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Food Security and Environmental Implications of Urban Wetlands Utilisation as Vegetable Gardens: The Case of Bamenda Municipality Cameroon

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Abstract

Wetland agriculture brings significant benefits to food security, health and income. However, ill-considered development often leads to deleterious environmental impacts and harmful consequences to people's livelihoods. This study using multi-criteria approach addresses possible environmental and food security hazards' in vegetable gardens in urban wetlands of the Bamenda municipality, besides conflicts over access. It evaluates their ecological status, soil heavy metal loads, and their accumulation in vegetables. Twenty one samples each of surface soils and Solanum scarbrum were collected from vegetable gardens in the municipality and analysed for their heavy metal (Cd, Pb, Cr, and Mn) content using the atomic absorption spectrometry. The results indicated that the wetlands of the municipality have been moderately modified with a loss and change of biota such as the Raffia fanifera. Pollution load indices varied considerably at the different sites, and ranged from unpolluted through slight pollution to medium pollution. The mean values of bioaccumulation factor (BAF) for Solanum scarbrum, stood at Cd>Mn>Pb>Cr, with respective values of1.23, 1.14, 1.01, and 0.48, insignificantly higher (P>0.05) than those of the control sample. Cadmium is easily transferred in this vegetable than any other metal. The intake of Cd was estimated at 9E-7 mg, representing approximately 0.009 % of the referenced dose (R_fD), established to 0.001 mg kg^{-1}.Due to the gradual degradation of wetlands in Bamenda and the urgent need to secure and improve people's quality of life while simultaneously safeguarding the ecological benefits derived from the wetland, policy makers should integrate conservation and development in planning.

Keywords: Wetland, environmental quality, food security.

1. Background of the Study

Wetlands and their allied resources contribute enormously to food production, and livelihoods. In Africa, most economies are largely agrarian-based with about 66% of wetlands used for agriculture (Adams, 1995; IWMI, 2006). However, achieving food security and environmental quality still remains a major concern (Pinstrup-Andersen, 2002; UN, 2007). Urban areas are characterised by a variety of human activities, which results to the discharge of a mixture of hazardous chemical substances into the environment. Similarly, the ever-growing land pressure aggravates the demand for arable farmlands. This hassled to an increasing number of people invading wetlands for agricultural activities. In this fight for survival, they often engage in unsustainable use of these natural resources, causing degradation and other adverse effects. If wetlands are not used sustainably, the functions, which support agriculture, as well as other food security components, ecosystem services, including water-related services, are undermined.

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Currently, the basis for making decisions on the extent to which, and how, wetlands can be sustainably used for agriculture is debatable. There is a general dearth of knowledge on the best agricultural practices to be applied within different types of wetlands and a lack of understanding on how to establish appropriate management arrangements that will adequately safeguard important ecosystem services (IWMI, 2006). Often, wetland policies are underpinned by a conservationist perspective that regards agriculture simply as a threat and disregards its important contribution to livelihoods. As with any natural resource, the sustainable utilization of wetlands, which underpins the concept of wise use, requires a comprehensive understanding of developments at the interface between human societies and the natural world.

This requires consideration of a large number of extremely complex and interrelated issues and poses intricate technical, social and political problems. A key difference between sustainable and traditional natural resource management is in the evaluation of trade-offs in relation to all costs, benefits and risks (Haimes, 1992). To assist decision-makers, a wide range of methods, and tools has been developed. These include methods of environmental valuation (Barbier *et al.,* 1997; Emerton and Bos, 2004), environmental and health impact assessment (World Bank, 1991; World Health Organization, 1999) and various methods of multi-criteria analysis (Harboe, 1992).

For a reasonable sustainability planning, the multi-criteria approach is widely recognized to be appropriate (Maness and Farrell 2004). Here, apart from the fact that stakeholder choices are rarely made with respect to just one criterion ,it is not possible to express all criteria as monetary values but multidimensional, consequently, a Multi-criteria analysis (MCA) has been developed (Stirling 1997). The main aim of MCA approaches is to incorporate both qualitative information and quantitative data, and encompass a broad range of variables. Ecological conditions of wetlands are classified on a qualitative scale varying from “natural” to “extensively modified”.

An assessment of possible hazards evaluates the potential consequences of implementing specific agricultural activities within a working wetland. It is based on an assessment of the risks both to existing livelihoods (i.e., in relation to the extent to which the wetland currently supports social welfare) and the current ecological condition of the wetland. This assessment must be undertaken within the context of the development pressure identified for the wetland and the likely benefits that will accrue.

