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Analytical Assessment of Trace Elements in Soils, Tomato Leaves and Fruits in the Vicinity of Paint Industry, Nigeria

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Abstract

Soil, tomato leaves and fruits samples collected for the period covering May to October, 2011 in the vicinity of paint factory were analytically digested and analysed for trace elements such as lead, cooper, cadmium, nickel, zinc, chromium, manganese, arsenic, iron, selenium and cobalt respectively. Using atomic absorption spectrophotometer of model SP 1900 pye unicam. The results obtained revealed that all the aforementioned trace elements analysed were detected and metal concentrations were varied except cadmium, arsenic and selenium with constant value for all the months (0.01mg/kg). The mean concentrations of lead, copper, nickel, zinc, manganese and iron exceeded those of tomato leaves and fruits. The mean metal concentrations in the samples labeled SS_1, TLS_1 and TFS_1 located at the paint factory spot were higher than those samples located 200 metres and before and after the factory spot. This study is an indicator to monitor lead in consumable vegetables around industrial locations in Nigeria.

Keywords: Trace elements, soils and vegetables, paint factory, tomato leaves and fruits, bioaccumulation.

Introduction

Tomato is a common vegetable grown in the tropics and has attained worldwide importance because its versatility in use in very many preparations. Tomato can also be grown in both urban and rural areas irrespective of the weather condition in all parts of Nigeria. The characteristics of industrial waste waters can differ considerably both within and among industries. The impact of industrial discharges depends not only on their collective characteristics such as biochemical oxygen demand and the amount of suspended oxygen demand and the amount of suspended solids, but also on their content of specific inorganic and organic substances[1]. The metal uptake by plants is determined by the kinetics of metals mobilized in the soil solution in rhizosphere. In this manner, bioavailability of metals in soils may be defined on terms of a capacity factor, which describes how much is available and a rate factor, which relates the amount of metal to be absorbed by plants.[2] Long-term deposition of metals in soils can lead to accumulation, transport and biotoxicity/ zootoxicity caused by mobility and bioavailability of significant fraction of the metals [3].In soils highly contaminated with heavy metals, the risk arises primarily from the mobility (ie transport to water resources) and bioavailability (ie uptake by biota) of the chemicals[3].

The chemical and biological reactions occurring in the rhizosphere play an important role in the bioavailability of metals to plants. Metal uptake by plants depends on both edaphic and plant factors[4].

The concentrations of metal in vegetables harvested in the livestock soils revealed that trace metal uptake is plant-species dependent[5]. Plant uptake is one of the major path ways by which metal soils enter the food chain. The food-chain plants might absorb enough amounts of heavy metals to become a potential health hazard to consumers[6]. The automobile spare part market represents a potential source of lead, cadmium, iron and selenium to environment. Such metal sources could contaminate soils, vegetables, surface water, ground water, human and animal food chain[7]. The discharge of effluents arising from industries has caused severe pollution of both the surface water and groundwater and also contaminated soils and crops in agricultural land[8]. The adverse effects of oil pollution on economic plants have been reported[9,10]. Many studies have indicated that the accumulation of heavy metals in soil has had an adverse effect on the growth and development of wide variety of plants species. Although low concentration of some heavy metals such as copper and zinc are necessary for the proper functioning of most plant system, higher concentrations of copper and zinc have been found to be responsible for metabolic disturbances and growth inhibition of some plants[11]. Detrimental effects of heavy metals on plant have been found to prevent the uptake of valuable nutrients such as potassium and phosphorus[12].

The examined metals analysed in soil profiles of municipal waste dumps in Nigeria showed no significant correlation with soil physicochemical properties at the surface horizon which is suggestive evidence that these metals obtained arise from anthropogenic input[13]. Soil, whether in urban or agricultural areas represents a major sink for metals released into the environment from a variety of anthropogenic sources. Once in soil some of these metals will be persistent because of their fairly immobile nature[14].

A look at the metal levels in vegetations consumed by both man and livestock has shown that it is unsafe to consume vegetables around the Shell Petroleum Development Company **(**S P D C**)** operating areas. Trace elements are known to have carcinogenic effects on man and animals when accumulated in the body. [15] The bioavailability of a metal in soil customarily is defined by the amount of metal absorbed by growing plants or by concentration in the harvested plant tissue[16]. The uptake rate of chromium, iron, manganese, copper and lead in *Asystasia gangetica and Platostoma africanium* obtained around Delta glass factory in Ughelli was high. The high concentrations of the aforementioned trace elements could constitute environmental hazards[17]. These hazardous metals might either have been spilled or buried directly in the soil or might have migrated to the soil and water from a spill that has occurred elsewhere[18].

