48.15
0 - 5	DABY 21	68.60	RABY 21	88.78	DWTP 21	48.62	RWTP 21	53.04	DCLG 21	37.96	RCLG 21	43.29
5 - 10	DABY 22	42.61	RABY 22	76.98	DWTP 22	31.30	RWTP 22	31.96	DCLG 22	51.28	RCLG 22	59.02
10 - 20	DABY 23	60.00	RABY 23	85.00	DWTP 23	31.96	RWTP 23	39.44	DCLG 23	35.96	RCLG 23	57.94
0 - 5	DABY 31	54.88	RABY 31	72.59	DWTP 31	35.96	RWTP 31	60.52	DCLG 31	30.80	RCLG 31	64.60
5 - 10	DABY 32	51.95	RABY 32	80.85	DWTP 32	22.64	RWTP 32	63.92	DCLG 32	43.96	RCLG 32	34.63
10 - 20	DABY 33	56.61	RABY 33	50.41	DWTP 33	30.00	RWTP 33	35.47	DCLG 33	33.01	RCLG 33	17.32
0 - 5	DABY 41	55.28	RABY 41	35.90	DWTP 41	50.62	RWTP 41	75.58	DABY 41	21.98	RABY 41	30.64
5 - 10	DABY 42	65.90	RABY 42	88.64	DWTP 42	38.66	RWTP 42	10.74	DABY 42	17.32	RABY 42	26.64
10 - 20	DABY 43	57.28	RABY 43	128.00	DWTP 43	42.62	RWTP 43	46.00	DCLG 43	56.61	RCLG 43	47.95
0 - 5	DABY 51	63.94	RABY 51	93.39	DWTP 51	60.61	RWTP 51	54.36	DCLG 51	55.28	RCLG 51	28.44
5 - 10	DABY 52	55.94	RABY 52	95.67	DWTP 52	46.62	RWTP 52	40.16	DCLG 52	41.29	RCLG 52	28.64
10 - 20	DABY 53	63.94	RABY 53	79.75	DWTP 53	25.97	RWTP 53	79.75	DCLG 53	26.60	RCLG 53	41.96
RANGE MEAN		42.61-68.60 58.89±6.25		35.90-128.00 77.74±21.40		22.64-60.64 41.74±11.43		10.74-79.75 43.33±21.11		26.60-56.61 39.22±9.45		17.32-64.6 41.45±13.6

Table 3: Zinc Concentration (in mg/kg) in the Soil of the Studied Area

	Farm "A"				Farm "C"				Farm "C"			
Horizon (cm)	**Sample**	**Zn**	**Sample**	**Zn**	**Sample**	**Zn**	**Sample**	**Zn**	**Sample**	**Zn**	**Sample**	**Zn**
0 – 5	DABY 11	43.84	RABY 11	115.00	DWTP 11	96.36	RWTP 11	81.76	DCLG 11	62.78	RCLG 11	97.81
5 – 10	DABY 12	43.80	RABY 12	75.90	DWTP 12	127.00	RWTP 12	134.32	DCLG 12	65.70	RCLG 12	81.80
10 – 20	DABY 13	29.20	RABY 13	100.30	DWTP 13	84.68	RWTP 13	122.64	DCLG 13	68.62	RCLG 13	77.36
0 – 5	DABY 21	86.14	RABY 21	85.10	DWTP 21	91.98	RWTP 21	124.00	DCLG 21	74.46	RCLG 21	83.22
5 – 10	DABY 22	43.80	RABY 22	57.50	DWTP 22	86.14	RWTP 22	78.84	DCLG 22	97.82	RCLG 22	112.42
10 – 20	DABY 23	52.60	RABY 23	77.28	DWTP 23	112.42	RWTP 23	77.38	DCLG 23	64.24	RCLG 23	102.30
0 – 5	DABY 31	48.18	RABY 31	47.04	DWTP 31	112.42	RWTP 31	67.16	DCLG 31	70.36	RCLG 31	129.94
5 – 10	DABY 32	54.02	RABY 32	45.36	DWTP 32	62.78	RWTP 32	103.66	DCLG 32	94.90	RCLG 32	78.81
10 – 20	DABY 33	77.38	RABY 33	11.74	DWTP 33	62.50	RWTP 33	117.21	DCLG 33	83.22	RCLG 33	73.00
0 – 5	DABY 41	39.42	RABY 41	23.00	DWTP 41	116.80	RWTP 41	147.21	DABY 41	91.98	RABY 41	68.00
5 – 10	DABY 42	77.38	RABY 42	78.96	DWTP 42	56.94	RWTP 42	94.30	DABY 42	80.30	RABY 42	79.00
10 – 20	DABY 43	40.88	RABY 43	33.60	DWTP 43	83.22	RWTP 43	117.30	DCLG 43	160.72	RCLG 43	116.81
0 – 5	DABY 51	102.20	RABY 51	50.40	DWTP 51	108.00	RWTP 51	117.30	DCLG 51	124.00	RCLG 51	99.28
5 – 10	DABY 52	56.94	RABY 52	82.32	DWTP 52	112.42	RWTP 52	98.90	DCLG 52	51.52	RCLG 52	105.62
10 – 20	DABY 53	77.38	RABY 53	163.30	DWTP 53	80.30	RWTP 53	163.30	DCLG 53	61.52	RCLG 53	104.32
RANGE MEAN		2920-120.20 58.21±16.14		23.00-163.30 63.00±38.83		56.94-127.00 89.72±21.89		67.16-163.30 101.19±29.42		61.52-97.82 85.30±28.84		68.00-129.94 93.64±18.1

