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PROSPECTIVE PLANTS USED FOR IMPROVING FARMLANDS AND MINING SOILS IN NIGERIA

Bello, A. A.* Garba A. B. and Halima, H. M.

Department of Chemistry, Sa'adatu Rimi College Of Education, Kumbotso, Kano State.

Corresponding Author's Email: abbelbich@gmail.com 08065416295

ABSTRACT

The imbalance of soil nutrients poses health threat to mankind. Excesses result in toxicity of biota while deficiencies attribute to impaired health conditions. The aim of the paper is to find from the literature for plants (hyperaccumulators) that can be used to balance excess nutrients due to mining activity and compost same to improve farmlands in Nigeria. Potential contaminants from the prioritize mineral ores in Nigeria include Ba, Cd, Co, Cu, Ge, Hg Pb, Zn and SiO_2. Cu, Zn, B and Mo were found excessively in some soils in the country. The metals hyperaccumulating plants including Great mullein (Verbascum densiflora), Chinese brake fern (Pteris vittata), willow (Salix viminalis), Siam weed (Chromoleaeceae odarata), Indian Mustard (Brassica juncea), Sword grass (Imperata cylindrical), Helianthus annuus (Sunflower), Trifolium pratense (Red clover) and Atriplex halimus may remedy the contaminants and when composted amend deficiencies in the soils elsewhere. Research is required to arrive at optimum conditions for efficient soil phytoremediation and amendments.

Keywords; Soil nutrients, hyperaccumulators, phytoremediation, compost, soil amendments

INTRODUCTION

Nigeria's population growth of 2.7% prompt stress on natural resources and infrastructures in order to meet physical, psychological and social wellbeing (World Bank, 2016). Basic needs of food, shelter and clothing are essential and any means of attaining them may be justified. Particularly as there are indications of negative imbalance between food production and demand, for example rice the major staple food in Nigerian household showed an estimated demand of 5 million metric tons of milled but a production of just 3.2 which creates a deficit of 1.8million metric tons (Liverpool-Tasie, 2014).

However, the present generation through its livelihood activities to provide its needs should not compromise the survival of future ones. In essence, the present generation should interact with the environment sustainedly. Conversely, scientific reports and public opinions lament about the anthropogenic activities such as fertilizers application, fossil fuel combustion, and some industrial processes which result in environmental deterioration and endanger the health of present and future generations (All the information on Cadmium para 4.4, 2015)

Soil is the primary resource in meeting food demands. It supplies the nutrients for plant growth and subsequently human development via the food chain. For optimum supply of nutrients, processes involving release of nutrients from soil must be perpetual and synchronous with uptake. In contrast, weathering process that ensue nutrients from soil take long period not keeping pace with take up by plants, thus creating mineral deficiencies and prompts replenishment. Zabowski *et al*, (2007) reported the annual weathering rates to be 3–24 kg Ca/ha, 3–10 kg Mg/ha, 3–31 kg K/ha, and 0.2–2.5 kg P/ha. Comparing these values with nutrient removals by whole-tree it suggests that some nutrients may be depleted. The official report of the Earth Summit (1992) concluded "there is deep concern over continuing major declines in the mineral amounts in farm and range soils throughout the world". This statement was based on data showing that over the last 100 years, average mineral levels in agricultural soils had fallen worldwide by 72% in Europe, 74% in Africa, 76% in Asia and 85% in North America. FAO (2001) classified Nigeria as one of the countries with high declining soil fertility. The country was estimated to be losing an average of 24 kg nutrients/ha per year (10 kg N; 4 kg P_2O_5, 10 kg K_2O) in 1990 and 48 kg nutrients/ha per year in 2000, that is, a loss equivalent to 100 kg fertilizers/ha per year. However, this figure is postulated to have dropped appreciably since the government and other foreign organizations started investing heavily on fertilizer. Soils in most of Nigeria have inherently low fertility and do not receive adequate nutrient replenishment. With Nigeria falling under sub-Saharan African countries with low mineral fertilizer consumption, about 10 kg nutrients (N, P_2O_5, K_2O)/ha per year, compared to the world average of 90 kg, 60 kg in the Near East and 130 kg/ha per year in Asia. Research showed that the micronutrients status of Nigerian soils varies considerably from one element to another and micronutrients problems due to shortage of B, Cu, Mo and Zn and excess of Mn are likely. More so Nigerian soils are among countries of India, Pakistan, Zambia with low organic matter, nitrogen and low cation exchange capacity (FAO, 1982). Recent studies have shown low Zn status of soils in part of Gombe State, Nigeria (Mustapha, Mamman and Abdulhamid, 2010). Also, Cu and Zn deficiencies were observed in the cultivated soil of Nigeria Guinea Savanna but with suitable Fe and Mn content (Oluwadare *et al.*, 2013).