Tomatoes have been recognized as a good blood purifier. They are beneficial in cases of congestion of the liver and help protect the organ from cirrhosis, dissolving gallstones as well. Tomato is also a natural antiseptic and helps protect the body against various common infections. Potassium in tomato is important for the kidney and in the reduction of high blood pressure.

The potential needs of tomato to keep a person healthy for life cannot be overemphasized; hence consumption of tomato fruit is on the increase. As a result of the aforementioned benefits on the consumption of tomatoes, it became necessary for this study. The objectives of this study therefore are to determine the concentrations of some selected metals in soils, tomato leaves and fruit, to determine the effects of metal contamination on soil and tomato and to identify the source of pollution if any.

Material and Methods

Study Area: Agbor, is the Headquarter of Ika-South Local Government Area of Delta State of Nigeria. It is an urban town in which the Camelite Paint factory is located. The town lies on the latitude 6^0 16´N and Longitude 6^0 21´E Agbor is accessible by roads linking to the North, West, East and Niger Delta of Nigeria. It is bounded in the North and West by Edo State; and East by Anambra State and in the South by Rivers and Bayelsa States. It is a commercial centre to the surrounding villages whose chief occupations are farming and artisan. It is located in the rainforest part of Nigeria; hence subsistence agriculture is well practiced. The topography of the town brought about the existence of steep valley created by orogodo River.

Sampling of soil, Tomato leaves and Fruits: Top soils, tomato leaves and fruits were collected for the period covering May-October 2011. A total of nine sample locations were created in the vicinity of the paint factory. Sample labeled SS_{01}, TLS_{01} and TFS_{01} were collected by the factory; SS_{02}, TLS_{02} and TFS_{02} were collected before the factory and SS_{03}, TLS_{03} and TFS_{03} were lastly collected after the factory. The distance between each location was approximately 200 metres. At lease five random samples were constructed to obtain a composite sample by using a plastic soil auger. The labeled samples collected in polyethylene container were taken to the Laboratory. The soils and tomato leaves were air-dried. The dried soils were sieved to pass a 2mm sieve. The tomato fruits were cut into pieces with stainless knife and dried in the oven at 120^0C. These samples were stored in the refrigerator prior to analytical digestion.

Analytical Procedure: Dried tomato leaves and fruits samples were ground and homogenized in a blender prior to weighing aliquots. Digestion of soil, tomato leaves and fruits were weighed (1.0g for each case) 1.0g of each sample already weighed was put into acid washed platinum crucible. 20ml of concentrated HNO_3 was added left for 20 minutes. Thereafter, 2ml each of $HClO_4$ and Hcl was added and left for 10 minutes. The solution was placed on a hot plate for the temperature ranged 135-180^0C and evaporated almost to dryness. 10ml of deionised water was added and boiled gently to dissolve the residue[8,19]. The solution was cooled and filtered through No.42 whatman filter paper. The solution was made up to 100ml in a volumetric flask with deionised water. A blank was also prepared to be analysed along with the samples. All glassware was acid-washed using 10% nitric acid before use. Quality control was assured by the use of blanks and spikes. The spike recovery method was carried out by spiking some already analyzed samples with a known standard of the metals and reanalysing. The recovery for all metals was within 90±10%. All reagents were of analytical grades and all samples were run in triplicate using atomic absorption spectrophotometry of model SP 1900 Pye Unicam.

Results and Discussion

As a result of the significance of soil to the growth of tomato in Nigeria and worldwide, soil, tomato leaves and fruits were analyzed for trace elements using atomic absorption spectrometry. The results obtained revealed that all the selected toxic trace elements analyzed in the aforementioned samples obtained in the vicinity of paint factory were detected and they were variations in the values of metals, except some metals such as cadmium, arsenic, selenium and cobalt whose values for the period of this study were constant, particularly in the soil samples.

A look at the result in table 1 indicated the constant value of 0.01 mg/kg dry weight for cadmium, arsenic and selenium in soils, tomato leaves and fruits. These low levels of cadmium, arsenic, selenium and cobalt may not only be attributed to the operations of the paint factory and anthropogenic substances. This may have been as a result of the natural and geochemical sources from the soil.

