



ISSN 2278 – 0211 (Online)

## Depth Profile of Anthropogenic Pollutants in Some Arable Lands in Plateau State

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**Abstract:**

A depth profile approach was applied to twenty-five (25) soil samples collected from five different villages in plateau state to assess the environmental accumulation of possible anthropogenic pollutants. Depth wise collection was adapted from the top soil (0-5cm) to the deep soil (20-25cm). Walkley Black titration method was used to obtained organic matter content and Nitrogen. Bouyoucos method for particle size determination, and Phosphorus was by Bray P-1 method. AAS was used to determine Mn, Zn, Cu, and Fe while Na and K were by AES. The results indicated that the top soil (0-10cm) contained a higher amount of organic matter which ranges from (0-18%). These values decreased as the depth increased from the mid soil (10-20cm) to the deep soil (20-25cm). Values ranged from 0-4.9 and 2.2mg/g. Elemental concentrations also generally decreased as the depth increased. The maximum measured values were Mn 830 $\mu$ g/g (0-5cm), Cu 30 $\mu$ g/g (15-20cm), Zn 200 $\mu$ g/g (0-5cm), Na 1590 $\mu$ g/g (0-5cm), K 1140 $\mu$ g/g (0-5cm) and Fe 770 $\mu$ g/g (0-5cm). This indicates high surface soil elemental content which decreases as the depth increases. The profile (0-5cm) indicates the anthropogenic additions while that of (15-25cm) showed the natural additions. Metal concentrations also decreases as the organic matter decreased. In this area, clay was not an important agent in holding the metals in place because of the low percentage of clay recorded. The highest value was 8.8% for 5-10cm depth; insoluble organic matter was more significant in this case.

**Keywords:** Depth Profile, Anthropogenic Pollutants, Arable Land.**1. Introduction**

Pollution can be generally defined as the addition of any material or substances by human society to the environment which can cause injury to human health or damage to natural ecosystem (UNEP, 1992). Soils are described as independent natural bodies each with a unique morphology resulting from a particular combination of climate living plants and animals. Soil is also the thin layer of organic and inorganic material that covers the earth rocky surface. The organic portion derived from the decayed remains of plants and animals is mainly concentrated in the dark uppermost topsoil while the inorganic portion is made up of rock fragments, formed over a long period of years by physical and chemical weathering of bedrock (NCS, 2015).

Soils have horizons or layers more or less parallel to the surface and differing from above or below in one or more properties such as colour, texture, structure consistency, porosity and reaction. The horizons may be thick or thin, they may be prominent or weak that they can only be detected in the laboratory. The succession of horizons is called soil profile (McGraw Hill, 1980). The formations of soil proceed in stages. First is the accumulation of unconsolidated rock fragments (parent material) which may be moved by glaciers, wind, gravity or water or it may accumulate more or less in place of physical and chemical weathering of hard rocks. The formation of horizons is the next stage. This is a result of dominance of one or more of processes over others, producing a layer which differs from the layers above or below. The processes that promote horizon differentiation are gains, losses transfers and transformations of organic matter, soluble salts, carbonates, silicates, clay minerals, sequa oxides and silica. Gains consist of additions of organic matter and of oxygen and water through oxidation and hydration. Losses are mainly of mineral materials dissolved or suspended in water percolating through the profile or running off the surface. Transfers of both mineral and organic materials are common in soils (McGraw Hill, 1980). Soil fertility generally refers to the ability of soils to grow crops. Most soil however have constraints on this ability and therefore the need for fertilizer application (Gasser, 1988). Fertilizers mainly supply the soil with macro nutrients like

Nitrogen, Phosphorus, Potassium, Calcium etc and micro nutrients like Iron, Manganese, Zinc, Copper, Lead and Cadmium. Excesses of some of these trace elements like Cadmium and Lead in the environment can cause problems to both humans and plants (Gasser, 1988). This cumulatively leads to soil pollution.

Meanwhile productive soils are required for agricultural activities in order to supply the world with sufficient food. A soil (land) pollutant can be any factor which deteriorates the quality, texture and mineral content of the soil or which disturbs the biological balance of the organisms in the soil. Pollution in soil can adversely affects plants growth and can be associated with

1. Indiscriminate use of fertilizers.
2. Indiscriminate use of pesticides and herbicides
3. Dumping of large quantities of solid waste
4. Deforestation and soil erosion.

