Variation of Pollutant Levels in Vegetables: A Case Study of Kitale Municipality, Trans-Nzoia County, Kenya

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Abstract

There is growing public concern over the illegal cultivation of vegetables on soils amended with sewage sludge or irrigated with mixtures of sewage and sewage sludge. Effluents and wastewater from Bidii in Kitale treatment plant are used by vegetable farmers for the irrigation of their vegetables during dry season. These effluents may contain some toxic pollutants which bioaccumulate along the food chain. Moreover the uptake of such toxic metals by vegetables is governed by their availability and concentration in the soil. Therefore such vegetables may accumulate pollutants in excessive amount in their various parts. This may ultimately, adversely affect humans and other species that depend on such crops for food, hence the need to evaluate the variation of pollutant levels in vegetables samples in these areas. Samples of spinach and kales and top soils (0-20) cm were collected from the vegetable farms of Bidii and Taito area as control point. Random sample collections were made five (5) times during the period from the two plots between October to December 2012. The vegetables samples were dried in an oven at 80°C for 72 h. The dry samples were crushed in a mortar and pestle and the resulting powder digested by weighing 1.0 g of oven-dried ground and sieved (<1 mm) into an acid-washed porcelain crucible and placed in furnace for 4 hours at 500°C. The crucibles were removed and cooled. The weighed vegetable samples were transferred to 300 ml digesting flasks and then 27 ml of a mixture of HNO_3 and concentrated H_2SO_4 were added to the sample. The mixture was heated on a hot plate for about half an hour until brown fumes disappeared. The mixture was cooled, and 3 ml of percloric acid were carefully added and then heating continued until white fumes disappeared. The digested sample was filtered into a 100 ml volumetric flask and made up to volume with de-ionized water. Soil samples were digested using aqua regia and 1.0 g of the soil sample was placed in a flask and 6 ml of concentrated nitric acid (HNO_3) was added first before adding 18 ml of concentrated HCl. The mixture was then heated until a clear digest was obtained. The digest was then cooled and a few drops of water were added before filtering. The filtrate was then diluted with de-ionized water to 100 ml. The concentrations of heavy metals which include, Cu, Zn, Cr, and Pb, were determined using atomic absorption spectrophotometer (AAS). Levels of some anions (nitrate and phosphate were determined using Spectroscan 30 UV-Vis spectrophotometer. The results revealed that Cr and Pb had the highest concentrations, while Cu had the lowest in the leafy vegetables studied. The order of heavy metals was found to be Zn>Pb>Cr>Cu in soils while Pb>Zn>Cr>Cu in vegetables. The concentration of NO_3^- ranged between 2.176 mg/kg to 3.202 mg/kg while PO_4^{3-} 2.897 mg/kg to 3.342 mg/kg in vegetables. Levels of NO_3^- in soils were 1.88 mg/kg to 2.06 mg/kg while PO_4^{3-} had 4.66 mg/kg to 4.99 mg/kg. The vegetables from Bidii area contained much higher concentrations than those from Taito area. The levels of Cr and Pb in vegetables exceeded WHO Maximum Limit (0.05 mg/kg for Cr and 0.3 mg/kg for Pb). The variation in the parameters determined were found to be statistically significant ($p < 0.05$) as determined by one way ANOVA.

Key words: copper, lead, chromium, zinc, nitrates, phosphates, polluted soils, vegetables.

1. INTRODUCTION

Vegetables are the major sources of the daily intake of nutrients by human beings, supplying about 72 to 94% of the total intake. Soil contamination with anthropogenic pollutants, mainly from industrial activities, agricultural practices and atmospheric deposition, has received increasing attention in recent years (Zhang *et al.,* 2006). These pollutants can be easily accumulated in the topsoil, resulting in bio-toxicity to plants and animals. As cities are densely clustered with pollution sources resulting from human activities, urban soils are prone to be polluted by heavy metals and other pollutants. Extremely high levels of contamination with heavy metals in urban soils had been found in many countries

(Madyiwa *et al*., 2002).Each plant species has its nutritive requirements differing from others. Thus different plants supported by identical solutions will contain varying concentrations of minor and macro elements. Application of industrial effluent decreases the budding and growth rate of vegetables (Ihekeronye and Ngoddy, 1985).

Leafy vegetables occupy a very important place in the human diet, but unfortunately constitute a group of foods which contributes maximally to nitrate and other anions as well as heavy metals consumption. The excessive application of nitrogen and other inorganic fertilizers accumulate high levels of nitrate and other anions as well

as heavy metals. Consequently their consumption by humans and animals can pose serious health hazards. Although some heavy metals such as Cu, Zn, Mn and Fe are essential in plant nutrition, many of them do not play any significant role in the plant physiology. The uptake of these heavy metals by plants especially leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health (Ihekeronye and Ngoddy, 1985).