Depletion of micronutrients in Nigerian savanna soils has resulted from intensively cultivated soil with high nutrient-demanding crops, highly weathered rocks and leaching. Mustapha and Loks (2005), reported that the use of new high yielding crop varieties which are nutrient demanding have unraveled micronutrient deficiencies in some Nigeria Savanna soils. The result is production of low quality crops and forage which ultimately lead to nutrient deficiencies diseases to the consumers. This situation can be paradoxically considered as food insecurity, because food security encompasses food availability, food accessibility, nutritional factors and stability of supply Asogwa and Umeh (2012)

A report showed that more than 40% of human population suffers from mineral deficiency of varying degree. For example, Iron deficiency ranked ninth among 26 risk factors included in the global burden of disease study, with consequences of poor pregnancy outcome, impaired physical and cognitive development, increased risk of morbidity in children and reduced work productivity in adults. Large sections of populations in Africa and Asia are at risk of dietary zinc deficiency and resulting high rates of stunting. (Anon, 2004). In Nigeria, the nutritional status of children indicates that 37% are stunted, 18% are wasted and 29% are underweight due to micronutrient deficiencies, coupled with poor nutrition knowledge (Nutrition Society of Nigeria NSN, 2014). These points suggest that caution be taken to arrest the nutrient deficiency potential.

Many strategies were adopted to manage fertility status of soils historically based on biogeochemical factors of an area. Hamma and Ibrahim (2013) listed improving soil organic matter by live mulching system, agro forestry system, residue mulching, farmyard manure and compost, crop rotation and intercropping, use of fertilizers and use of water hyacinth compost as some management practice. Von Fragstein *et al.* (1988), Leonardos *et al.* 1987, reported application of ground silicate rocks a by-product of quarry industry to infertile soils mostly in temperate regions. This article propose another means of fertilizing cultivated farms by using hyperaccumulators compost obtained from phytoremediation of contaminated lands such as dumpsites, mining areas etc. The method served dual purposes, that apart from improving cultivated soil, also it cleanses contaminated ones. Therefore, looks as a potential practice for sustainable simultaneous agricultural-solid minerals mining activities which is the current pursuit for Nigerian economic growth.

PHYTOREMEDIATION

Phytoremediation was defined by Pérez-esteban, *et al.,* (2010) as the use of green plants and their associated microorganisms in order to remove, degrade, or isolate toxic substances from the environment. The range of substances remediated include heavy metals (such as Pb, Zn, Cd, Cu, Ni, Hg), metalloids (As, Sb), inorganic compounds (NO_3^-, NH_4^+, PO_4^{3-}), radioactive chemical elements (U, Cs, Sr), petroleum hydrocarbons, pesticides and herbicides (atrazine, bentazone, chlorinated and nitro aromatic compounds), explosives (TNT, DNT), chlorinated solvents (TCE, PCE) and industrial organic wastes (PCPs, PAHs), and others'' (Ensley, 2000).

The technique is cost-effective and environmental-friendly. It is achieved by one or combination of six different strategies of phytodegradation, phytoimmobilization, phytovolatilization, phytofiltration, phytostimulation and phytoextraction (Kumar, 2013). Phyotoextraction is the most promising strategy for decontamination and fertilization, the rest are best for cleansing only. Phyotoextraction uses hyperacccumulators which are plants capable of accumulating more than 100 times compared to normal concentrations of specific metals in their aerial parts (Brooks *et al.*, 1977) to the extent that some elements can be extracted just like the ore, a phenomenon called phytomining. Hyperaccumulators absorbs the contaminants via root and translocate to the shoot. Efficient hyperaccumulators should be (i) heavy-metal tolerant, (ii) grow rapidly with a high biomass yield per hectare, (iii) have high metal accumulating ability in the foliar parts, (iv) have a profuse root system, and (v) a high bioaccumulation factor (Wuana and Okieimen, 2010).

POTENTIAL HYPERACCUMULATORS IN NIGERIA

Solid minerals mining activities is associated with environmental pollution. Considering the vast number of proven and unproven deposits in over 800 locations in just 10% of the nation that was mapped (Okunlola, 2015) in which 40 minerals have been discovered including gold, barite, bentonite, limestone, coal, bitumen, tantalite, columbite, barites, gemstones, granite, marble, gypsum, talc, iron ore, lead, zinc, lithium, silver, etc. However, not all the minerals are available in commercial quantities. As part of the strategies to reform the sector, the Ministry of Mines and Steel Development (MMSD) has prioritized seven (7) strategic minerals, namely, Coal, Bitumen, Limestone, Iron Ore, Barites, Gold and Lead/Zinc for priority development. (KPMG Nigeria Mining Sector, February, 2012). Possible pollutants arising from mining of these prioritize minerals and potential hyperaccumulators for remediating the land sought from literature are given in Table 1

In an experiment Chinese brake fern (*Pteris vittata)* was found to have more advantages over Indian mustard (*Brassica juncea*) and beard grass (*Polypogon monospeliensis*). In that Chinese brake fern had withstand the toxicity of Hg while Indian mustard and beard grass plants showed severe stress symptoms resulting from mercury exposure. Even though, beard grass had greater total accumulation of Hg <65 mg/kg in the shoot and 2298 mg/kg for root, little is harvestable. However, brake fern accumulated a harvestable 1469 mg/kg in shoot from a soil treated with 1000 mg/kg $HgCl_2$ (Su *et al*., 2007). Oloyede (2012) identified *Pteris vittata* scantly growing in the forest wetland of Ibadan, Nigeria. The plant can be propagated as a suitable hyperaccumulator for Hg, NO_x, SO_2 which may pollute the fields of an estimated 16 billion probable reserve of bitumen in the neighbouring Ondo State (KPMG Nigerian Mining Sector, 2012).

