HEAVY METAL POLLUTION AND URBAN AGRICULTURE IN MSIMBAZI RIVER VALLEY: HEALTH RISK AND PUBLIC AWARENESS

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ABSTRACT : Awareness of the urban population on the potential environmental and human health risks resulting from and consuming vegetables polluted with heavy metals from Msimbazi river, Dar es Salaam city, Tanzania was investigated. Results show that more than 71% of the 35 respondents use Msimbazi river as a major source of water for vegetable irrigation. High levels of chromium, lead and copper have been observed in four most popular vegetables namely *Amaranthus blitum*, *Amaranthus gangeticus*, *Cucurbita maxima*, *Ipomea batata* and *Brasica oleracea*. The survey indicated further that about 69% of respondents are not aware on industrial pollution in the Msimbazi River. 63% of respondents do not know the potential human health effects attributed to the current irrigation practice. Vegetables grown along the Msimbazi river valley feeds most of markets in the City. The study also established the risk value as well as population at risk through oral exposure to vegetables grown in Msimbazi River valley. Results on vegetable consumption shows that 95.6% of adults, 30.7% of children aged 6-12 years and 12.5% of children aged 2-6 years are at risk of getting lead carcinogenic effects. Additionally, children aged 2-6 years (5%) followed by children aged 6-12 years (2.8%) and adults (1.2%) are at risk from carcinogenic cadmium effects. For non carcinogenic effects, 0.7% adults, 1.18% children aged 6-12 years, and 0.122% children aged 2-6 years are dermal exposed to copper in vegetables.

Keywords: Exposure, Heavy metal, Msimbazi, Population, Vegetables

INTRODUCTION

Increase of poverty, hunger, lack of formal employment opportunities, demand for food proximity to markets and availability of cheap resources such as urban organic wastes and wastewater have stimulated the development of diverse of agricultural production systems in and around cities (D'Mello, 2003). Different groups of people are practicing urban agriculture, including those from poor, low, mid and high level of income. The most common urban agricultural activities are community gardens (formal and informal), home gardens, institutional gardens and nurseries managed by schools, hospitals, prisons, and factories (Mubofu, 1999).

Growing vegetables is one of the major features of urban agriculture. Vegetables constitute essential components of the diet by contributing proteins, vitamins, iron, calcium and other nutrients which are usually in short supply. They also act as buffering agents for acid substances obtained during the digestion process (Thompson & Kelly, 1990). Whilst support for increased production and consumption of fresh vegetables is an important goal, urban communities have a right for safe vegetables supplied to them which must be free from contamination.

Despite the goodness of urban agriculture as a source of income and supplement of food supply, the practice is associated with serious environmental and public health effects. One of the associated risks is contamination of crops by heavy metals and other toxic chemicals. The major entry is through roots and leaves absorbing the chemicals from contaminated soil, water and air (Zurera et al, 1989). The sources of heavy metals in these areas include industrial effluents and institutional wastewater. Other toxic chemicals that accumulate in crops include estrogenic substances from personal care products, bacteria from human excreta, PCBs and PAHs from transformers and unburnt fuel from vehicles and power generators, respectively. Additionally, urban agriculture is known to be the source of environmental contaminants due to various types of agrochemicals used (i.e. fertilizers, pesticides and fungicides). Agrochemical residues have been reported in food crops, animal products and drinking water (Ellen et al., 1990).

Heavy metals are one of a range of important types of contaminants that can be found on the surface and in the tissues of fresh vegetables. Heavy metals may enter the human body through consumption of food plants grown in contaminated soils (Cambra et al., 1999). Chronic low levels intake of heavy metals such as lead, cadmium, mercury and copper have damaging effects on human beings. Prolonged human consumption of foodstuffs contaminated with heavy metals may lead to the disruption of numerous biological and biochemical processes in the human body. Heavy metal accumulation gives rise to toxic concentrations in the body, while some elements (e.g. arsenic, cadmium, chromium) act as carcinogens and others (e.g. mercury and lead) are associated with developmental of abnormalities in children (D'Mello, 2003). Other associated health problems include acute and chronic poisoning which can cause headaches, vomiting, anxiety, loss of sight, toxicity, transmission of diseases from domestic animals to people (zoonosis) and occupational health risks particularly through improper handling of agrochemicals and untreated wastewater in food production and food-processing industries (Ellen et al, 1990).