Table 1: The results of metal concentrations in soils, Tomato Leaves and Fruits in Mg/Kg dry weight

Sample Code		Pb Mg/Kg	Cu Mg/Kg	Cd Mg/Kg	Ni Mg/Kg	Zn Mg/Kg	Cr Mg/Kg	Mn Mg/Kg	As Mg/Kg	Fe Mg/Kg	Se Mg/Kg	Co Mg/Kg
SS_1	Mean±SD	10.14±2.04	2.28±0.50	0.01±0.00	3.96±0.82	7.88±1.58	0.15±0.01	14.53±2.05	0.01±0.00	66.00±10.50	0.01±0.00	0.01±0.00
	Range	8.05-14.08	2.00-3.35	—	3.02-4.90	6.02-9.74	0.10-0.20	13.15-16.03	—	60.80-72.20	—	—
	% C.V	4.05	22.02	—	20.02	20.05	6.67	14.11	—	15.91	—	—
SS_2	Mean±SD	7.01±0.80	2.01±0.05	0.01±0.00	2.03±0.16	5.53±1.05	0.16±0.05	12.15±1.25	0.00±0.00	70.12±11.20	0.01±0.00	0.01±0.00
	Range	5.20-9.30	1.80-2.24	—	1.66-2.37	3.98-7.08	0.05-0.27	10.50-13.80	—	58.00-82.20	—	—
	% C.V	11.41	2.49	—	7.88	18.99	31.25	10.29	—	15.97	—	—
SS_3	Mean±SD	9.12±0.60	2.24±0.10	0.01±0.00	3.01±0.04	4.35±0.50	0.01±0.00	11.52±0.95	0.01±0.00	61.22±9.10	0.01±0.00	0.01±0.00
	Range	8.02-10.22	1.90-2.34	—	2.80-3.22	3.75-4.95	—	10.00-13.05	—	50.10-72.12	—	—
	% C.V	6.58	4.46	—	1.33	1.33	—	8.25	—	14.86	—	—
TLS_1	Mean±SD	4.01±0.05	4.01±0.05	0.01±0.00	1.83±0.06	4.89±1.05	0.16±0.03	4.51±0.52	0.01±0.00	7.13±0.45	0.01±0.00	0.15±0.08
	Range	3.50-4.52	3.50-4.52	—	1.60-2.06	3.02-6.76	0.10-0.22	3.50-5.52	—	6.00-8.28	—	0.10-0.20
	% C.V	1.25	1.25	—	3.29	21.47	18.75	11.53	—	6.31	—	53.33
TLS_2	Mean±SD	3.84±0.05	1.56±0.05	0.01±0.00	2.07±0.04	4.00±0.05	0.41±0.03	4.48±0.92	0.01±0.00	8.15±0.65	0.01±0.00	0.04±0.01
	Range	3.40-4.28	1.05-2.07	—	1.86-2.28	3.00-5.00	0.30-0.52	3.28-5.20	—	7.01-9.30	—	0.03=0.05
	% C.V	1.30	3.21	—	1.93	1.25	7.32	20.54	—	7.98	—	25.00
TLS_3	Mean±SD	4.03±0.07	1.75±0.08	0.01±0.00	2.01±0.05	4.52±0.10	0.01±0.00	4.42±0.25	0.01±0.00	8.11±0.95	0.01±0.00	0.01±0.00
	Range	3.80-4.25	1.50-2.00	—	1.85-2.17	4.00-5.05	—	3.98-4.86	—	7.02-9.20	—	—
	% C.V	1.74	4.57	—	2.49	2.21	—	5.66	—	11.71	—	—
TFS_1	Mean±SD	2.96±0.25	0.41±0.10	0.01±0.00	1.35±0.06	3.33±0.12	0.01±0.00	3.83±0.19	0.01±0.00	6.38±0.50	0.01±0.00	0.01±0.00
	Range	2.45-3.47	0.30-0.53	—	1.10-1.60	3.00-3.66	—	3.40-4.36	—	5.20-7.56	—	—
	% C.V	8.46	5.95	—	4.44	3.60	—	4.96	—	7.84	—	—
TFS_2	Mean±SD	3.01±0.08	1.35±0.04	0.01±0.00	1.88±0.08	2.98±0.09	0.15±0.02	3.01±0.10	0.01±0.00	5.09±0.60	0.01±0.00	0.05±0.01
	Range	2.80-3.22	1.10-1.60	—	1.46-2.31	2.45-3.51	0,10-0.20	2.56-3.46	—	3.98-6.20	—	0.03-0.07
	% C.V	2.66	2.96	—	4.26	3.02	13.33	3.32	—	1.39	—	20.00
TFS_3	Mean±SD	3.92±0.15	1.44±0.05	0.01±0.00	1.82±0.09	3.73±0.12	0.01±0.00	3.05±0.08	0.01±0.00	6.00±0.14	0.10±0.00	0.01±0.00
	Range	3.00-4.15	1.20-1.68	—	1.60-2.04	3.01-4.36	—	2.85-3.25	—	4.60-7.40	—	—
	% C.V	3.83	3.47	—	4.96	3.22	—	2.62	—	2.33	—	—