The hazard rating is classified from “none” (i.e., class 5), very low (class 4), low (class 3) moderate (class 2) to “high” (i.e., class 1). However, evaluation of ecological hazards considers the uniqueness of the particular local, national and international scales. In evaluating the ecological hazards, it is important to consider the “uniqueness” of the wetland at local, national and international scales. Adverse effects on groups that depend on consumption of the wetland’s natural resources.

Bamenda is one of the most rapidly emerging municipalities in Cameroon with factories ranging from metallurgical, soap production, food processing, garage works, oil exchange services to traffic releases which generates huge amounts of wastes. The wastes are drained or deposited on soils or into water systems that supply wetland. The wetlands apart of their ecological importance are used for the cultivation of crops including vegetables consumed all over the country and beyond. Waste water irrigation is known to contribute significantly to the heavy metal content of soils (Devkota and Schmidt, 2000; Mapanda et al., 2005). Leafy vegetables are popular and preferred by the population of the area because of their vital dietary components and indispensability as ingredients in soups or sauces that accompany carbohydrate staples, and are increasingly in demand. In general, the vegetables have multifaceted importance in the livelihoods of the urban and peri-urban poor (Asongwe et al., 2014) but could accumulate heavy metals endangering health. These areas have received little attention from the research and extension divisions. The suitability of a wetland for the agricultural activities defined through identification of the development pressures is dependent on a complex combination of wetland attributes, as well as catchment characteristics and the broader socioeconomic setting in which the wetland is situated. Consequently, both biophysical and socioeconomic criteria need to be evaluated when considering the suitability of a wetland for the proposed agricultural activities. This work synthesizes findings from multicriteria studies which addresses possible environmental and food security hazards’ in vegetable gardens in urban wetlands of the Bamenda municipality, by evaluating the ecological and possible hazard assessment(soil heavy metal loads, and their accumulation in vegetables)approaches of the working wetland potential.

2. Materials and Methods

2.1. Description of the study area

The area covered by this study includes urban and peri-urban wetlands in the Bamenda City Council of the North West Region of Cameroon (Figure 1). It is bounded on the West, North and East by the Cameroon Volcanic Line (made up of basalts, trachytes, rhyolites and numerous salt springs).

The geologic history of this area originates from the Precambrian era where there was vast formation of geosynclinal complexes, which became filled by clay-calcareous, and sandstone sediments (Yerima and Van Ranst, 2005b). These materials, crossed by intrusions of crystalline rocks, were folded in a generally NE-SW direction and underwent variable metamorphism (Yerima and Van Ranst, 2005a). It is part of the Bamenda escarpment and located between latitudes 5° 55''Nand 6° 30''Nand longitudes 10° 25''Eand 10° 67''E.The town shows an altitudinal range of 1200 - 1700 m, and is divided into two parts by escarpments; a low lying gently undulating part with altitudes ranging from 1200 to 1400 m, with many flat areas that are usually inundated for most parts of the year, and an elevated part at 1400 to 1700 m altitude that forms the crest from which creeks, and streams, supplying the low lying parts take their rise.

This area has two seasons; a long rainy season, which runs from mid-March to mid-October and a short dry season that spans from mid-October to mid-March. It lies within the thermic and hyperthemic temperature regimes. Mean annual temperatures stand at 19.9°C. January and February are the hottest months with mean monthly temperatures of 29.1°C and 29.7°C, respectively. The Ustic and Udic moisture regimes dominate this area with the Udic extending to the south (Yerima and Van Ranst, 2005b). Annual rainfall ranges from 1300 – 3000 mm (Ndenecho, 2005). The area has a rich hydrographical network with intense human activities and a dense population along different watercourses in the watershed. The Rocks in the area are thus of igneous (granitic and volcanic) and metamorphic (migmatites) origin (Kips *et al.,* 1987), which give rise to ferralitic soils (GP- DERUDEP, 2006).

The main human activity in and around this area is agriculture, which according to Grass field Particpatory-Decentralised and Rural Development Project (GP-DERUDEP, 2006) involves over 70% of the population that use rudimentary tools. More than 81.7% of the active agricultural populations are involved in farming, 11.6% in fishing and 6.5% in grazing (GP- DERUDEP, 2006). Farming and grazing involves the use of organic and fertilizers that is a potential source of pollution. The area equally harbours the commercial Centre that has factories ranging from soap production, and mechanic workshops to metallurgy, which may be potential sources of pollutants. An important vegetation type in this area is the raffia palm (*Raffia farinifera)* bush, which is largely limited to the wetlands (Valleys and depressions). *R. farinifera* provides raffia wine, a vital economic resource to the inhabitants who are fighting against the cultivation of these wetlands by vegetable farmers.

