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HEAVY METAL CONTAMINATION AND FAECAL COLIFORMS IN PERI-URBAN MARKET GARDENING SITES IN BENIN AND CAMEROON

Running Title: Heavy metals and faecal coliforms in market gardening sites.

Rousseau Djouaka[1], Francis Zeukeng[1,2,*], Murielle Farrelle Eurydice Soglo[1,3], Razack Adeoti[1], Omolacho Merdie Zinsou Ahoukpo[3], Taïra Sarah Tamou-Tabe[4], Armand Paraïso[4], Innocent Djegbe[1,5], Manuelle Tamo[6], Victor Manyong[7], Sali Atanga Ndindeng[8].

[1]AgroEcoHealth Platform, International Institute of Tropical Agriculture (IITA), 08 P.O.Box 0932, Tri-Postal Cotonou, Benin.

[2]Faculty of Science, Department of Biochemistry, University of Yaoundé I, P.O.Box 812, Yaoundé, Cameroon.

[3]Faculty of Agronomic Science, Department of Nutrition and Foods Science, University of Abomey-Calavi, P.O.Box 526, Cotonou, Benin.

[4]Faculty of Agronomy, Department of Science, Techniques and Vegetal Production, University of Parakou, P.O.Box 123, Parakou, Benin.

[5]Ecole Normale Superieure of Natitingou, University of Science, Arts and Techniques of Natitingou, P.O.Box 123, Natitingou, Benin.

[6]International Institute of Tropical Agriculture (IITA), 08 P.O.Box 0932, Tri-Postal Cotonou, Benin.

[7]International Institute of Tropical Agriculture (IITA), P.O.Box 34441, Dar-es-Salaam, Tanzania.

[8]Institute of Agricultural Research for Development (IRAD), Nkolbisson, P.O.Box 2123, Messa-Yaounde, Cameroon.

***Corresponding author:** zeusfranck07@yahoo.com,
Tel: (+229) 61252901, (+237) 677682563

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ABSTRACT

Water used for irrigation always contains measurable quantities of dissolved substances that may accumulate in the soil with serious consequences on human health and the environment. A descriptive study was carried out on market gardeners in Cotonou and Parakou in Benin and Yaoundé in Cameroon to assess the presence of coliforms and heavy metals contamination in water used for irrigation and their fresh produces on the farm fields. Ninety structured questionnaires were administered on farmers to get information on market gardening practices (water sources used for irrigation, watering systems and cultivated fresh produces), consumption of fresh produces, and human health risks. Waters used for irrigation and vegetables were carefully collected to assess the heavy metals contamination (Pb, Cd, As, Cu) and faecal coliforms using the new advanced Metalyser Pro HM3000 and the membrane filtration methods respectively. Heavy metals concentrations which are below the WHO threshold limits in both irrigation water sources and fresh produces ranged as Cu>Pb>As>Cd from the study sites in Cameroon and Benin. The average concentrations of faecal coliforms found in both irrigation water sources and their fresh produces were harmful when compared to WHO threshold limits. The study site of Baouèra in Benin had the highest level of harmful contaminants in irrigation water sources (*F = 18.78; P = 0,003)* and the corresponding fresh produces (*F = 5.16; P = 0.049*). The results also revealed that the health risks awareness of these contaminants might impact the consumption of fresh produces in market gardeners in Baouèra. Regular monitoring for safe market gardening practices is strongly recommended in order to break down the harmful levels of contaminants found in consumed fresh produces.

Keywords: Irrigation water, vegetables, heavy metal, faecal coliforms, Benin, Cameroon.