Heavy metal pollution of soil is recognized as a potential health problem because metals in soils can reach human directly through the inhalation of dust and ingestion of dirt on hands or can be taken up by food plants through their roots which is a major path of entry of lead into the bio system. Humans are exposed to cadmium entirely through food and cigarette smoking. (Davies,1988).

In this paper, the land under study is the arable land where agricultural activities take place. Therefore, the anthropogenic pollutants here are the agricultural inputs into the soil meant to enhance the quality of the soil for greater productivity and maximum yield. The land in the southern part of plateau can be generally described as gently undulating plains with scattered hills, rocks with about 0-2% slopes (FDALR, 1990). These soils, are derived from base complex rocks especially granite, gneiss and schist. They are well drained found on lower slopes (FDALR, 1990).

A depth profile of the pollutants was established to determine some possible anthropogenic pollutants that might have been introduced in the soil as a result of agricultural activities and was correlated with the percentage clay and organic matter level in the soil. Several scientists have provided some evidence to show that heavy metal concentration in soils is of concerned. Dilek *et al* (2001) carried out a study of heavy metal contamination in soils and compared the runoff and soil concentration levels. The results showed that heavy metal contamination in the top 0-15cm of soil samples were high compared to local background levels. The maximum measured amount of zinc was 1430mg/kg (at 0-10cm depth), metal content in the soil decreased rapidly with depth and also decreased as organic carbon (matter) decreased. Gibson and Farmer (1984) applied a six step sequential leaching procedure to analyze soil samples compared to street dust to understand environmental mobility and bioavailability of zinc and copper. The results revealed that the exchangeable fraction was relatively less in the soil. Zn was about 3% and Cu to be 2.5%.

Hewitt and Candy (1990) examined levels of Zinc soil samples around the city of Cuenca, Ecuador and found concentration of Zn to be between 155-1018mg/kg. Provini *et al* (1989) study sediment cores of Lake Varese to estimate the ecological risk from identified pollutants. Results showed that organic matter ranged between 11.8% to 25.5 % at five different locations, total P ranged between 5.6 to 14.3mg/g. The concentration of metals generally showed a peak near the surface layer. The profile of Zn was the least regular compared to the other metals in concentration. Hartayani *et al* (2000) observed that pollution of soils is a danger to the health of people, even those living in cities. The anthropogenic pollution caused by heavy industries entered plants then goes through the food chain and ultimately endanger the human health.

Santos *et al* (2000) used the method of GC-FIIS to determine phenoxy acid herbicides and 2, 4-D in soil samples. The residues in the soil samples were between  $76 \pm 4\%$  and  $97 \pm 7\%$  at concentration levels of 5 and 10ng/cm<sup>3</sup> respectively. Li *et al* (2000) determine copper and Zinc in muddy soil by heating air-dried samples with 1cm<sup>3</sup> H<sub>2</sub>O and 6M concentrated HNO<sub>3</sub>. After dilution, solutions were analyzed by Flame AAS with absorbance taken at 324.7nm and 213.6nm respectively. The results were noted to be comparable to those obtained by the published methods. Malley *et al* (1999) investigated a possible means of measuring pH, determinations of Na, K, Fe and Mn in soils using an NIR spectrophotometer. Results showed good correlations for elemental analyses and less comparable for the pH measurement.

Kebir and Bouhadjera (2011) studied the presence of Pb, Zn, Ni, Cu, Cd, Mn, Cr, Fe and as in soil and plant in the industrial area of West Algeria using Inductive Coupled Plasma Atomic Emission spectrometry (ICP-AES) and found that the plant samples were highly contaminated with Zn Cd and Mn. She revealed a health risk for human and livestock due to the spread of the metal pollution from waste dumpsite to agricultural areas.