2.2 Assessing the Ecological Condition of a Wetland

Following McCartney et al. (2004), based on expert knowledge and comparing with undisturbed wetlands in the region; coupled to historical knowledge of the wetland users and local communities, the present ecological condition of the wetland was classified.

Figure 1: Map of Bamenda municipality Cameroon, showing soil sampling points in Wetlands

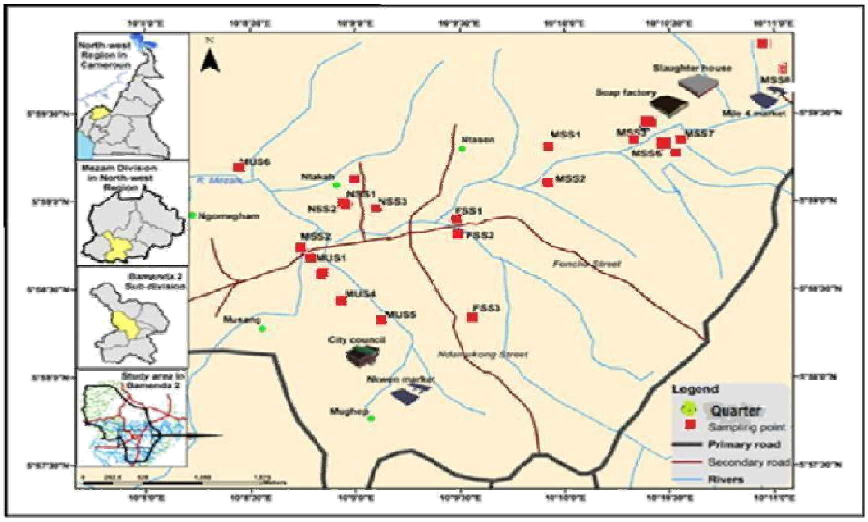


Table 1: Guideline approach for assessing the ecological condition of wetlands.

Description	Example	Possible desirable features	Possible negative features
Natural			
Natural habitat and functions are unmodified.	Either no human interaction or only human intervention to maintain "natural" system (e.g., nature reserves , and national parks where human populations are excluded).	High biodiversity. a Habitat for rare species. Natural hydrological functions (e.g., flood attenuation, etc.). High aesthetic value.	.Source of disease; e.g., malaria, and schistosomiasis. No natural resource exploitation available for local people.
Largely Natural			
Few modifications. A small change from natural habitats and biota may have taken place, but the wetland "natural functions" are essentially unchanged.	Small amount of human intervention (e.g., fishing, hunting, and collection of medicinal plants) but limited long-term impact.	People's livelihoods benefit from natural resources and the extraction is sustainable in the long-term.	Source of disease; e.g., malaria and schistosomiasis
Moderately Modified			
A loss of and change from natural habitats and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	Some land-use change (e.g., < 20% of wetland area) and /or minor modification to natural hydrological regime.	Some agricultural production supports some people's livelihoods. Natural resource exploitation is still possible and sustainable.	Limited water control, so crops/Livestock at risk from flooding/drought. High labor requirements to control weeds and natural pests. Prevalence of disease may Increase as people spend longer in the wetland.
Largely Modified			
A large loss of natural habitat, biota and basic wetland functions has occurred.	Significant land-use change (e.g., 21-75% of wetland area) and/or significant modification of the natural hydrological regime.	Agricultural production suppor many people's livelihoods.	Significant reduction in natural resource exploitation. Loss of beneficial hydrological functions. Some soil erosion. Prevalence of disease may increase as people spend
Extensively Modified			
The loss of natural habitats, biota and basic ecosystem functions (i.e., natural goods and services) is extensive.	Wetland ecosystem very significantly altered from its perceived "natural" condition. For example, extensive land-use change (>75% of wetland area) and highly modified hydrological regime (e.g., through drainage).	High and reliable agricultural production sustains many people's livelihoods. Reduced incidence of water-related disease due to improved socioeconomic conditions.	Massive reduction in biodiversity. Loss of beneficial hydrological functions, possibly including pollution of water sources. Soil erosion. Low aesthetic value. Risks of disease may still exist.

In general, natural diverse habitats are highly valued and many wetlands have high biological diversity. However, in some wetland types, biodiversity is naturally low and human interventions (e.g., application of fertilizers to wet grassland to improve pasture or cutting and draining of peat bogs) will increase the diversity of communities and species in the wetland. Consequently, the number of species a wetland contains is not, in itself, a sufficient indicator of ecological condition.

