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Effect of Distance from Tarauni Highway in Kano Municipal, on Lead Contents of Soil and Growing Cowpea *(Vigna unguiculata)*

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Abstract: *Numerous investigators have observed gradients of decreasing lead concentrations in soils and plants with increasing distance from the highway. Their results covered a broad range of values depending upon the size of the highway, the sampling and analytical methods used, and other circumstances. In this study, cowpea seeds were planted in three different locations to monitor the effects of proximity of planting sites to Tarauni highway in Kano Municipal, on lead contents in soil and growing cowpea plant. The planting sites were screen house at International Institute of Tropical Agriculture (IITA) station, Tarauni Kano, Tarauni road by IITA gate and Gado village in Kumbotso local government area, Kano State. There was a highly significant decrease in total lead after harvest (Pr = 0.0043 < 0.01) with increasing distance of planting site from Tarauni road, which was attributed to high concentration of particulate lead from vehicle exhausts. No significant differences were found in water soluble lead after harvest (Pr = 0.57 > 0.05) and exchangeable lead after harvest (Pr = 0.64 > 0.05). The pH after harvest differed highly significantly (Pr < 0.01) from its value before planting. The root lead was the same in all sites, but the mode of translocation of lead to aerial parts of the plant differed from one site to another. This was due to greater localization of Pb in walls of the root than in other parts of plant. High concentrations of lead in roadside plants were primarily due to surface contamination rather than uptake of lead from the soil.*

Keywords: *Cowpea (Vigna unguiculata); Highway; Proximity; Particulate lead; Surface contamination, Translocation.*

1. Introduction

Increased use of Pb since the industrial revolution has resulted in elevated concentrations of this element in virtually all sectors of the environment. Lead is used as antiknock additive of 2 to 4g of tetramethyl and tetraethyl lead per gallon (3.8L) of gasoline (Quarles *et al,*1974). Upon combustion of petrol in the engine, the organic lead is oxidized to lead oxide (PbO).

$$2Pb(C_2H_5)_4 + 27O_2 \longrightarrow 2PbO + 20H_2O + 16CO_2$$

The lead oxide, formed reacts with the halogen carriers (the co-additives) to form particles of lead halides $PbCl_2$, PbBrCl, $PbBr_2$, which escape into the air through the vehicle exhaust pipes. By this, about 80% of Pb in petrol escapes through the exhaust pipe as particles, while 15–30% of this amount is air borne (Ademorati, 1996). The areas adjacent to major highways receive the greatest input of these Pb particulates. A distant gradient of increased Pb concentration usually exists for about 80metres on either side of the highway; lesser elevated concentrations extend even farther. Increased Pb concentrations have been found in air, soil and plants within this zone. Its distribution and effects are important because Pb might adversely affect all forms of life in this area, including man (Daines *et al,* 1970). Aremu *et al,* (2006) reported high values of Pb in crops planted in locations along Keffi-Abuja, Keffi-Akwanga and Akwanga-Lafia roads with traffic volumes of 800-1000 vehicles per hour.

2. Materials and Methods

2.1 The Study Area

The soil sample and cowpea seeds (*Vigna unguiculata*) used for this study were collected from the International Institute of Tropical Agriculture (IITA) farm in Wase village, Minjibir Local Government Area of Kano State. Figures 1 to 3 show the locations of sampling and planting sites.

