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COMPARING THE EFFECTIVENESS OF ETHYLENEDIAMINE TETRAACETIC ACID (EDTA) AND CITRIC ACID (CA) ASSISTED PHYTOREMEDIATION OF LEAD (Pb) FROM SOIL IRRIGATED WITH TEXTILE EFFLUENT USING *Jatropha curcas and Calotropis procera*

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Abstract

Soil contamination by toxic heavy metals through urbanization and industrialization is a major concern. Phytoremediation, an eco friendly plant based solar driven technology has been proven to be a better alternative to the non-sustainable conventional methods. The limited bioavailability of heavy metals for root uptake has necessitated the application of chelating agents to the soil. In this study, the efficiency of EDTA and CA in the extraction of Lead from soil irrigated with textile effluent was investigated using *Jatropha curcas*. The seeds of *J. curcas* and were planted in separate pots containing 1kg of soil obtained within the premises of Funtua textile mill and irrigated with textile effluent. EDTA (5ml of 0.1mmol) and CA (5ml of 0.5mmol) were added separately on the 10^{th}, 11^{th} and 12^{th} week. The plants were harvested after 13 weeks of planting and the average shoot heights of the plants were recorded. The Pb contents in the roots and shoots of the plants in the soils with different amendments were also analysed. The results obtained showed that the individual application of EDTA and CA to the soil increased the average shoot heights of *C. procera* while that of *J. curcas* decreased relative to control. The results also showed that EDTA increased the shoot heights of both plants better than CA. The result also showed that the uptake of Pb in the plant tissues of both plants was higher in CA amended soil than in EDTA amended soil. Phytoextraction ability was assessed in terms of bio concentration factor (BCF) and transfer factor (TF). The BCF values of *C. procera* for Pb in EDTA and CA amended soils and the BCF of *C. procera* and *J. curcas* for Pb in control were less than 1 (BCF < 1) but greater than 1 (BCF > 1) for *J. curcas* in EDTA and CA amended soils. The obtained TF values showed that the removal of Pb by *C. procera* and *J. curcas* in EDTA and CA amended soils and *C. procera* in control was by phytoextraction while Pb removal by *J. curcas* in control was removed Pb by phytostabilization.

Key words: Phytoremediation, textile effluent, chelating agents.

1. INTRODUCTION

The paucity of water in tropical and semi tropical parts of the world has led to the reuse of waste water for irrigation purpose (Ruma and Sheikh, 2010) and this may have an adverse effect on soil and crops (Sherine *et al.*, 2019). The nature of waste dumped into the water determines the suitability of the water for agricultural purpose (Nazif *et al.*, 2006) and these wastes include effluents discharged from industries (Samaila and Lateefat, 2017), waste water from different domestic activities, refuse and sewage dumped into the drainage channel, wastes generated from markets and other business activities (Usman Armaya'u *et al.*, 2020). Waste water contains metals and nutrients that are essential for plant growth as well as a high level of toxic heavy metals that are carcinogenic and may also pollute the environment once it is discharged to nature (Jadia *et al.*, 2009; Khaled *et al.*, 2008). These heavy metals are concentrated on the soil surface and get into plants through absorption by plant roots (Sherine *et al.*, 2019).The presence of these high concentrations of toxic heavy metals is of great concern to human because they find their way into food chain and get into human body through the consumption of plants grown on heavy metals contaminated soil or soil irrigated with waste water containing heavy metals. This serves as a threat to food safety, human health the ecosystems, surface and ground waters (Li *et al.*, 2009). Unfortunately, this contaminated water containing toxic heavy metals is often used for irrigation of food crops and vegetables by many farmers in drought prone areas without treatment and this has implications on the soil quality, the crops cultivated on the soils, underground water and on human being. Heavy metals can affect the physicochemical properties and microbiological content of the soil which may in turn affect soil fertility and productivity (Wuana *et al.*, 2010) as soil plays a vital role in food security (Muthusaravanan *et al.*, 2018). Different processes in plants such as the physiological and biochemical processes, photosynthesis, homoeostasis, transport and respiration process can be disrupted by heavy metals which can lead to plant death (Muthusaravanan *et al.*, 2018; Gupta *et al.*, 2011). Higher doses of heavy metals can cause metabolic disorders which can lead to inhibition of seeds and further seedling development in some plants species and this can cause reduction in overall plant growth and in turn affect the yield of the crops (Yaqvob 2011, Muhammad *et al.*, 2008) hence, the need to remediate the soil using cheap available and sustainable method. Conventional methods of soil cleanups are not sustainable or are not practically feasible especially on large scale contaminated farmland due to their extremely high cost, destruction of soil, generation of secondary waste and lack of a long-term solution (Danh *et al.*, 2009; Prasad., 2003: Mamdouh *et al.*, 2014) unlike phytoremediation, an emerging eco friendly plant based cost effective technology that uses plants and their associated microbes to remove environmental pollutants or to render them harmless (Mamdouh *et al.*, 2014;Chigbo., 2013).