Food and vegetable crops production and its attendant security is an important aspect of a nation's economic stability. It requires access to fertile land, water and in some cases all other inputs so as to boast the production particularly in poor and developing countries of the world. There has recently been an increased provision of fertilizers, herbicides, pesticides and modern farm equipments to boost both dry and rainy seasons farming of food and vegetable crops production. While efforts are being consolidated by the government towards improving and increasing food and vegetable crops production, the problem of industrial effluents into water bodies is undermining these efforts, especially in Bidii wastewater effluents are discharged into drain which is used for the irrigation of vegetable crops during the dry season farming. Mineral elements are known to be essential in our diet and may enter the food crops or vegetables from soil through mineralization by crops, food processing or environmental contamination (Onianwa et al., 2001; Miller, 1996).

Many researchers have reported trace metals like As, Cr, Cu, Fe, Pb and Zn as components in wastewater effluents (Yisa, 2004). A number of factors influence the concentration of heavy metals on and within plants. These factors include climate, atmospheric deposition, the nature of the soil on which the plant is grown and the degree of maturity of the plant at the time of harvesting, (Voutsa *et al*., 1996). The nature of the soil is one of the most important factors in determining the heavy metal content of food plants (Madyiwa et al., 2002).

However, the heavy metal content in plants can also be affected by other factors such as the application of fertilizers, sewage sludge or irrigation with wastewater (Devkota and Schmidt, 2000; Frost and Ketchum, 2000). Heavy metal contamination of agricultural soils can pose long-term environmental problems and is not without health implications (Sauvé *et al.,* 1996). When the metals are derived from anthropogenic sources, this can strongly influence their speciation and hence bioavailability as is the case when metal contaminated sewage sludge is applied to agricultural land. The Nzoia Sewerage Company (Kitale Municipal) was established in 1980 in order to provide a disposal route for sewage sludge and wastewater from industries and estates. The plant is situated 4 km from the town centre and is located in Bidii Farm near Kibomet estate. The cultivation of vegetables on the farm by residents using wastewater for irrigation raises concerns about the safety of such vegetables with respect to their heavy metal content. The residents divert wastewater and the mixture of sewage sludge and wastewater from the flood irrigation channels by creating trenches to direct the flow to their crops. The vegetables produced are consumed by the villagers, largely supplying their entire dietary requirement. This study was therefore initiated to assess the concentrations of heavy metals in soils and plants grown on these plots. Of particular interest were the leaves and stems of the spinach *(Spinacia oleracea and sukumawiki (kales),* which are grown in large quantities during the dry season and are frequently their only source of fresh vegetable during this period (October to December 2012). Food safety is a major public concern worldwide. During the last decade; the increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and/or toxins (D'Mello, 2003).Vegetables constitute essential components of the diet, by contributing protein, vitamins, iron, calcium and other nutrients which are usually in short supply. Vegetables also act as buffering agents for acidic substances obtained during the digestion process. However, these plants may contain both essential and toxic elements, such as heavy metals, at a wide range of concentrations (Bahemuka and Mubofu, 1999). Metals, such as lead, chromium, cadmium and copper are cumulative poisons. These metals cause environmental hazards and are reported to be exceptionally toxic.Contamination of vegetables with heavy metals may be due to irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, the harvesting process, storage and/or at the point of sale. Human beings are encouraged to consume more vegetables and fruits, which are a good source of vitamins, minerals, fibre and are beneficial for health. However, these plants contain both essential and toxic metals over a wide range of concentrations. It is well known that plants take up metals by absorbing them from contaminated soil as well as from deposits on parts of the plants exposed to the air from polluted environments (Khairiah *et al*., 2004).

Environmental pollution nowadays is a big concern. Anthropogenic activities have altered the environment significantly throughout the world like mining, industry and agriculture (Wang *et al.,* 2008). Environmental contaminants are widely distributed in air, water and soils and, therefore, they will have an effect on the trophic chain (vegetables, animals and men). Heavy metals are of considerable behavior. Trace quantities of certain heavy elements, such as chromium, cobalt, copper, manganese and zinc are essential micronutrients for higher animals and for plant growth (Omgbu and Kokogbo, 1993). Lead, cadmium, and nickel are significant environmental pollutants. Anthropogenic activities, such as agriculture, industry and urban life increase the Pb, Cd, and Ni contents of soils and waters and, therefore, have an effect on the metal contents of vegetables (Alegria *et al.,* 1991). Vegetables absorb heavy metals from the soil as well as from surface deposits on the parts