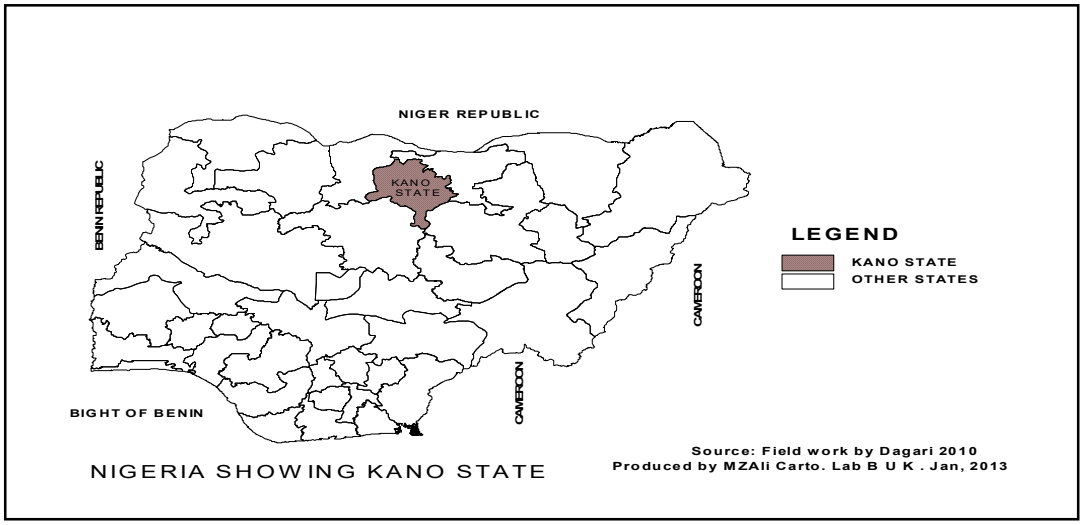


Figure 1: Map of Nigeria Showing Kano State

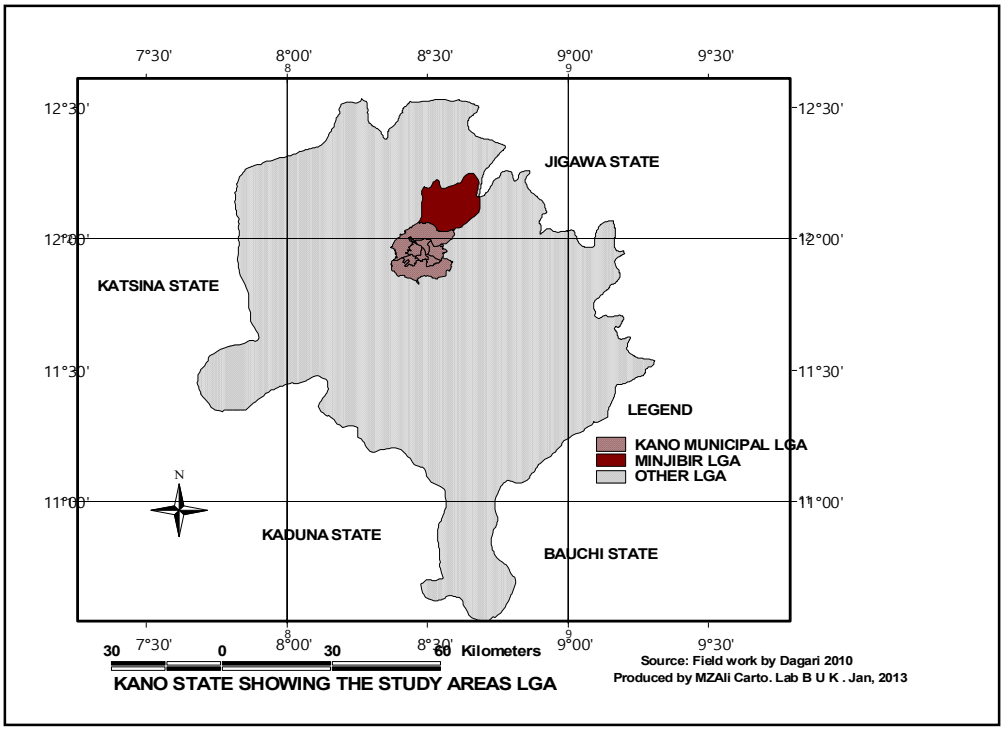


Figure 2: Map of Kano State Showing the Study Local Government Area

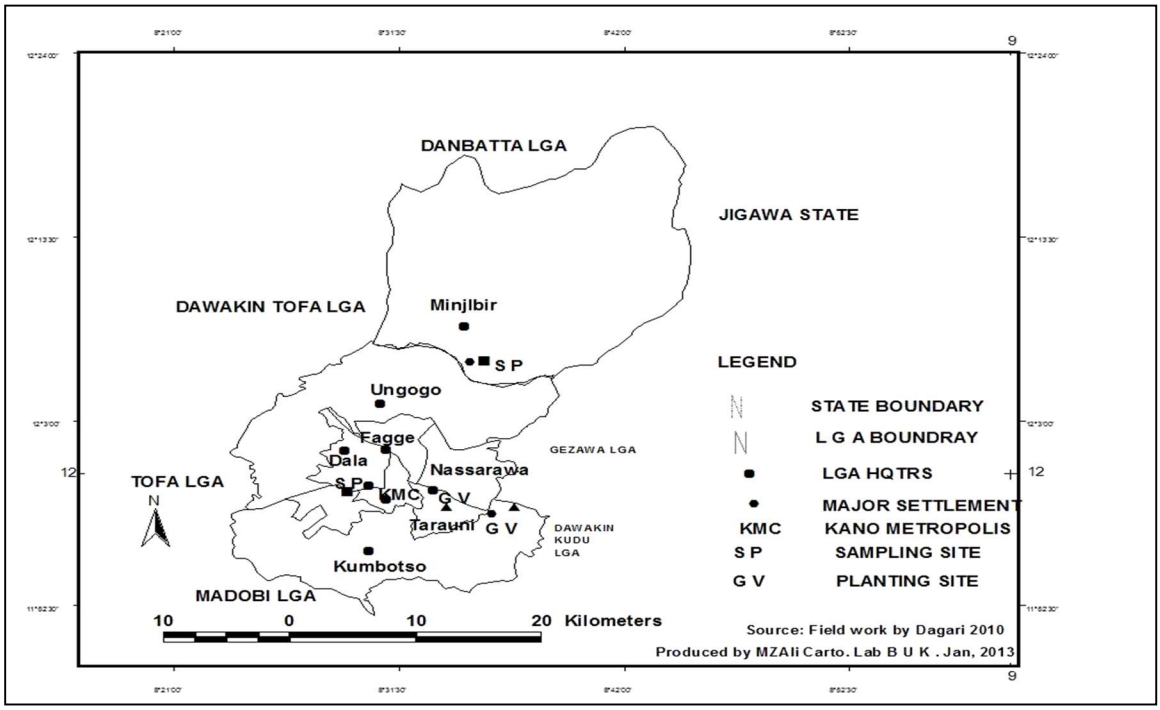


Figure 3: Kano State L.G.A. Map Showing Sampling and Planting Sites

2.2 Instruments, Apparatus and Reagents

All equipment and instruments used in this research were calibrated before conducting the experiments. All glassware used were thoroughly washed with detergents and tap water and then rinsed with deionized water. Suspected contaminants were cleaned with 10% concentrated nitric acid (HNO_3) and metal surfaces rinsed with deionized water. In preparation of reagents, chemicals of analytical grade purity and distilled water were used. All glassware and plastic containers were washed with detergents.

2.3 Soil Sampling and Pre-Treatment

The soil sample was collected using the method recommended by (Petersen, 1994). $100m^2$ of the land was divided into ten equal sized grid cells of $10m^2$. A steel augur was used to dig the soil to a depth of 25cm. Samples collected from all cells were thoroughly air dried, mixed and stored in large plastic bags.