In Tanzania it has been a common practice to cultivate vegetables along river valleys passing through the cities. In Dares Salaam for instance, urban agriculture has been a normal practice along various river valleys. These river/streams have been reported to be highly polluted by toxic chemicals from industries which discharge wastewater untreated into these receiving water bodies (Kihila, 2003). Recent studies by Mwegoha and Kihampa (2010) and Kihampa and Mwegoha (2010) revealed heavy metal pollution in soils, water and vegetables grown along the Msimbazi river valley. This paper reports results of public awareness survey on the imminent health hazard associated with consumption of vegetables grown in this area.

MATERIALS AND METHODS
Description of the study area
Dar es Salaam City is located at latitude of 6°4′ S and 7°00′ S, longitude 39°00′ and 39°19′ E, with an area of about 700 km². The population of Dar es Salaam Region is estimated to be over 4 million. The study sites are located along Msimbazi River as shown in Figure 1. The areas are well known for vegetables cultivation all year round. Vegetable cultivation use contaminated water from the river for vegetable irrigation. Msimbazi River receives effluent discharges from several industries of different manufacturing processes such as batteries, steel, paints and dyes, food processing, Vingunguti abattoir, leachate from old Vingunguti damp site, and electrical products industries and covers a distance of 45.25 km, also receives effluent from Luhanga tributary 12.15 km; Mambizi, Ubungo sub tributary, Sinza , Zimbire tributary, Kimanga, Kinyenyele and Kwangula sub tributaries 6.5 km, 20 km, 19.25 km, 3.6 km, 3 km, 4.35 and 2.25 km respectively.

Site visits and interviews
Site visits were conducted to the local vegetable growers and vendors of along the Msimbazi river valley. A total of 50 questionnaires (35 questionnaires for vegetable growers and 15 questionnaires for vegetable vendors in the market) were administered randomly. Interviews were conducted at different areas including Jangwani, Kigogo (Msimbazi Valley), Buguruni/Tabata as well as Vingunguti). Market questionnaires were conducted at Mwananyamala, Mwenge and Buguruni markets in order to identify the sources of vegetables for vendors and the level of awareness on the quality of water used for vegetable irrigation.
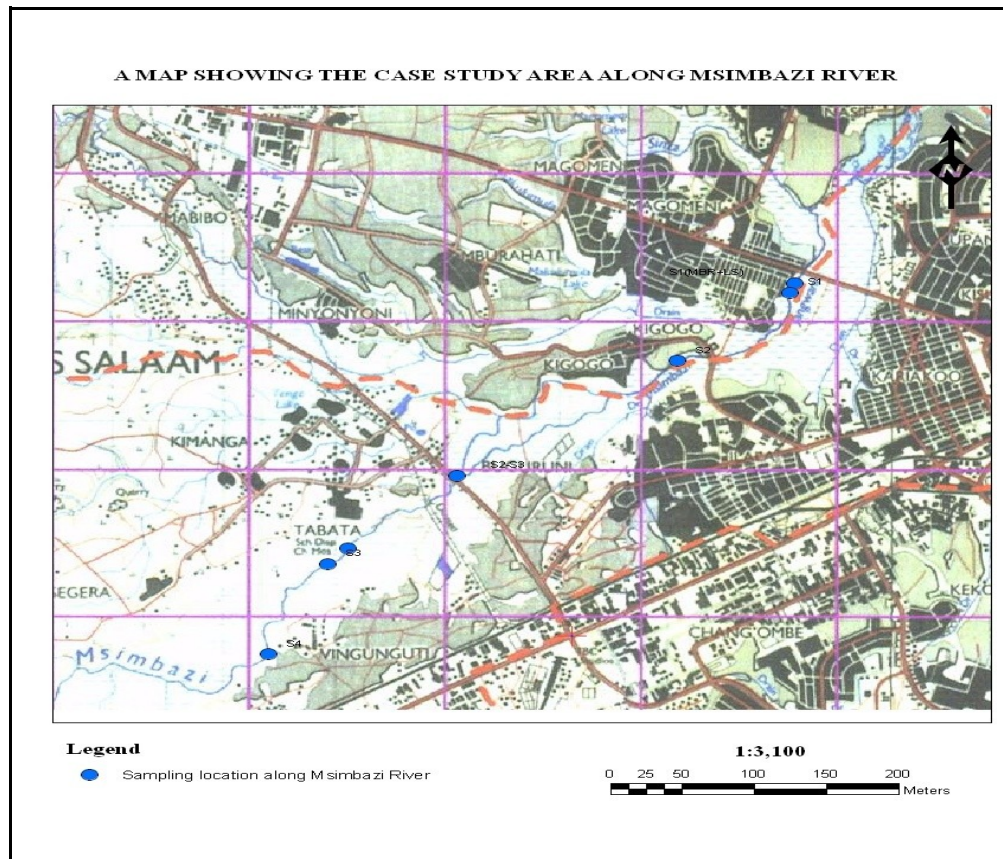
Key: **SI**: Jangwani,**S2**:Kigogo,**S3**:Tabata,**S4**:Vingunguti

