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EVALUATION OF HEAVY METALS IN THE SOILS OF URBAN AND PERI-URBAN IRRIGATED LAND IN KANO, NORTHERN NIGERIA

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ABSTRACT
Smallholder irrigation for the production of market gardening is important in urban and peri-uban Kano in northern Nigeria. This involves the use of polluted stream water flowing along the major streams in the city. Three streams were selected based on their source of pollutions: Domestic and industrial sources and an ideally non-polluted stream was used as Control. Soil samples were collected from these irrigated sites and analysed for some selected heavy metals including cadmium, chromium, zinc manganese, iron, copper and nickel. The results were compared with the control site and the European Regulatory Standard (EURS). It was found that all the seven heavy metals are higher in the Domestic source pollution (DSP) than in the Industrial source pollution (ISP), prominent among them are Zn, Cu, Fe and Ni, of which their main source is domestic sewage sludge. The high concentration of Cd, Ni and Zn could be associated with tyre wear and combustion of petroleum from the heavy traffic prevalent in this part of the city. The Industrial source pollution stream was found to be less polluted in Mn and Fe which are even less than the control site. There is also continuous accumulation of Fe, Mn and Zn in the DSP sites, this is possibly due to heavy disposal of domestic sewages along the stream. However, the mean concentration of all the heavy metals with the exception of Cd were found to be lower then the European Regulatory Standard, thus there is urgent concern for the authority to look into the continuous accumulation of Cd in especially DSP sites, where the values were above the European Regulatory Standard. Cd can reach human body through crop uptake to the people that consume the crop, this may cause heart and kidney disease.

Keywords: Heavy Metals, Domestic Source Pollution (DSP), Irrigated Land, Industrial Source Pollution (ISP) European Regulatory Standard (EURS)

INTRODUCTION

In the developing countries, rivers and streams that flow through cities are badly kept with their banks as disposal sites for municipal wastes and with public sewage system draining into the streams. They are heavily polluted and even those in the industrial areas are not exception. However most of the available land by the side of the streams is used for irrigation of vegetables, fruits and other high valued crops for the consumption of city dwellers (Binns *et al.*, 2003). The contamination of urban and peri - urban surface water through such process are due to inadequate sewage facilities, landfills with wastes, agro – chemicals, domestic sewage and industrial effluents. The use of this contaminated water for irrigation, therefore, poses the greatest threat to the safe agricultural practices and risks potentials to the system of land use (Binns *et al*, 2003).

Previous studies have established the presence of some heavy metals in some domestic and industrial effluents discharged into the urban streams, and in the waters used for irrigation (Sahoo and Klopker, 1995; Binns *et al.*, 2003; Dawaki and Alassan, 2008). However, the concentration of these metals has not been investigated, especially in the soils which is at risk of being polluted thereby affecting its productive capacity to function. This poses the greatest potential risk to this system of land use and health hazard for consumers of the crops grown in such areas. It has also been established that some farmers use sludge along these rivers as manure for crop production, which has negative effect on soils' physical and chemical properties and with their associated health hazard (Olofin, 1999; Tanko, 2004).

The presence of heavy metals in soils is one of the greatest environmental problems that hampers the agricultural use as the metals may be absorbed by crops, which would consequently be consumed by man. The sources of contamination in urban soils are mainly from domestic wastes, exhausts from automobile and emissions from industries. These are the biggest anthropogenic pollution sources (Tyrry, 1999; NVSWC, 2008). These pollutants may finally get into public sewage system, which ultimately discharges into rivers that are usually utilized in various ways including irrigation. The exhausts of motorized machines and vehicles are also of great concern in metropolitan areas, as organic wastes and corrosive metal wastes (Bada *et al.*, 2001; NVSWC, 2008). These metallic wastes get into different phases as gaseous, liquids or solids (Ferguson, 1990).

Though some heavy metals are required by crops but at trace levels, high concentration of these metals affect soils chemical and physical properties which influence the productive capacity of the soils and may have harmful effect to man who consumes the crops (Singh *et al,* 1983).

The concentration of heavy metals in the soils of the urban irrigation system in the area under study is not well investigated. This work tries to assess the concentration of some heavy metals from two major pollution sources in the urban area: Domestic and industrial sources of pollution in the irrigated farming in urban Kano of northern Nigeria.