For the purpose of preliminary studies, 1kg of the air-dried sol was taken. After removing the debris, the soil was ground in a wooden mortar and sieved through a 2mm mesh. It was then stored in a labeled plastic container.

2.4 Planting of Cowpea Seeds at Different Locations

Two cowpea *(Vigna unguiculata)* seeds each were planted in four replicates in 3kg soil in plastic pots perforated at the base (Wong and Lau, 1985) after watering with tap water for two days at the following locations;

- Screen house at IITA station, Tarauni Kano with coordinates latitude 11°58'49"N, longitude 008°33'26.5 "E and altitude 492.5m above sea level
- Tarauni road by IITA gate.
- Gado village in Kumbotso local government area, Kano State. The coordinates of Gado village are latitude 11° 56' 47.3'', longitude 008° 37' 04.7'' and altitude 495m above sea level.

2.5 Ashing of Plant Materials

The various plant parts harvested were ground to fine powder. Based on availability, 0.125 or 0.25g (root), 1.00g (stem), 0.75g (leaf) and 0.50g (seed) were used for analysis. They were weighed into porcelain crucibles and ashed at 450°C in a muffle furnace to constant weight. The ash was dissolved in $0.100moldm^{-3}$ nitric acid, filtered and made to mark in a $25cm^3$ volumetric flask (IITA, 1979).