1. INTRODUCTION

Farmers usually take advantage of the water available at their vicinity for crop irrigation and are not often aware on the quality of the water and the implications of using contaminated water for crop cultivation (Mustapha and Adeboye, 2014; Farooq et al., 2008). It is a fact that crops irrigated with contaminated water may be unsafe for human consumption. Generally, about 18% of crops are irrigated with wastewaters and 40% of our food produces are from these crops, which feed over 10% of the world's population (Akrong et al., 2012; Gleick, 2000). Wastewaters contain large amounts of organic materials, pathogens, inorganic elements and substantial amounts of toxic heavy metals (Zavadi, 2009; Arora et al., 2008; Lone et al., 2003), as well as non essential metals which when present in large amounts could be transferred to animal and human beings through food chain (Lone et al., 2003). These substances are generally from both natural (weathering, erosion of parent rocks, atmospheric deposition and volcanic activities, etc.) and anthropogenic (sewage irrigation, addition of manures, fertilizers and pesticides, etc.)

activities (Sekemo et al., 2011). Yadav et al. (2002) and Datta et al. (2000) showed that long-term application of contaminated irrigation waters can result in the accumulation of metals and/or microbial pathogens in soil and consequently in crops. In fact, by overcoming the innate immune response of plants, surface pathogenic microorganisms can actively enter the plants and survive for a long periods (Schikora et al., 2008) and might escape postharvest treatment procedures. Similarly, toxic metals may be absorbed by vegetables through several processes and finally enter the food chain at high concentrations which are capable of causing serious health risks to consumers (Lugwisha and Othman, 2014; Kihampa et al., 2011). Unfortunately, the presence of these substances is harmful to human health because of the persistent and non-biodegradable nature of the heavy metals and their potential to accumulate in different parts of the body (Lugwisha and Othman, 2014; Lawal and Audu, 2011). Accumulation of high toxic metals as Cadmium (Cd) even at low concentration in waters and crops leads to the buildup of Cadmium in kidneys and eventually leading to kidney diseases. Other effects of metal toxicity may include damage or reduce mental and central nervous function, lower energy levels, damage to blood composition, lungs, kidneys, liver and other vital organs (Kihampa et al., 2011). Although climate, atmospheric deposition, nature of soil on which plants are grown and the degree of maturity of plants at the harvesting time can influence the concentrations of heavy metals in plants (Farooq et al., 2008; Muchuweti et al., 2005), contaminants uptake in crops is regulated by several factors including bioavailability in soil, distribution in crop, and the contaminant and crop type (Tom et al., 2014; Rattan et al., 2005). Vegetables with short growth cycles like carrot, lettuce, tomato, cabbage, and celery, are often eaten uncooked and stand as potential source for development of microorganisms that could easily infect human. The high population, poverty and sometimes high cost of living in urban and peri-urban cities of developing countries in Africa have forced urbanites to farm these crops within and around the cities for consumption and income generation (Schackleton et al., 2009). Water and soil in these cities are rich in nutrients (N, P, K, S and Mg) generally from wastes which make vegetables large and appealing (Mutune et al., 2014). This makes urban and peri-urban sustainable agriculture a major concern for both the environment and human health. There is therefore a need to address this constraint and help to inform relevant policy interventions. This present study was designed to investigate the concentration of some selected toxic heavy metals (Pb, Cd, As, Cu) and faecal coliforms in waters used for irrigation and the resulting fresh produces from market gardening sites in Parakou and Cotonou (Benin) and Yaoundé (Cameroon).

2. MATERIAL AND METHODS

2.1 Study areas

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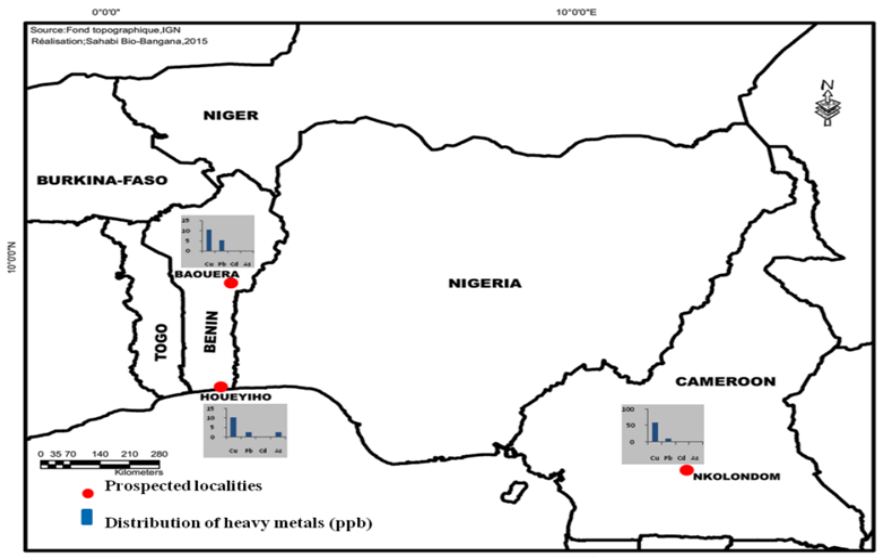
The study was carried out in Benin (West Africa) and Cameroon (Central Africa). Two market gardening sites (Houeyiho and Baouèra) in Benin and one in Cameroon (Nkolondom) used for this study are described below (**figure 1 and table 1**) (Allagbe et al., 2014; Temple et al., 2008; Akomagni, 2006; Kora, 2006; Temple and Moustier, 2004).



