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Synthesis and Characteristics of Polystyrene Nanoparticles and Polystyrene Monolayers

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Abstract some selected tubers; yam, cocoyam, sweet potatoes and irish potatoes and their surface, sub-surface soils were analyzed for some heavy metal levels. levels of Mn, Pb, Cr, Cd and Cu were investigated using AAS in tubers and their soil samples. The samples were digested with a mixture of nitric acid, sulphuric acid and perchloric acid (5:5:1 v/v). Only Mn, Cr, and Cu were detected, while Cd and Pb were undetected. Mn in the entire tuber (0.00-10.20mg/kg) and their corresponding soils samples (25.60-651.00mg/kg) were found to be within the permissible limit. The range of concentrations of Cr and Cu obtained in tubers were (0.50-3.50mg/kg) and (0.50-5.70mg/kg) respectively, some of these concentration were within the WHO permissible limits. The range of concentrations of Cr and Cu obtained in soil sample were (2.30-25.20mg/kg) and (0.50-13.20mg/kg) respectively, most of the concentrations were within the permissible limits. Consumption of tuber over time with concentration of metals higher than the permissible limit may cause possible health hazards to humans.

Keywords Heavy Metal, AAS, Digestion, Yam, Cocoyam, Sweet Potatoes, Irish Potatoes.

Introduction

"Heavy metals" are chemical elements with a specific gravity that is at least 5 times the specific gravity of water [7]. The specific gravity of water is 1 at 4^oC (39^oF). Simply stated, specific gravity is a measure of density of a given amount of a solid substance when it is compared to an equal amount of water, some well-known toxic metallic elements with a specific gravity that is 5 or more times that of water are arsenic, 5.7; cadmium 8.65; iron, 7.9; lead, 11.34; and mercury. 13. 546 [7].

A heavy metal is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides trace elements, a trace element is an element in a sample that has an average concentration of less than 100 parts per million atoms, or less than 100 micrograms per gram.

In small quantities, certain heavy metals are nutritionally essential for a healthy life some of these are referred to as the trace elements (e.g iron, copper, manganese, and zinc). These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products [6]. Diagnostic medical applications include direct injection of gallium during radiological procedures, dosing with chromium in parental nutrition mixtures, and the use of lead as a radiation shield around x-ray equipment [8]. Heavy metals are also common in industrial applications such as in the manufacture of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel, and so forth. [6]. Many of these products are in our homes and actually add to our quality of life when properly used.

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissue. Heavy metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure accounts for a common route of exposure for adults. Ingestion is the most common route of exposure in children [8].

Heavy metal concentrations in soil are associated with biological and geochemical cycles and influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods [10].

Heavy metals are among the contaminants in the environment. Beside the natural activities, almost all human activities have potential contribution to produce heavy metals as side effects. Migration of these contaminants into non contaminated areas as dust or leachates through the soil and spreading of heavy metals containing sewage sludge are a few examples of events contributing towards contamination of the ecosystem. Rural and urban soils in both industrial parks and near small factories outside the parks are affected by a wide variety of contaminants. The most serious of soil contamination are [3];

- Heavy metals in hazardous waste, including materials from chemical production, dyeing, electroplating and heat treatment, the production of batteries, metal treatment, mining and extractive industries, scrap yards, service stations and tanning;
- Hazardous organic waste materials, including those from medical centers, oil production, and storage, and paint and pesticide production and
- Corrosive metal waste materials, including those from acid/alkali plants and chemical engineering works.

Lead (Pb), with atomic number 82, atomic weight 207.19 and a specific gravity of 11.34 is a bluish or silvery-grey metal with a melting point of 327. 5^{o}c and a boiling point at atmospheric pressure of 1740^{o} c. It has four naturally occurring isotopes with atomic weights 208, 206, 207 and 204, in decreasing order of abundance. Despite the fact that lead has four elections on its valence shell, its typical oxidation state is + 2 rather than + 4, since only two of the four electrons ionize easily. Exposure to lead in humans may result in a wide range of biological effect depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing fetus and infants being more sensitive than adults. It has also been observed that high exposure levels may result in toxic biochemical effects in the syntheses of haemoglobin, effects