2.6 Extraction of Water Soluble and Exchangeable Lead

The water soluble lead was extracted from a mixture of 10g of pre-treated soil and $100cm^3$ of deionized water in a $120cm^3$ of plastic bottle. The exchangeable fraction was extracted by adding $100cm^3$ of 1M ammonium oxalate to the residue of the water soluble fraction (Stober *et al,* 1976).

2.7 Procedure for Tri-acid Mixture Digestion of Soil to Determine Total Lead

0.2 g of each soil sample was weighed into a platinum crucible and few drops of deionized water added to the sample. A predigestion was carried out by adding AnalaR concentrated nitric acid and 1 mL AnalaR 48% per chloric acid.

The mixture was heated gently on a sand bath until water appeared. The purpose was to remove the readily oxidizable material. The crucible and contents were then allowed to cool and 1 mL of per chloric acid and 5 mL hydrofluoric acid were further added. The crucible and contents were again heated on a sand bath at temperature of 200-230^{o}C and the acid evaporated to dryness. The crucible was removed from the sand bath and allowed to cool. 10 mL of 6M nitric acid was then added and the resulting solution was boiled for 10 minutes. The mixture was filtered and the filtrate made up to 100 mL with deionized water and stored in a plastic container. Blank experiments were carried out involving all the reagents used. The resulting filtrates were kept for analysis (Stober *et al,* 1976)

2.8Atomic Absorption Spectrometric Analysis

The soil and plant extracts were analyzed for lead at 283.5nm using flame atomic absorption spectrophotometry. Blank determinations were made prior to sample analysis. Concentrations of Pb^{+2} in soil and plant extracts were obtained in quadruplicates from calibration curves and expressed as mg/kg (IITA, 1979).

2.9 Statistical Analysis

The data were analyzed in triplets and expressed as mean and standard deviation. The mean of all treatments was subjected to a One-way analysis of variance (ANOVA) using IBM SPSS Statistics 23 software and mean differences were performed using the Tukey test. All graphs were plotted using Microsoft Excel 2013.

3. Results and Discussion

Numerous investigators have observed gradients of decreasing lead concentrations in soils and plants with increasing distance from the highway (Chow 1970; Lagerverff and specht 1970; Motto *et al,*1970; Ter Haar 1970; Williamson and Evans 1972; Cannon and Bowles 1962; MaClean *et al,*1969). Their results covered a broad range of values depending upon the size of the highway, the sampling and analytical methods used, and other circumstances of the study. Wright *et al,* (1955) reported a pronounced accumulation of lead in the A0 horizon of podzol and Brown Podzolic soil. One sample contained 108μgg^{-1}. Swaine and Mitchell (1960) reported an instance of 550μgg^{-1} lead in the horizon of a Scottish soil. In a comparison of 19 orchard and non-orchard A1 soil samples in Nova Scotia, Chishohm and Bishop (1967) found that the lead content was usually above 50μgg^{-1} in the former and below this amount in the latter.

3.1 Effect of Distance of Planting Sites from Tarauni Road on Lead Content of Soil

Concentrations of Pb^{+2} in various soil fractions are presented in **Table 1.**

Table 1: Concentrations of Pb^{+2} in Soil Fractions

		Concentration (mg/kg)					
PS	**DTR(km)**	**TLBP**	**TLAH**	**WSLBP**	**WSLAH**	**ELBP**	**ELAH**
RS	0.00	49.63±3.68	124.08±9.19	3.309±0.637	2.206±0.849	6.985±1.219	6.985±0.735
SH	0.27	49.63±3.68	88.24±46.79	3.309±0.637	2.941±1.698	6.985±1.219	6.250±1.219
GV	5.00	49.63±3.68	51.47±0.00	3.309±0.637	2.574±0.735	6.985±1.219	6.618±0.735

