



GEOSPATIAL DISTRIBUTION OF HEAVY METALS IN COCOA PLANTATIONS ACROSS NIGERIA

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ABSTRACT

Black pod disease is the main limiting factor confronting cocoa cultivation in Nigeria. Copper-based fungicide is used annually to control the disease. Accumulation of copper in soil can increase the level of Cu residue in cocoa beans and soil contamination. Soil samples under cocoa plantation in Nigeria were collected and analyzed for Cu, Pb and Cd. Result showed that, 2% of the total land area under cocoa cultivation had Cu residue above WHO tolerance limit of 36mg/kg while only 0.23% and 0.06% had traceable Pb and Cd residues respectively. Correlation analysis showed that, annual rainfall and volume of cocoa output were the main factors responsible for the level of copper in cocoa plantations.

INTRODUCTION

Cocoa is the main cash crop that contributes to national foreign earnings in Nigeria. The incidence of black pod disease caused by *Phytophthora megakarya* is the main setback for Cocoa production in Nigeria. Under high frequency of rainfall, high humidity and low temperature, *Phytophthora* incidence can lead to 100% yield loss if left uncontrolled (Akrofi, 2015). To control the menace of black pod disease, Nigerian Cocoa farmers apply copper based fungicides. Only 15% of applied pesticides gets to the target while the rest 85% is distributed between the surrounding air and soil (Leonila, 2002). Due to the metallic nature of Copper, it is non biodegradable and does accumulate in soil. Studies have shown that, 85% of heavy metal residue in cocoa beans is absorbed from the soil environment while the rest is absorbed from the fungicide sprayed on the pods (Aikpokpodion et al. 2013). Due to the physiological significance of heavy metals on human health, the European Union has set maximum residue limits for selected heavy metals in cocoa beans. Currently, information on geospatial distribution of heavy metals in cocoa soils in Nigeria is limiting. The levels of Cu, Pb and Cd in cocoa plantations across cocoa growing states in Nigeria were determined to ascertain if their concentrations in cocoa soils are within the permissible limits set by the World Health Organization.

METHODOLOGY

Soil samples were obtained with soil auger at the depth of 0-20cm from 1,500 cocoa farms across the states that account for 99% cocoa output in Nigeria. The coordinates of sampling points were taken with GPS. The samples were air-dried at 25°C and processed according to standard procedure. Cu, Pb and Cd were extracted by digestion with Aqua Regia and determination by Optima 8000 ICP-OES. Data obtained from the laboratory analysis were used for the creation of maps showing the geospatial distribution of Cu, Pb and Cd in Nigeria. Inverse distance weighting (IDW) was used for the multivariate interpolation of the data.

RESULTS AND DISCUSSION

Copper (Cu) residue

Copper was detected in all the soil samples obtained from the 1,500 cocoa plantations. Cu residue ranged between 0.43 and 68.99mg/kg with an average value of 9.84mg/kg.

Distribution of Copper residue in cocoa plantations across Nigeria (Figure 1) shows that, 62% (397,095 hectares) of the total land area cropped with Cocoa had Cu residue ranging from 0.43-10.99mg/kg while 30% and 6% had Cu residue between 11.00-25.99mg/kg and 26.00-36.00mg/kg respectively. On the other hand, only 2% of the total land area under cocoa cultivation had Cu residue above 36mg/kg which is the tolerance limit set by the World Health Organization.