The selection of appropriate plants is very crucial for effective phytoremediation. Plants used for phytoremediation should produce high biomass, have fast growth rate, tolerate high levels of metals and accumulate them in their tissues (Mamdouh *et al.*, 2014). Edible plants are not recommended for the purpose of phytoremediation due to the fear of re-introducing the extracted metals back into food chain through consumption by human beings and animals (Sherine *et al*., 2019). Plants like *Jatropha curcas* and *Calotropis procera* are suitable for this purpose because of its availability, good growth rate in drought prone area, contaminated soils and dump sites, aesthetic purpose and not being consumed by both human being and animals. Also, the by-product such as bio fuel can find a wide range of application. A major problem limiting the efficiency of phytoremediation is the low mobility and bioavailability of some heavy metals especially Pb in contaminated soils as well as slow growth and low biomass of hyper accumulator plants. This can be overcome by the use of fast growing high biomass plants with the addition of chemical chelators to the soil which can dissolve these metals from their various surfaces of attachment and also increase the uptake and translocation of heavy metals towards shoot tissues (Azeez *et al.*, 2020; Seyed *et al.*, 2021). Chelators such as ethylenediamine- tetraacetic acid and citric acid have been tried by numerous researchers and found to be effective in the dissolution and mobility of heavy metals for root uptake thereby enhancing the remediation of heavy metal contaminated soils through phytoremediation (Azeez *et al.*, 2020; Muthusaravanan *et al.*, 2018; Shakoor *et al.*, 2013). Chelating agents can increase metal accumulation in non hyperaccumulating plants more than they can normally hold thereby making these plants useable for soil remediation (Liphadzi *et al.*, 2005). EDTA is the most popular chelator that can increase the bioavailability of heavy metals in the soil, enhance root uptake and facilitate transfer to shoot (Subasic *et al.*, 2002) but can affect soil microorganisms, inhibit plant growth, contaminate surface and underground water due to low degradability, high toxicity and solubility. In addition, chelation of micro and macro nutrients may occur with EDTA which may affect soil nutrient (Seyed *et al.*, 2021; Shinta *et al.*, 2021).

CA an organic chelating agent has been suggested as an alternative to EDTA for enhancing phytoremediation due to its high biodegradability. CA also has the ability to mobilize heavy metals in soil, increase root uptake and translocation to the shoot with less hazardous effect (Seyed *et al.*, 2021; Shinta *et al.*, 2021). Reduced toxic effect of heavy metals on plants and increased growth of plants in soils ameliorated with CA has been reported. This study aims at evaluating the efficiency of EDTA and CA in the phytoremediation of Pb from soil irrigated with textile effluent using *J. curcas* and *C. procera*.

II. MATERIALS AND METHODS

2.1. Sample Collection and Treatment

Soil sample used for this experiment was obtained from different locations within the premises of Funtua textile in Funtua Local Government Area of Katsina state. Surface soil (0 – 15 cm) samples were collected at ten different locations of the sampling site. The soil samples were thoroughly mixed to obtain a representative sample, air dried for four days then crushed into fine powder and made to pass through 2mm mesh sieve. The parent soil was characterized in terms of physicochemical properties (pH, textural analysis, soil organic matter and cation exchange capacity) using standard procedures. Effluent from Funtua textile was collected directly from effluent discharge point in an acid cleaned container.

2.2. Experimental Design

This experiment was divided into two parts. The first part monitored the growth of the plants in control (unamended soil), EDTA and CA amended soils. This was achieved by comparing the average shoot height of *C. procera* and *J. curcas* planted in the soils after 13 weeks of planting. The second part compared the efficiencies of EDTA and CA in the removal of Pb from soils irrigated with textile effluent. All experiments were in triplicates and placed in the biological garden of Umaru Musa Yar'adua University, Katsina.