MTERIALS AND METHODS

Study Area and Sampling Sites

The study area includes three streams that flow through urban and part of the peri urban Kano city in northern Nigeria (Figure 1). The first two streams are contaminated from different sources; domestic and industrial. The first Domestic source pollution (DSP) i.e. Jakara stream flows right through the centre of the city through highly populated quarters and drains into the peri-urban. The Jakara stream sample sites are located between Latitude 12^{o} 01` - 12$^{o}$ 02`North and Longitude 8^{o}29` - 8$^{o}$34`East. This stream is contaminated through such process as defecations, urination, baths, washing and domestic sewages. Most part of the stream banks are used as waste disposal sites. However, any available lands by the stream bank are used for irrigation. There are also heavy traffic and road networks all over the area.

The other second stream i.e. Salanta (Figure 1) flows through the industrial area of the city and is termed as Industrial source pollution (ISP). It is located between Latitude 11^{o} 56` - 11$^{o}$ 57` North and Longitude 8^{o}33`- 8$^{o}$36` East. There are light industries, such as textiles, plastic and bottling companies. Even though not heavily populated but some of the industries discharge their effluents into the stream water. Whereas the third stream i.e. Watari serves as control (CS). Its source of water is entirely outside the city metropolis. Though there are smallholder rural farmlands, which are under rainfed cultivation along the bank of the stream. The sample sites for Watari stream is located between Latitude 11^{o} 56` - 12$^{o}$ 04`North and Longitude 8^{o}18` - 8$^{o}$24`East.

