



Soil characteristics and nutritional parameters of *Telfairia occidentalis* Hook around auto-mechanic workshop in Ibesikpo-Asutan, Akwa Ibom State, Nigeria

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Abstract

Soil characteristics and mineral nutrients parameters of *Telfairia occidentalis* Hook around auto-mechanic workshop in Ibesikpo-Asutan, Akwa Ibom State, were investigated with the aim of ascertaining the level of petroleum oil contamination on the site. Soil samples were collected (0-20cm depth) from four (4) sampling locations (M_0 , M_1 , M_2 , and M_3) in triplicates, giving a total of twelve (12) representative samples. M_1 , M_2 , and M_3 were sampling units at the auto-mechanic workshop, while M_0 sampling unit was the control treatment (an area outside the auto-mechanic workshop). Soil samples obtained from M_1 was 15m away from the auto-mechanic workshop and with a corresponding distance from M_1 to M_2 as well as M_2 to M_3 .

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Leaf samples of *T. occidentalis* were obtained around the auto-mechanic workshop using the corresponding distance with the soil samples. Complete randomized block design was used as research design. The pH of soils around the auto-mechanic workshop (M_1 , M_2 and M_3) was slightly acidic (4.30 ± 0.36 , 4.50 ± 1.32 and 4.70 ± 0.52 , respectively), with values approaching neutral status as the distance from contamination site increased. The values of pH at the contamination site (M_1 - M_3) were significantly lower ($P < 0.05$) than that of the control (M_0 : 5.20 ± 2.10). The soil nitrogen and phosphorus levels decreased considerably with increase in carbon contents in soils around the auto-mechanic workshop (M_1 - M_3). The contents of calcium, magnesium and potassium at the contaminated site were significantly lower ($P < 0.05$) than those of the control site (M_0). Conversely, the heavy metal (zinc, copper, iron and lead) contents in soils of the contaminated site were significantly ($P < 0.05$) higher than those of the control site (M_0). There were marked variations in contents of Ca, P, N, Mg, K, Fe, Pb and Cu in the tissue of test crop between the sampling locations (M_0 , M_1

M₂ and M₃), with values of P, Fe, Pb and Cu being significantly ($P < 0.05$) higher than those of the control site (M₀), while the Ca, N, Mg and K contents in the test crop tissue were significantly ($P < 0.05$) lower than those of the control site (M₀). This study clearly revealed that petroleum oil wastes affected both soil chemical properties and contents of mineral element in the tissues of *T. occidentalis*.

Keywords: soil; mineral elements; auto-mechanic workshop; petroleum oil waste; contamination.

1.0 Introduction

Global contamination of air, water, and soil is one of the consequences of civilization of modern age (Etukudo and Osim, 2019). The transformation of petroleum oil into various products and components for use by industries and vehicles has led to contamination of the environment (Ahmed et al., 2016). Petroleum oil contains toxic components, which contribute to deleterious effects on the ecosystem (Ujowundu et al., 2011). Auto - mechanic workshops contribute considerable proportion of petroleum wastes to cultivated lands (Nkwoada et al., 2008; Demie, 2015). It is important to note that environmental degradation is eminent in areas where auto-mechanic workshops are operational due to lack of regulatory standards as regards the disposal of used oil and wastes (Kpakpavi, 2015). The adverse effects of crude oil pollution resulting from this irregular disposal of petroleum oil waste include among others, adsorption of oil to soil particles, generation of an excess carbon that may be limited to microbial use as well as reduction of important soil nutrients such as nitrogen and phosphorus (Okolo et al., 2005; George-Okafor et al., 2009).

Crude oil is regarded as a highly toxic mixture of more than 10000 different hydrocarbons.

Accidental spills of crude oil in environment cause severe contamination of marine and continental ecosystems. Contamination due to spill of processed petroleum derivatives such as diesel and fuel is an important problem in waters (Lopez-Rodas et al., 2009). This contamination is usually generated from both natural and anthropogenic processes (Hughes et al., 1997; Haghghat et al., 2008; Atlas and Bragg, 2009). Also these environmental stresses influence the physiological activities of living organisms. In consequence, when a change in the environment exceeds a certain threshold level, some metabolic pathways are inhibited or abolished and some of others are enhanced or induced as may be evident in petroleum oil contaminated sites (Amirlatifi et al., 2013).