Figure 1: Study area at Msimbazi River in Dar es Salaam City

RISK ASSESSMENT

Risk assessment is based on the carcinogenic and non carcinogenic heavy metals where by copper represents the non carcinogenic heavy metal and lead and cadmium as carcinogenic heavy metals. The exposure pathways are oral contact in vegetable consumption. The Reference Doses (RfD) and slope factors (SF) value for non carcinogens and carcinogens respectively have been obtained from various sources US EPA toxicological database being the major one.

Hazard identification

Determination of the toxicity score for each chemical in each medium

Non carcinogens

$$TS = \frac{C\max}{RfD}$$

Where: TS = Toxicity score, RfD = Reference dose, Cmax = Maximum concentration (the highest concentration of each heavy metal).
Copper in samples: 176.938mg/kgdw (*Amaranthus gangeticus*) S4 (8.879 mg/L).

Reference doses for copper

The Oral Chronic and sub chronic Reference Dose for Copper is 4 x10^{-2} (mg/kg-day)
The Dermal Chronic and sub chronic Reference Dose for Copper is 1.2 x 10^{-2} (mg/kg-day)
The Dermal Reference Doses for Copper are based on a gastrointestinal absorption factor of 0.3
Source: http://rais.ornl.gov/tox/profiles/co (Last updated on 4th, September, 2009).

Table 1: Toxic Scores for Copper in vegetable samples

Exposure pathway	Oral	Dermal
……...........................Kg/L-d……………………..........		
Results for chronic RfD	221.975	739.917
Results for sub chronic RfD	221.975	739.917

b) For Carcinogens

$$TS = SF \times C \max \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots........................1.1$$

Where:- SF = Slope factor/potency factor (mg/kg-d)$^{-1}$, Cmax = Maximum concentrations

Vegetable samples (Cd =5.274 mg/kg, Pb = 396.906 mg/kg)

Table 2: Slope factors for selected metals (Source:www.oehha.ca.gov/air/cancer)

Slope Factor	Cadmium	Lead
…………………………………(mg/kg-day)$^{-1}$…………………….......		
Oral SF value	0.038	0.042

Table 3: TS for carcinogenic heavy metals in vegetable samples, for oral and dermal exposure

Exposure pathway	Oral	
…………………kg/L-day………………………		
Cadmium	0.01	
Lead	0.8365	

Exposure assessment

The major source of heavy metals identified in this study is from effluents from industrial, domestic, agricultural sources as well as air deposition. Such chemicals are being transported by the river to different parts where by such contaminated water is used for different activities, major being for vegetable irrigation. The main route of entry is through ingestion. Dar es Salaam City residents are exposed to these heavy metals as they consume contaminated vegetables grown along Msimbazi River.

Daily intake determination

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

Where: I = Daily Intake (mg/kg of body weight - day), CR = Contact Rate (e.g. L/day or mg/day), EF = Exposure Frequency (day/year), ED = Exposure Duration (year), BW = Body Weight (kg), AT = Average Time (30 yrs x 365days), C = Concentration at exposure point (mg/L in water). Vegetable samples (Cd =5.274mg/kg (0.265 mg/L), Pb = 396.906mg/kg (19.917 mg/L), Cu = 176.938mg/kg (8.879 mg/L).

Table 4: US EPA standard default exposure factors, modified from Kolluru (1993)

Parameter	Adults	Child age 6-12	Child age 2-6
Average body weight (kg)	70	29	16
Retention rate (inhaled air)	100 %	100 %	100 %
Exposure frequency (days)	156	156	156
Exposure duration (years)	30	6	4
Consumption of vegetables (g)	80	80	80

a) Carcinogenic heavy metals

Table 5: Intake determination for vegetable samples with carcinogenic heavy metals by oral exposure

Heavy metal intake	Daily intake for adults	Daily intake for child age 6-12 years	Daily intake for child age 2-6 years
…………………………….mg/kg-day……………………………………			
Cadmium	0.3029	0.73103	1.325
Lead	22.7622	54.943	99.585

b) Non carcinogenic heavy metals

Table 6: Intake determination for non carcinogenic heavy metals in vegetable samples

Name of heavy metal	Daily intake for adults	Daily intake for child age 6-12 years	Daily intake for child age 2-6 years
…………….............................mg/kg-day…………………………...............			
Copper in vegetable sample	10.1474	24.4938	44.395

RESULTS AND DISCUSSION
Source of water for vegetable irrigation
About 71% of 35 respondents indicated that they use Msimbazi river as a major source for vegetable irrigation and 26% use Luhanga and the remaining 3% use dug wells as a source for vegetable irrigation. Visual inspection revealed that those who use shallow wells dig some wells very close to the river bank, which allows infiltration of river water into these wells.