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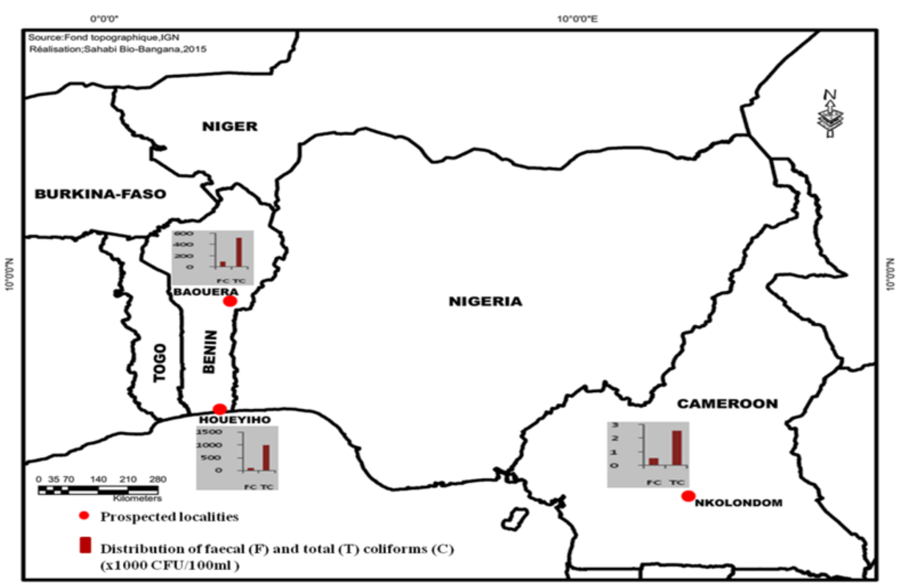

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Figure 1: Geographic map of study sites in West and Central Africa with heavy metals distribution (1a) and coliforms distribution (1b).

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Table1: Description of market gardening sites in Cameroon and Benin

CHARCTERISTICS	STUDY SITES		
	Nkolondom (Yaounde)	**Houeyiho (Cotonou)**	**Baouèra (Parakou)**
Location in Africa	Central Africa	West Africa	West Africa
Country	Republic of Cameroon	Republic of Benin	Republic of Benin
Administrative position	Political city (Centre Region)	Political city (Cotonou) (South region)	North capital (North region)
Urbanisation level	Urban	Urban	Urban
Geographical location	3º55'N-11º31'E	6º36'N-2º41'E	9º31'N-2º63'E
Mean altitude	800m	20m	350m
Climate type	Equatorial (four seasons)	Sub-Equatorial (four seasons)	Wet Tropical (two seasons)
Mean annual rainfall	1.700mm	1.100mm	1.200mm
Mean annual Temp	27ºC	27ºC	29ºC
City Population	1, 8 million inhabitants	665.100 inhabitants	149. 819 inhabitants
Main Ethnic groups	Bétis, Etons, Bassas, Bafias, Boulous, Fangs	Fon (32.9%), Goun (15.2%), Mina (5.9%), Yoruba (5.5%)	Batonu (29.4%), Fon (18.7%), Dendi (15.4%), Yoruba (14.9%)
Main sources of water	Camwater, rivers (Mfoundi, Mefou, Nyong, Ntsas, Ntem), wells, drillings and dregs	SONEB, Atlantic Ocean, Nokoué lake, Lagoon, wells, drillings and dregs	SONEB, rivers (Okpara, Ouemé), wells anddrilligs
Nature of soil	Hydromorphic and ironic	Sandy and acidic soil	Light texture soil (poor)
Main Agricultural crops	Tubers, Cereals, vegetables (lettuces,	Vegetables (cabbage, carrot, lettuce,	Cereals, tubers, vegetables (cabbage, carrot, lettuce,