of vegetables exposed to polluted air. Moreover, the presence of heavy metals in fertilizers contributes an additional source of metal pollution for vegetables (Yusuf *et al.,* 2003). A major pathway of soil contamination is through atmospheric deposition of heavy metals from point sources, such as metalliferous mining, smelting and industrial activities. Other non point sources of contamination affecting predominately agricultural soils are due to various inputs, such as fertilizers, pesticides, sewage sludge, organic manure and compost (Singh, 2001). Additionally, foliar uptake of atmospheric heavy metals from emission gas has also been identified as an important pathway of heavy metal contamination in vegetable crops (Kaur, 2006). Accumulation of heavy metals by plants may depend on plant species and soil properties. These heavy metals are not abundant in soil, but their accumulation through urban wastes and industrial effluents. The uptake of heavy metals in cereals and vegetables is likely to be higher and their accumulation of these toxic metals in human body created growing concern in the recent days. For instance the daily vegetable consumption by an adult of Bangladesh is 130 g (Islam *et al.*, 2005). Different kinds of vegetables are grown during the year in tropical Bangladesh, but very little is known about the metal contents of vegetables (Alam *et al.,* 2003). Information regarding the accumulation of heavy metals in vegetables in industrially polluted areas in Bangladesh is scarce. But such information is vital for the production of quality vegetables as well as healthy food stuffs. Nitrates are generally found in surface waters and shallow ground water. Plants naturally release nitrogen when they die and decompose (rot). The nitrogen from the rotting plants oxidize (combine with oxygen) to form nitrates. During a rainfall, surface water can move through the soil and carry these nitrates down to the underground drinking water (ground water) (Alam *et al.,* 2003).Other ways water can be contaminated with nitrates is through the use of products that contain large amounts of ammonia. Ammonia is oxidized (combines with oxygen) and forms nitrites. Liquid ammonia fertilizer spills can form nitrates that also make their way through the soil to the ground water. Because humans and animals (mammals) eat vegetables and preserved meats, nitrates and nitrites can be found in human and animal waste. Old and poorly maintained sewage systems and improper well construction can contaminate ground water with nitrates as well (Alam *et al.,* 2003).

3. METHODOLOGY

3.1 Sample area and sampling

The study was done in Kitale which is located in Trans Nzoia County and is at an altitude of 1896 m above sea level with an estimated population of 780,787 people according to the 2009 population census (KBS, 2009). The study used an experimental design which involved determination of concentration of zinc, copper, lead, chromium, nitrates and phosphates in leaves of kales and spinach vegetables. The soil from which the plants were planted was also analyzed for the levels of the essential trace elements. The leaves samples were collected from two sampling areas of Bidii and Taito. From each area, five stations were chosen. The samples analyzed were picked at random from the plots in which they were planted. The plant samples were collected five times during the period of study.

3.2 Research design
The study used an experimental design which involved determination of concentration of zinc, copper, lead, chromium, nitrates and phosphates in Spinach (*Spinacia oleracea*) and kales(*Sukuma wiki*) planted at Bidii and Taito area.

3.3 Sample preparation and digestion for heavy metals determination

The soil samples were collected from the same area as that of the vegetable samples. The samples were collected in a plastic container by scooping in three layers each of a height of about 3 cm up to a depth of about 20 cm and sealed. The soil samples were also dried at temperatures below 80 °C, ground into powder, labeled and kept in plastic containers (Valkavic, 1983). Portions of 1.0 g dried vegetable samples were weighed using an electronic analytical balance Shimadzu AUW220 model. The weighed plant samples were transferred to 300 ml digesting Khjedal flasks and then 27 ml of a mixture of HNO_3 and concentrated H_2SO_4 were added to the sample. The mixture was heated on a hot plate for about half an hour until brown fumes disappeared. The mixture was cooled, after which 3 ml of percloric acid ($HClO_4$) were carefully added and then heating continued until white fumes disappeared. The digested sample was filtered into a 100 ml volumetric flask and made up to volume with de-ionized water.

Soil samples were digested using aqua regia as recommended by Golia *et al*., (2008). In this procedure, 1.0 g of the soil sample was placed in a khjedal flask and 6 ml of concentrated nitric acid (HNO_3) was added first before adding 18 ml of concentrated HCl. The mixture was then heated until a clear digest was obtained. The digest was then cooled and a few drops of water were added before filtering using a Whatman No. 42 filter paper. The filtrate was then diluted with de-ionized water to 100 ml.