2.3 Environmental quality and food security assessment

Twenty-one top soil samples were randomly collected within the wetlands (Figure 1) and taken to the laboratory in black plastic bags. The soil samples were air-dried and screened througha 2-mm sieve. They were analysed for soil heavy metals (Cr, Mn, Pb and Cd) using the atomic absorption spectroscopy (detection limit of 1% in the Soil and Environmental Chemistry Laboratory of the University of Dschang Cameroon. Two grams of each soil sample were digested in a mixture of HCl and HNO_3 in the ration 1:3. The solutions were then aspirated into the AAS set up for determination. A reference soil sample was used to ascertain the rate of recovery of the AAS machine. The reference soil sample was previously analysed as ordered by Pr. Cheo Emmanuel Suh of the University of Buea, Cameroon at the Activation Laboratories Limited in Canada using the ICP-MS equipment with a detection limit of 1%.

2.4 Vegetable sampling and analysis

Vegetable samples (*Solanum scarbrium*),which grow rapidly, producing high biomass and common in the area, were purchased and harvested directly from farms in the area of study corresponding to the soil collection.
After several cleanings with distilled water to remove heavy metals deposited on plant surfaces, the vegetable samples were weighed, air dried and later dried at 40 ^{o}C in an oven. Two grams of each pulverized dried sample were digested with 10 mL of aqua regia. The solution was then aspired into an atomic absorption spectrophotometer with different lamps of 228.80 nm, 217.00 nm, 357.87 nm, and 279.48 nm for the determination of Cd, Pb, Cr and Mn, respectively.

2.5 Statistical analysis

The degree of environmental quality (soil pollution) for each metal was calculated using the pollution load index (PLI) technique depending on soil metal concentrations.

PLI = Csoil (Samples)/Ccontrol………Liu et al. (2005)

Where *Csoil* and *Control* are metal concentrations in soil samples and control, respectively. Based on PLI, soil contamination levels are classified into four grades: Pi < 1 (grade 1), unpolluted; 1 > Pi < 2 (grade 2), slight pollution; 2 > Pi < 3 (grade 3), medium pollution; Pi >3 (grade 4), heavy pollution (Liu *et al*., 2005)**.**
Based on dry weight, the bio-accumulation factor (BAF), an index of the ability of the vegetables to accumulate a particular metal (food security) with respect to its concentration in the soil substrate (Ghosh and Singh, 2005), was calculated as follows:

BAF = Cplant/Csoil………Cui et al. (2005)

Where *Cplant* and *Csoil* represent the heavy metal concentration in the edible part of vegetables and soils, respectively.

3 Results and Discussions

3.1 Current Ecological Condition

The wetlands are floodplains of River Mezam located at an altitude of about 400 m above the sea level. The area is dominated by sandy loam soils and is flooded during the wet season. In the dry season, the water table is shallow; typically less than 50 cm below the ground surface. In the wetlands, many economic trees such as raffia *(Raffia faninera)* existed. These plants were/and are used for economic, social and cultural purposes (Yerima and Van Ranst, 2005a; Kometa, 2013). These raffia bushes have largely been destroyed. The destruction of these raffias that serve as buffers in flood regulation exert additional burdens on the wetlands, especially during the rainy seasons. Some patches of the wetland are reclaimed for infrastructural development in defiance of existing national regulations. Semi aquatic and marshland plants species found in the wetlands during the study were mainly herbaceous and shrubby and most showed discoloration in patches throughout the wetland. Human activities involving cutting, of raffias and woody species resulted to an open vegetation with shrubs scattered all over the wetlands. Hyde and Wursten (2007) noted similar vegetation composition in the mining-impacted sites in wetlands along Lake Victoria in East Africa. This could be indicative that, the areas have suffered some degree of disturbance.

In some ponded areas close to the main river course, floating macrophytes were observed. Tita *et al.* (2012) did not identify such plants in the urban segment of the Mezam River system nor made mention of them in ponded areas proxy to it. The latter reported that in 2007, the Nkoup River system was characterized by entropic species such as *Potamogeton spp* and *Ceratophyllum demersum* in the upstream segments considerably impacted by agriculture whereas the downstream and urban segments were dominated by floating and emergent species all of which accumulate and bio concentrate significant amounts of metal pollutants. The fact that these plants were not reported in the agricultural wetlands in Bamenda Municipality is an indication that this wetland is under stress activities and, thus continually degrading. Diverse urban amenities with some having considerably noxious activities have come to existence within the environs of this agricultural wetland of the municipality. These activities either impinge directly through physical alteration and development and/or indirectly through widespread diverse chemical inputs on the agricultural soils. Acho-Chi (1998) had commented on this alteration. Currently 13.5 ha of the area are cultivated for market gardening.