Cadmium (Cd) with atomic number 48, atomic weight 112.41 and a specific gravity of 8.65, is a silvery- white metal with a melting point of 321.07^{o}c and a boiling point of 767^{o}c. it demonstrates oxidation state + 2. Cadmium makes up about 5 x 10^{5}% of the earth curst and thus it's a rare metal. Cadmium and numerous of its compounds are toxic. The metal first came into dispute in Japan with the occurrence of "itai-itai" disease which causes several skeletal changes and often leads to death. Accumulation of cadmium in the liver and kidney is critical and it is also a potential carcinogenic metal [9].

Copper (Cu) is an essential trace nutrient to all plant and animal lives. In animals, including humans, it is found primarily in the blood stream as a co-factor in various enzymes and in copper based pigment. However, in large amounts, copper could be poisonous and even fatal to organisms. Copper has a significant present in decorative art. It has been used as an antigen surface that can add to the anti-bacteria and anti-microbial features of a building such as hospitals. Copper is also an essential substance to human life, When ingested in high doses could cause anemia, liver and kidney damage as well as stomach and intestinal irritation. Copper is normally obtained from drinking water [4]. Physical symptoms of copper include insufficient oxygen in the cells, lowered levels of cholesterol, skin problems, swollen ankles, and anemia. Low copper is also linked to low enkephalins produced in the brain Psychological symptoms include auditory hallucinations, depression. The body contains 50-120 mg copper which enters the body from the stomach and upper intestine. It is excreted from the body through the liver and bile.

Chromium (Cr) was first identified as an essential mineral for mammals in 1959. The amount of chromium varies widely with people in the United State of America and component in the maintenance of pH of body fluid and a key constituent of essential molecules [9]. Chromium is a lustrious, bristle, hard; its colour is silver gray and highly polished. It does not tarnish in air, when heated, but burns and forms the green chromic oxide. Chromium is unstable in oxygen, but immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below.

People could be exposed to chromium through breathing, eating or drinking and through skin contact with chromium or chromium compounds. The level of chromium in air, water and in drinking water is generally low, while contaminated well water may contain the more dangerous chromium (VI) which is hexavalent chromium. For most people eating food that contains chromium (III) is the main route of chromium uptake because chromium (III) occurs naturally in many vegetables, fruits, meat, yeast and grains. Various ways of foods preparation and storage may also alter the chromium contents of food. Food stored in steel tanks or cans usually have average chromium concentration.

Manganese is a trace metal and is present in tiny amount in the body. It is found mostly in bones, the liver, kidneys and pancreas. Manganese helps the body to form connective tissue, bones, blood clotting factor and set hormones. It also plays a role in fat and carbohydrate metabolism, calcium absorption and blood sugar regulation. Manganese is a superoxide dismutase (SOD) which helps fight free radicals. Low levels of manganese in the body can contribute to infertility, bone malformation weakness and seizures. However too much manganese in the diet could lead to high levels of manganese in the body tissue. Abnormal concentration at Mn in the brain are associated with neurological disorders.

Materials and Methods

Materials

All chemicals and materials used were of analytical grade.

Methodology

Sampling of tubers

Two of the tuber species namely Sweet potato (*Ipomecea batatas*) and cocoyam (Xanthosama *sagittifolium*) were collected from a farmland in Gumau, Toro LGA of Bauchi State. The tuber species yam (*Dioscorarea ratundata*) was collected from a farmland in Gindiri, Mangu LGA and the Irish potato (*Solanum tuberosum)* was collected from a farmland in Bokos LGA both in Plateau State. The four different types of tubers were randomly collected at three (3) different locations in the farmland.

Sampling of Soil samples

The soil samples of the sampled tubers were collected in duplicate by digging at surface level (0- 10 cm depth) and subsurface level (10-20 cm depth). The representative samples from each depth was spread on clean paper sheet for air drying and crushed in cleared ceramic mortar. These samples were passed through a 2 mm mesh size sieve and stored at ambient temperature before analysis.