3.4 Elemental analysis of samples

Determination of Cu, Zn, Cr and Pb were made directly on each final solution using SpectrAA 200 Atomic Absorption Spectroscopy.

4. Determinations of nitrate and phosphate in vegetables

4.1 Determination of nitrate

The concentration of nitrate and nitrite were analyzed in each of the vegetable samples were carried out using Spectrophotometer. Vegetable samples solutions were prepared by chopping each sample into smaller sizes. A known amount (1 g) of the chopped sample was transferred into 100 mL flask and soaked with 50 mL of distilled water. The flask was capped and shaken for 30 min, then filtered into another 100 ml volumetric flask and the volume made to the mark with distilled water (Radojevic and Bashkin, 1999).

4.2 Determination of phosphate

Each of the vegetables samples was chopped into small pieces. The chopped samples were then air-dried. The air-dried samples were ground and sieved with a siever of mesh 1mm. A known amount (1 g) of each of the ground and sieved samples was weighed into acid-washed porcelain crucibles. The crucibles were labeled and 5 mL of magnesium acetate were added and evaporated to dryness. The crucibles were then transferred into the furnace and the temperature was raised to 500 °C. The samples were ashed at this temperature for 4 hours. Removed and cooled in desiccators. 10 mL of 6 M HCl were then added to each of the crucible and covered, then heated on a steam bath for 15 min.

The contents of each crucible were completely transferred into different evaporating basins and 1 ml of concentrated HNO_3 was added. The heating was made to continue for 1 h to dehydrate silica. 1 mL of 6 M HCl was then added, swirled and then followed by the addition of 10 mL-distilled water and again heated on the steam bath to complete dissolution. The contents of the evaporating basins were cooled and then filtered through a What man No.42 filter paper into 50 mL volumetric flasks and the volumes made up to the marks with distilled water(Radojevic and Bashkin, 1999). Phosphate was determined using Spectroscan 30 uv-vis model spectrophotometer.

4.3 Digestion of soil samples and determination of nitrate and phosphate in the soil distillates

Soil samples were then dried in an oven at 105 °C for 24 hours until they were brittle and crisp. A portion (1g) of dried, disaggregated and sieved soil sample were placed in 50 ml beakers and then digested with 10 ml of aqua regia to near dryness at 80 – 90°C on a hot plate. The digests were filtered into a 50 ml volumetric flask using what man No. 42 filter paper. Nitrate and phosphate concentrations in the soil distillates were then determined by using spectrophotometer, similar to those previously described for the vegetable samples.

5. Data analysis

Mean concentrations of pollutants in soils and vegetable were analysed using Statistical Programme for Social Sciences (SPSS version 17.0), Analysis of Variances (ANOVA) and Excel computer packages.

5. RESULTS

Table 1: The concentrations of heavy metals in soil

Concentration (mg/kg) of heavy metals in Bidii and Taito area			
	Soils	Soils	Safe limits*
Cu	0.544 ± 0.18	0.396 ± 0.09	135-270
Zn	6.288 ± 1.84	1.093 ± 0.44	300-600
Pb	4.588 ± 0.54	0.988 ± 0.07	250-500
Cr	1.167 ± 0.26	0.297 ± 0.19	300

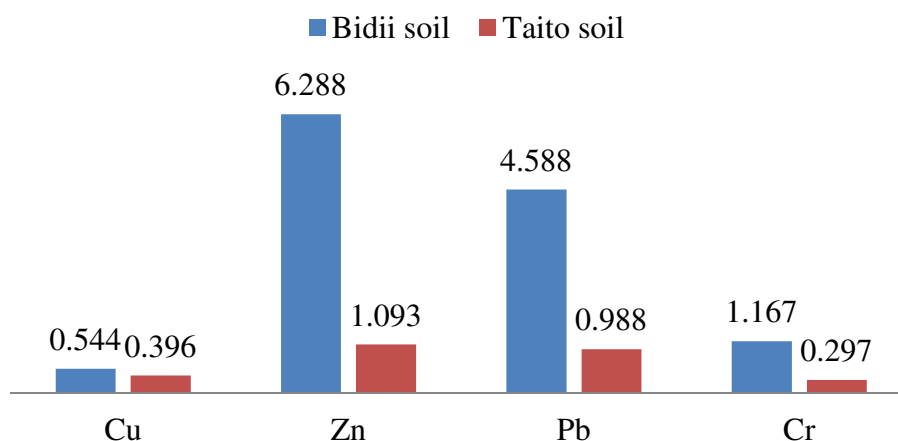**Comparison of mean concentrations (mg/ kg) of heavy metals in soil of Bidii and Taito**