The farmers mostly use buckets and watering cans to convey water from streams to their farms, which are often far away from water sources. At times, they spontaneously construct irrigation channels for the canalisation of the main watercourse into their farms. A few use water pumps and dug up wells to complement the situation. Hydrological analysis indicates that current farmer and urban activities interventions have had medium impact on downstream flow regimes. Similarly, there have been adverse impacts on the water quality of the stream. Apart from vegetables cultivation, the wetlands are exploited for sand excavation all which heavily impacts the ecology of the wetland. Using the definitions for ecological classification of wetlands, the current ecological condition of the wetlands is classified as “moderately modified.”

3.2 Environmental and Health Risk Assessment

3.2.1 Pollution load index and contamination grading

Table 2summarises the pollution load indices and pollution grading’s of the soil samples from the wetland gardens. The pollution load indices for Cr, Mn, Pb, and Cd were averagely 1.01, 1.14, 1.23and 0.48, respectively using the control soil sample of this study as the background concentration. This indicates that the levels of the metals in the soils are slightly but insignificantly higher (P>0.05) than those of the control sample. Though higher, the insignificant difference is an indication that the level of contamination of the soils at moment is not a major problem. However, the indices at different sites were slightly different. The distribution of metals in farmlands at each site was mainly affected by the location of the farmland and agricultural practices. The results strongly agree with those of Tita *et al.* (2011) of metals in soils studying levels of Metals in huckleberry along the banks of river Mezam but contrast those of Liu *et al*. (2005) and Khan *et al.* (2007) who reported significant higher levels of contamination by metals in China irrigated with wastewater. The higher level of contamination observed by them could be associated with the longstanding level of industrialisation of Beijing China as opposed to Bamenda Cameroon, which has few industries.
From the pollution grading, apart from Pb that showed slight pollution, the level of pollution associated with other metals was variable ranging from unpolluted through slight pollution to medium pollution.

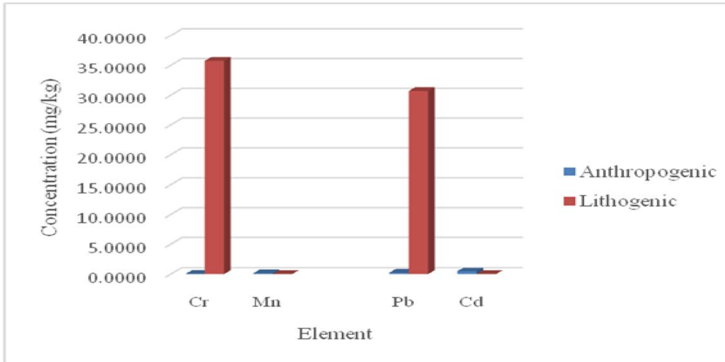
Table 2: Summary of pollution load indices (PLI) and pollution gradings of the soil samples from the wetland gardens in Bamenda Municipality, Cameroon.