Treatments

The tubers and vegetables were separately washed with water to get rid of adhered soil and impurities on them. The tubers were pealed. The samples of the same species were separately cut into pieces, air –dried; ground using porcelain pestle and mortar sieved through a 2.00 mm mesh, labeled appropriately and kept.

Sample Pre-Treatment and Determination

Digestion of Samples

Each Soil and tuber sample1.00 g was digested after adding 15 ml of tri-acid mixture (HNO_3 H_2SO_4, $HC10_4$ in ratio 5:1:1) in a 250 ml conical flask at 80^{o}C in a fume cupboard until a transparent solution was obtained [1]. After cooling, the digested sample was filtered using Whatman filter paper and the filtrate was finally diluted to 50 ml with water in a volumetric flask, Digested samples were analyzed for trace metal concentration using Atomic Absorption Spectrophotometer.

Determination of Trace Metals in Samples

The concentrations of the trace metals in the sample were determined by Atomic Absorption Spectrophotometer (210VGB-ASS buck scientific). The trace metal determined include: Lead (Pb), Cadmium (Cd), Chromium (Cr), Manganese (Mn) and Copper (Cu).

Results and Discussion

The Concentration of Metals in Tubers and Soil Samples

The mean concentrations of metals in tubers and the soil samples from which the tubers were obtained are shown below:

Figure 1 shows the concentration of the heavy metals manganese, chromium and copper (Mn, Cr and Cu) in yam tuber and it's soil samples. The means of triplicate determination of these metals are 0.00 mg/kg 403 mg /kg, and 651 mg/kg for Mn in yam tuber, surface soil and sub-surface soil respectively. The mean concentration of 2.00 mg/kg, 8.50 mg/kg, 8.50 mg/kg and 9.00 mg/kg were obtained for the Cr in yam tuber, surface soil and subsurface soil respectively. The means of 0.50 mg/kg, 3.7 mg/kg and 4.30 mg/kg were obtained for metal Cu in yam tuber, surface soil and sub- surface soil respectively.

The concentration of the metals in soil samples (surface and subsurface) from the yam farmland were of the order Mn > Cr > Cu. Mn was found to be within the range of average concentration of trace metals in soil. However, the concentrations of Cr and Cu were below the average concentration. It was observed that all the three (3) metals detected (Mn, Cr and Cu) were within the standard permissible limits in the yam tubers and were in the order Cr > Cu > Mn. It was observed that all the three (3) metals follow the same order of concentration with the tuber (yam) having the least concentration of the metals and the sub-surface soil having the highest concentration of all the metals. Values obtained from Cr (2.00 mg/kg) and Cu (0.50 mg/kg) in the yam tuber were close to those obtained for Cr (1.26 mg/kg) and Cu (0.23 mg/kg) in yam tubers grown in Rivers State of Nigeria from a study carried out by [2].

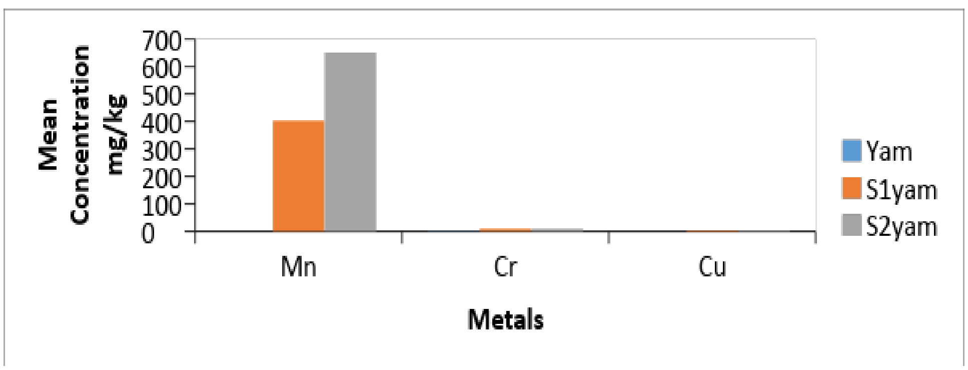

Figure 1: Mean concentration of triplicate determinations of heavy metals in yam tuber, surface soil and subsurface soils