Figure 1: Comparison of mean concentrations (mg/ kg) of heavy metals in soil of Bidii and Taito

From figure 1, the maximum concentration of Cu (0.544 mg/kg) and minimum was 0.396 mg/kg. Zn was found maximum in Bidii soils (6.288 mg/kg), the highest level of Pb was found to be (4.588 mg/kg) from Bidii while Cr had the maximum value of 1.167 mg/kg from Bidii. The order of heavy metals was found to be Zn > Pb > Cr > Cu in soils (See table1). The results showed a significant in the levels of zinc, lead and chromium in both kales and spinach from Bidii area. This implies that zinc is accumulated in leaves depending on the geographical location on which they were grown and also the variation in soil types (Jonson, 2005).

Maximum Pb concentration in soil was 4.588 mg/kg, Pb content was much higher compared to earlier studies by Mutune *et al.,* (2014) who studied vegetables planted in urban and peri-urban, Nairobi. However, the contents of Pb reported in this study are generally lower than those reported by Oti and Nwabue (2013) and Nabulo *et al.*, (2007) who studied heavy metals effect due to contamination of vegetables from Enyigba lead mine, Nigeria.

This would be explained by occasional waste flowing and irrigation using wastewater by the farmers. Industries found in Kitale town include maize millers, Kenya Cooperative Creameries, vehicle garages that use paints that contain lead oxide, glass that may contain Pb, and oil spills some of which still contain Pb. Sewage area where the effluent from the treatment plant of the municipality is used by farmers to irrigate the plants contained up to 4.588 mg/kg and Pb levels above 20 mg/kg are toxic to plants (Audu and Lawal, 2006).

Cu values ranged from 0.544 mg/kg to 0.396 mg/kg in soils, with Bidii registering the highest levels. Soil Cu content was, however, much higher compared to earlier studies conducted by Kimani (2007) who worked on Dandora dumpsite, Kenya, but less than values reported by Yebpella *et al.,* (2011) who worked on sites along a Nigerian river. These values were, however, within WHO permissible limits. Contents of Cu mainly derived from anthropogenic sources, with the urbanization, agricultural and industrial activities as main sources.

Zn content ranged from 6.288 mg/kg to 1.093 mg/kg with Bidii showing very high levels as compared to Taito gardens. These values were much lower compared to earlier studies conducted by Kihampa *et al.,* (2011).

Although some soils in ordinary farm sites had deficient Zn content, none had higher than those reported by Kimani (2007).The elevated trace metal levels could have originated from municipal treatment plant located in Bidii which discharged its effluents directly into the gardens bordering it. This study found that industry and municipal wastes were the major sources of heavy metal contamination. Zn industrially is used for galvanization, in dry cell batteries, cosmetics and medicines (ATSDR, 2005).

Taking too much zinc into the body through food, water, or dietary supplements can also affect health. However, levels of zinc that produce adverse health effects are much higher than the Recommended Dietary Allowances (RDAs) for zinc of 11 mg/day for men and 8 mg/day for women. If large doses of zinc (10–15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur (Fytianos *et al*., 2001).

Ingesting high levels of Zn for several months may cause anaemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol. Eating food containing very large amounts of Zn (1,000 times higher than the RDA) for several months caused many health effects in rats, mice, and ferrets, including anaemia and injury to the pancreas and kidney (Radwan and Salama, 2006). Rats that ate very large amounts of Zn became infertile while those that ate very large amounts of Zn after becoming pregnant had smaller babies. Putting low levels of certain zinc compounds, such as zinc acetate and zinc chloride, on the skin of rabbits, guinea pigs, and mice caused skin irritation. Skin irritation from exposure to these chemicals would probably occur in humans. EPA has determined that because of lack of information, zinc is not classifiable as to its human carcinogenicity Kihampa *et al.,* (2011).

Cr concentration ranged between 0.297 mg/ kg- 1.167 mg/kg, and these values were slightly higher than those reported by Mutune *et al.,* (2014). Cr levels in soil were, however, within permissible levels set by WHO (2001). The Cr levels in soils varied greatly depending on the composition of the parent rock. Basalt and serpentine soils, ultramafic rocks, and phosphorites may contain Cr as high as a few thousand mg/kg whereas soils derived from granite or sandstone will have lower concentrations of chromium.