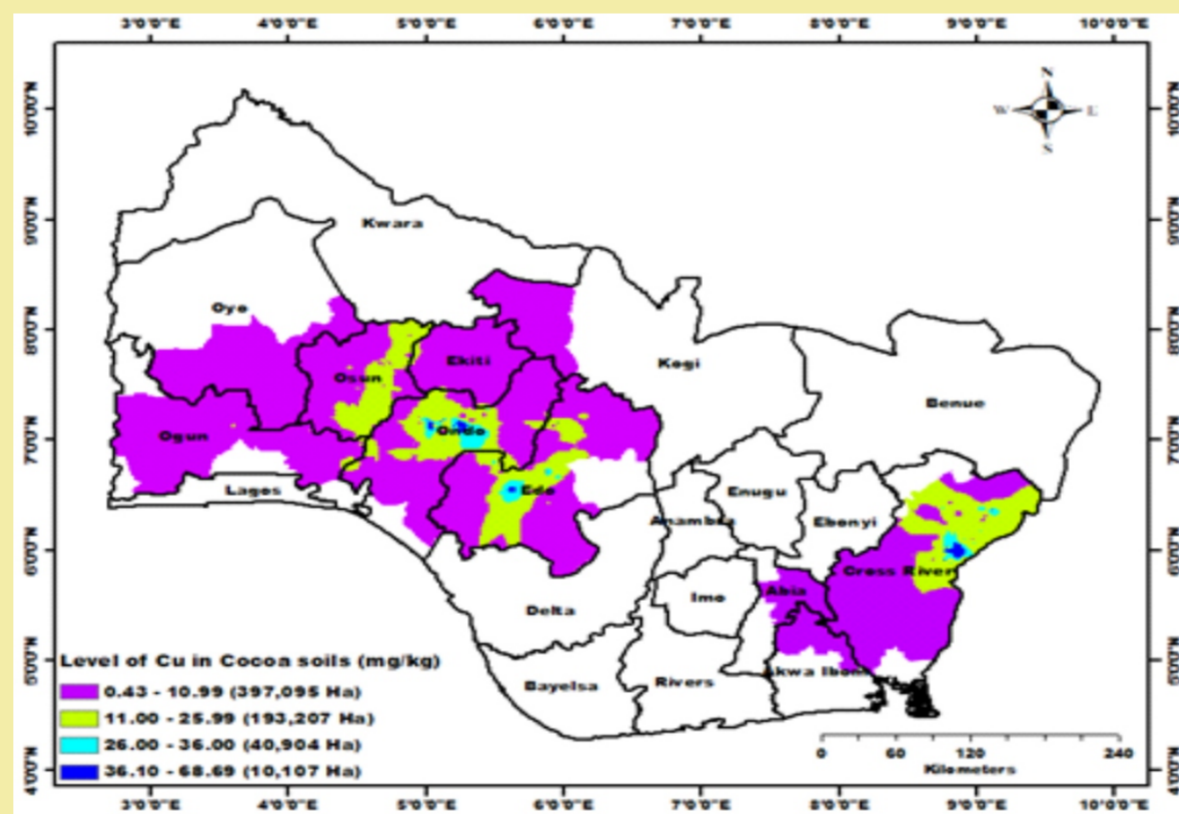


Figure 1: Distribution of Copper residue in Cocoa Plantations in Nigeria

Figure 2 shows that, 74% (7,487 hectares) of the total cocoa land area which exceeded 36mg Cu/kg soil belong to cocoa farmers in Cross River State while 25% (2,478 hectares) and 1% (142 hectares) of the total land area belong to farmers in Ondo and Edo States respectively. The significant contribution of Cocoa soils in Cross River State to the overall percentage of cocoa land area that exceeded 36mg/kg was a consequence of higher rainfall and humidity in the state compared to Ondo and Edo States. Such differential climatic conditions leave the farmers with no option than to increase the rate of fungicide application which correspondingly increased Cu accumulation in the soil. Statistical analysis showed significant positive correlation ($p \leq 0.05$) between cocoa output and soil copper residue while it showed positive correlation between rainfall and copper residue.