Heavy metal concentrations in vegetables
Heavy metal concentrations in vegetable samples of Amaranthus blitum, Amaranthus gangeticus, Ipomea batata and Cucurbita maxima sampled are as presented in Kihampa and Mwegoha(2010). The results show high levels of chromium, lead and copper in all vegetables studied. The maximum concentration of heavy metals were observed in Amaranthus gangeticus, with 396.906 mg/kg of lead, 176.938 mg/kg of copper, 45.405mg/kg of Cr and 5.274mg/kg of Cd. The possible sources of heavy metal concentrations in vegetables at Sampling S4 are the effluents from nearby abattoir and leachates from old Vingunguti dump site.

Msimbazi River in Tabata receives effluents from Vingunguti WSP's which consists of various industrial, domestic, garage and agricultural wastes. These are possible source of heavy metal availability in soil as well as in vegetables. Maximum concentration of copper 119.761 mg/kg in Amaranthus blitum, 7.973mg/kg, 71.938mg/kg,0.138 mg/kg of lead, Cr and Cd respectively were observed in Cucurbita maxima. All these concentrations exceeded permissible limit as per WHO/FAO.

The summaries of all concentrations from the vegetables sampled from all points are as presented in Kihampa and Mwegoha 2010. Maximum concentration of Pb in all sampling points was between 396.906mg/kg (Vingunguti) in Amaranthus gangeticus and 1.103mg/kg in Ipomea batata at sampling SI (Jangwani). These values exceed permissible levels in food as per WHO and FAO of 0.3mg/kg. This is a highest degree of contamination of Lead in vegetables compared with permissible levels given by the FAO and WHO which is 0.3mg/kg.

Therefore, over all bioaccumulations of heavy metals in vegetables are in a trend of Amaranthus blitum > Amaranthus gangeticus > Cucurbita maxima > Ipomea batata and the heavy metal concentrations are as Cu > Cr > Pb > Cd.

Awareness on Problems related to polluted water used for irrigation

About 69% of 35 respondents indicated that they are not aware on industrial pollution in the Msimbazi River. 31% indicated to be aware on the same problem. Results in Figure 2 show further that 63% of respondents do not know the potential human health effects caused by river water used for vegetable irrigation and only 37% indicated to know some problems caused by polluted water in Msimbazi River. Out of the remaining 37%, about 20% mentioned that the water causes skin diseases, 6% bilharzias, 9% cholera and 2% poisons. Suffice to say, therefore, that the majority of vegetable growers along Msimbazi River are not aware on the consequences of using polluted water for vegetable irrigation, hence no precautions are being taken to safe guard human health for growers, vendors and consumers.
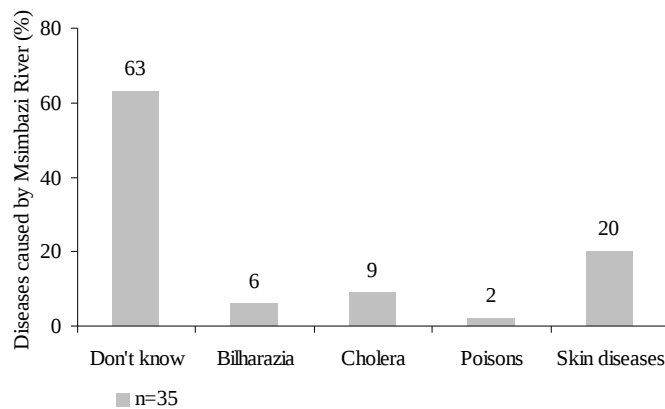

Figure 2: Awareness on diseases related to pollution of Msimbazi River

Possible non point source of heavy metals
About 97 % of respondents interviewed use pesticides in their plots and 3 % don't use pesticides. About 100 % indicated that they use insecticides to kill insects which are likely to destroy different vegetables in the plots. Insecticides are also a source of heavy metals. Various vegetables irrigated using Msimbazi River have different growing period ranging from 22 days for *Amaranthus blitum*, 24 days *Ipomea batata* 29 days for *Amaranthus gangeticus* and 34 days for *Cucurbita maxima*.