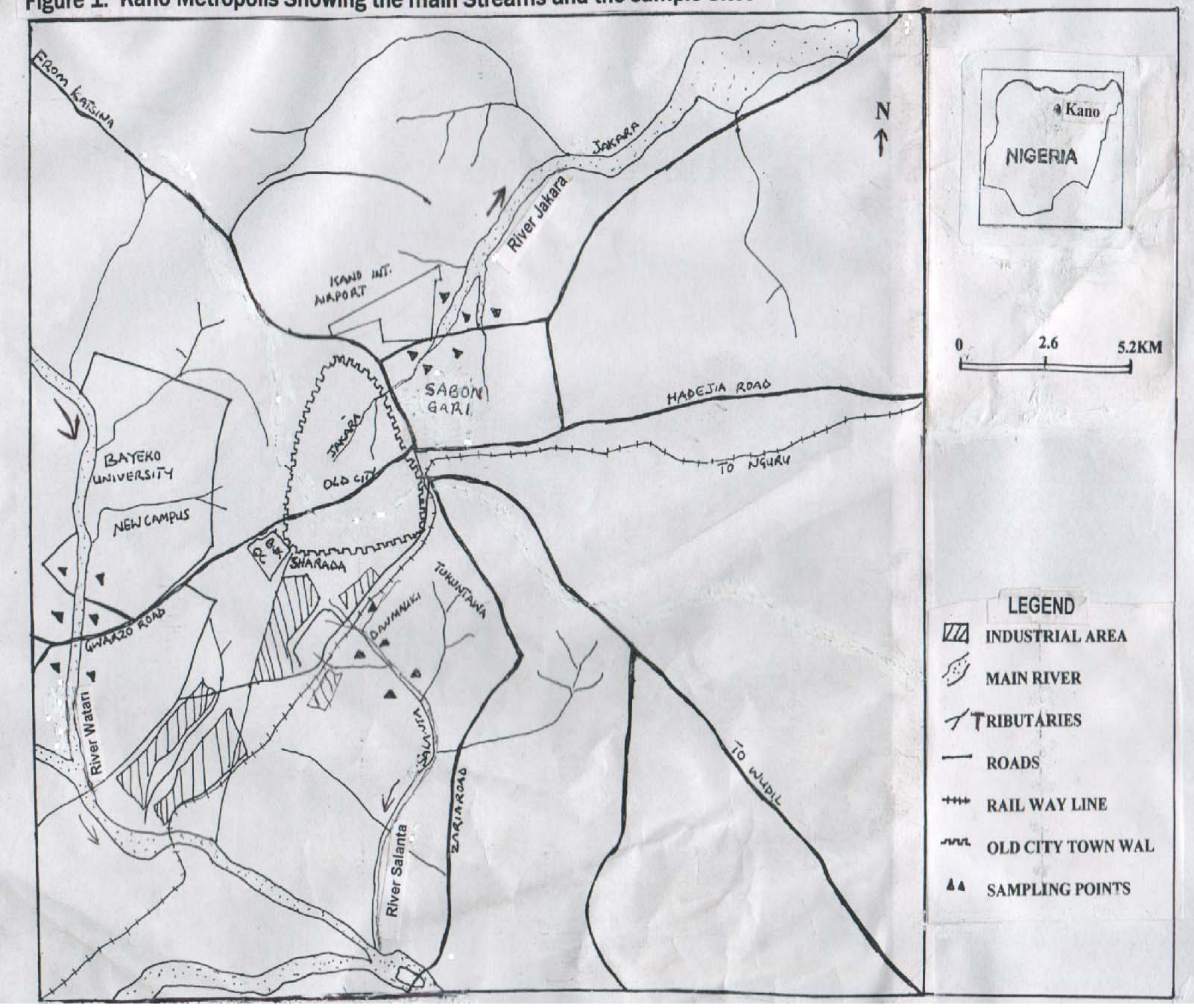

Figure 1. Kano Metropolis Showing the main Streams and the sample Sites

The either bank sides of these three streams are used for irrigation, cultivating vegetables, fruits and a few other crops. It has been established that the water from Jakara (DSP) and Salanta (ISP) streams are not suitable for human consumption (Tanko, 2004)

The farmers use the stream water to irrigate the crops by the use of portable hand machines and tube wells and in some cases open wells in the plots. The crops cultivated in the urban and peri – urban irrigation of Kano consist of vegetables (tomatoes, onion, cabbage, lettuce, spinach, carrot, pumpkin, water melon, garden egg, okra and so on); fruits (guava, orange and citrus), maize and rice.

Sampling Technique

The cultivated farmed plots on the banks of the three streams were used for sampling. Fifteen farm plots were selected along each of the three streams using stratified sampling; selecting a farm plot after every 5 plots. In each farm a composite sample was collected from the top 20 cm using soil auger.

The soil samples were collected in the dry season between the months of March and April so as to avoid the effect of dilution and leaching effect of rain water. The samples were analysed for seven selected heavy metals which includes cadmium (Cd), chromium (Cr), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu) and nickel (Ni). These were determined using standard analytical procedures.

Laboratory Techniques

Wet Digestion method (Anderson, 1974) was used in which 5g of air dried, ground and sieved soil sample was weighed in to a clean 30cm^3 platinium crucible and concentrated HCl HNO_3 mixture was added. The soil – acid was then heated on a hot plate at a temperature between 80 – 90 ^oC. It is further heated at 150 ^oC, then the crucible plus content cooled, and 10cm^3 of distilled water was added. This was filtered and used for analysis. The digestion was done in triplicate and blank sample was also prepared.

The Atomic Absorption Spectrophotometer (AAS) (Buck Sc: Model 210 VGP) was used for the heavy metal analysis at appropriate wavelengths for each analyte (e.g. Cd (228.8), Cu (324.7), Pb (217.0) and so on). While the concentrations of the seven heavy metals were determined, these consist of cadmium (Cd) chromium (Cr), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu) and nickel (Ni).

Statistical Analysis

Analysis of Variance (ANOVA) was used to compare the concentration of the heavy metals within each of the study sites as well as with the European Regulatory Standards. The EUR is quite universal and used in most developing countries. Other simple statistical techniques such as averages and standard deviation were used.

RESULTS AND DISCUSSION

The mean concentrations of the heavy metals in the soil of Domestic source pollution unit (DSP) and Industrial source pollution Unit (ISP) were compared with mean values of the control site (CS) as well as with the European Community Regulation Values (ECRV).

Variation in Concentration of Heavy Metals Between Domestic and Industrial Sites

The detection of these heavy metals and their variability in concentration in the soils of Jakara (domestic source of pollution) and Salanta (industrial source of pollution) could be attributed to the behavior of the individual metals in nature and in soils, especially as it relates to their anthropogenic sources of contamination (Dawaki and K/Naisa, 1998).