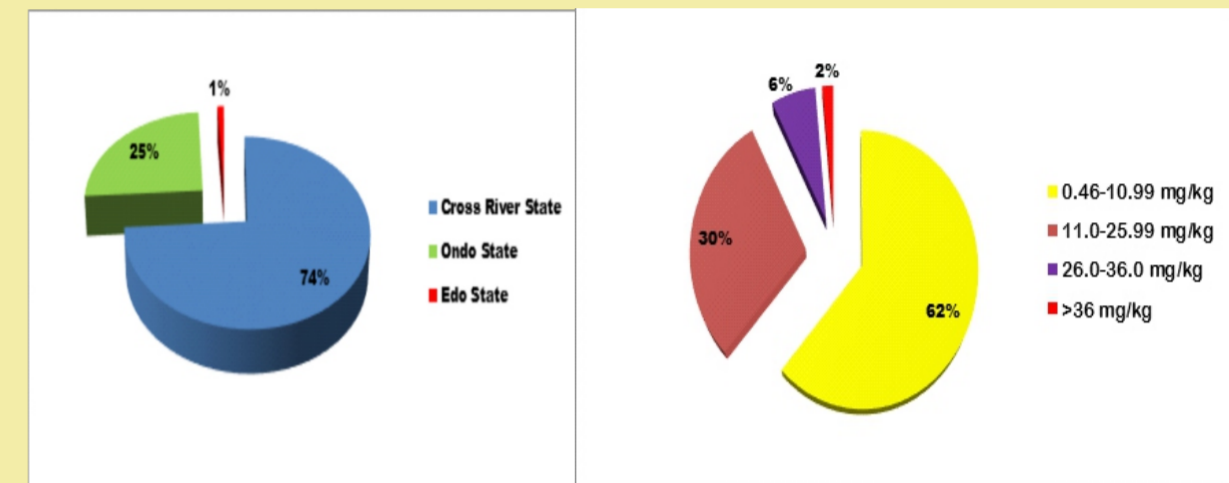


Figure 2: Percent contribution by State to Cu residue > 36mg Cu/kg Soil in Nigeria

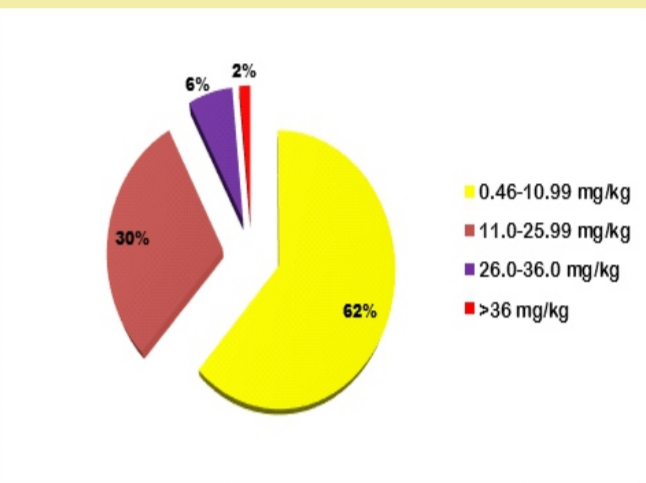


Figure 3: Distribution of copper residue by percentage in cocoa plantations in Nigeria

Lead (Pb) residue

Pb was detected in 2.04% of the total cocoa plantations. The detection of Pb was observed in few cocoa plantations in Cross River, Osun, Ogun and Oyo State. Figure 4 shows that Pb in cocoa soils ranged between 0.81 and 2.70mg/kg in 1,192 hectares while it ranged between 2.71 and 9.77mg/kg in 274 hectares. However, Pb was not detected in 99.77% of the total land area under cocoa cultivation in Nigeria. The presence of Pb in the affected cocoa plantations is inherent rather than anthropogenic