PS: Planting site **RS:** Road side **SH:** Screen house **GV:** Gado village

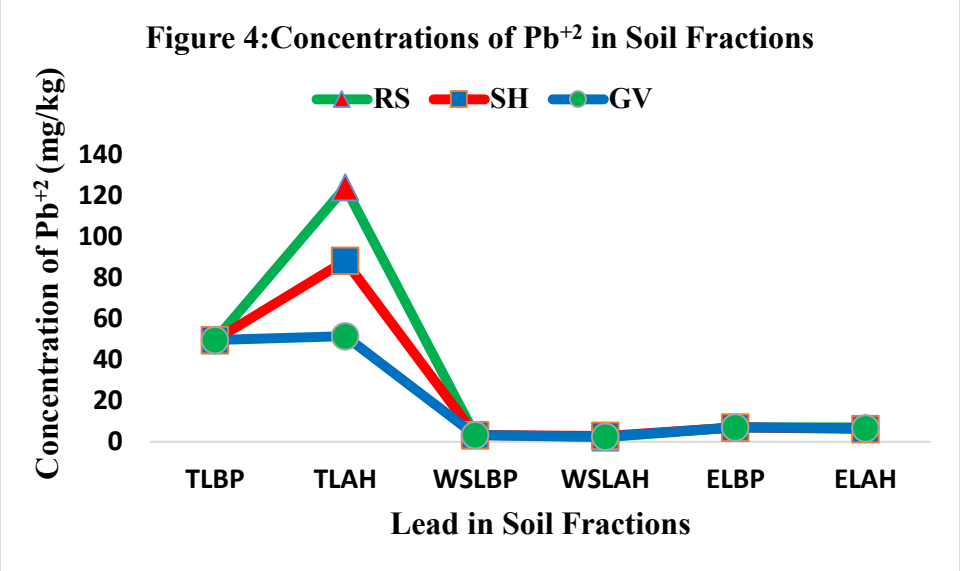
DTR: Distance of planting site from Tarauni road **TLBP:** Total lead before planting

TLAH: Total lead after harvest **WSLBP:** Water Soluble lead before planting

WSLAH: Water soluble lead after harvest **ELBP:** Exchangeable lead before planting

ELAH: Exchangeable lead after harvest

The concentrations of Pb^{+2} in various soil fractions are shown in **Figure 4.**



The roadside sample had the highest value of 124.08±9.19mg/kg for total lead after harvest, which was attributed to high concentration of particulate lead from vehicle exhausts, a result consistent with the findings of (Chow, 1970; Lagerverff and Specht, 1970; Motto *et al,* 1970; Williamson and Evans, 1972).This value of total lead after harvest significantly decreased (Pr = 0.0043 < 0.05) to 88.24±46.79mg/kg at the screen house, 0.27km from the roadside to

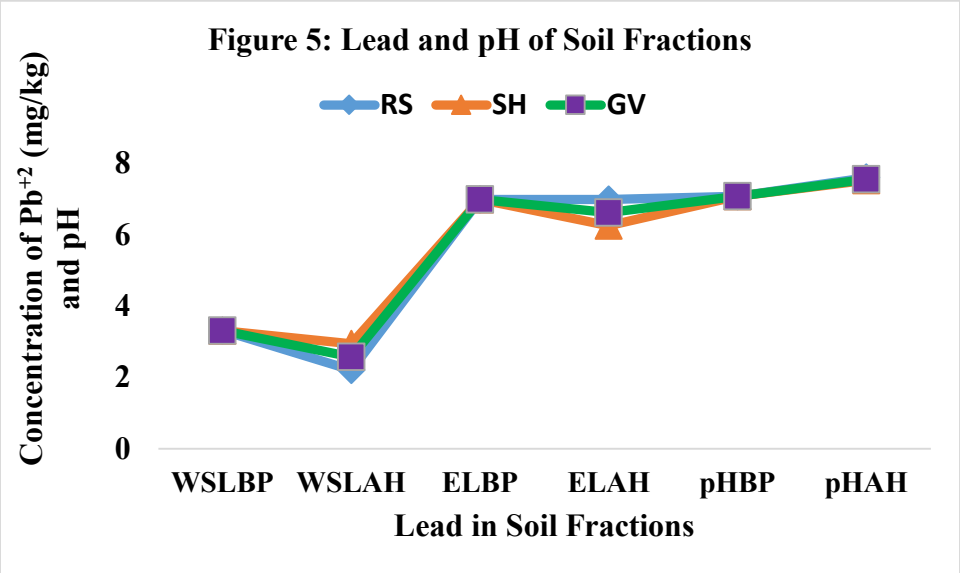
51.47±0.00mg/kg at Gado village, 5km away from Tarauni roadside. There were no significant differences in water soluble lead after harvest (Pr = 0.57 > 0.05) and exchangeable lead after harvest (Pr = 0.64 > 0.05), which agreed with the reports of Marten and Hammond (1966) and Weller and Supple, (1971) that soils contaminated with lead may release only a small portion of it to plants. The chemical form of lead found in the soil samples along the highway is probably largely lead dihalide such as PbBrCl. This composition arises from the scavenging agents, ethylene dibromide and ethylene dichloride which are added to gasoline (Stoker and Seager 1972). These lead salts are insoluble in water (Weller and Supple, 1971).