Markets for vegetables grown along Msimbazi River
According to the vegetable growers along Msimbazi River, 16% of vegetables are sold at Ilala, followed by Kariakoo and Tazara (6%), Buguruni (5%) and Vetenari (3%). Vegetables grown along Msimbazi River feed most of markets in Dar es Salaam City (Figures 3 and 4).

Markets visited
Different vegetables are sold in the markets. However the most ones are *Amaranthus blitum*, *Amaranthus gangeticus*, *Cucurbita maxima*, *Ipomea batata* and *Brasica oleracea* as indicated in Figure 5. However *Brasica oleracea* is not grown in Dar es Salaam city due to growing conditions needed for growth.

Market questionnaire was conducted at Mwananyamala, Mwenge and Buguruni markets previously mentioned where they do buy vegetables for their business. Out of 15 respondents, about 34% buy vegetables from Buguruni, 16% from Ilala and 21% from Kariakoo markets, followed by Mwananyamala, Mabibo and Kawe as shown in figure 4. Such information can be linked with markets where vegetable growers do sell their vegetables. Therefore Msimbazi River contributes much to the vegetables distributed in Dar es Salaam City.

Vegetable vendors views on water used for vegetable irrigation
Most of vegetable vendors in Mwananyamala, Mwenge and Buguruni markets seem not to bother on water used for irrigation. Interviews conducted indicate that about 64% of respondents do not know the source of water for irrigation and only 36% claimed to know. This information can imply that most of vegetable sellers aren't aware of health implications of the source of vegetables that they are selling.

Income generation for vegetable growers
About 35 respondents interviewed, have indicated that vegetables are the major source of income to those who are not employed in formal sectors, who identify themselves to be poor. Depending on the size of the plots, a single plot yields 10-600 bundles of vegetables per day, a single plot takes 1-3 days to harvest per month depending to the customers available as shown in Table 7, most of interviewed respondents sell 300-400 bundles of vegetables per day. The cost ranges from 50 to 200 Tanzanian shillings (TZS) per bundle. However Table 9 indicates that most of vegetable growers sell vegetables 100 TZS per bundle.
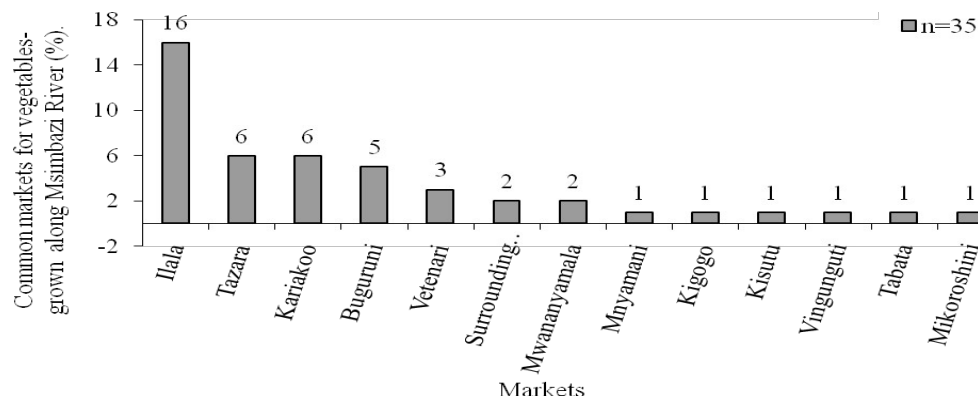

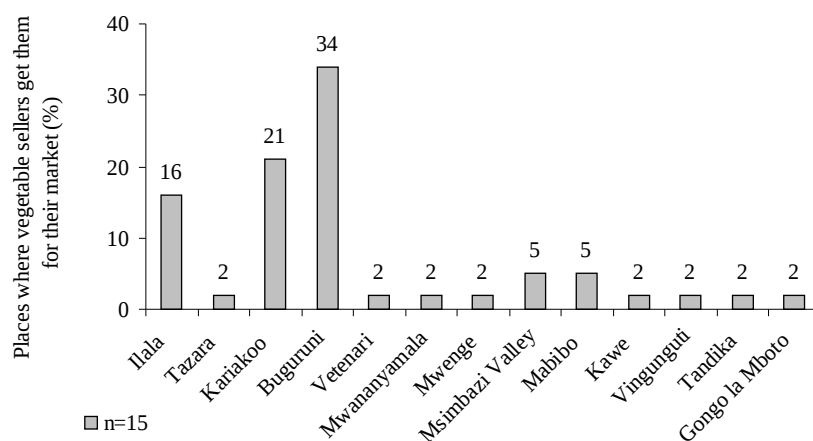Figure 3: Markets where vegetable growers sell their vegetables