Site	Cr (mg/kg)	PLI	Pollution grade	Mn (mg/kg)	PLI	Pollution grade	Pb (mg/kg)	PLI	Pollution grade	Cd (mg/kg)	PLI	Pollution grade
Fuwambi Near Ntasen	36.43	1.03	Slight Pollution	0.04	0.57	Unpolluted	32.88	1.31	Slight Pollution	0.00	0.00	Unpolluted
Fuwambi near GTTC	36.00	1.02	Slight Pollution	0.06	0.86	Unpolluted	31.45	1.25	Slight Pollution	0.00	0.00	Unpolluted
Slap 1	35.62	1.01	Slight Pollution	0.06	0.86	Unpolluted	28.03	1.11	Slight Pollution	1.00	1.00	Slight Pollution
Slap 2	36.21	1.02	Slight Pollution	0.04	0.57	Unpolluted	31.43	1.25	Slight Pollution	0.00	0.00	Unpolluted
Slap 3	34.71	0.98	Unpolluted	0.15	2.14	Medium Pollution	31.13	1.24	Slight Pollution	0.31	0.31	Unpolluted
Slap 4	35.92	1.01	Slight Pollution	0.07	1.00	Medium Pollution	32.68	1.30	Slight Pollution	0.16	0.16	Unpolluted
Slap 5	34.84	0.98	Unpolluted	0.14	2.00	Medium Pollution	30.73	1.22	Slight Pollution	0.93	0.93	Unpolluted
Mile 4 market	36.26	1.02	Slight Pollution	0.08	1.14	Medium Pollution	28.23	1.12	Slight Pollution	1.27	1.27	Slight Pollution
Foncha right of road	34.98	0.99	Unpolluted	0.13	1.86	Medium Pollution	32.15	1.28	Slight Pollution	0.00	0.00	Unpolluted
Foncha left of road	36.14	1.02	Slight Pollution	0.05	0.71	Unpolluted	31.20	1.24	Slight Pollution	0.00	0.00	Unpolluted
Ndamukong	35.86	1.01	Slight Pollution	0.07	1.00	Medium Pollution	32.30	1.28	Slight Pollution	0.13	0.13	Unpolluted
Ntahkah inn	36.27	1.02	Slight Pollution	0.05	0.71	Unpolluted	29.33	1.16	Slight Pollution	0.27	0.27	Unpolluted
Ntahkah out	35.60	1.00	Slight Pollution	0.08	1.14	Medium Pollution	31.15	1.24	Slight Pollution	0.67	0.67	Unpolluted
Ntahkah before bridge	35.30	1.00	Unpolluted	0.12	1.71	Medium Pollution	30.73	1.22	Slight Pollution	0.47	0.47	Unpolluted
Mulang council junction	35.53	1.00	Slight Pollution	0.11	1.57	Medium Pollution	32.18	1.28	Slight Pollution	0.33	0.33	Unpolluted
Mulang left of road	35.34	1.00	Unpolluted	0.08	1.14	Medium Pollution	28.03	1.11	Slight Pollution	1.50	1.50	Slight Pollution
Mulang middle	36.07	1.02	Slight Pollution	0.04	0.57	Unpolluted	28.88	1.15	Slight Pollution	0.74	0.74	Unpolluted
Mulang 4 near houses	36.12	1.02	Slight Pollution	0.06	0.86	Unpolluted	30.53	1.21	Slight Pollution	1.29	1.29	Slight Pollution
Army Rescue	35.87	1.01	Slight Pollution	0.07	1.00	Medium Pollution	32.85	1.30	Slight Pollution	0.11	0.11	Unpolluted
Ngomegham	35.83	1.01	Slight Pollution	0.09	1.29	Medium Pollution	32.38	1.29	Slight Pollution	0.33	0.33	Unpolluted
Average	**35.75**	**1.01**	**Slight Pollution**	**0.08**	**1.14**	**Medium Pollution**	**30.91**	**1.23**	**Slight Pollution**	**0.48**	**0.48**	**Unpolluted**

3.2.2. Anthropogenic and Lithogenic Metal Inputs

The results indicated that (Figure 2) there was significantly very little anthropogenic input of Cr and Pb in the soils of the study area. Contrarily, the amount of Cd added by anthropogenic activities outweighed that contributed by lithogenic activites.

Figure 2. Comparative levels of anthropogenic and lithogenic metal inputs in the wetland gaderns of Bamenda Municipality



The main sources of this metal in soils of the area might not have been restricted to industrial effluents, but may include other municipal, domestic and agricultural sources. Studies in the area (Asongwe*et al.*, 2014) had revealed high use of pesticides and fertilizers, which are all major sources of these elements

3.2.3. Bioaccumulation Factor

The mean values of bioaccumulation factor (BAF) for the metals Cr, Mn, Pb and Cd in Solanum scarbrumstood at 0.0011, 0.082, 0.0012, and 0.1191, respectively (Table 3) with a trend of Cd>Mn>Pb>Cr. This indicates that Cr is the least accumulated metal while Cd and Mn are easily taken up. Tita et al. (2011) had also reported the high rate of transfer of Mn from soils to vegetables in the area. A similar high transfer potential of Cd has been reported by Khan et al. (2007) and Liu et al.(2005) in China. The high transfer valuesfor Cd and Mn from the soil to plants indicates a strong accumulation of the respective metals by food crops, particularly the leafy parts of the vegetables. Typically, the soil-to-plant transfer factor is one of the key components of human exposure to metals through the food chain. The results indicated that the BAF values were lower than those reported in literature by Khan et al. (2007) and Liu et al. (2005) in China which could be ascribed to differences in soil properties.

3.2.4 Daily Intake of Heavy Metals through the Food Chain

The daily intake of heavy metals was estimated according to the average daily vegetable consumption (0.1995kg dry matter for Solanum scarbrum). The estimated daily intake through the food chain (Table 4) was calculated for an adult of an average weight of 65 kg over a lifespan of 55 years (average lifespan in Cameroon). The daily intake values for the heavy metals were significantly low.The intake of Cd was estimated as 9E-7 mg, which represents approximately 0.009 % of the referenced dose (RfD), established to 0.001 mg kg–1 of body weight per day by (FAO/WHO, 2013). The content of Cd intake found was lower than that reported in literature, which ranged between 0.0018 and 0.052 mg per day (Tripathi et al., 1997; Santos et al., 2004; Guerra et al., 2012). Cadmium is a dangerous element because it can be absorbed via the alimentary tract, penetrate through the placenta during pregnancy, and damage membranes and DNA. Once in the human body, it may remain in the metabolism from 16 to 33 years and is connected to several health problems, such as renal damages and abnormal urinary excretion of proteins. Decrease in bone calcium concentrations and increase of urinary excretion of calcium have also been attributed to exposure to Cd, eventually causing death. It also affects reproduction and endocrine systems of women (WHO, 2004). Vegetables may contribute to about 70 % of Cd intake by humans, varying according to the level of consumption (Wagner, 1993).