S_1: surface soil; S_2: Sub-surface soil

Figure 2 shows the concentration of the heavy metals (Mn, Cr and Cu) in cocoyam and its soil samples (sub-surface and surface). The mean of triplicate determination of these metals were 10.00 mg/kg, 157.00 mg/kg, 235.00 mg/kg for Mn in cocoyam tuber, surface and subsurface soils respectively. The means of 3.50 mg/kg, 25.20 mg/kg and 3.20 mg/kg were obtained for Cr in cocoyam, surface, and subsurface soil respectively. The mean concentrations of Cu were 5.70 mg/kg, 11.20 mg/kg, 13.20 mg/kg in cocoyam surface soil and subsurface soil respectively. The concentrations of Mn and Cu in the soil samples (surface and subsurface) from the cocoyam farmland were within the range of average concentrations of trace metals in the soil, while the concentration of Cr in both soil samples was below the average concentrations of trace metals in the soil. The concentration of Mn in cocoyam tuber was within the standard permissible limit. However, the concentrations of Cr and Cu in the cocoyam tubers were higher than standard permissible limits. The concentrations of Mn and Cu in the cocoyam tuber and its soil samples showed a similar order of concentration to that of the yam tuber and its soil samples, with the highest concentration of the metal in the subsurface soil and the least in the tuber. The highest concentration of Cr was observed in the surface while the subsurface soil had the least.

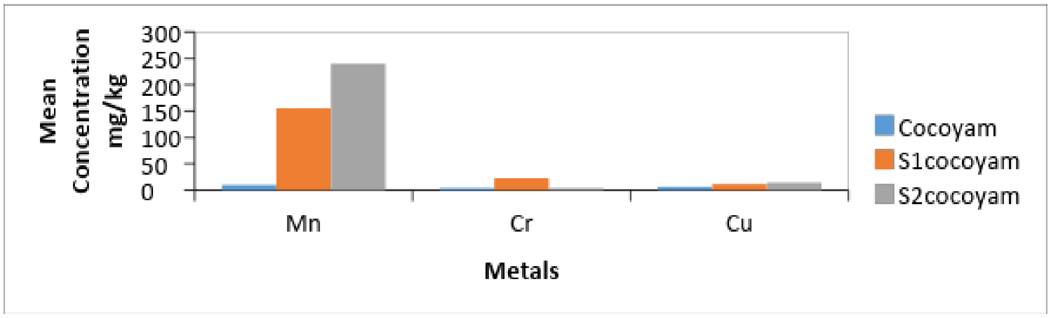

Figure 2: Mean concentration of triplicate determinations of heavy metals in Cocoyam tuber, surface soil and subsurface soils

S_1: surface soil; S_2: Sub-surface soil

Figure 3 shows the mean concentrations of triplicate determinations of the trace metals (Mn, Cr and Cu) in irish potatoes and its soil samples (surface and subsurface) were 10.20 mg/kg, 120.20 mg/kg, 90.20 mg/kg for Mn in irish potatoes tuber, surface and subsurface soils respectively. The means of 0.50 mg/kg, 8.20 mg/kg and 6.30 mg/kg were obtained for Cr in irish potatoes tuber, surface, subsurface soils respectively. The mean concentrations of Cu were 4.20 mg/kg, 8.80 mg/kg, and 5.30 mg/kg. in irish tuber, surface soil and subsurface soil respectively.

The concentrations of Mn and Cu in the soil samples (surface and subsurface) from the irish potatoes farmland were within the permissible limit while the concentration of Cr is lower than the average concentration of trace metals in the soil.

The concentrations of Mn and Cr in the tuber were within the permissible limit. However, the concentration of Cu is slightly higher than the permissible limit.

The concentrations of Mn, Cr and Cu in irish potatoes and its two soil samples (surface and subsurface) were at the order: surface soil > subsurface soil > irish potatoes tuber.

The results obtained from Mn (10.20 mg/kg) and Cu (4.20 mg/kg) in irish potatoes were higher than that obtained by [5], (3.95 mg/kg and 3.23 mg/kg) for Mn and Cu respectively. The result obtained for Cr (0.50 mg/kg) was lower than that obtained by [5], (2.00 mg/kg). This may be due to environmental variation.