2.3. Phytoremediation Studies

Seeds of *J. curcas* were planted in six (6) different plastic pots of dimension 25cm by 30cm filled with treated soil sample (1.0 kg) and watered with textile effluent diluted with water (5:1). The seedlings were thinned to four after germination. EDTA (5ml, 0.1mmol) was added to three of the pots while CA (5ml, 0.5mmol) was added to the other three on the 10^{th}, 11^{th} and 12^{th} week of planting. The same experimental set up was repeated using *C. procera*. The controls were setup the same way but without the addition of EDTA and CA and the growth of the plants were monitored. Each set was in triplicate and placed in the biological garden of Umaru Musa Yar'adua University, Katsina. The growths of the plants were monitored and the plants were harvested after thirteen weeks of planting. The average shoot height of the plants in the control and EDTA and CA amended soils were compared. The concentration of Pb in the roots and shoots of the plants was also determined.

2.4. Treatment of Plant Samples

The plants were harvested separately according to soil treatment and plant type after 13 weeks of planting and were brought to the laboratory. These plants were washed thoroughly with tap water and later with deionized water to remove earthy impurities and any other form of dirt. This was to ensure that only the metals absorbed by the plant will be analyzed. The washed plants were separated into roots and shoots, dried in open air for 2 days then in the oven at a temperature of 80°c for 5hrs. The dried plant samples were grinded to a fine powder using a cleaned ceramic pestle and mortar and sieved using a 2mm mesh sieve. The fine powdered sample of each part of the plant were stored and labeled in an acid cleaned container and kept for further analysis.

2.5. Measurement of Heavy Metal Contents in Samples

The plant samples were digested by weighing the powdered samples (0.5g) of each part of the plant (roots and shoot) separately in into a digestion flask ($100cm^3$) followed by the addition of aqua regia (10 cm^3) (a mixture of 3 parts concentrated HCl to 1 part concentrated HNO_3) (Kisku *et al*, 2000).The effluent sample ($50cm^3$) was digested with concentrated HNO_3 ($20cm^3$) in a digestion ($100cm^3$) flask (APHA, 1998).The soil sample was digested by heating 1.0g portion of the soil was with concentrated HNO_3 (5 cm^3) and $HClO_4$ (2 cm^3) a digestion flask ($100cm^3$) (Waziri *et al*, 2016). All the mixtures were heated on a hot plate in a fume cupboard, until a clear solution was obtained. The digests were diluted with de-ionized water, filtered into a volumetric flask using Whatman No. 4 filter paper and then made up to mark ($50cm^3$) with more de-ionized water. This was then transferred into an acid cleaned sample bottle ($50cm^3$) for elemental analysis. The concentration of Pb in all the samples were determined using Microwave plasma atomic emission spectrophotometer (MP - AES)

2.6. Bio-concentration Factor (BCF) Index and Transfer Factor (TF)

The ratio of heavy metal concentration in whole plant tissues to that in the soil was determined using the formula:

$$BCF = \frac{\text{metal concentration in root } (mg\ kg^{-1})}{\text{metal concentration in soil } (mg\ kg^{-1})}$$ (Yoon *et al*., 2006; Cluis, 2004).

The capability of plants to take up heavy metals in their roots and to translocate them to their above-ground parts (shoots). This was calculated using the formula:

$$TF = \frac{\text{metal concentration in shoot } (mg\ kg^{-1})}{\text{metal concentration in root } (mg\ kg^{-1})}$$ (Marchiol *et al*., 2004).