## 2. Materials and Methods

Soil samples were collected in five different villages of Shendam in Plateau state namely, Yelwa-Nshar, Lakushi, Kalong, Lu-Kurung and Laraba. Samples were collected using a plastic shovel to a depth of 0-5cm, 5-10cm, 10-15cm, 15-20cm and 20-25cm with a transparent meter rule. Composite samples were gotten and packaged in a polythene bags. Reagents were all of analytical grade from BDH. About 20g of the air dried samples of size 2mm were dissolved in 20cm<sup>3</sup> of distilled water in a beaker to measure the pH. Particle size was determined by the methods described by Bouyoucos (1951) and Day (1953), organic carbon (matter) was determined according to methods described by Walkley (1956) Walkley and Black (1934), (OAU manual, 2001).

Nitrogen was determined as nitrate using the Black *et al* 1954, Jackson, 1988, Nzewi, 1979, OAU manual, 2001. Phosphorus was by the Bray No.1 Method, IITA Manual, 1979. The sieved soil samples of 0.5mm were digested using 10cm<sup>3</sup> of 50% H<sub>2</sub>O and 20cm<sup>3</sup> of 2M HNO<sub>3</sub>. The mixtures were heated on a water bath at about 90°C for 2 hrs. The solutions were removed, cooled and filtered with deionized water and a little of 2M HNO<sub>3</sub> used to wash the residue. The filtrate was diluted to a volume of 250cm<sup>3</sup> in a volumetric flask and stored in plastic bottles in refrigerator at 4°C until it was ready for analysis. Metal concentration determination was done using flame AAS while Na and K were determined by flameless AES.

A calibration curve was obtained using standard solutions of each element. Then the various absorbances of the soil solutions were obtained from the corresponding concentration extrapolated from the curve and multiplied by the dilution factor 250.

### 3. Results and Discussion

The results are presented in the table below.