3.2 Relation between Concentrations of Pb^{+2} in Soil Fractions and pH

Concentrations of Pb^{+2} in various soil fractions with their corresponding pH values are presented in **Table 2.**

		Concentration (mg/kg)					
PS	**DTR(km)**	**WSLBP**	**ELBP**	**WSLAH**	**ELAH**	**pHBP**	**pHAH**
RS	0.00	3.309±0.637	6.985±1.219	2.206±0.849	6.985±0.735	7.075±0.050	7.600±0.000
SH	0.27	3.309±0.637	6.985±1.219	2.941±1.698	6.250±1.219	7.075±0.050	7.525±0.050
GV	5.00	3.309±0.637	6.985±1.219	2.574±0.735	6.618±0.735	7.075±0.050	7.550±0.058

The concentrations of Pb^{+2} in various soil fractions with their corresponding pH values are shown in **Figure 5.**



Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient (Sparks, 2003). The pH of the soil solutions ranged from 7.075 to 7.600, which is neutral to slightly alkaline by USDA (2010) classification. The pH values after harvest increased highly significantly (Pr < 0.01) from their initial values before planting, corresponding to significant

decrease (Pr < 0.05) in water soluble and exchangeable Pb^{+2}, a result consistent with the findings of Richard and Stephen, (1996).

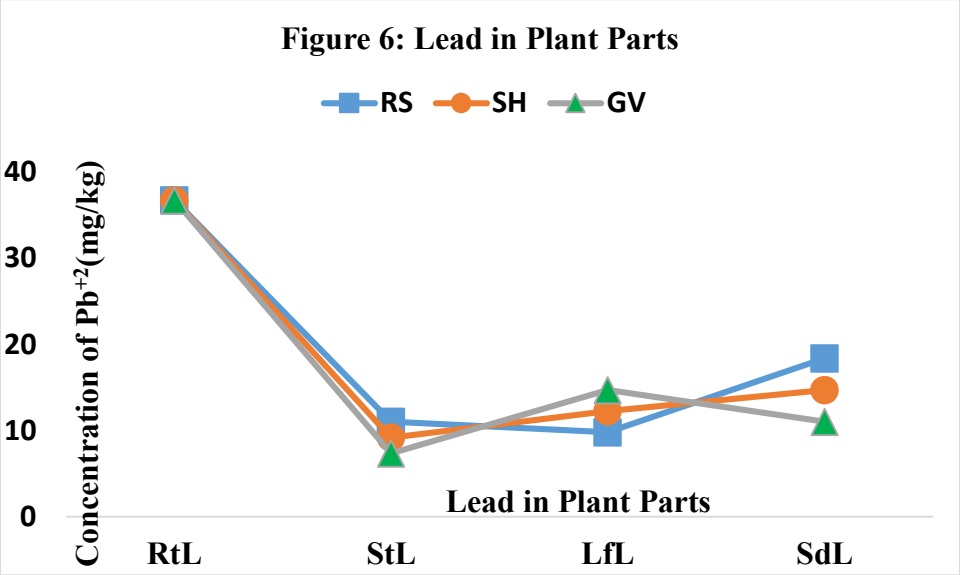
.3.3 Lead in Plant Parts for Various Planting Sites

Concentrations of Pb^{+2} in plant parts for various planting sites are presented in **Table 3**