6. HEAVY METALS IN VEGETABLES

Table 2: mean concentrations (mg kg^{-1}) of Cu, Zn, Pb and Cr in kales and Spinach

Parameter/sample	Cu	Zn	Pb	Cr
Kales(Bidii)	0.789 ±0.35	1.365±0.003	1.842±0.23	0.938±0.014
Kales(Taito)	0.403 ±0.22	0.101±0.15	0.902±0.47	0.019±0.01 [b]
Spinach (Bidii)	1.110±0.39	1.294±0.22	1.745±0.05	0.893±0.007
Spinach (taito)	0.224±0.08	0.070±0.14	0.859±0.09	0.020±0.01
WHO*	3.00	100	0.30	0.05

From Table 2 the maximum concentrations of Cu (1.11 mg/kg) from Bidii while Taito recorded amount of 0.224 mg/kg from Taito area. Zn was found minimum in kales from Taito (0.070 mg/kg) while maximum in kales (1.365 mg/kg) from Bidii. The highest levels of Pb in kales was (1.842 mg/kg) from Bidii while Taito recorded amount of (0.859 mg/kg) while Cr had the maximum levels in kales (0.938 mg/kg) from Bidii while Taito recorded (0.0019mg/kg).The order of heavy metals was found to be Pb > Zn > Cr > Cu in vegetables.

The highest mean concentration of Zn was found in kales (1.365 mg/kg) followed by spinach (1.294 mg/kg) from Bidii and these values were higher than those obtained from Taito gardens which recorded 0.070 mg/kg in spinach and 0.101 mg/kg for kales. These values, however, were lower than those reported by Kimani (2007); Gupta *et al*., (2008), Iyaka (2007), Smith *et al*., (1996) and Tandy *et al*., (2004).

There were higher levels of Cr in kales (0.938 mg/kg) while spinach had (0.893 mg/kg) but were lower than the findings of Sharma *et al.,* (2007, Rattan *et al.,* (2005) and Mutune *et al.,* (2014). However, these values were higher than the recommended safe limit of WHO (2001). In all the vegetables, Cr was above the dietary recommended limit in vegetables (0.3 mg/kg) (Yebpella et al., 2011). Continued low-intake of oral Cr may cause negative gastrointestinal, musculoskeletal, renal and neurological effects (Kumar *et al.,* 2007). A common source of Cr exposure is from food. Total Cr levels in most foods typically range from <10 to 1,300 μg/kg, with the highest concentrations being found in meat, fish, fruits, and vegetables (ATSDR, 2005). Contamination of the samples from Bidii is then most probably from the parent materials making up the soil in this area. The Cr value was not above the recommended 3 mg/kg (WHO 2001).
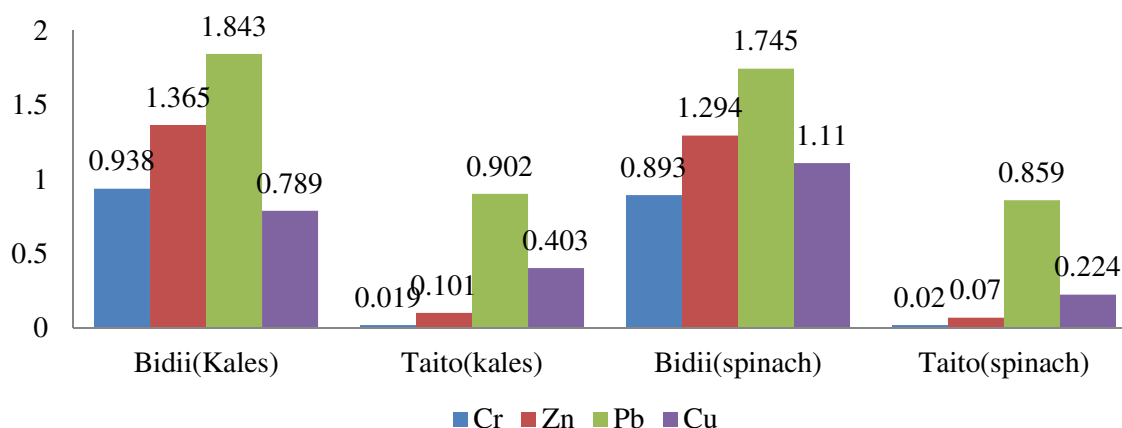

Figure 2: mean concentrations (mg kg^{-1}) of Cu, Zn, Pb and Cr in kales and Spinach

CAC (2001) set the limit of Zn intake at 60 mg/kg; therefore the content in this study may be acceptable. The value from the study were, however, lower than WHO permissible limits and most of the Zn in soil is bound and so does not dissolve in water. But, depending on the type of soil, some Zn may reach groundwater, and contamination occurs from hazardous waste sites. Zn may be taken up by animals eating plants or drinking water containing Zn. Zn is also a trace mineral nutrient and as such, small amounts of zinc are needed in all animals. Normal Zn content in vegetables range should be within 25 - 300 mg/kg (Taber, 2009). Zn is least toxic among the heavy metals in this study; its deficiency could be more detrimental than toxicity (Kumar *et al.,* 2007).