2.7. Statistical analysis

Data were evaluated relative to the control to understand their statistical variation. A triplicate of water, soil and plant samples from each treatment were recorded and used for statistical analysis. The mean and standard deviations (SD) were calculated using the Microsoft Office Excel 2003. Statistical significance was assessed using T- test with values for $p < 0.05$ considered significantly different. Differences between treatments were analyzed by analysis of variance (ANOVA) with statistical package for the social sciences (SPSS) version 20.0 and results were presented in tables and graphs

III. Result

3.1. Table 1 Physicochemical Parameters of Soil.

Physicochemical parameters	Values	Method of analysis
Particle size (%) Clay	13.00	Hydrometer method
Sand	77.00	
Silt	10.00	
Soil pH	6.2	Potentiometric method
Moisture content (%)	84.03	Gravimetric method
Soil organic matter	2.33	Walkley – Black method
Cation Exchange Capacity, CEC ($cmol/kg^{-1}$)	5.30	Ammonium Acetate Method
Concentration of Pb (mg/kg) in soil sample	0.540	Microwave plasma Atomic emission spectrophotometer
Concentration of Pb (mg/l) in waste water sample	0.137	Microwave plasma Atomic emission spectrophotometer

3.2. Plant growth and toxicity symptoms in soil irrigated with textile effluent

The average shoot height of *C. procera* and *J. curcas* in EDTA and CA amended soil are presented in **Table 2** below. The data obtained showed that the individual application of EDTA and CA to the soil increased the average shoot height of *C. procera* relative to control (unamended soil). *C. procera* in control attained an average shoot height of 18.50cm which increased non-significantly ($P > 0.05$) to 19.20cm and 18.75cm respectively with the individual application of EDTA and CA to the soils. On the other hand, *J. curcas* had an average shoot height of 25.00cm in control which reduced significantly ($p < 0.05$) to 18.40cm and 17.67cm respectively when EDTA and CA were individually applied to the soil.

3.3. The effect of EDTA and CA on metal accumulation by plants

The result for the uptake of Pb in the tissues of *C. procera* in control, CA and EDTA amended soils are presented in **Table 3** and **Figure 1**. the result showed that *C. procera* in control accumulated 0.160mg/kg Pb in the tissues and this decreased non-significantly ($P > 0.05$) to 0.140mg/kg when EDTA was applied to the soil but increased significantly ($P < 0.05$) to 0.210mg/kg with the application of CA. Varying the distribution of Pb in the tissues of *C. procera*, it was observed the root of *C. procera* in control and EDTA amended soil both accumulated 0.050mg/kg which increased to 0.060mg/kg when CA was applied to the soil. The shoot of *C. procera* in control accumulated 0.11mg/kg Pb which decreased to 0.090mg/kg in EDTA amended soil but increased to 0.150mg/kg with the application of CA.

Pb uptake in the tissues of *J. curcas* sown in soils individually amended with EDTA and CA increased relative to control (**Table 3** and **Figure 2**). *J. curcas* sown in unamended soil accumulated 0.440mg/kg Pb and this uptake increased non - significantly to 0.660mg/kg with EDTA amendment and significantly ($P < 0.05$) increased to 0.700mg/kg with the application of CA. Varying the distribution of Pb in the root and shoot of the plants, *J. curcas* in control accumulated 0.230mg/kg in the root which reduced to 0.200mg/kg with the application of EDTA to the soil but increased to 0.260mg/kg with the application of CA to the soil. Shoot Pb uptake increased from 0.210mg/kg in control to 0.460mg/kg and 0.440mg/kg respectively with the individual application of EDTA and CA to the soil.

3.4. Bio Concentration Factor and Transfer Factor

The BCF values *C. procera* and *J. curcas* for Pb in soils irrigated with textile effluents and amended individually with EDTA and CA are shown in **Table 3.**The result showed that the BCF of *C. procera* for Pb in control, EDTA and CA amended soils are 0.30, 0.26 and 0.39 respectively and 0.81, 1.22 and 1.30 respectively for *J. curcas*. The TF values of *C. procera* for Pb in control, EDTA and CA amended soils are 2.2, 1.8 and 2.5 respectively and 0.91, 2.30 and 1.69 respectively for *J. curcas*.

Table 2: Average shoots heights of plants in soil with and without amendments

	Shoot height of C. procera (cm)	Shoot height of J. curcas (cm)
Control	18.50±0.70	25.00±0.00
Soil +EDTA	19.20±0.00	18.40±2.12
Soil + CA	18.75±3.03	17.67±4.16

Table 3: Concentration (mg/kg) of metals in the root and shoot of *C. procera* and *J. curcas*, BCF and TF