	tomato, black morel, amaranth, celery, etc.)	amaranth, cucumber, etc.)	amaranth, cucumber, etc.)
Characteristics of farms (agricultural area)	200-2500 meter square per market gardener, with a total of 400-500 farmers. High use of chemical pesticides.	14 hectares for 3000 farmers and important use of chemical pesticides and fertilizers	12 hectares with important use of chemical pesticides and fertilizers

2.2 Study type

Descriptive cross-sectional study was conducted between October to November 2014 in selected farms using systematic random selection criteria after the aims and objectives of the study were explained to the volunteered farmers. A structured field questionnaire was administered to 90 volunteered farmers (30 per site) to gather the socio-demographic information (age, sex, social status and number of children), identify farming practices (types of vegetable cultivated, cropping periods and annual cropping frequency, type of water used for irrigation and watering system, pesticide regimes (types of pesticides used and treatment frequencies), and farmer's perceptions on: the quality of waters used for irrigation, the quality of vegetables produced, the estimated frequency of vegetable consumption in households and potential health risks associated with vegetable consumption. In addition to the questionnaire, a direct observational form was used to record additional information during field surveys.

2.3 Sampling of water sources used for irrigation

Irrigation water samples were aseptically collected in the 3 selected vegetable farms (Nkolondom, Houeyiho and Baouèra). Early morning collection of water samples was made at the irrigation spot. A composite sample consisting of each irrigation spot was constituted and sampled water was transferred into sterile glass bottles for microbial analysis and in clean high-density polyethylene bottles for metal analysis. The polyethylene bottles were washed and soaked in HCl 0.01N overnight, and now washed three times with deionized water following the cleaning method described by (Chary et al., 2008). All water sources used for vegetables irrigation were sampled in three replicates, labelled, refrigerated and transported to Agriculture, Environment and Health Laboratory of the International Institute of Tropical Agriculture in Benin (AgroEcoHealth Laboratory, IITA-Benin) for subsequent heavy metal analyses. Microbial

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analysis was always done on the day of collection to avoid any microbial development. A total of 18 water samples were analysed from the study sites.

2.4 Sampling of fresh vegetable produces

Vegetables (lettuce, carrot, and celery) identified in each study site were randomly and aseptically collected in the morning. Composite samples were made and at least 500g of the edible part of each vegetable was sampled in three replicates, stored in zip bags and properly labelled. The samples were then refrigerated and transported for analysis at the AgroEcoHealth Laboratory in IITA, Benin.

2.5 Heavy metal analysis in waters and fresh vegetable produces

2.5.1 Extraction of metals from fresh produces

Heavy metal analysis was done after the fresh produce was digested and metals extracted into an aqueous solution. Each vegetable collected was rinsed with deionized sterile water to remove soil particles and sliced into smaller portions. The vegetables were oven dried (50ºC-12h and 120°C-24h) and ground into powdered form to facilitate plant digestion and metal extraction (Koumoloua et al., 2013). The extraction was performed using Metalyser HM4000 machine (Trace2O, Berkshire, UK). One gram of each vegetable powder was introduced into a digestion beaker, dissolved in 18 ml deionized water with one tube of each digestion solution containing the mixture of strong acids and oxidants (D1, D2 and D3), connected to a digestion probe and digested using the Metalyser HM4000 for 30 minutes. The reaction was now left to settle for 5 minutes. The supernatant was removed with the filtered syringe and introduced into the analysis beaker, and the beaker was filled up to 70ml with deionised water.