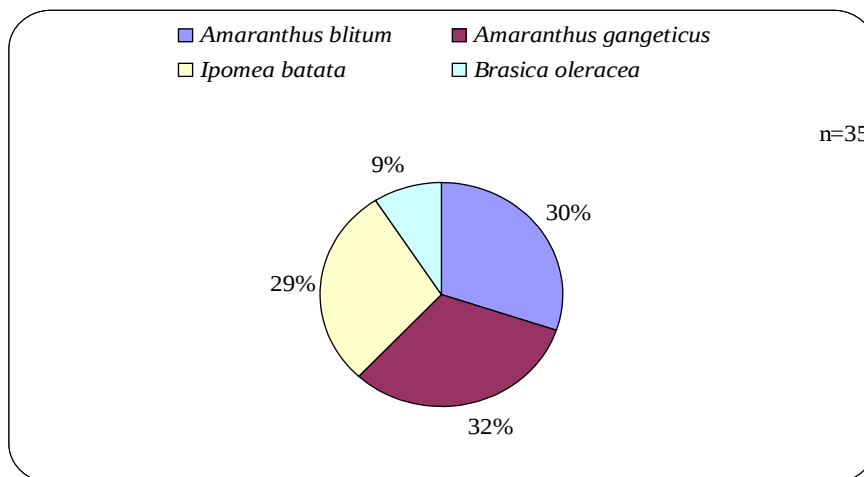Figure 4: Markets where vendors buy vegetables for their markets

Figure 5: Vegetables sold by vendors in the market

Table 7: Income generated from vegetables grown along Msimbazi River per month

Statistics	Bundles of vegetables sold per day (n)	Cost per bundle (TZS)	Days to harvest all vegetables in a plot (n)	Monthly income per plot (TZS)
Mean	298	118	4	87,452
Range	590	150	9	280,000
Minimum	10	50	1	20,000
Maximum	600	200	10	300,000

Awareness level on urban agriculture and environmental pollution

Through the interviews, most of respondents, about 83 % reported to have not received education or awareness training on effects of using polluted water as a source of water for vegetable irrigation. Only 17% indicated to have received awareness raising information from different sources, e.g. extension officers, NGO's, publications etc. This is a small proportion and probably that's the reason as to why they use wastewater without knowing the long term effects to human health.

Risk characterization

In this section, calculations on risk or hazard resulting from potential exposure to chemicals via the pathways and routes of exposure are determined. Risk characterization integrates and summarizes the information presented in the exposure and toxicity assessments (US EPA, 1986). This involves estimation of the risk of both carcinogens and non carcinogens. It is focused on interpreting results for decision making. The US EPA (1991) has defined acceptable risks for carcinogens as within the range of 10^{-4} to 10^{-6} excess lifetime cancer risk and non-carcinogens as a hazard index of less than 1.0. The U.S FDA deemed that less than 10^{-7} cancer risk for saccharin was "acceptable" and the local citizens were willing to accept a risk much than 10^{-4} for a copper smelter. Clearly, acceptability is a personal concept and demands that public, which ultimately must have jurisdiction over what level of risk is acceptable, be informed. At many sites it is ultimately the public which determines by its influence which level of potential health risks are acceptable. The U. S. EPA uses 10^{-6} excess lifetime cancer risk as a point of departure, meaning that a higher risk may be deemed acceptable only there was a special extenuating circumstances.

(a) Carcinogenic risk determination

The product is a real term: the probability of excess lifetime cancer from exposure to this chemical. The computation is as follows;

$$Risk = CDI \times SF$$

Table 8: Risk determination in vegetable samples for carcinogenic heavy metals by oral exposure

Heavy metal of Risk	Risk for adults	Risk for child age 6-12 years	Risk for child age 2-6 years
………...…………………….mg/kg-day…………………….....................			
Cadmium	0.0115	0.028	0.05
Lead	0.956	0.3076	0.1826

US EPA (1991) has provided the limit of carcinogenic risk to be between 10^{-4} - 10^{-6}, meaning that, above 10^{-4}, it is defined as high risk. The results for Pb and Cd in Table 8 have exceeded the allowable US EPA limit for carcinogenic heavy metals, implying that people who consume vegetables irrigated using Msimbazi River are at high risk of getting cancer and other health effects explained earlier.