The average daily intake of Pb was 0.0002 mg estimated at 5 % of the RfD of 0.004 mg/kg of body weight per day set by FAO/WHO (2013). The value is below those reported in literature for rice (0.025 and 0.521 mg/day) (Tripathi et al., 1997; Santos et al., 2004; Guerra et al., 2012). Lead is a very toxic element and it’s reported toxic effects focus on several organs, such as liver, kidneys, spleen and lungs, causing a variety of biochemical defects. The nervous system of infants and children is particularly affected by the toxicity of this heavy metal. Adults exposed occupationally or accidentally to excessive levels of Pb exhibit neuropathology.

Maihara and Favaro (2006) have reported a strong association between Pb in human body and increase of blood pressure in adults. The daily intake of Cr was 0.0001 mg which is lower than the RfD of 1.5 mg kg–1 per day established by FAO/WHO (2013). This value was also significantly (P< 0.01) lower than that recommended by the US National Council (NRC, 1989) for Cr3+,of 0.05 to 0.2 mg. The daily intake of Cr estimated in this work was also lower than that reported in literature, which ranges between 0.013 and 0.098 mg per day (Biego et al., 1998; and Santos et al., 2004, Guerra et al., 2012). Cr is an important element for the insulin activity and DNA transcription, however, an intake below 0.02 mg per day could reduce cellular responses to insulin (Kohlmeier, 2003).

Table 3: Bioaccumulation factor (BAF) for Cr, Mn, Pb and Cd in Solanum scarbrum in urban and peri-urban wetlands of Bamenda.

Site	Cr soil mg/kg	Cr plant mg/kg	BAF	Mn soil mg/kg	Mn plants mg/kg	BAF	Pb soil mg/kg	Pb plant mg/kg	BAF	Cd soil mg/kg	Cd plant mg/kg	BAF
Fuwambi Near Ntasen	36.43	0.04	0.0011	0.04	0.08	2.00	32.88	0.03	0.0009	0.00	0.05	0.0000
Fuwambi near GTTC	36.00	0.07	0.0019	0.06	0.07	1.17	31.45	0.04	0.0013	0.00	0.02	0.0000
Slap 1	35.62	0.04	0.0011	0.06	0.05	0.83	28.03	0.02	0.0007	1.00	0.01	0.0100
Slap 2	36.21	0.02	0.0006	0.04	0.08	2.00	31.43	0.05	0.0016	0.00	0.05	0.0000
Slap 3	34.71	0.01	0.0003	0.15	0.05	0.33	31.13	0.03	0.0010	0.31	0.08	0.2581
Slap 4	35.92	0.06	0.0017	0.07	0.06	0.86	32.68	0.06	0.0018	0.16	0.02	0.1250
Slap 5	34.84	0.04	0.0011	0.14	0.04	0.29	30.73	0.04	0.0013	0.93	0.02	0.0215
Mile 4 market	36.26	0.02	0.0006	0.08	0.06	0.75	28.23	0.07	0.0025	1.27	0.03	0.0236
Foncha right of road	34.98	0.03	0.0009	0.13	0.06	0.46	32.15	0.07	0.0022	0.00	0.03	0.0000
Foncha left of road	36.14	0.02	0.0006	0.05	0.02	0.40	31.2	0.03	0.0010	0.00	0.05	0.0000
Ndamukong	35.86	0.03	0.0008	0.07	0.04	0.57	32.3	0.04	0.0012	0.13	0.04	0.3077
Ntahkah inn	36.27	0.06	0.0017	0.05	0.08	1.60	29.33	0.02	0.0007	0.27	0.07	0.2593
Ntahkah out	35.60	0.02	0.0006	0.08	0.06	0.75	31.15	0.01	0.0003	0.67	0.08	0.1194
Ntahkah before bridge	35.30	0.08	0.0023	0.12	0.08	0.67	30.73	0.02	0.0007	0.47	0.07	0.1489
Mulang council junction	35.53	0.01	0.0003	0.11	0.06	0.55	32.18	0.04	0.0012	0.33	0.03	0.0909
Mulang left of road	35.34	0.04	0.0011	0.08	0.08	1.00	28.03	0.01	0.0004	1.5	0.05	0.0333
Mulang 4 near houses	36.12	0.02	0.0006	0.06	0.01	0.17	30.53	0.06	0.0020	1.29	0.02	0.0155
Army Rescue	35.87	0.08	0.0022	0.07	0.04	0.57	32.85	0.04	0.0012	0.11	0.08	0.7273
Ngomegham	35.83	0.07	0.0020	0.09	0.07	0.78	32.38	0.04	0.0012	0.33	0.08	0.2424
Mbelewa	35.44	0.03	0.0008	0.07	0.04	0.57	25.18	0.04	0.0016	0	0.08	0.0000
Average	**35.71**	**0.04**	**0.0011**	**0.08**	**0.06**	**0.82**	**30.73**	**0.04**	**0.0012**	**0.44**	**0.05**	**0.1191**