Table 1: The mean Concentration of Heavy Metals in the 3 Sites with the European Regulatory Standard (in mg/kg)

				Heavy Metal (mg/kg)				
SITE		**Mn**	**Fe**	**Zn**	**Cu**	**Cd**	**Cr**	**Ni**
Domestic Source Pollution	**DSP**	**51.96**	**281.14**	**78.59**	**4.86**	**3.06**	**2.59**	**7.67**
Standard Deviation		7.2	19.1	6.3	0.3	0.3	0.5	4.0
Industrial Source Pollution	**ISP**	**27.02**	**59.80**	**26.42**	**1.01**	**2.94**	**2.34**	**6.28**
Standard Deviation		4.4	12.2	10.7	0.5	0.6	0.5	0.6
Control Site	**CS**	**42.39**	**164.57**	**18.38**	**0.81**	**2.76**	**1.03**	**5.54**
Standard Deviation		4.4	12.4	17.0	0.2	0.6	0.4	1.6
E U Regulatory Standard	**EURS**	**1500**	**1500**	**300**	**30.00**	**3.00**	**100**	**50.00**

Comparison of heavy metals in the 3 sites with the European Regulatory Standard was made (Table 1). Statistical analysis for the significance differences of the 3 sites were drawn at $\leq$ 0.05 level of significance. It was found that there is significant difference in all the mean concentration values of all the heavy metals in the 3 sites, indicating that the soils of the three areas have different levels and sources of contamination.

Table 1 shows the variation in the mean concentration of heavy metals in the soils of the study areas; Jakara (domestic source of pollution), Salanta (industrial source of pollution) and Watari (control sites) which shows that all the heavy metals under investigation were found to be higher in Jakara (DSP) than the mean value of these metals in Salanta (ISP).

The relatively higher mean values of heavy metals in the soils of domestic source of pollution (DSP) is probably due to the fact that most of the heavy metals especially zinc (Zn) and copper (Cu) were predominated in domestic sewage sludge (Wild, 1996). It was believed that Jakara river (DSP) was contaminated mostly by domestic sewage from densely populated city center of high density quarters, while the sources of cadmium (Cd), nickel (Ni) and zinc (Zn) are due to domestic sewage, tyre wear and combustion of petroleum from automobiles, which are believed to be generated from high traffic flow of dense city center (NVSWC, 2008). The area is considered the busiest in terms of traffic flow compared to ISP (Salanta site) (Dawaki and Alhasan, 2008).

Comparison of Mean Concentration of Heavy Metals

The Fe and Mn concentration was found to be lower in the Industrial source pollution (ISP Salanta) than in the control site (Figure 2). This is due to the fact that the major source of contamination of soils with Fe and Mn are mainly from fly ash, inorganic fertilizers, compost and ferrous smelting waste rather than industrial waste (USEPA, 1993; Brady and Weil, 1999). The control site is surrounded by rainfed cultivated fields and some of the farm plots are under application of inorganic fertilizers and manure (Tanko, 2004). This account for the relative high concentration of Fe and Mn.