(b)Non-carcinogenic risk

Non-carcinogenic risk is normally characterized in terms of a hazard index. This is simply the ratio of estimated intake dose from the exposure to the reference dose RfD. Reference doses are dependent on the route of exposure and may only be used with exposure data from the same route. The HI is calculated as follows;

$$HI = \frac{CDI}{RfD}$$

Where: HI = hazard index (dimensionless), CDI = chronic daily intake, (daily intake, I) (mg/kg-day), RfD = reference dose (mg/kg-day),

Table 9: HI determination for non carcinogenic heavy metal in vegetables using chronic and sub chronic RfD values through oral exposure

Heavy metal of Risk	Risk for adults	Risk for child age 6-12 years	Risk for child age 2-6 years
…………………………………..mg/kg-day ………………………………			
Copper (vegetable samples)	0.678	0.825	0.925

ESTIMATION OF POPULATION AT RISK

Calculation on population projection from 2002 to 2009

The projection of the population on this study is based on the arithmetic method as one of the method used in projection of the population. The method requires only simple information such as present population, projection period and population growth rate.

Requirements:

Projection period = 7 years

Growth rate, r = 4.3%

Specific population for a District as per 2002 National Census (Ilala = 637,573, Kinondoni =1,088,867 and Temeke =771,500).

Projection starting from 2002 – 2009

Formula:

$$P_n = P_o (1 + \frac{r}{100})^n$$

Where P_n=Future population, P_o=Present population, R=Annual growth rate, n=Projection period (7 years**)**

Table 10: Population of the Districts as per 2002 Census

District Population	Population in 2002	Present Population(2009)	95%Present population
Kinondoni	1,088,867	1,462,060	1,388,957
Ilala	637,573	856,091	813,287
Temeke	771,500	1,035,920	984,124
Total Population	**2,497,740**	**3,354,071**	**3,186,368**

Table 11: Population according to age

Description	Population 2002 census		
	Adult(12+)	6-12 years	2-6 years
Ilala	358556	82684	73251
Kinondoni	785460	116709	66922
Temeke	534364	103382	93100
Total population	1,678,380	302,775	233,273
Projected population 2002-2009	2,253,619	406,547	313,224
95% of present population at risk	2,140,938	386,220	297,563

Assumptions

Population at risk is determined by the following equation:

Population at Risk = Risk according to age x Total 95 % current Population

Assuming vegetable grown along Msimbazi River are mainly distributed in different markets as identified in questionnaire analysis and are being consumed by 95 % residents in the respective District. This is due to the fact that majority of residents depends on vegetables in daily food consumption. 5 % is assumed to be higher class who are likely to consume vegetables irrigated using DAWASCO water or do buy vegetables from supermarkets or elsewhere considered to be safe.

Oral exposure

i) *Carcinogens*

Table 12: Population at risk determination in vegetable samples for carcinogenic heavy metals by oral exposure

Heavy metal of Risk	Population at risk for adults	Population at risk for child age 6 -12 years	Population at risk for child age 2-6 years
Cadmium	24,621	10,733	14,879
Lead	2,046,737	118,802	37,188

ii) Non carcinogens

Table 13: Population at risk determination for non carcinogenic heavy metal in vegetable samples using chronic and subchronic RfD values through oral exposure

Heavy metal of Risk	Population at risk for adults	Population at risk for child age 6 -12 years	Population at risk for child age 2-6 years
Copper in vegetable samples	1,450,807	318,632	275,246

Figure 6 shows that 2,046,737adults which is about adults 95.6 % are exposed to carcinogenic effects from vegetable consumption, 118802 children aged 6-12 years (30.7 %) and 37188 (12.5 %) children aged 2-6 years are as well exposed to such effects caused by lead bioaccumulation in vegetables. Population at risk due to cadmium present in vegetables is also shown in figure 6. Adults are most vulnerable (95.6 %) for lead carcinogenic effects due to the fact that they are the group who mostly involve in food preparation and probably consumes more than children aged 2-6 years, however cadmium carcinogenic effects are vice versa where by children aged 2-6 years about 14 879 (5 %) are at risk followed by children aged 6-12 years which are 10733 (2.8 %) and the last group for cadmium effects being adults who are 24 621 (1.2 %).