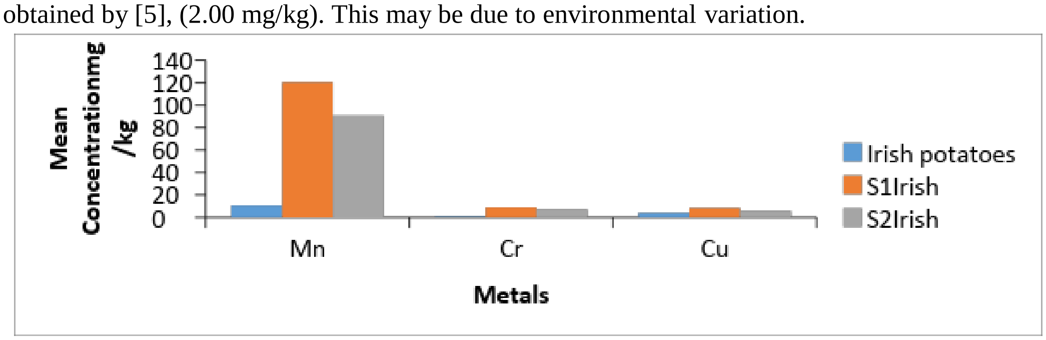

Figure 3: Mean concentration of triplicate determinations of heavy metals in Irish potatoes tuber, surface soil and subsurface soils

S_1: Surface soil; S_2: Sub-surface soil

Figure 4 shows the mean concentrations of triplicate determinations of the trace metals (Mn, Cr and Cu) in Sweet potatoes and its soil samples (surface and subsurface) were 5.00 mg/kg, 125.20 mg/kg, 25.60 mg/kg for Mn in sweet potatoes tuber, surface and subsurface soils respectively. The means of 1.50 mg/kg, 15.20 mg/kg and 10.30 mg/kg were obtained for Cr in sweet potatoes tuber, surface, subsurface soils respectively. The mean concentrations of Cu were 3.50 mg/kg, 4.00 mg/kg, and 0.50 mg/kg. in sweet potatoes tuber, surface soil and subsurface soil respectively.

The concentration of Mn and Cr in the tuber samples were within the permissible limit and Cu was slightly higher. The concentration of Mn in the soil sample was within limit while the concentrations of Cr and Cu were below the permissible range. The concentrations of the metals in sweet potatoes surface soil and subsurface soil were in the order: surface soil > subsurface soil > sweet potatoes tuber in both Mn and Cr. The order for Cu was surface soil > sweet potatoes tuber > subsurface.

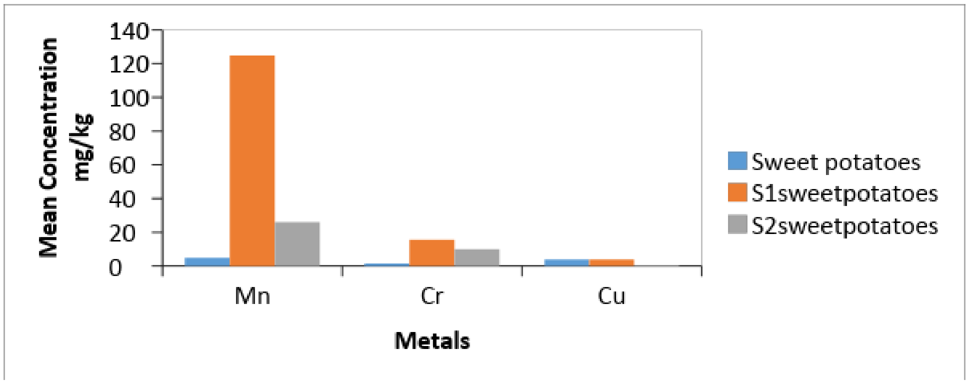

Figure 4: Mean concentration of triplicate determinations of heavy metals in sweet potatoes tuber, surface soil and subsurface soils

S_1: surface soil; S_2: Sub-surface soil

Conclusion

The concentrations of Mn in tubers and their soil samples were found to be within the permissible range. Some of the concentrations of metals Cr and Cu exceeded the permissible range in both tubers and soil samples.

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