2.5.2 Metal analysis of water and fresh produce extracts

Levels of Cd, Pb, Cu and As in irrigation water sources and fresh produces were obtained using the Metalyser HM3000 machine (Trace2O, Berkshire, UK). The method used was the Voltammetric analysis technique and 15 heavy metals of 14 M groups can be quantified. The metals analyzed in this study constitute the M1 group (Cd and Pb), M3 group (As) and M4 group (Cu). The analysis probe contains three types of electrodes including the reference, the counter and the working electrodes (WE1, WE2 or WE3), the temperature probe and the stirrer. The Working Electrode (WE) is selected accordingly to the metal of interest. Reagents (buffers and standards) and sample analysis beakers were also selected according to the metal M groups. The metal analysis procedure consists of three steps: electrode conditioning, sample analysis and graphical displaying of results.

2.5.2.1 Quantification of Cadmium and Lead

Working Electrode 1 (WE1) and M1 group reagents were used to analyze Cd and Pb. WE1 was polished using the polishing slurry and checked that no scratches or scuffs were present. Electrode conditioning was then achieved with M1, 4,5 conditioning solution to form a very thin grey plate on the surface of the working electrode. The solution was half filled into the analysis beaker fitted to the analysis probe and M1, 4,5 conditioning was selected from the Measurements available menu, the condition electrode was launched on the analysis panel and the analysis was achieved at approximately 5 min. One sachet of M1 4,5a and M1 4,5b buffers were added into the analysis beaker with 70ml sample before connected to the probe. The Single Point Standard Addition Procedure was used for the analysis. The Metalyser was first used to scan the sample to determine if the metals were present and measured the response. A prompt was given to add a standard to the sample, then, 280µL of M1 standard was added corresponding to 20ppb of Cd and Pb. This gave an increase in peak height from which the sample concentration was calculated. The deposition time used was 60s. The results were showed in the analysis window and were displayed as graphs or voltammogram (plot of output current vs applied potential). The results (concentrations) in part per billion (ppb) were automatically entered into the results log. Two graphs were displayed, the first (black) was the scan of the concentration of original sample and the second (red) was after the standard addition. The first peak displayed was for Cd and the second was for Pb.

2.5.2.2 Quantification of Cooper and Arsenic

Analysis of Cu (M4 group) and As (M3 group) was carried out as described for Cd and Pb using different electrodes and reagents (buffers and standards). For As analysis, M3 reagents and Working Electrode 2 (WE2) were used whereas M4 reagents and Working Electrode1 (WE1) were used for Cu analysis. However, only one peak was displayed and corresponded to As or Cu concentration.

2.6 Quantification of total and faecal coliforms

Microbial analysis is based on the detection of pathogens that originated from faecal contaminations. The membrane filtration method was used to determine the number of faecal and total coliforms bacteria populations in irrigation waters and vegetables produced. This method consists of filtering water sample on a 0.45µm sterile filter which retains bacteria, incubating the filter on a selective medium, and counting typical colonies on the filter (Rompre et al., 2002). The culture medium Membrane Lauryl Sulphate Broth provided by the supplier (Trace2O, Berkshire, 2014, UK) and selective for coliforms analysis was used (Mallmann and Darby,

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1941). Two milliliters of the broth was also added on sterile absorbent pads into a sterile petri dish provided by the same supplier.

Each irrigation water sample (10 ml) was aseptically introduced into a sterile erlenmeyer flask with the use of a pipette, diluted tenfold by adding 90 ml of sterile physiological saline water, and followed by subsequent decimal dilution (up to 10^{-5}) using the same diluent. Fresh produce sample (50 g) was aseptically ground, diluted by adding 450ml of sterile physiological saline water into a sterile glass bottle, and homogenized for 10min. A serial decimal dilution (up to10^{-5}) using the same diluent was now prepared. From each dilution, 50ml was filtered through a 0.45µm filter membrane and the membrane was laid down on petri dishes containing the culture broth. Each encoded petri dish was left for an hour in the hood for bacteria revivification and incubated for 24h at 37°C for total coliforms or 44ºC for faecal coliforms analysis. Colony of coliforms appeared yellowish after the incubation time and was expressed as the number of colony in 100 ml (CFU/100ml).

