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Available Zinc in Soils around Two Industrial Waste Dumpsites in Kaduna Metropolis

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ABSTRACT

Understanding the distribution of zinc (Zn) and its fractions is important for effective and efficient management of the fertilizer resources given the world-wide limitations of crop production and food quality by insufficient Zn. This research attempted to study the zinc fractions and its available form in two soils subjected to long term dumping of industrial wastes, using a fractionation scheme. The zinc was segmented into water soluble (Ws), exchangeable, specifically adsorbed (SA), and soluble (As) manganese (Mn) oxide-occluded (Mn-Ox) organic matter occluded (Om), amorphous iron (Fe) oxider-bound (AFi-Ox), crystalline Fe oxide-bound (CFe-Ox) and Residual Zn forms. A similar trend of distribution was observed in the two dumpsite (Dirkaniya and Nasarawa). More than 70% of the total Zn content occurred in the relatively inactive and mineral-bound residual form (Res), whereas only a small segment occurred in Ws, Ex, Om, AFe-Ox and CFe-Ox fractions. Among all the fractions, water soluble and exchangeable (which are vital for plant use) were higher in Dirkaniya than Nassarawa soils.

Keywords: Zinc, Fractions, Dumpsites, Water, Soil.

1. Introduction

Availability of Zinc (Zn) to plants is reported to be linked to its distribution among soil fractions. Therefore, understanding of the distribution of Zinc among the fractions of soils will help to characterize chemistry of Zn in soils and possibility its availability for plant uptake. However, the distribution of Zn among various chemical forms may vary significantly in response to changing soil properties (Adhikari, 2007). A series of fractionation quantifies the element distribution between fractions of different binding strengths, as defined by properties of selected extract ants. Viets (1962) defined five (5) distinct pools for micronutrients. These are

A. Water soluble
B. Exchangeable
C. Adsorbed, complexed and chilated species
D. Associated with secondary minerals and insoluble metal oxides and
E. Associated with primary minerals.

Zinc deficiency in soils suggests that both natural and applied Zn react with the inorganic and organic phases in the soils, which influences plant-availability of Zn. Viets (1962) reported that the distribution of Zn among active and non-active soil constituents and soil solution is also fundamental to an understanding of the soil chemistry of Zn..

Metals in the soil solution existed in different fractions (Iuo and Iuo, 2002), with potentially different bioavailability and environmental mobility of various chemical forms management systems alter the Zn pools in soils e.g. Dvorak et al (2003) reported that the application of industrial wastes together with inorganic Zn fertilization increased Zn mobility.

This research aimed at assessing the distribution of Zn and its potential availability in soils around 2 industrial waste dumpsites.

2. Material and Method

Soils: Surface layer (0-30cm) of both Dirkaniya and Nasarawa dumpsites were collected. The soils were mixed thoroughly and sieved through a 2mm sieve. Subsamples were taken and ground into fine powder for analysis.

Table 1

Soil Properties of the Sampled Sites

Soil Properties	Dirkaniya	Nasarawa
Organic carbon g/kg^{-1}	4.24	2.2
pH cacl$_2$	7.2	6.7
pH H$_2$	7.1	6.7

phosphorous $mgkg^{-1}$	27	22
potassium $mgkg^{-1}$	121**	125*
DTPA extractable Zn $mgkg^{-1}$	0.8*	0.6**
Total Zn $mgkg^{-1}$	148	50

*and** denote significant differences at the 0.05 and 0.01 probability levels, between the two locations respectively.

3. Sequential Fractionation Methods

The sequential fraction procedure except the residual fractions to study the distribution of Zn fractions in the two dumpsites followed the one used by Miller et al 1956. Soil sample mass used was 1.5g after each fractionation step, samples were washed with deionised water.

For the respective fractions, the following extract ants and procedure were used.

Water soluble (Ws): Soil samples were shaken with 25ml H_2O for 16h. exchangeable (Ex) 25ml of 0.5m calcium nitrate $(Ca(No)_3)_2$ solution and shaking for 16h. specifically absorbed (Lead(Pb)) – displaceable fraction (SA) shaking in 25ml of 0.05m lead nitrate $Pb(No_3)_2$ and 0.5m ammonium acetate at pH 6.0 for 2h. acid soluble fraction (As) 25ml of 2.5% (v/v) acetic acid and shaking for 2h.

Manganese-oxide bound fraction (Mn-Ox): Samples were shaken in 50ml of 0.1m hydroxylamine hydrochloride solution at pH 2.0 for 30min.

Organic matter bound-fraction (OM): 50ml of 0.1m potassium pyrophosphate solution at pH 10.0 and shaking for 2h.

Amirphonsiron 0xide occluded fraction (AFe-ox): Samples were treated with 50ml of 0.1m oxalic acid solution and 0.175m oxalate $((NH_4)_2C_2O_4)$ solution of pH 3.2 for 4 h in the dark.

Crystalline iron-oxide occluded fraction (CFe-ox): Samples were kept in 50ml of 0.1m oxalic acid, 0.175m $(NHu)_2C_2O_4)$ and 0.1m ascorbic acid in a boiling water both for 30min.

Residual Friciton (Res): This friction was estimated by subtracting the sum of all Zn fractions measured as described above from Zn total Zn, as per Row et al (2009).

Total Zn: A well-mixed sample of about 0.5g soil was digested in 12ml as described by Cheng and Ma (2001). After extraction all aforementioned samples were centrifuged and Zn was determined using an atomic absorption spectrophotometer (AAS).

Statistical Analysis

The data were subjected to statistical analysis like the linear correlation analysis.

4. Results and Discussion

Total Zn in soil indicates the potential capacity of soil to supply Zn for crop production given the capacity of crop to exploit it.

However, total Zn in soil does not indicate Zn availability to plants. Soil Zn fractions is influenced by different factors for example Adhikan (2007) reported that soil pH and organic matter level markedly alter the distribution of Zn among the plant available pools. Table 2 shows the distribution of Zn in the two dumpsites. There were significant differences in total Zn content in both sites. The distribution pattern of Zn fractions and total Zn was found to be similar in both locations except the Mn-Ox fractions that differed in the two dumpsites.

Table 2

Distribution of Zinc Fractions $mgkg^{-1}$ in Kakuri and Nasarawa Dumpsites

Zinc Fractions	Dirkaniya	Nasarawa
Water soluble	0.20	0.1
Exchangeable Ex	0.23*	0.03
Specifically absorbed (Sa)	0.24*	0.05
Acid soluble (As)	0.31*	0.02
Manganese-oxide-occluded (Mn-Ox)	0.76*	0.86
Organic matter occluded (Om)	0.58*	0.75

Amorphous iron (Fe) oxide bund	0.60*	0.36
Crystalline Fe oxide bound (DFe-ox)	0.21*	0.28*
Residual (Res)	11	8.3
Total (Zn)	14	12*

*denotes significance at the 0.05 probability level between the two locations.

For plant production point of view Ws, and ExZn are important which is higher in both locations. In all the locations Zn levels were enhanced because of the high organic content of the wastes Iwasaki (1993).

5. Conclusion

The two dumpsites revealed high Zn content and thus potential Zn availability however care should be taken when using these soils for crop production as possibility exists of toxicity by other heavy metals.

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