The mean Cu content in vegetables ranged from 0.224 mg/kg to 1.110 mg/kg and these values were higher than those reported by Chove *et al.,* (2006) but lower than those reported by Gupta et al., (2008) and Liu et al., (2005). However, the variation of Cu concentration in vegetables in the current study was strongly supported by the findings of Arora *et al.,* (2008). This study has shown that the concentration of Cu in both kales and spinacia oleracea from the Bidii was relatively similar. However, samples of spinacia oleracea from Bidii showed significantly higher concentrations. It has been reported that Cu release rates from contaminated soils are comparatively lower than those for Pb and some other heavy metals (Amusan *et al.,* 2005). This high tendency of added Cu to remain in the soil could be the main controlling factor for its uptake rates by plants. According to Taber (2009), normal Cu content in vegetables should range from 2 - 20 mg/kg and WHO (2001) set it at 40 mg/kg. Therefore the concentrations in this study were within the acceptable range. Many vegetables contained lower than 1.5 mg/kg which is the recommended lower limit of Cu in plant tissue because some soils were deficient; or when they had sufficient Cu, a pH imbalance or an excess of other nutrients such as phosphorous could have limited absorption by vegetables (Taber 2009). The maximum limit for Cu ions in vegetables is 40 mg/kg; this has been set to prevent a disagreeable test of Cu ions in vegetables, as well as providing adequate protection from toxicity. The levels of Cu obtained in vegetables from the present study, reveal the elevated uptake of the heavy metals in plants grown in Bidii areas of Kitale. The levels of Pb in kales was in the range 0.902 mg/kg to 1.843 mg/kg while in spinach was 0.859 mg/kg to 1.745 mg/kg which exceeded the acceptable tolerance levels of WHO (2001) for Pb by approximately six times, but lower than those reported by Gupta *et al.* (2008) and comparatively higher than the Pb levels reported by Liu *et al.* (2005), Sharma *et al.*, (2007) and Mutune *et al.,* (2014). However, the Pb values in this study were significantly lower than the mean concentration of Pb reported by Turkdogan *et al.,* (2002). Human exposure to Pb above baseline levels is common. Some of the more important Pb exposures have occurred as a result of living in urban environments, particularly in areas near stationary emission sources. Consumption of these vegetables will certainly result in health consequences (Mutune *et al.,* 2013). Most of the accumulated Pb is sequestered in the bones and teeth. This causes brittle bones and weakness in the wrists and fingers. Pb that is stored in bones can re-enter the blood stream during periods of increased bone mineral recycling (that is; pregnancy, lactation, menopause and advancing age). Mobilized Pb can be redeposited in the soft tissues of the body and can cause musculoskeletal, renal, ocular, immunological, neurological, reproductive, and developmental effects. The introduction of Pb into the food chain may affect human health and thus, studies concerning Pb accumulation in vegetables have increasing importance.

7. NITRATE AND PHOSPHATE CONCENTRATIONS IN THE SOIL SAMPLES
Table 3: Concentrations (mg kg^{-1}) of nitrate and phosphate in soil samples obtained from Bidii and taito (control) sites.

Sampling site	Nitrate	phosphate
Bidii	2.06 ±0.95	4.99 ± 2.54
Taito	1.88 ±0.83	4.66 ± 2.63

Phosphates were relatively higher than the nitrate levels in the samples. The phosphate levels ranged between 4.66 mg/kg to 4.99 mg/kg in Taito and Bidii, respectively. These values, however, are lower than those reported by (Egbuchua, 2012). The nitrate concentrations ranged between 1.88 mg/ kg to 2.06 mg/ kg in Taito and Bidii, respectively. However, these values are lower than those reported by Egbuchua (2012). Low values of nitrate and across the soil units could be due to the leaching of nutrient in the soils (Cui *et al.*, 2008).

High mobility of nitrates in the soil is due to their negative charges which makes them not easily absorbed by most soil colloids and thus, more vulnerable to leaching. This contributes to possible pollution of the soils necessitating excessive usage of fertilizers, herbicides and other agrochemicals as well as the use of wastewater for irrigating the soils coupled with the environmental conditions pertinent in the area (Santamaria *et al.,* 1999).