Table 4: Daily intake of heavy metals from the consumption of *solanum scarbrum* cultivated in the urban and peri-urban wetland gardens of Bamenda Municipality

Site	Cr (mg/kg)	Daily intake (mg/kg)	Mn (mg/kg)	Daily intake (mg/kg)	Pb (mg/kg)	Daily intake (mg/kg)	Cd (mg/kg)	Daily intake (mg/kg)
Fuwambi Near Ntasen	0.04	0.0001	0.08	0.0002	0.03	0.0001	0.05	7E-7
Fuwambi near GTTC	0.07	0.0002	0.07	0.0002	0.04	0.0001	0.02	4E-7
Slap 1	0.04	0.0001	0.05	0.0002	0.02	0.0001	0.01	1E-7
Slap 2	0.02	0.0001	0.08	0.0002	0.05	0.0002	0.05	1.2E-6
Slap 3	0.01	0.0000	0.05	0.0002	0.03	0.0001	0.08	1.1E-6
Slap 4	0.06	0.0002	0.06	0.0002	0.06	0.0002	0.02	6E-7
Slap 5	0.04	0.0001	0.04	0.0001	0.04	0.0001	0.02	4E-7
Mile 4 market	0.02	0.0001	0.06	0.0002	0.07	0.0002	0.03	1E-6
Foncha right of road	0.03	0.0001	0.06	0.0002	0.07	0.0002	0.03	1E-6
Foncha left of road	0.02	0.0001	0.02	0.0001	0.03	0.0001	0.05	7E-7
Ndamukong	0.03	0.0001	0.04	0.0001	0.04	0.0001	0.04	8E-7
Ntahkah inn	0.06	0.0002	0.08	0.0002	0.02	0.0001	0.07	7E-7
Ntahkah out	0.02	0.0001	0.06	0.0002	0.01	0.0000	0.08	4E-7
Ntahkah before bridge	0.08	0.0002	0.08	0.0002	0.02	0.0001	0.07	7E-7
Mulang council junction	0.01	0.0000	0.06	0.0002	0.04	0.0001	0.03	6E-7
Mulang left of road	0.04	0.0001	0.08	0.0002	0.01	0.0000	0.05	2E-7
Mulang 4 near houses	0.02	0.0001	0.01	0.0000	0.06	0.0002	0.02	6E-7
Army Rescue	0.08	0.0002	0.04	0.0001	0.04	0.0001	0.08	1.5E-6
Ngomegham	0.07	0.0002	0.07	0.0002	0.04	0.0001	0.08	1.5E-6
Mbelewa	0.03	0.0001	0.04	0.0001	0.04	0.0001	0.08	5E-7
Average	**0.04**	**0.0001**	**0.0565**	**0.0002**	**0.04**	**0.0001**	**0.05**	**9E-7**

4. Conclusion

The main focus of this study was to address possible environmental and food security hazards' in vegetable gardens in urban wetlands of the Bamenda municipality, by evaluating the ecological status of the wetland and possible hazard assessment from heavy metals. The results indicated that the wetlands of the municipality have been moderately modified with a loss and change of biota such as the *Raffia fanifera*. Pollution load indices varied considerably at the different sites, and ranged from unpolluted through slight pollution to medium pollution. The mean values of bioaccumulation factor (BAF) for *Solanum scarbrum*, stood at Cd>Mn>Pb>Cr, with respective values of1.23, 1.14, 1.01, and 0.48, insignificantly higher (P>0.05) than those of the control sample. Cadmium is easily transferred in this vegetable than any other metal. The intake of Cd was estimated at 9E-7 mg, representing approximately 0.009 % of the referenced dose (R_fD), established to 0.001 mg kg^{-1}. Due to the gradual degradation of wetlands in Bamenda and the urgent need to secure and improve people's quality of life while simultaneously safeguarding the ecological benefits derived from the wetland, policy makers should integrate conservation and Development in planning.

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Competing Interest

All authors have declared that no competing interests exist.

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