Table 3: Concentrations of Pb^{+2} in Plant Parts for Various Planting Sites

		Concentration (mg/kg)				
PS	**DTR (km)**	**RtL**	**StL**	**LfL**	**SdL**	**DWP (g)**
RS	0.00	36.76±0.61	11.03±4.25	9.80±0.00	18.38±7.35	6.21±0.76
SH	0.27	36.76±14.71	9.19±3.68	12.25±4.90	14.71±12.01	6.36±1.51
GV	5.00	36.76±28.16	7.35±0.00	14.71±5.66	11.03±7.35	6.41±0.84

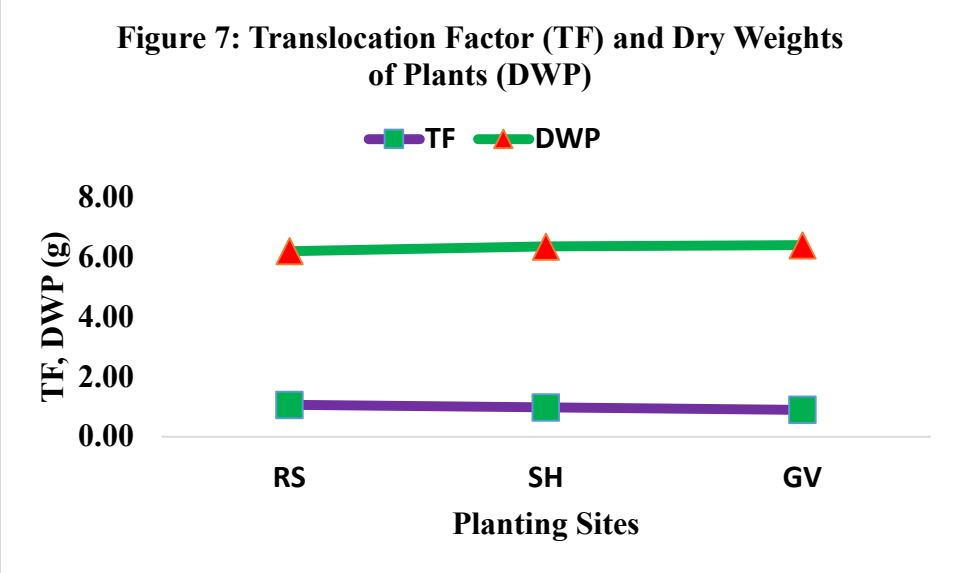
The concentrations of Pb^{+2} in plant parts for various planting sites are shown in **Figure 6**



Proximity of planting sites to Tarauni road had little or no effect on lead accumulated by various plant parts. There were no significant differences in root lead (Pr = 1.00 > 0.05), stem lead (Pr = 0.24 > 0.05), leaf lead (Pr = 0.24 > 0.05) and seed lead (Pr = 0.24 > 0.05). The root lead was the same in all sites, but the mode of translocation of lead to aerial parts of the plant differed from one site to another. This was due to greater localization of Pb in walls of the root than in other parts of plant (Tung and Tample, 1996).

3.3 Translocation Factor and Dry Weights of Plants

The translocation factor and dry weights of plants are shown on **Figure 7**



Proximity of planting sites to Tarauni road had little or no effect on translocation factor and dry weights of plants. There was no significant difference (Pr = 0.97 > 0.05) in dry weights of plants and translocation factor, though the mode of translocation of lead to aerial parts of the plant differed from one site to another (Tung and Tample, 1996). High concentrations of lead in road side plants are primarily due to surface contamination rather than uptake of lead from the soil. The bulk of the contamination is found on exposed portions of the plants, little or none in the roots (CBEAP, 1972).

4. Conclusion

There was a significant decrease in total lead (Pr = 0.0043 < 0.05) with increasing distance of planting site from Tarauni road, which was attributed to high concentration of particulate lead from vehicle exhausts. Proximity of planting sites to Tarauni road had little or no effect on water soluble, exchangeable lead, pH, dry weights of plants and translocation factor.

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Authors' Contributions

Dagari M.S.: Conceptualization, design, undertaking the research work, write-up and data analysis

Jimoh W.L.O.: Supervision of the research work; Editing of the write-up

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