	C. procera				**J. curcas**			
	Root (mg/kg)	Shoot (mg/kg)	BCF	TF	Root (mg/kg)	Shoot (mg/kg)	BCF	TF
Control	0.05±0.00	0.11±0.00	0.30	2.2	0.23±0.00	0.21±0.00	0.81	0.91
Soil+ EDTA	0.05±0.00	0.09±0.00	0.26	1.8	0.20±0.00	0.46±0.01	1.22	2.30
Soil +CA	0.06±0.00	0.15±0.00	0.39	2.5	0.26±0.00	0.44±0.10	1.30	1.69

IV. Discussion

4.1. Physicochemical Properties of Soil Sample.

The particle size distribution of the soil sample showed that the soil sample has 13% clay, 10% silt and 77% sand thereby classifying the soil as sandy loam according to textural triangle **Table 1**. The soil sample has 84.03% soil moisture content, 2.33% soil organic matter CEC of 6.10. Soil organic matter is an important indicator for judging soil fertility (Sen *et al.*, 2019) and it also controls the behaviour of trace metals in the soil because it has the ability to reduce the phytotoxic effects of metals in the soil by forming metal-organic complexation (Gupta *et al.*, 2007). CEC is a very important soil property that influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification. It particularly measures the ability of soils to allow for easy exchange of cations between its surface and solution (Wuana *et al.*, 2010). The pH value for the soil sample was slightly acidic (6.2) according to The US Department of Agriculture Natural Resources Conservation Services classification and is within the pH range of agricultural soils. Soil pH is a major factor influencing the availability of metals in the soil for plant uptake and many chemical processes in the soil. Metals are available in the soil under acidic conditions because H^+ions from the acid displace metal cations from the cation exchange complex (CEC) of soil components and cause metals to be released from surfaces to which they have been chemisorbed (McBride, 1994), also the adsorption of metals to soil organic matter is also weaker under acidic condition, resulting in more available metal in the soil solution for root absorption. The concentrations of Pb in the soil and waste water samples were determined using MP – AES. The level of Pb in the soil sample is 0.540mg/kg while the waste water sample had 0.137mg/l Pb. From the results presented, it could be seen that the levels of the metals in the soil and water samples were not within the permissible limits set by WHO/ FEPA for soil (0.400mg/kg) and waste water (0.010mg/l) used for irrigation.

4.2. Plant Growth and Toxicity Symptoms in Soil Irrigated with Textile Effluent

This study investigated the effects of individual application of EDTA and CA on the growth of *C. procera* and *J. curcas* sown in soil irrigated with textile effluent. Textile effluent contains different heavy metal which can serve as micro nutrients that enhance plant growth as well as inhibit plant growth. In this study, the individual application of EDTA and CA to soil irrigated with textile effluent increased the average shoot height of *C. procera* relative to control (unamended soil) while the average shoot height of *J. curcas* was inhibited with respect to control. The increase in shoot height of *C. procera* could be due to the chelation of heavy metals which reduced the toxic effects of the metal on the plant. Nawazi *et al.*, (2020) opined that the application of chelating agent can improve plant tolerance to heavy metals and enhance plant height, shoot fresh and dry weight and this was probably due to the chelation of the heavy metals which reduced the toxic effects of the metal on the plant but in some cases, reduced growth is observed due to excess solubilization of metals by the addition of chelators to the soil thereby causing toxicity to the plant such as suppressed growth. Comparing the efficiencies of EDTA and CA in the increase in plant shoot height, it was observed that the application of EDTA to the soil increased the average shoot height of both *C. procera* and *J. curcas* when compared to the average shoot height of the plants in CA amended soil. Muhammad *et al.,* (2020) reported that EDTA improved plant growth, biomass, chlorophyll contents, gas exchange attributes and ultra-structure of chloroplast while ameliorating oxidative stress by enhancing the anti oxidative defence system. Yuqin *et al.*, (2019) also observed that CA treatments significantly inhibited the growth of the arsenic (As) hyper accumulator *Pteris vittata L.*

4.3. Concentration (mg/kg) of Metals in the Root and Shoot of *C. procera* and *J. curcas*

High tolerance to heavy metal toxicity, fast growth and large biomass are some of the pre - requisites for plants used for phytoremediation (D. Muhammad *et al.,* 2009). Non-hyper accumulators have fast growth with large biomass but low metal accumulating capacity. The application of chelating agents to the soil has been shown to improve the ability of plants to accumulate heavy metals. In this study, the uptake of Pb by *C. procera* in CA amended soil was about 31% higher than control therefore indicating the positive effect of CA in metal uptake but reduced by 13% with the application of EDTA. Hassan *et al.*, (2016) reported that CA application enhanced antioxidant enzyme activity and gas exchange parameters which may increase heavy metals in the shoots and roots.