Table 1: Nigerian prioritized solid minerals, their soil contaminants, health risks and potential hyperaccumulating plants.

Mineral	Pollutant	Exposure medium	Health risk	Hyperaccumulaor plant	References
Barite	Ba, SiO_2	Dust, soil, drinking water	[1] Paralyses, high blood pressure, stomach irritation, swelling of brain and liver, kidney and heart damage [3] Silicosis	[4]Great mullein (*Verbascum densiflora)*	(1) Lenntech (1998) (2) Eurobitume,(2014) (3) Salisu *et al*., (2015) (4) Kowalska *et al.*, (2012)
Bitumen			[2]No known health hazard	-	(5) Colinet (2010)
Coal	Hg, NO_x, SO_2,	Surface and ground water.	Heart chronic disease, cancer, stroke and lower respiratory diseases.	[7] Chinese brake fern (*Pteris vittata*)	(6) Pradhan and Patra (2014) (7) Su *et al*., (2007)
Gold	Hg in form of CH_3Hg	Water runoff, air during roasting	Irritation of skin and eye	[7]Chinese brake fern (*Pteris vittata*)	(8) Wilberforce (2015) (9) Wikipedia (2019) (10) Pérez-esteban, *et al.*, (2010)
Iron ore	Particulate matter	Water, air during roasting	[6]Jaundice, Typhoid, blood pressure, chronic respiratory illnesses,	-	
Limestone	SiO_2 dust	Air dust	[5]Lung diseases:bronchiti, pneumoconiosis, emphysema, silicosis	-	
Lead/Zinc	Pb, Zn, Cd, Cu, Co, Ge	Air, water run off	Arthralgia, osteomalacia,	Willow (*Salix viminalis*) for Cd, *Chromoleaeceae odarata*[8] (Siam weed) *Helianthus annuus* (Sunflower)[9] for Cu and Indian Mustard (*Brassica juncea*) for Pb, [8]Sword grass(*Imperata cylindrical*) *Trifolium pratense* (Red clover)[9] *Atriplex halimus* [10]	

Indian mustard (*Brassica juncea*) was found to be capable of removing 1550 kg Pb/acre. Siam weed is more promising as it was tested along with *Helianthus annus*, (Sunflower), *Imperala cylindrical* (Sword grass), *Sida acuta burn* (Broom weed), *Gossypium* spp (Cotton), *Eleusine indica* (Goose grass) and was found to have accumulated greater concentration of 417.2 and 234.2 mg/kg Pb in leaves and stem respectively. While sword grass was efficient in Cu accumulation to up to 340.1, 312.2 and 366.4 mg/kg for leaves, stem and root respectively, having other metals at lower concentrations (Wilberforce, 2015), hence it may serve as compost in Cu deficient soils.

Imperata cylindrical was described as an invasive weed covering 9 – 97 % of farmers' field in West Africa *a*nd impact negatively on crop production. The plant accounts for between 62 and 90 % yield reduction in maize, and 28.5 % and 52.6 % yield reduction in soy bean in the Middle Belt of Nigeria (Aluko *et al.*, 2018). Therefore, *Imperata cylindrica* can be used for the remediation of the Lead/Zinc ores deposits in Central Nigeria, however, the reclaimed land may be more suitable for other purposes but not agricultural due to its weedy nature.

Uyi *et al*., (2014) reported that *Chromoleaeceae odorata* is also a weed found growing in most parts of Nigeria covering 23/36 states of the country. The plant can serve as hyperaccumulator as well as the established advantages of its perceived ethno-pharmacological, funcigicidal and nematicidal importance and its use as a fallow species and soil fertility improvement plant in slash and burn rotation system of agriculture.

Helianthus annuus is an important oil seed crop which grows under several climatic and soil conditions, and found to fit well into Nigeria farming systems (Ogunremi, 1979). Apart from hyperaccumulating Cu, also it accumulates 40.1 and 65.7 mg kg^{-1} shoot dry weight for Cd and Pb, respectively (Alaboudi *et al*, 2018). *Atriplex halimus* could be used in abandoned or active Cu mining areas as it grows on all types of soils,even where there is gypsum and salt (FAO, 2007).

CONCLUSION

So far, some substances are predicted to contaminate prioritized mining lands in Nigeria while deficiency of the same was established in various cultivated lands. Plants capable of removing the substances were sought from the literature. Researches are required to find more efficient hyperaccumulators or improve on the efficiency of tested ones. Also research is required to ascertain best conditions for composting the plants in order to amend farmlands soils.

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