Sample Depth cm	pH	%TOC	%OM	%clay	%Silt	%Sand	%Nitrogen	Total Phosphorus mg/kg	Na <sub>p</sub> /g	K <sub>p</sub> /g	Fe <sub>p</sub> /g	Mn <sub>p</sub> /g	Zn <sub>p</sub> /g	Cu <sub>p</sub> /g
<b>S1</b>														
0-5	6.42	0.84	1.46	6.00	22.00	72.00	0.020	22.50	1270	760	360	10	160	14
5-10	6.24	0.46	0.80	8.80	22.40	68.80	0.018	20.00	1160	740	260	18	150	4
10-15	6.31	0.40	0.69	6.00	24.40	69.60	0.037	17.00	1230	640	220	22	120	0
15-20	6.99	0.24	0.42	6.60	21.20	72.20	0.028	25.00	1130	500	170	5	100	3
20-25	6.29	0.18	0.31	7.40	21.80	70.80	0.023	50.00	1290	600	220	6	140	10
<b>Range</b>	<b>6.24-6.99</b>	<b>0.18-0.84</b>	<b>0.31-1.46</b>	<b>6.00-8.80</b>	<b>21.20-24.40</b>	<b>68.80-72.20</b>	<b>0.018-0.028</b>	<b>17.00-50.00</b>	<b>1130-1290</b>	<b>500-760</b>	<b>170-360</b>	<b>5-18</b>	<b>100-160</b>	<b>0-14</b>
<b>Mean =</b>	<b>6.25±0.16</b>	<b>0.52±0.08</b>	<b>0.74±0.45</b>	<b>6.69±1.70</b>	<b>22.36±1.49</b>	<b>70.68±2.19</b>	<b>0.025±0.008</b>	<b>26.90±13.20</b>	<b>1216±69</b>	<b>640±107</b>	<b>246±71</b>	<b>12.2±7.5</b>	<b>134±24</b>	<b>6.2±5.7</b>
<b>S2</b>														
0-5	6.36	2.19	3.80	6.80	29.00	64.20	0.018	60.00	1310	1140	770	480	200	8
5-10	5.67	1.71	2.97	6.60	20.00	73.40	0.025	50.00	1470	790	770	820	130	7
10-15	6.29	0.92	1.60	6.80	17.40	75.80	0.017	65.00	810	220	250	90	50	10
15-20	6.11	0.99	1.72	7.80	15.00	77.20	0.022	45.00	800	380	360	130	60	14
20-25	6.22	1.11	1.92	8.20	14.20	77.60	0.023	45.00	1370	920	670	200	160	15
<b>Range</b>	<b>5.67-6.36</b>	<b>0.92-2.19</b>	<b>1.60-3.80</b>	<b>6.60-8.20</b>	<b>14.20-29.00</b>	<b>64.20-77.60</b>	<b>0.017-0.025</b>	<b>45.00-65.00</b>	<b>810-1370</b>	<b>220-1140</b>	<b>250-770</b>	<b>90-820</b>	<b>50-200</b>	<b>7-15</b>
<b>Mean</b>	<b>6.13±0.28</b>	<b>1.38±0.30</b>	<b>2.40±0.90</b>	<b>7.24±0.51</b>	<b>19.12±8.91</b>	<b>73.64±30.55</b>	<b>0.021±0.003</b>	<b>53.00±9.10</b>	<b>1152±322</b>	<b>690±3822</b>	<b>564±243</b>	<b>344±307</b>	<b>120±64</b>	<b>10.8±3.6</b>
<b>S3</b>														
0-5	6.06	0.34	0.59	6.80	12.80	80.40	0.025	32.50	1290	710	150	70	190	20
5-10	6.21	0.38	0.66	7.00	12.20	80.80	0.018	50.00	1330	720	170	60	180	16
10-15	6.23	0.36	0.62	6.20	15.00	78.80	0.027	30.00	1290	680	150	50	170	20
15-20	6.11	0.28	0.49	7.80	12.20	80.00	0.022	37.50	1590	660	110	40	180	14
20-25	6.21	0.32	0.55	8.40	14.00	77.60	0.028	30.00	1350	720	86	20	160	20
<b>Range</b>	<b>6.06-6.23</b>	<b>0.28-0.38</b>	<b>0.49-0.66</b>	<b>6.20-8.40</b>	<b>12.20-15.00</b>	<b>77.60-80.80</b>	<b>0.018-0.027</b>	<b>30.00-50.00</b>	<b>1290-1590</b>	<b>660-720</b>	<b>86-170</b>	<b>20-70</b>	<b>160-190</b>	<b>14-20</b>
<b>Mean</b>	<b>6.13±0.28</b>	<b>1.38±0.30</b>	<b>2.40±0.90</b>	<b>7.24±0.51</b>	<b>19.12±8.91</b>	<b>73.64±30.55</b>	<b>0.021±0.003</b>	<b>53.00±9.10</b>	<b>1152±322</b>	<b>690±3822</b>	<b>564±243</b>	<b>344±307</b>	<b>120±64</b>	<b>10.8±3.6</b>
<b>S4</b>														
0-5	7.00	0.92	1.60	8.20	15.40	76.40	0.025	58.00	1180	520	270	70	100	17
5-10	7.04	0.94	1.63	6.00	16.40	77.60	0.028	47.50	1160	510	320	90	100	16
10-15	7.10	0.99	1.72	6.40	15.20	78.40	0.022	37.50	810	280	280	110	40	14
15-20	7.00	1.07	1.86	6.20	15.00	78.80	0.021	40.00	1330	830	830	110	170	30
20-25	7.00	1.23	2.13	5.60	22.20	72.20	0.031	32.00	1440	670	760	100	190	22
<b>Range</b>	<b>7.00-7.10</b>	<b>0.92-1.23</b>	<b>1.60-2.13</b>	<b>5.60-8.20</b>	<b>15.00-22.20</b>	<b>72.20-78.80</b>	<b>0.021-0.031</b>	<b>32.00-58.00</b>	<b>810-1440</b>	<b>280-830</b>	<b>270-830</b>	<b>70-110</b>	<b>40-190</b>	<b>14-30</b>
<b>Mean =</b>	<b>7.03±0.04</b>	<b>1.03±0.02</b>	<b>1.79±0.22</b>	<b>6.48±1.01</b>	<b>16.84±9.27</b>	<b>76.68±7.11</b>	<b>0.025±0.004</b>	<b>43.00±10.10</b>	<b>1184±238</b>	<b>580±220</b>	<b>580±220</b>	<b>96±17</b>	<b>120±60</b>	<b>19.8±6.4</b>
<b>S5</b>														
0-5	5.74	1.39	2.41	6.60	11.00	82.40	0.014	11.50	1360	670	670	830	190	21
5-10	5.82	1.31	2.27	6.40	11.60	82.00	0.022	9.00	1310	690	690	350	180	25
10-15	5.86	1.27	2.20	6.80	14.40	78.80	0.017	8.00	1300	650	650	200	180	23
15-20	5.98	1.21	2.10	8.80	14.80	76.40	0.019	10.00	1380	690	690	250	180	18
20-25	5.89	1.17	2.03	8.60	12.40	79.00	0.018	8.50	1350	730	730	100	190	23
<b>Range</b>	<b>5.74-5.98</b>	<b>1.17-1.39</b>	<b>2.03-2.41</b>	<b>6.40-8.80</b>	<b>11.00-14.80</b>	<b>76.40-82.40</b>	<b>0.017-0.022</b>	<b>8.00-11.50</b>	<b>1300-1380</b>	<b>650-730</b>	<b>650-730</b>	<b>100-830</b>	<b>180-190</b>	<b>18-25</b>
<b>Mean =</b>	<b>5.80±0.06</b>	<b>1.27±0.01</b>	<b>2.20±0.15</b>	<b>7.44±1.26</b>	<b>12.84±2.85</b>	<b>79.72±6.19</b>	<b>0.018±0.003</b>	<b>9.40±1.40</b>	<b>1340±40</b>	<b>680±30</b>	<b>686±30</b>	<b>346±294</b>	<b>184±5.5</b>	<b>22±2.6</b>