2.7 Statistical analysis

The data were statistically analyzed using STATISTICA, version 7.1 and the Microsoft Excel, 2010 computer package. Non-parametric test (Kruskal-Wallis-One Way ANOVA) was used for assessing differences in the heavy metals and coliforms concentrations among investigated matrixes and locations. Results were explained in terms of arithmetic mean and standard deviation. The level of significance was set at 5%.

3. RESULTS

3.1 Demography of the study population

Data obtained from the socio-demographic study revealed an equal proportion of female and male involved in market gardening in Nkolondom. In contrast, most vegetable farmers in Benin were male with 86.7% in Houeyiho and 96.7% in Baouèra ($p<0.001$). It was observed that women in Benin are mostly found at the end of the vegetable production chain for either buying or selling vegetable produces. A good number of the farmers are between 31-60 years with an average age of 45±10.6, 42.2±13.8 and 37.9±16.8 years in Nkolondom, Houeyiho and Baouèra. Analysis of matrimonial status of market gardeners revealed that most farmers are married in Nkolondom (83.3%), Houeyiho (73.3%) and Baouèra (60%) with a minimum number of four children in each family. While some single farmers agreed to have only one child (**table 2a**).

Table 2a: Baseline data of market gardeners in study sites.

Farmer'scharacteristics		Nkolondom		Houeyiho		Baouera	
		N	F (%)	N	F (%)	N	F (%)
Number collected		30	100	30	100	30	100
Sex	Male	17	56.7	26	86.7	29	96.7
	Female	13	43.3	4	13.3	1	3.3
Age group (*years*)	18-30	4	13.4	8	26.7	13	43.3
	31-60	25	83.3	18	60	14	46.7
	>60	1	3.3	4	13.3	3	10
Social status	Single	5	16.7	8	26.7	12	40
	Married	25	83.3	22	73.3	18	60
Average Number of children according to social status	Single	1.4±2.1		0.3±0.7		0.7±1.6	
	Married	4.5±2.2		4±2.2		6.2±4.3	

Values are expressed as number of cases (N) with frequencies (F) in percentage (%).

3.2 Source of waters used for irrigation and irrigation systems

The waters used for irrigation and the irrigation water systems adopted by farmers in Cameroon and Benin were investigated (**table 2b**). In the study site of Nkolondom in Yaoundé, water used for irrigation is mainly from rivers (100%) and the irrigation systems put in place include watering can (100%) and motor-pump (33.3%). Irrigation systems in Benin are from four different sources which include well water, wastewater, drilling and swamps. At least two of these waters are used simultaneously in the same field. In the vegetable farm of Houeyiho in Cotonou, 73.3% of interviewed farmers use drilling, 63.3% use well and 20% use swamp waters for irrigation. In the vegetable site of Baouèra in Parakou, sources of irrigation waters used include well (83.3%) and wastewater (63.3%). No river was identified for vegetables irrigation in Benin. Considering the irrigation systems in Benin, watering can constituted the main watering system used with 93.3% in Houeyiho and 100% in Baouèra. Other watering systems used included motor-pumps.

Table 2b: Distribution of irrigation water sources and watering systems in study sites.

Irrigation water source and Watering system		Nkolondom		Houeyiho		Baouera	
		N	F (%)	N	F (%)	N	F (%)
Irrigation water source	River	30	100	0	NA	0	NA
	Well	0	NA	19	63.3	25	83.3
	Wastewater	0	NA	0	NA	19	63.3
	Swamp	0	NA	6	20	0	NA
	Drilling	0	NA	22	73.3	0	NA
Watering system	Watering can	30	100	28	93.3	30	100
	Motor-pump	10	33.3	19	63.3	3	10
	Tourniquet	0	NA	16	53.3	0	NA
	Link	0	NA	11	36.7	0	NA

Values are expressed as number of cases (N) with frequencies (F) in percentage (%). NA: Not applicable.