Pb translocation to the shoot of *C. procera* was enhanced when with the soil was amended with CA relative to control but reduced in EDTA amended soil. Increased shoot Pb uptake in CA amended soil according to Khalled *et al.*, (2013) could be due to passive transport of leaked Pb–CA complex to the shoot through the root membranes via transpiration stream. Hart *et al.*, (2022) stated that one of the problems associated with the use of EDTA on Pb-contaminated soil is the increased mobility of macronutrients (Ca, Mg, P) and total water-soluble micronutrients (Cu, Fe, Mn). Anna *et al.*, (2005) opined that the applied EDTA aided the mobility of Phosphorous in the soil and eventually, uptake and translocation within the plant. This in turn increased the internal concentration of phosphorous within the plant hence, the inability of the plant to tolerate Pb.

The uptake of Pb in the tissues of *J. curcas* in CA and EDTA amended soil were 59% and 50% higher than control indicating the effectiveness of the chelating agents in the accumulation of Pb in the plant tissues. The result also showed that translocation of Pb to the shoot was enhanced better by EDTA than CA. This result is consistent with the findings of Aghelan *et al.*, (2021) where EDTA increased Pb uptake in shoots higher than CA using *Amaranthus caudatus L*.

The efficiencies of EDTA and CA were compared in terms of Pb accumulated in the tissues of *C. procera* and *J. curcas*. It was observed that Pb uptake in the tissues of *C. procera* and *J. curcas* increased by 33% and 6% respectively with CA amendment compared to EDTA amendment. Thus, it can be concluded that CA was more effective in the mobilization of Pb from the soil to the root of *C. procera* and *J. curcas* plants and also aided the uptake of Pb by the roots of the plants. Several authors have compared the efficiency of EDTA and CA in the mobilization and uptake of Pb from contaminated soils. For example, Hart *et al.*, (2022) observed that CA was found to be more effective than EDTA in increasing Pb phytoextraction from multi metal contaminated sediment by castor bean (*Ricinus communis L.*) and chicory (*Cichorium intybus L.*). Chen *et al.*, (2012) observed higher metal removal with CA while EDTA had less metal removal. Magdy *et al.*, (2017) observed increase in Pb uptake when CA was applied and attributed it to the chelation effect of the acid on the added metal. The reduced Pb uptake in EDTA amended soil according to Wu *et al.*, (2004) could be that EDTA may have chelated with Pb in the soil and enhanced the mobility of soil Pb in the long term.

4.4. Bio concentration Factor and Transfer Factor

The relation between metal contents in the different plant parts and its total content in soil was calculated as bio concentration factor (BCF) (Yoon *et al.*, 2006; Cluis. 2004). Therefore, it is suggested that the plant species having the higher metal concentration in its tissues than the soil can be considered as accumulator for phytoremediation. The accumulation efficiency of plants was categorized into three depending on their BCF levels (Blaylock *et al.*, 1997). BCF was categorized as; excluder if BCF <1; accumulator if BCF = 1 – 10; hyper accumulator if BCF > 10. In this study, it was observed that the application of CA to the soil increased the BCF of *C. procera* (0.39) *and J. curcas* (1.30) for Pb than with the application of EDTA (*C. procera*; 0.26, *J. curcas*; 1.22). It was also observed that the BCF of *C. procera* for Pb in control, CA and EDTA amended soils were less than 1 (BCF < 1) therefore classifying the plant as an excluder. The BCF of *J. curcas* in control was less than 1 but greater than 1 with the application of CA and EDTA. This implies that *J. curcas* in control is an excluder but can be an accumulator with EDTA and CA amendment. The ability of plants to transfer metals from the root to the shoot is determined by transfer factor (TF) and this also determines the phytoremediation technology used by the plant for the removal of heavy metals (Marchiol *et al*,. 2004). The result of the TF of *C. procera* and *J. curcas* for Pb is presented in Table 3.0. The result showed that relative to control, the TF of *C. procera* decreased when EDTA was applied to the soil while it increased with the application of CA to the soil. A decrease of about 18% was observed in the TF *C. procera* for Pb when EDTA was applied to the soil relative to control. On the other hand, the TF *C. procera* for Pb in CA amended soils increased by about 14% relative to control. The individual amendment of the soil with EDTA and CA induced an increase of about 153% and 86% in the TF of *J. curcas* for Pb relative to control. This result is in accordance with the report of Yue *et al.*, (2009) who observed that the concentrations of Pb in aerial parts of the plants were significantly increased after the treatments of EDTA compared with those in the control. Translocation was facilitated by the easy movement of EDTA – Pb complex through the xylem cell walls with high cation exchange capacity (Begonia *et al.*, 2013). The result also showed that the TF of *C. procera* in control, CA and EDTA amended soils were greater than 1 (TF > 1). This implies that the Pb was removed by phytoextraction technology. Similarly, the TF of *J. curcas* in EDTA and CA amended soils were greater than 1 (TF > 1). This indicates that more Pb was translocated to the above part hence, the metal was removed by phytoextraction but lesser Pb was observed in the shoot of *J. curcas* in control. This indicates that the metal was stabilized in the root (TF < 1).