SS_1–SS_3=Soil Samples ,TLS_1–TLS_3=Tomato Leaves Samples, TFS_1- TFS_3= Tomato Fruits Sample, % C.V=Percentage of co-efficient of variance and SD=Standard deviation.

The mean concentrations of trace elements such as lead, manganese, iron, nickel and zinc respectively in soil were higher than those of tomato leave and fruits. This is due to the fact that soils are the reservoir for all the pollution loads. Hence the plants could absorb these metals through their heir roots. The high concentration of lead, manganese and iron in this study could also be traced to oil exploration activities and soil nature in the Niger Delta region of Nigeria.[20] The soil nature in the Niger Delta area contains high pyrite. Most soil analysed in the Niger Delta is prone to have high level of iron[20].

The tomato leaves and stem host the consumable tomato fruits. When plant is healthy, it will also bring about a healthy fruit. A further look at table 1 clearly indicate that the trace element mean concentrations of zinc, nickel, copper lead, chromium, manganese and iron in the tomato leaves exceeded those of the fruits. This is an indication that the bioaccumulations of the aforementioned metals are higher in the stem and leaves, since healthy leaves will lead to healthy fruits. These high levels of trace metals in this study are also an indication that the soil in which the tomato leaves and fruits were obtained is contaminated. Also the consumption of the tomato fruits could lead to ill health on the long-term basis.

Samples SS_1, TLS_1 and TFS_1 were obtained by the paint factory spot. The mean concentrations of the lead, copper, nickel zinc and manganese in these samples exceeded those values obtained in other two sample locations. This is an indication that the paint factory could be one of the major pollutants in soils and plants. However, other factors such as waste dumps, oil exploration, leachate, air pollution, geochemical nature of the soils and other possible phenomena.

The soil and vegetable metal values in this study were lower than those value obtained from soil and vegetation at shallee mine[21]. On the other hand, the trace metal values in this study exceeded those values obtained in soils and vegetables in the vicinity of livestock in Nigeria [5] and in Delta region of Nigeria, lead, copper and chromium levels analysed in consumable vegetables were lower than the values obtained in this study[22]. On the other hand, iron, zinc and cadmium levels in some vegetables exceeded those obtained in this study[22].

Trace metals play an essential biological role in plant and human metabolism. Copper and zinc are considered as good source of protein, zinc and copper are activators and coenzymes[5]. However, other metals such as lead, cadmium, nickel, zinc, chromium, manganese, arsenic, iron, selenium and cobalt could be toxic when found above the required limits in vegetables. The toxic doses of some selected trace metals in vegetables are in the following range: 10-200mg/kg dry for iron; 0.5-10mg/kg dry for chromium; 3-20mg/kg for lead and 60-400mg/kg for zinc respectively.[23] The toxic level for man are: 200mg/day for chromium, 200mg/day for iron; 1.00 mg/day for lead and 150-600 mg/day for zinc[23]. The lead levels in this tomato leaves and fruits in this study could results to the symptoms of acute lead poisoning to the tomato fruits and leaves consumption. The lead poisoning symptoms are headache, irritability, abdominal pain and various symptoms related to the nervous system[24].

Conclusion

Trace elements were analysed in soil, tomato leaves and fruits in the vicinity of paint factory. The selected metals such as lead, copper, cadmium, nickel, zinc, chromium, manganese, arsenic, iron, selenium and cobalt respectively, so analysed were all detected. Higher values of these metals were higher than those obtained before the factory and after the factory showing that the factory is one of the contributors to the high levels of metal contaminants. The bioaccumulation of lead and iron could cause illness on long-term basis because majority of the Nigerians consume tomato as a result of its importance. This study is an indicator to monitor lead toxicity around industrial locations in Nigeria. Metals such as copper, cadmium, chromium, arsenic, selenium and cobalt levels are not attributed to the paint factory's activities, other factors such as anthropogenic wastes, soil leachate mechanic workshops and geochemical activities may be responsible for their presence.

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