3.3 Distribution of fresh produces

The type of vegetables cultivated in this study is based on the vegetable demands in the market; as a matter of fact farmers grow vegetables with high market demands. Almost 20 varieties of fresh produces were identified in each study site (**table 2c**). There was low production of fruit-vegetables (tomato, pepper, cucumber, etc.). Generally, lettuce (*Lactuca sativa*), carrot (*Daucus carota*), celery (*Apiumgra veolens*), morel (*Solanumma crocarpon*), cabbage (*Brassica oleracea*), amaranth (*Amaranthus hybridus*) and parsley (*Petroselinum sativum*) were among the most common crops found. In Nkolondom, 100% of farmers grow lettuce, 83.3% celery, 80% parsley, 80% morel, and 66.7% amaranth. A similar trend was recorded in Houeyiho and Baouèra in Benin. Carrot was grown by 100% and 93.3%, lettuce by 100% and 93.3%, cabbages by 90% and 73.3%, amaranth by 63.3% and 63.3%, and morel by 100% and 43.3% of farmers in Houeyiho and Baouèra respectively. In contrast to Nkolondom, celery was found to be less cultivated in Baouèra and Houeyiho. On the other hand, carrot was not found in Nkolondom. This justifies why our analyses were carried out on lettuce and Carrot in the studies sites of Benin, and lettuce and celery in Nkolondom.

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Table 2 c: Distribution and treatment of fresh produces in study sites.

Distribution and treatment of fresh produces			Nkolondom		Houeyiho		Baouèra	
			N	F (%)	N	F (%)	N	F (%)
Fresh produces (Scientific name)	Carrot (Daucus carota)†		0	NA	30	100	28	93.3
	Lettuce (Lactuca sativa)†		30	100	30	100	28	93.3
	Celery (Apium graveolens)†		25	83.3	1	3.3	5	16.7
	Cabbage (Brassica oleracea)		4	13.3	27	90	22	73.3
	Amaranth (Amaranthus hybridus)		20	66.7	19	63.3	19	63.3
	French bean (Phaseolus vulgaris)		0	NA	5	16.7	15	50
	Morel (Solanum macrocarpon)		24	80	30	100	13	43.3
	parsley (Petroselin umsativum)		24	80	19	63.3	12	40
	Sweet pepper (Capsicu mannuum)		3	10	19	63.3	9	30
	Cucumber (Ecballium elaterium)		4	13.3	21	70	6	20
	Vernonia (Vernonia amygdalina)		6	20	25	83.3	4	13.33
	Pepper (Capsicum frutescens)		10	33.3	15	50	3	10
	Tomato (Lycopersicone sculentum)		4	13.3	13	43.3	3	10
	Mint (Mentha spicata)		1	3.3	17	56.7	2	6.7
	Potager (Corchorus olitorius)		11	36.67	0	NA	2	6.7
	Gombo (Abelmoschus esculentus)		2	6.7	0	NA	2	6.7
	Aubergine (Solanume sculentum)		1	3.3	6	20	2	6.7
	Beetroot (Beta vulgaris)		0	NA	0	NA	1	3.3
	Leek (Allium porrum)		4	13.3	9	30	0	NA
	Watermelon (Citrullus lanatus)		1	3.3	0	NA	0	NA
	Basil (Ocimum basilicum)		17	56.7	5	16.7	0	NA
farm's characteristics	Use of pesticides	YES	30	100	30	100	20	66.6
		NO	0	NA	0	NA	10	33.3
	Use of fertilizers	YES	30	100	30	100	30	100
		NO	0	NA	0	NA	0	NA

Values are expressed as number of cases (N) with frequencies (F) in percentage (%). †: vegetables used for chemical and microbial analysis. NA: Not applicable

3.4 Heavy metal composition of irrigation waters

Using the advanced Metalyser Pro HM3000 machine (Trace2O, Berkshire, UK), we analysed the concentrations of lead (Pb), Cadmium (Cd), Arsenic (As) and Cupper (Cu) in irrigation waters and fresh vegetable produces from the three target agricultural sites. Result showed that the concentrations of As and Cu in waters used for irrigation were significantly different among the study sites (As: p=0.011; Cu: p=0.014). However, the concentrations of Cd and Pb were not statistically different among irrigation water sources. The concentrations of metals in all water sources were under the WHO threshold limits and the mean concentrations ranged as Pb>Cu=As=Cd in river in Nkolondom (**figure 2a**). In Houeyiho (**figure 2b**), these concentrations ranged as Cu>As>Pb>Cd in well, As>Pb>Cu=Cd in drilling and Pb>Cu>As=Cd in swamp while in Baouèra (**figure 2c**), the order was Cu>Pb>As=Cd both in well and wastewater.