Figure 7 shows that effects of non carcinogenic effects for vegetables. Children aged 2-6 years are the most group at risk, followed by 11802 (82.5 %) children aged 6-12 years and the last group is adults who are 1450807 (67.8 %) at risk of suffering non carcinogenic effects in the long run.
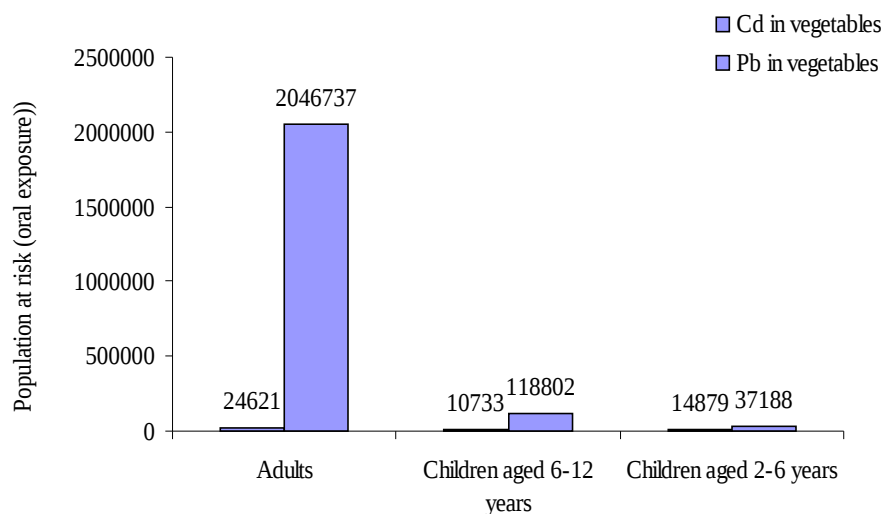

Figure 6 Population at risk determination in vegetable samples for carcinogenic heavy metals by oral exposure

In general it was found that all groups of population are at risk of getting carcinogenic effects; however children are highly at risk with regard to lead and cadmium due to dermal and oral exposure if they use water, soil and vegetables grown along Msimbazi River. Also Dar es Salaam populations are at risk of getting non carcinogenic effects through vegetable consumption, through bioaccumulations in consumers and can lead to different effects.

Moreover the overall population subgroups risks differ from type of exposure and media through which they are exposed. Figure 7 shows that, for the overall effects adults are most vulnerable (96.75%) from vegetable consumption due to lead and cadmium exposure through oral and children aged 2-6 years are most vulnerable (12.8%) to oral exposure carcinogenic effects compared to the rest population sub groups.
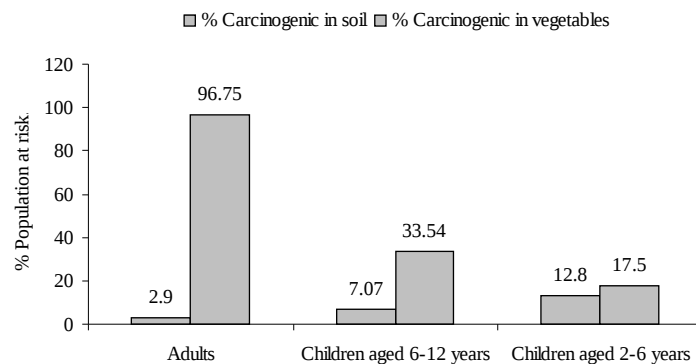
% Carcinogenic in soil % Carcinogenic in vegetables

Figure7: Overall carcinogenic and non carcinogenic effects

CONCLUSIONS

The risk assessment shows that there is possibility of suffering carcinogenic effects from lead and cadmium for oral exposure both through soil ingestion and vegetable consumption as the risk in vegetables and soil are greater than $1x10^{-4}$ recommended by EPA, hence vegetables grown along Msimbazi River are not safe for human consumption. Children aged 6-12 years are mostly (7.07%) at risk of getting cancer from carcinogenic effects from soil and adults (96.75 %) are at great risk of carcinogenic effects from vegetable consumption grown along Msimbazi River. The risk assessment shows every population sub group to be at risk of suffering carcinogenic and non carcinogenic effects especially through oral pathway, therefore the bodies concerned should take appropriate reactions and actions to protect vegetable growers and consumers whose health fate is not known. Msimbazi River should not be used for vegetable irrigation as water observed to have heavy metals exceeded permissible limits as per WHO and TBS. A fundamental change in policy approaches to food safety is required which are based on prevention rather than command and control of food quality at the retail end of the food chain.

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