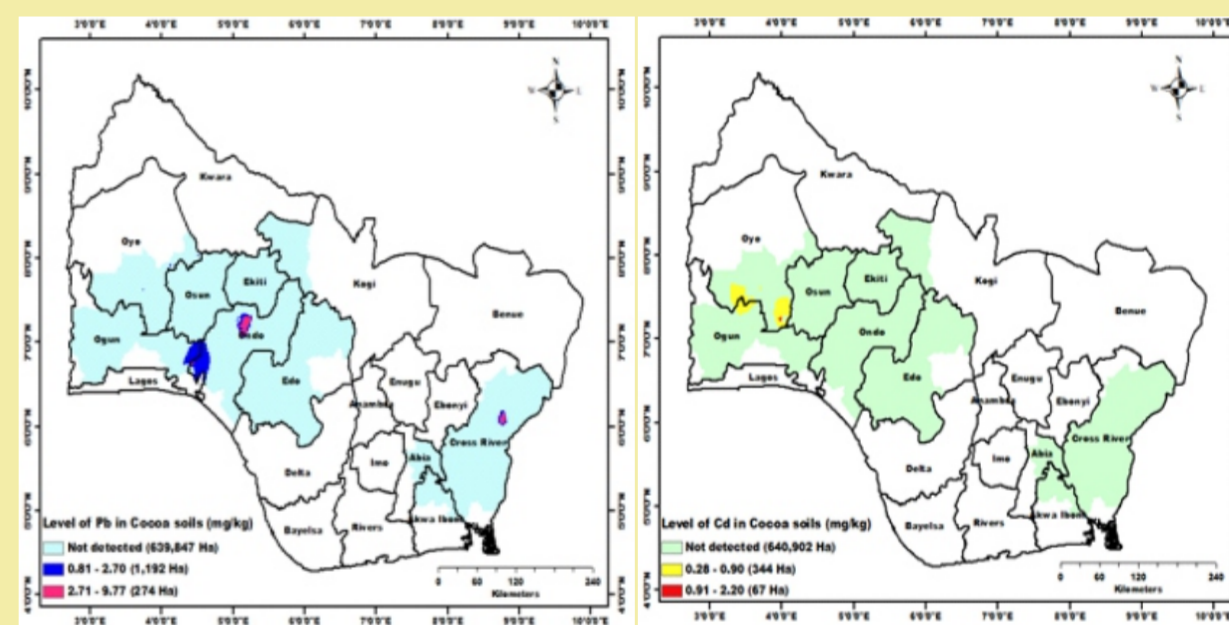


Figure 4: Distribution of Pb in Cocoa plantations in Nigeria

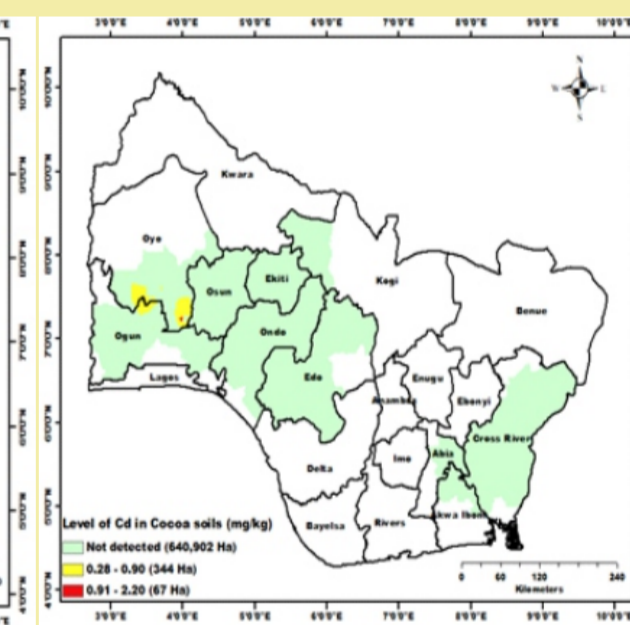


Figure 5: Distribution of Cadmium in Cocoa plantations in Nigeria

Cadmium (Cd) residue

In Nigeria, traceable cadmium was only detected in few cocoa plantations in Oyo and Ogun States. Figure 5 shows that, a total land area of 344 hectares under cocoa cultivation had Cd concentration ranging from 0.28-0.90mg/kg while 67 hectares had traceable Cd between 0.91 and 2.20mg/kg. In all, 99.93% of the total land area under cocoa cultivation in Nigeria had no traceable cadmium. The detection of Cd in the few cocoa farms is natural as no observable agronomic activity of Nigerian cocoa farmers introduces cadmium into farm environment.

CONCLUSION

Significant proportion of soils under cocoa cultivation in Nigeria has copper residue below WHO tolerance limit.

Annual rainfall and volume of cocoa output are the main determinants of copper accumulation in cocoa plantations in Nigeria.

Proportion of cocoa plantations in Nigeria with traceable Pb and Cd residues is negligible compared with cocoa plantations without traceable Pb and Cd.

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