Table 4: Concentration (in mg/kg) of Extractable Phosphorus in the Soil of the Studied Area

	Farm "A"				Farm "C"				Farm "C"			
Horizon (cm)	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**
0 - 5	DABY 11	6.70	RABY 11	11.22	DWTP 11	12.00	RWTP 11	11.60	DCLG 11	13.90	RCLG 11	15.40
5 - 10	DABY 12	11.10	RABY 12	10.00	DWTP 12	9.10	RWTP 12	10.90	DCLG 12	13.99	RCLG 12	12.30
10 - 20	DABY 13	12.33	RABY 13	11.40	DWTP 13	13.44	RWTP 13	12.50	DCLG 13	14.90	RCLG 13	16.40
0 - 5	DABY 21	6.44	RABY 21	11.60	DWTP 21	16.58	RWTP 21	16.90	DCLG 21	16.40	RCLG 21	13.40
5 - 10	DABY 22	8.62	RABY 22	14.32	DWTP 22	12.32	RWTP 22	12.40	DCLG 22	17.80	RCLG 22	13.90
10 - 20	DABY 23	10.00	RABY 23	13.44	DWTP 23	15.40	RWTP 23	17.60	DCLG 23	16.99	RCLG 23	15.00
0 - 5	DABY 31	11.21	RABY 31	10.66	DWTP 31	13.50	RWTP 31	12.00	DCLG 31	8.77	RCLG 31	9.86
5 - 10	DABY 32	10.45	RABY 32	12.00	DWTP 32	12.65	RWTP 32	12.90	DCLG 32	11.00	RCLG 32	10.60
10 - 20	DABY 33	11.00	RABY 33	12.22	DWTP 33	14.00	RWTP 33	13.20	DCLG 33	11.65	RCLG 33	11.90
0 - 5	DABY 41	4.32	RABY 41	8.23	DWTP 41	10.34	RWTP 41	9.34	DABY 41	10.33	RABY 41	11.40
5 - 10	DABY 42	10.21	RABY 42	12.00	DWTP 42	12.60	RWTP 42	12.70	DABY 42	11.92	RABY 42	11.52
10 - 20	DABY 43	12.40	RABY 43	12.43	DWTP 43	11.50	RWTP 43	10.66	DCLG 43	12.09	RCLG 43	13.94
0 - 5	DABY 51	10.64	RABY 51	11.50	DWTP 51	13.66	RWTP 51	12.32	DCLG 51	16.80	RCLG 51	12.90
5 - 10	DABY 52	11.70	RABY 52	11.70	DWTP 52	12.50	RWTP 52	14.63	DCLG 52	17.60	RCLG 52	13.86
10 - 20	DABY 53	11.93	RABY 53	12.50	DWTP 53	14.00	RWTP 53	15.77	DCLG 53	17.76	RCLG 53	15.35
RANGE MEAN		- 4.94±+2.39		- 11.68±1.49		- 12.90±1.85		- 13.03±2.02		- 14.13±3.14		- 13.18±1.91