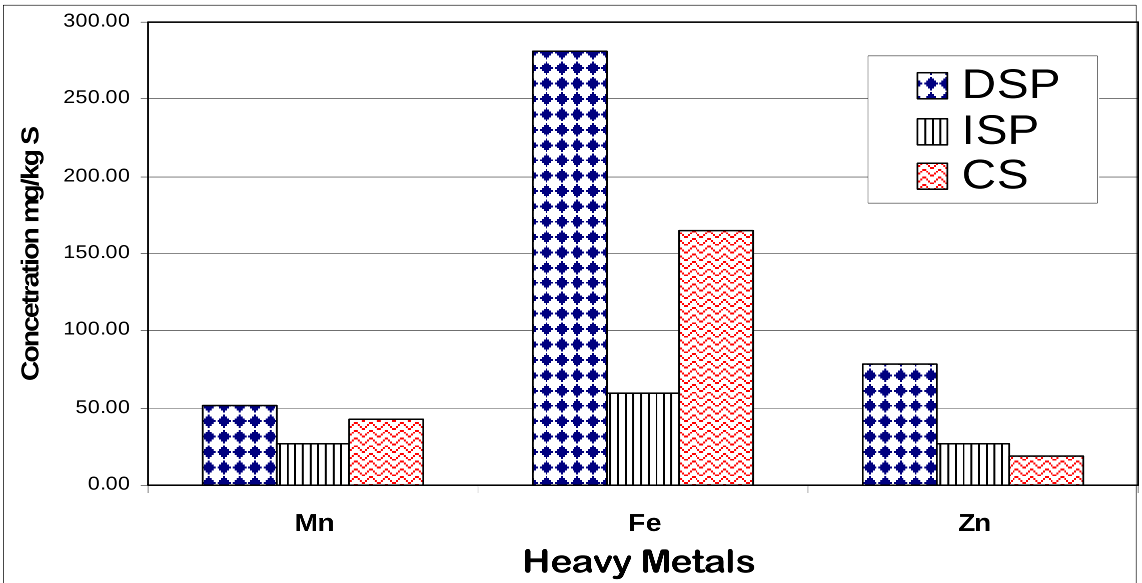

Figure 2: Concentration of Mn, Fe and Zn in the Soils of the three study areas in mg/kg

From Figure 2 and Table 2, Mn and Fe were found to be higher in the Domestic source pollution and the control site than the Industrial source pollution. This indicates that the industrial source pollution area is not polluted with these metals. The industrial effluents, which are assumed to be the major source of heavy metals, may not have very direct effect on the soils on the banks of this stream. It is also found that most of the industries are light, such as bottling and textiles companies. However the values of the 3 metals (Mn, Fe and Zn) are very much higher in the Domestic source pollution (DSP) than in ether Industrial source pollution (ISP) or the control site (CS). More significance is the Fe of which the concentration is over thrice in DSP as compared with the Industrial source pollution and twice of the control site (Figure 2). This is a clear indication that there is continuous accumulation of Fe, Mn and Zn in the Domestic source pollution sites. It was established that there is heavy disposal of domestic sewages in most part of Domestic source pollution (stream) as reported by Dawaki and Alhassan (2008). The stream goes across three major high density city centers of Sabon gari, Brigade and Gwagwarwa quarters (Figure 1) where there is constant dumping of sewage sludge and other domestic wastes.

This observation agrees with that of Wild (1996) that some heavy metals especially Zn, Cu and Mn predominate in domestic sewage than in the industrial sewage sludge.
Though it can be noted that the mean concentrations of Fe and Mn (Figure 2) in the soils of control site was significantly higher than that of Industrial source pollution. This could be explained from the fact that inorganic fertilizers, manure and compos are the major sources of these metals (Brady and Weil, 1999). Also farmers in the rural areas around this stream (control site) do apply inorganic fertilizers as well as ash manure (Tanko, 2004).