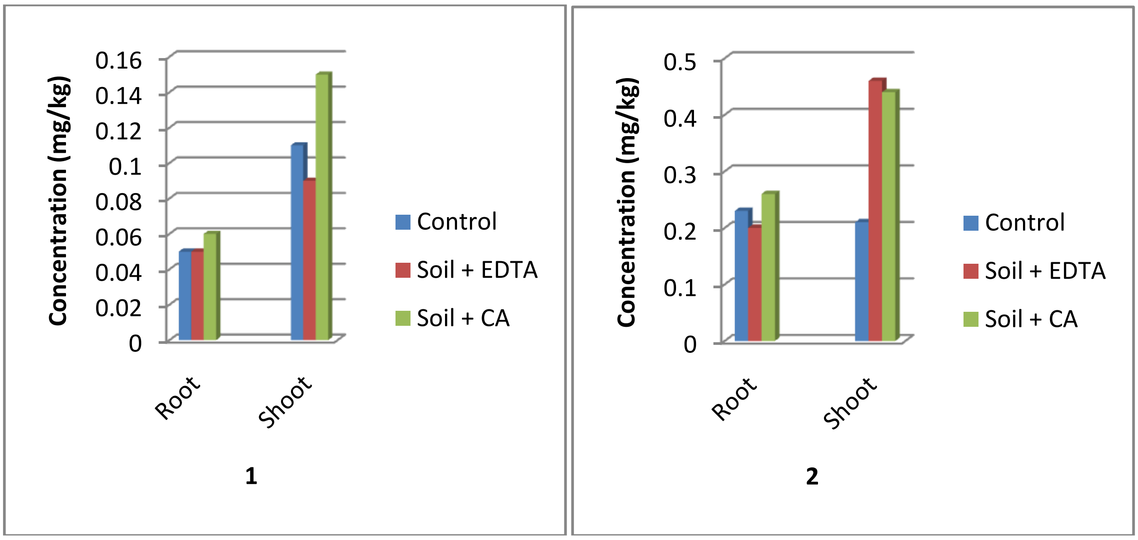

Fig 1 and 2: Mean concentration of Pb in the root and shoot of *C. procera* and *J. curcas*

V. CONCLUSION

This study compared the efficiency of EDTA and CA in the phytoextraction of Pb from soil irrigated with textile effluent using *C. procera* and *J. curcas*. The effect of EDTA and CA on shoot height of the plant was also examined. The results obtained showed that shoot heights of the plants increased better in EDTA amended soil than in CA amended soil. The results also showed that heavy metal uptake in the plant tissues increased when the soil was amended with CA than EDTA. The BCF values obtained showed that *C. procera* was an excluder in both amended and unamended soils while *J. curcas* in unamended soil was an excluder but an accumulator when the soil was individually amended with EDTA and CA. The obtained TF values showed that the removal of Pb by *C. procera* in amended and unamended soils and *J. curcas* in amended soils was by phytoextraction while *J. curcas* in unamended soil removed Pb by phytostabilization. This study showed that CA can be applied to heavy metal contaminated soil in place of EDTA which can contaminate surface and ground waters due to low degradability.

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