Table 1: Physico-Chemical Properties and Nutrient Status of Soil under Study

S1 = Yelwa-Nshar Village  
 S2 = Lakushi Village  
 S3 = Kalong Village  
 S4 = Lu-kurung Village  
 S5 = Laraba Village

TOC = Total Organic Carbon  
 OM = Organic Matter

### 4. Discussion

The soil in the area studied could be generally described as deep well drained with few poorly drained soils, reddish brown as observed at Yelwa Nshar (S<sub>1</sub>), loamy sand and dark in colour as observed at Lakushi (S<sub>2</sub>) and Kalong (S<sub>3</sub>) villages, sandy clay loam with gravely sub-soils and dark brown in colour as observed at Lu-Kurung (S<sub>4</sub>) and Laraba (S<sub>5</sub>) areas respectively. The pH of the soil as determined in water for these areas was found to be within 5.85-7.03 which was similar to the values obtained by FDALR (1990) in this zone. The soils in the area under study therefore can be generally said to be slightly acidic to neutral.

The percentage organic matter content of the soil at the five stations varied from 0.07% at Kalong to 2.20±0.15% at Laraba village indicating quite a high soil organic matter compared to values obtained by Ogugbuaja and Nwaneri (2000) at Maiduguri and Bauchi areas. It was also found in this study that organic matter generally decreased with depth especially at Yelwa-Nshar, Lakushi and Laraba villages. This showed that more organic matter is deposited on the surface of the soil (top soil) and gradually sank to the subsoil, over a long period of time. Organic matter has been found to influence the level of trace, heavy metals in aqueous sediments. It plays an important role as a scavenging medium of heavy metals, for example, aqueous sediment with much organic matter may produce environment which maintains Mn and Fe oxides in a hydrous microcrystalline condition (Chao, 1979). Thus their scavenging

ability is enhanced. Within a given environment soils high in organic matter should naturally exhibit higher concentration of trace metal as evident in this study. Concentration of Fe ranged between  $133\pm 34\mu\text{g/g}$  to  $564\pm 243\mu\text{g/g}$  at the five locations with Lakushi (S1) and Laraba (S5) having the highest values. Concentration of Mn ranged from  $12.20\pm 7.5\mu\text{g/g}$  to  $346.00\pm 294.00\mu\text{g/g}$  with the highest values at Lakushi (S2) and Laraba (S5) villages. Zn concentrations were from  $120.00\pm 60.00\mu\text{g/g}$  to  $184.00\pm 5.50\mu\text{g/g}$  with the highest values at Kalong (S3) and Laraba (S5) villages.