Table 4: Mean concentrations (mg kg^{-1}) of Nitrate and Phosphate in kales and Spinach

Sampling site	Nitrate	phosphate
Kales(Bidii)	3.202 ±2.11	3.011 ±2.21
Spinach (B)	2.214 ±1.06	3.342 ±2.34
Kales (Taito)	2.796 ±2.02	2.897 ±2.21
Spinach(Taito)	2.176 ±1.63	3.239 ±2.35

The levels of nitrate ranged from 2.796 mg/ kg-3.202 mg /kg kales; 2.176 mg /kg-2.214 mg/kg spinach (Table 4). The levels of phosphate were, however, slightly lower than those reported by Egbuchua (2012) and Alex (2012). The values of phosphates and nitrates in the vegetable samples show that the vegetables are rich in these nutrients contents.

These values were found to be higher than those reported by Egbuchua (2012) who studied alluvial vegetables including kales and spinach production system in delta, Nigeria but lower than those reported by Alex (2012). In a similar study conducted by Santamaria *et al.,* (1999) observed that nitrate and phosphate contents were higher in leaves compared to stems and roots. Zhou *et al.,* (2000) reported that vegetables that are consumed with their leaves have a high nitrate and phosphate accumulation

mg/kg, respectively as obtained from the two sampling areas. From table 4, the trend of nitrates variation was in order: kales > spinach. The concentration of phosphates in the leafy vegetables was in order: spinach > kales and this was in agreement with the fact that phosphate contents in vegetables are usually high as shown in table 4. The values of nitrates and phosphates in the vegetable samples show that the leafy vegetables are rich in these anions. Similar study was carried out by Santamaria *et al.,* (1999) who reported that nitrate and nitrite content of various parts of a plant differ in the order of leaf> stem> root> tuber> bulb> fruit> seed. Zhou *et al.,* (2000) reported that vegetables that are consumed with their roots, stems and leaves have a high nitrate and nitrite accumulation, whereas melons and those vegetables with only fruits as consumable parts have a low nitrate accumulation. This observation was also noted by Santamaria *et al.,* (1999) and who reported that leaf and stem accumulate the most nitrates followed by stem and roots and also noted that nitrate and nitrite tend to accumulate in vegetables and it was noted that leafy vegetables such as spinach and lettuce contain nitrate, phosphate and nitrite at significant levels. It was also noted that plants that develop fruits or storage organs, such as potato and tomato, usually have low nitrite and nitrate concentrations. Nitrite content in vegetables is usually very low compared-nitrate (Zhou *et al.,* 2000). Result from this study agreed with the above observations. The high levels of these anions in the dry season is attributed to the used of untreated effluents from treatment plant by farmers for the irrigation of these vegetables. Hence suggesting a possible pollution of the Bidii soils.

8. CONCLUSIONS AND RECOMMENDATIONS
8.1 CONCLUSIONS
i). The levels of zinc, lead and chromium in soils from Bidii were significantly different from those of Taito. And there was a slightly smaller significant difference in the level of copper from all the areas. There was no significant difference in the level of Phosphate from the two areas. Therefore, Bidii soils are richer than those of Taito and this may be due to contamination resulting from waste disposal from industrial, municipal, domestic and agricultural activities.

ii). High levels of Pb and Cr was found in kales and spinach. These amounts may be hazardous if the vegetables are taken in large quantities.

iii). The atmospheric deposition from urban and agricultural areas may play an important role in the enrichment of agricultural produce from Cr and/ or Pb. The use of fertilizers and metal based pesticides in agriculture are also responsible for the contamination with Cu, Nitrates and Zn.

i). However, the results of this study indicate that the levels of Cu were below the WHO permissible limits and may not constitute a health hazard for consumers. Nonetheless, all these metals and anions have toxic potential, but the detrimental impact becomes apparent only after decades of exposure.

8.2 RECOMMENDATIONS FROM THE STUDY

i). Following the findings, there is need for environmental monitoring strategies to identify potentially toxic and elevated trace metal and anion concentrations in the environment and to implement appropriate mitigation measures to minimize possible food contamination.

ii). The vegetables considered in this study had satisfactory levels of pollutants in their leaves. Therefore, Trans nzoia County government should sensitize communities on the possible effects of these vegetables on health.

8.3 SUGGESTIONS FOR FURTHER STUDY

i). These findings warrant further work by a more controlled experiment, and could take into consideration variations in uptake between different species, cropping history, speciation studies and the difference in vegetable uptake between soils and foliar mechanisms.

ii). Factors that may affect the levels of pollutants in vegetables such as cooking and processing should be investigated.

iii). The roots and stems of other vegetables grown in the area should be analyzed for the trace elements.

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