Table 5: Organic Carbon Content (in%) in the Soil of the Studied Area

	Farm "A"				Farm "C"				Farm "C"			
Horizon (cm)	**Sample**	**C**	**Sample**	**C**	**Sample**	**C**	**Sample**	**C**	**Sample**	**C**	**Sample**	**C**
0 - 5	DABY 11	1.70	RABY 11	2.70.	DWTP 11	2.70	RWTP 11	3.50	DCLG 11	2.15	RCLG 11	2.80
5 - 10	DABY 12	1.50	RABY 12	2.65	DWTP 12	2.50	RWTP 12	3.20	DCLG 12	2.10	RCLG 12	2.50
10 - 20	DABY 13	1.32	RABY 13	2.20	DWTP 13	2.00	RWTP 13	3.00	DCLG 13	2.00	RCLG 13	2.40
0 - 5	DABY 21	1.40	RABY 21	3.20	DWTP 21	2.40	RWTP 21	6.10	DCLG 21	2.25	RCLG 21	2.20
5 - 10	DABY 22	1.20	RABY 22	3.15	DWTP 22	1.80	RWTP 22	5.80	DCLG 22	1.70	RCLG 22	2.15
10 - 20	DABY 23	0.93	RABY 23	2.98	DWTP 23	1.40	RWTP 23	5.40	DCLG 23	1.68	RCLG 23	1.60
0 - 5	DABY 31	1.80	RABY 31	2.00	DWTP 31	2.50	RWTP 31	10.30	DCLG 31	2.90	RCLG 31	4.70
5 - 10	DABY 32	1.62	RABY 32	1.86	DWTP 32	2.40	RWTP 32	7.90	DCLG 32	2.85	RCLG 32	4.52
10 - 20	DABY 33	1.58	RABY 33	1.72	DWTP 33	2.20	RWTP 33	6.00	DCLG 33	2.40	RCLG 33	4.00
0 - 5	DABY 41	1.72	RABY 41	1.90	DWTP 41	2.00	RWTP 41	4.70	DABY 41	3.70	RABY 41	3.00
5 - 10	DABY 42	1.68	RABY 42	1.78	DWTP 42	1.15	RWTP 42	4.30	DABY 42	2.60	RABY 42	2.40
10 - 20	DABY 43	1.59	RABY 43	1.73	DWTP 43	0.50	RWTP 43	4.00	DCLG 43	2.00	RCLG 43	1.90
0 - 5	DABY 51	1.30	RABY 51	1.40	DWTP 51	1.60	RWTP 51	2.00	DCLG 51	1.90	RCLG 51	4.00
5 - 10	DABY 52	1.25	RABY 52	1.33	DWTP 52	1.40	RWTP 52	1.80	DCLG 52	1.36	RCLG 52	3.80
10 - 20	DABY 53	1.19	RABY 53	1.20	DWTP 53	1.35	RWTP 53	1.79	DCLG 53	1.30	RCLG 53	3.00
RANGE		-		-		-		-		-		-
MEAN		1.45±0.24		2.12±0.66		1.89±0.46		4.65±2.35		2.15±0.62		3.00±1.01

Table 6: Distribution Profile of Mo, P, Cr, Zn (in mg/kg) and Carbon (in%) in the Soils of the Studied Area

Farm	Sample	Horizon (cm)	Mo	P	Cr	Organic C	Zn
	Dry-season topsoil	0-5	2.92	7.86	55.94	1.58	48.84
	Dry-season sub soil	5-20	2.16	10.98	46.22	1.39	54.35
	Rainy-season topsoil	0-5	0.93	10.66	93.28	2.24	115.00
"A"	Rainy-season subsoil	5-20	1.36	12.20	74.89	2.16	62.12
	Dry-season topsoil	0-5	2.08	13.22	50.62	2.24	96.36
	Dry-season sub soil	5-20	2.40	12.24	38.29	1.71	83.29
	Rainy-season topsoil	0-5	2.31	12.43	25.83	5.30	81.76
"B"	Rainy-season subsoil	5-20	1.59	13.33	41.51	4.32	104.23
	Dry-season topsoil	0-5	3.47	13.24	36.63	2.48	62.78
	Dry-season sub soil	5-20	2.85	14.58	30.15	2.00	74.38
	Rainy-season topsoil	0-5	2.62	12.59	50.62	3.34	81.80
"C"	Rainy-season subsoil	5-20	2.15	13.48	31.41	2.83	87.45

Table 7: Distribution of Molybdenum (in mg/kg) in the two Soils Horizons of the Studied Area

Farm	Sample	Horizon (cm)	Mo	pH
"A"	Dry-season	Topsoil (0-5)	2.92	5.7
	Dry-season	Subsoil (5-20)	2.16	5.7
	Rainy-season	Topsoil (0-5)	0.93	6.1
	Rainy-season	Subsoil (5-20)	1.36	6.1
"B"	Dry-season	Topsoil (0-5)	2.08	6.1
	Dry-season	Subsoil (5-20)	2.40	6.1
	Rainy-season	Topsoil (0-5)	2.31	5.7
	Rainy-season	Subsoil (5-20)	1.59	5.7
"C"	Dry-season	Topsoil (0-5)	3.47	6.3
	Dry-season	Subsoil (5-20)	2.85	6.3
	Rainy-season	Topsoil (0-5)	2.62	5.8
	Rainy-season	Subsoil (5-20)	2.15	5.8