It was observed that in the preparation of sediment samples for analysis where strong acid leaching method was employed like in this study, many heavy metals are removed in a rather consistent ratio to Fe and Mn (Trefey, 1976). The high values of Fe and Mn concentrations reported here compared to other trace metals like Zn and Cu which serve as a pointer to anthropogenic contamination. (Trefey, 1976). The particle size determined by Federal Department of Land Resources FADLR (1990) showed a highest percentage of sand (83%) and in this study, sand was determined to be in the range of 64.20% - 82.40% at the five locations. Silts ranged between 11.00-29.00% while clay ranged between 5.60-8.80%. Generally, this shows that the soil in the area studied could be said to be of sandy loam type, as observed. The particle size of sediments has been observed to help determine the concentration of trace metals in aqueous sediments. The pattern is that the fine grained particles usually should have a higher concentration of trace metals as compared to coarse and sandier sediments (Trefey, 1976). The high percentage of sand in the soil samples indicates that the soil contained coarser material which may act as a dilutant to trace metals. The low values of some of the trace metals like Cu and Zn determined in this study could thus be accounted from this observation. Cu concentration was in the range of  $6.20\pm 5.70\mu\text{g/g}$ - $22.00\pm 2.60\mu\text{g/g}$  while Zn had concentration in the range of  $120.00\pm 6.00\mu\text{g/g}$ - $184.00\pm 5.50\mu\text{g/g}$  in all the five locations studied. Therefore, the higher the percentage of clay in a given sample or sediment, the higher the amount of trace metals it retained.

The effect of the presence of Fe and Mn oxides in sediments is that they act as scavengers to other heavy metals. They are found as hydrous oxides in clays, soils and sediments both as coating on other mineral surfaces and as fine particles in clusters and aggregates of colloidal dimension in water. This general mode of occurrence of these oxides gives them the propensity to exert chemical influence on other mineral species that is far out of proportion to their actual concentration (Mahanan, 1979). This fact is evident in this study as can be seen in the concentration values of Fe and Mn obtained.

It was also observed in this study that metal concentrations generally decreased as the depth increased from 0-25cm. Only Cu, Zn and Na have fairly constant concentrations as the depth increased, but those of Mn, Fe and K oscillates almost to the 25cm depth showing that there may be little of man- introduced pollution (anthropogenic) disturbance in this area. However, for all the metals determined the concentrations' decreased steadily up to a depth of 15cm, when fluctuation started setting in. This shows that the anthropogenic pollution is still at the top soil (0-15cm). The oscillations of metal concentrations of depth 15-25cm are likely attributable to the presence of tree and shrub rhizospheres from natural processes. Root respiration promotes modifications in the redox state and thus changes in metal speciation. This same pattern was observed by a study on metal and nutrient distribution in sediments from Capivari River watershed. Metals determined in the study includes Cu, Zn, Mn and Fe at depth profile of 0-25cm and similar oscillations in the depth profile, metal concentration plots were obtained by Francisco *et al* (2001).

The nitrate content of the soil was determined as percentage nitrogen and phosphate as phosphorus using the rating for soil data interpretation by Black (1951). The nitrogen content could be rated as very low ( $0.018\pm 0.003$ - $0.025\pm 0.008\%$ ). The phosphorus content could be rated as moderate to high ( $9.40\pm 1.40$ - $53.00\pm 9.10\text{mg/kg}$ ). The lowest value of nitrogen content was observed at Laraba village (S1) and the highest value at Lu-Kurung (S3) and Yelwa-Nshar respectively. Phosphorus was observed lowest at Laraba village (S5) and highest at Lakushi village (S2). This shows that the use of fertilizer in this area has been minimal and has not led to any appreciable amounts of pollutants in the soil here. Therefore, the use of nitrogenous fertilizer especially N, P K (15, 15, 15) and urea is still encouraged to enhanced crop production in the area. The ratio of Potassium to Sodium at the topsoil (0-5cm) for the five arable lands studied showed a range of 0.4-0.9. The range confirms that the arable lands examined are indeed heavily utilized for agricultural activities where fertilizer is liberally used to enhance the soil productivity.

From the results shown in this study, it is evident that anthropogenic pollution is low, therefore fertilizer used, still encourage to supplement nitrogen and phosphorus especially at Laraba village (S1) but with expert advice on the requirements of the crops and the time of application to avoid eutrophication of nearby rivers and possible introduction of pollutants into the soil. It is therefore recommended that more studies and research be further carried out to investigate the effects of pesticides application on the soil. This will enable farmers in this area to knowledgeable maximize the use of modern farming techniques with minimal risk to the environment. Pollution due to agricultural practices thus is generally minimized to a great extent here.

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