The test crop *Telfairia occidentalis* Hook, commonly called fluted pumpkin belongs to the family, Curcubitaceae (Grubben and Denton, 2004). Its leaves and immature seeds have lots of nutritive value, hence are cooked and consumed as vegetable while the rind and pulp of the fruits are used as fodder for livestock (Oderinde et al., 1990; Schippers, 2002; Grubben and Denton, 2004). Some auto-mechanic workshops are usually sited around agricultural soils, which are under continuous cultivation. Fluted pumpkin could be grown on such soils near auto-mechanic workshops, hence the necessity for this study. Assessment of soil characteristics in petroleum contaminated sites have been reported, however, this study was designed to evaluate soil chemical properties and its relationship to selected mineral nutrient profiles of *Telfairia occidentalis* Hook around auto- mechanic workshop in Ibesikpo-Asutan, Akwa Ibom State, Nigeria.

2.0 Materials and Methods

2.1 Study Area

The study area was located in Ikot Oduot in

Ibesikpo Asutan Local Government Area, Akwa Ibom State, Nigeria. Its geographical Coordinates are: Latitude 4.9188° - 4.9219° N, and longitude 7.9484° - 7.9524°E. Ibesikpo-Asutan is characterized by wet season, which is overcast and the dry season is mostly cloudy, and it is hot and oppressive all year round. Over the year, the temperature typically varies from 64°F to 91°F and is rarely below 58°F or above 94°F (Zwiefelhofer, 2022; Weather Spark, 2022).

2.2 Collection of soil samples

Soil samples were collected (0-20cm depth) from four (4) sampling locations (M_0 , M_1 , M_2 , and M_3) in triplicates, giving a total of twelve (12) representative samples. M_1 , M_2 , and M_3 were sampling units at the auto-mechanic workshop, while M_0 sampling unit was the control treatment (an area outside the auto-mechanic workshop) (Osim *et al.*, 2020). Soil samples obtained from M_1 was 15m away from the auto-mechanic workshop, and with a corresponding distance from M_1 to M_2 as well as M_2 to M_3 . Complete randomized block design was used as research design. The samples were collected using an acid clean soil auger pack in a well labeled black polythene bag and taken to the laboratory for analysis.

2.3 Collection of plant samples

Leaf samples of *Telfairia occidentalis* were obtained around the auto-mechanic workshop in Ibesikpo-Asutan, Akwa Ibom State. They were stored in air tight containers and kept in the laboratory cupboard.

2.4 Analysis of soil samples

The soil samples were air-dried at room temperature for two (2) weeks and ground to pass through 2mm mesh sieve. The samples were then analyzed for both physical and chemical

properties of the soil. Standard methods were used to analyze soil samples for physico-chemical properties. Soil pH was measured in water at ratio 1:1 (soil: water) by glass electrode pH meter (McLean, 1965). Organic matter was determined by wet dichromate acid oxidation method (Nelson and Sommers, 1982). The cation exchange capacity (CEC) was determined by extracting the cations with 1 M ammonium acetate buffered at pH 7. 30 ml of 1 M $\text{CH}_3\text{COONH}_4$ was added to 5 g of soil. The suspension was shaken for 2 hours and then centrifuged (15 min, 6000 rpm). After centrifugation and filtration, the filtrate was transferred into a 100 ml flask and two other volumes of 30 ml ammonium acetate were added successively after 30 min of agitation and centrifugation. The final filtrates were completed to 100 ml with ammonium acetate solution. Calcium (Ca) and magnesium (Mg) were determined by EDTA titration while potassium (K) was determined by flame photometry. Available phosphorous (Av. P) was extracted with Bray solution 11 and the phosphorous determined by the molybdenum method described by Udo and Ogunwale (1978). The percentage of organic matter (%OM) was calculated from the percentage of organic carbon (OC%) measured using wet oxidation method of Walkley and Black (1934). Total nitrogen (TN) was determined using the modified Kjeldahl distillation methods (Juo, 1979).

2.5 Determination of heavy metal contents of soil

One gram of each of the sieved soil samples was digested using the nitric/perchloric acid digestion procedure (Odu, 1986). The concentrations of heavy metals, Pb, Zn, Fe, and Cu were determined using atomic absorption spectrophotometer (Unicam Solaar 32 model)

following the standard procedures (APHA, 1985).