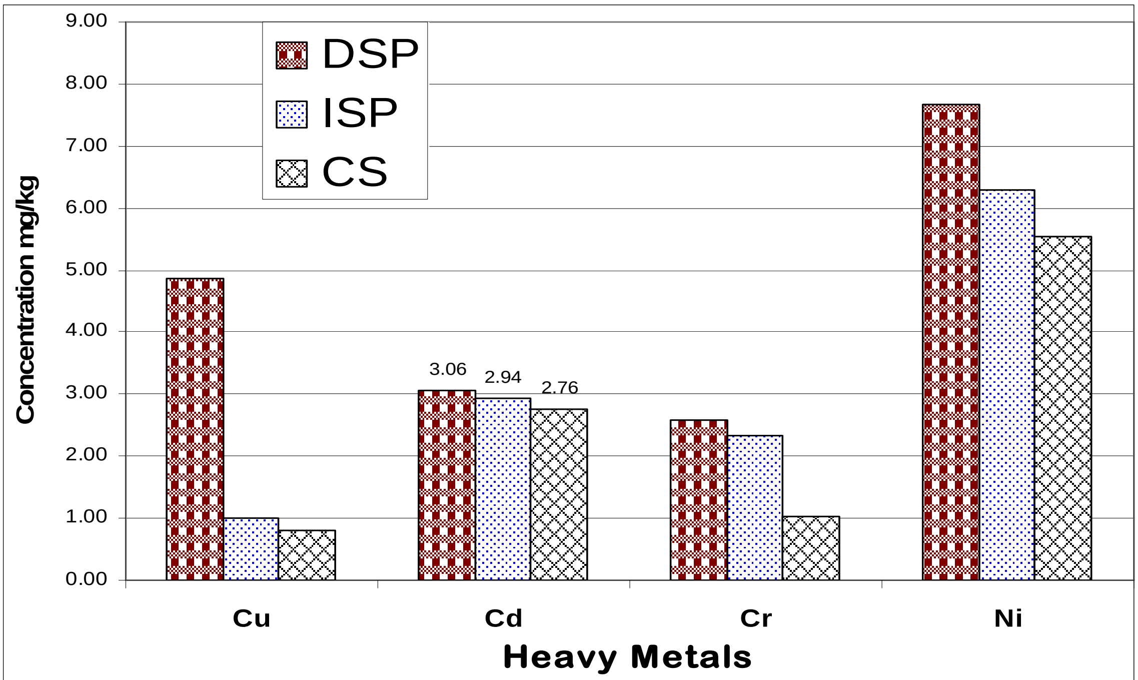

Figure 3 Concentration of Cu, Cd, Cr and Ni in the Soils of the three study areas in mg/kg

Moreover, the Domestic source pollution (DSP) area has more road networks and traffic than the industrial site. This shows that there is serious contamination of the soils of DSP in especially Cd, Ni and Zn (Figure 3), which could have been added to the soils through tyre wears and combustion of petroleum from automobiles as their major source to the soils (Tailor and Francis, 2006).

The DSP site has also higher mean concentration of Cu, Cd, Cr and Ni than either Industrial source pollution and the control site (Figure 3). A marked difference is in Cu, where DSP site is over four times that of ISP and control site. However the mean concentration of Zn, Cd, Cr and Ni were found to be higher than the control site (Figure 3), which shows that the industrial areas (ISP) are also source of contamination from these metals, possibly from the industrial waste water. In this area, Binns *et al* (2003) asserted that there was the presence of some heavy metals in the effluent-discharge into the Industrial source pollution stream that comes from some industries of which the water is used for irrigation.

It can be concluded based on the present levels of heavy metals in the soils of Domestic source pollution that human-induced activities, in form of disposal of wastes, sludge, tyre wears and automobile combustion, have heavily induced the contamination of the soils of the Domestic source pollution, and the industrial areas has less impact in terms of soil pollution of these metals.

It is also found that the mean concentration values of all the heavy metals under investigation with the exception of Cd were lower than European Regulatory Standard. The mean values of Cd was found to be a little higher (Cd, 3.06mg/kg) than European Regulatory Standard Regulation (Cd, 3.00 mg/kg) at Domestic source pollution site. The use of this soil for cultivation of crops is risky as Cd can reach human through crop uptake, and the subsequent consumption of the crop which may lead to heart and kidney disease (Ferguson, 1990). It can be noted that even the soils of the control site are close to the European Regulatory Standard though the average value was found to be not significantly different at 0.05 level of significance.

CONCLUSSION AND RECOMMENDATIONS

It is established that the high density, heavily populated areas with activities, such as sewage and sludge disposal, with high concentration of traffic and automobile combustion are prone to danger of soil contamination with heavy metals especially Mn, Cu, Ni, Fe and Zn.

There is also some evidence of soil contamination of some heavy metals in the Industrial source pollution areas, with Zn, Cr, and Ni, which is lower, compared to Domestic source pollution.

Concentration and accumulation of Cd is seriously noticeable in both Domestic source pollution and Industrial source pollution where the values was close to the allowable limit of 3.00 mg/kg in the Industrial source pollution and even above in the Domestic source pollution (3.06 mg/kg). This is a more urgent concern to the policy makers, for Cd being above the level allowable by European Regulatory Standard.

It is recommended that farmers in this area should intensify the use of other types of organic manure which helps to improve the water holding capacity of the soils, increase pH level, thereby reducing the solubility and availability of the heavy metals to crops. The farmers should also avoid direct use of the contaminated water for irrigation or use of sludge as manure, instead, hand dug wells and tube wells should be opened and used for irrigating the crops so as to reduce the level of contaminant flush as irrigated water.

It is also recommended that the farmers could change the cultivated crops, possibly to cereal and other fruits; such as garden egg, water melon, tomatoes, cucumber and seed crops which have less heavy metals uptake then the roots and tuber crops.

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