2.6 Mineral analysis of leaves of *Telfairia occidentalis*

Standard methods of AOAC (2003) and Hack (2000) were used to determine the mineral elements in leaves of the test plant. Leaves segments of *Telfairia occidentalis* were first shadow-dried for 3 days, and macerated to small components. They were then oven-dried at 100^oC for 4 hours. They were crushed and ground to powder, then 2 grams each of the powders were weighed into Porcelain crucibles and placed in a muffle furnace and the furnace was set at 450^oC to ash. The ashing was done for 6 hours. The resulting ash was acid-digested in 15ml of concentrated HNO₃ (Trioxonitric acid) on a hot plate. 20ml of distilled water was then added to the crucible to dilute the acid in the crucible. The mixture was then filtered in 100ml volumetric flask and made up to the mark with distilled water. All the samples were then ready for AAS analysis. The AAS machine was then set-up and the various elements were analyzed at the specific wavelengths, lamps, currents, and gas mixtures.

2.7 Statistical analysis

Values of mean data obtained from the replicate readings were used to calculate standard error and data were subjected to analysis of variance (ANOVA). The differences in the means were tested using Least Significant Difference (LSD) at 0.05 level of probability (Obi, 2002).

3.0 Results and Discussion

The chemical properties of experimental soils are presented in Table 1. The pH of soils around the auto-mechanic workshop (M₁, M₂ and M₃) was slightly acidic (4.30 ± 0.36, 4.50 ± 1.32 and 4.70

± 0.52, respectively), with values approaching neutral status as the distance from contamination site increased. The values of pH at the contamination site (M₁ - M₃) were significantly lower (P < 0.05) than that of the control (M₀: 5.20 ± 2.10). This result is in line with pH reduction in petroleum oil contaminated soil as reported by Jia *et al.* (2009) and Eziegbo *et al.* (2013). Other studies have shown decreased value of pH in soil due to total petroleum hydrocarbon (Gong *et al.*, 2008; Kistic *et al.*, 2009). The adverse effects of petroleum oil pollution on pH might have contributed significantly to poor growth parameters of the test crop in pollution treatment as shown in this study. Soil pH directly affects solubility of many nutrients in soil for proper plant growth and development (Udoh *et al.*, 2005; Anoliefo, 2006). However, higher pH has been reported in petroleum hydrocarbon soil (Stanley *et al.*, 2017; Nyarko *et al.*, 2019). The soil nitrogen and phosphorus levels decreased considerably with increase in carbon contents in soils around the auto-mechanic workshop (M₁-M₃). This result is in line with the findings by Okolo *et al.* (2005), Hussein (1997) and Etukudo *et al.* (2015) that crude oil pollution adversely affects the soil components due to adsorption to soil particles, increase in carbon that might be unavailable for microbial utilization and induction of a limitation in soil nitrogen and phosphorus. The phosphorus and nitrogen levels of soils around the auto-mechanic workshop (M₁ - M₃) were significantly lower (P < 0.05) than those of the control site (M₀), thus, contradicting the higher levels of these mineral nutrients in similar contaminated sites as reported by Nyarko *et al.* (2019), but corroborates with the lower levels of these mineral nutrients in crude oil contaminated soil (Etukudo *et al.* 2011; Udo *et al.* 2018;). Reduction in nitrogen and phosphorus contents in soil as affected by petroleum oil contamination resulted from anaerobic soil

condition, thus, leading to unavailability of these important elements (Chen *et al.*, 1995; Okonwu *et al.*, 2010). The calcium and magnesium contents ranged between 2.07 ± 1.03 and 2.33 ± 0.34 mg/100g, and 3.35 ± 0.52 and 3.70 ± 0.17 mg/100g, respectively, in soils around the auto-mechanic workshops. In addition, the contents of calcium, magnesium and potassium at the contaminated site were significantly lower ($P < 0.05$) than those of the control site (M_0). Conversely, the heavy metals (zinc, copper, iron and lead) contents in soils of the contaminated

site were significantly ($P < 0.05$) higher than those of the control site (M_0). The content of Copper showed increases over that of the control, but was below the WHO limit of 150.0 mg/kg. Similarly, Lead and Zinc showed increases over the control values, but were generally below their permissible values of 40.0 and 500.0 mg/kg, respectively (WHO, 1984). These variations may be attributed to differences in the chemical, physical and biological compositions of the sites (Baker *et al.*, 2000).

Table 1: Chemical characteristics of Experimental soil

Soil Properties	Sampling Units			
	M_0	M_1	M_2	M_3
pH	5.20±2.10	4.30±0.36	4.50±1.32	4.70±0.52
Avail. P (mg/100g)	4.37±0.42	3.17±1.60	3.23±0.62	3.40±0.71
Total N (%)	2.73±0.60	1.06±1.43	1.24±0.51	1.36±0.32
Org. C (mg/100g)	1.80±0.12	1.30±1.80	1.87±0.20	2.06±1.22
Ca (mg/100g)	5.20±0.37	2.07±1.03	2.19±0.26	2.33±0.34
Mg (mg/100g)	6.14±0.25	3.35±0.52	3.42±0.64	3.70±0.17
K (mg/100g)	1.66±0.23	1.40±0.20	1.27±0.13	1.20±0.18
Zn (mg/100g)	0.42±0.06	1.30±0.44	1.16±0.40	1.10±0.33
Cu (mg/100g)	0.23±0.04	1.81±0.20	1.42±0.21	1.33±0.20
Fe (mg/100g)	0.10±0.08	1.42±0.13	1.34±0.25	1.28±0.22

Mean ±standard error from three replicates

The mineral element contents in leaves of *Telfairia occidentalis* are presented in Table 2. Variation in soil pH between the auto-mechanic workshop ($M_1 - M_3$) and the control site (M_0), could have contributed significantly to bioavailability of soil nutrients, hence, the disparity in contents of these elements in the tissue of test crop between the sampling locations (M_0, M_1, M_2 and M_3). Bioavailability of soil mineral elements has been reported to have a profound influence on the supply of metallic ions

to plants (Nabulo *et al.*, 2008). The soil physical and chemical conditions, which have significant influence on pH, binding and ion exchange of soil medium play a major role in the supply of nutrients to plants (Pellet *et al.*, 1995). This result contradicts the findings that higher amount of Mg^{2+} , Na^+ and P were found in maize seeds subjected to crude oil amendment when compared with their counterparts not exposed to oil treatment, but corroborates with the increase in K^+ , and reductions in Ca^{2+} values as the

concentration of crude oil in soil increased (Agbogidi *et al.*, 2007). This further contradicts the findings that showed increase in exchangeable Ca^{2+} and Mg^{2+} contents as a result of crude oil application (Amadi *et al.*, 1993). Various findings are in line with the findings of this study (Udoh *et al.*, 2005; Etukudo *et al.*, 2015). pH has been reported to act indirectly on plant growth by affecting availability of nutrients, the presence of toxins and growth of soil micro organisms.

pH affects plant growth primarily through its effects on nutrient availability.

High or low pH results in deficiencies in essential nutrients that plants need to grow such that in acidic soils deficiencies in certain mineral elements are observed, while alkaline elements are lost with increasing acidity, phosphorous is more available in acidic soil conditions (Wang *et al.*, 2008; Agbede, 2009).

Table 2: Mineral Elements in Leaves of *Telfairia occidentalis*

Mineral Elements	Sampling Units			
	M ₀	M ₁	M ₂	M ₃
Ca (mg/100g)	2.02±0.10	1.30±0.22	1.34±1.20	1.37±0.25
P (mg/100g)	1.22±0.23	1.28±0.40	1.42±0.54	1.46±0.15
Total N (%)	1.12±0.34	0.36±0.03	0.39±0.05	0.40±0.02
Mg(mg/100g)	2.80±0.25	2.12±0.36	2.15±0.39	2.19±0.27
K(mg/100g)	2.42±0.38	2.08±0.33	2.06±0.12	2.03±0.41
Fe(mg/100g)	0.07±0.02	0.39±0.06	0.34±0.07	0.28±0.07
Pb (mg/100g)	0.05±0.03	0.24±0.04	0.18±0.02	0.15±0.06
Cu (mg/100g)	0.09±0.02	0.55±0.09	0.49±0.07	0.43±0.04

Mean ±standard error from three replicates

4.0 Conclusion

This study showed a marked variation in the chemical properties as well as test crop mineral element contents between the control (M₀) and the surrounding soils at auto-mechanic workshop (M₁, M₂ and M₃). This study revealed that the auto-mechanic workshop operations would pose a negative effect on *Telfairia occidentalis* and the surrounding soils due to the petroleum oil wastes usually generated from such operations.

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