The concentration of As was very low (<0.001 ppb) in all water sources found in Nkolondom and Baouèra. However, As was more concentrated in drilling (8.67±.58 ppb) and well (3.33±2.89 ppb) in Houeyiho. The highest concentration of Cu was found in Wastewater (5.99±3.30 ppb) in Baouèra and well in Houeyiho (5.48±1.31 ppb). Overall, the concentration of Cd was very low (<0.001 ppb) in all water sources found in the three study sites. The levels of Pb in Baouèra were 2.41±1.11 ppb in wastewater and 0.84±1.46 ppb in well while a very low concentration was found in Nkolondom (river). This study showed that Cu and Pb were more accumulated in surface or opened-air waters (well, swamp, river and wastewater) than in ground-water (drilling). In addition, the metal concentrations were smaller in fluvial water from streams compared to stagnating water from pools.

3.5 Heavy metal composition of fresh produces

The fresh produce analysed in this study were found to be contaminated by heavy metals. The levels of metals found differ with vegetable site and the type of cultivated produces. Cu and Pb were the main contaminants detected in fresh produces from Nkolondom, Houeyiho and Baouèra. The concentrations of Cd (p=0.013), Cu (p=0.08), and Pb (p=0.011) were statistically different among investigated fresh produces. The metal concentrations ranged from Cu>Pb>As=Cd in lettuce and celery in Nkolondom (**figure 2a**). In Houeyiho (**figure 2b**), it ranged from Cu>Pb>As=Cd in lettuce and Cu>Pb>Cd>As in carrot. Heavy metal concentrations in lettuce and carrot from Baouèra also ranged as Pb>Cu>As=Cd, and Cu>Pb>Cd>As respectively (**figure 2c**). Only carrot was found to be contaminated by Cd in Houeyiho (0.64±0.06 ppb) and Baouèra (0.192±0.332 ppb). Cu was found to be more concentrated in celery (111.52±47.19 ppb) and lettuce (60.68±15.28 ppb) in Nkolondom. The most significant

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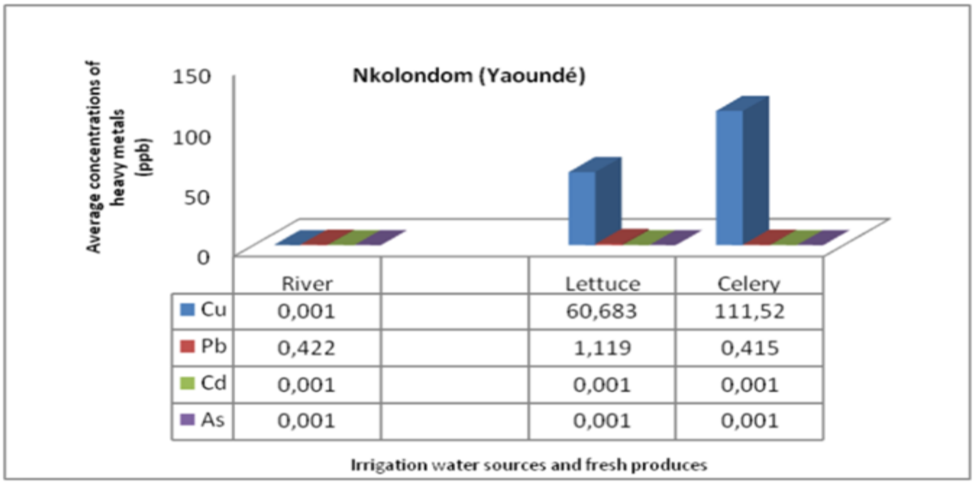
concentrations of Pb were found in lettuce (9.19±6.58 ppb) and carrot (7.97±1.53 ppb) from Baouèra. The concentrations of Pb and As remained very low in fresh produce from Nkolondom.



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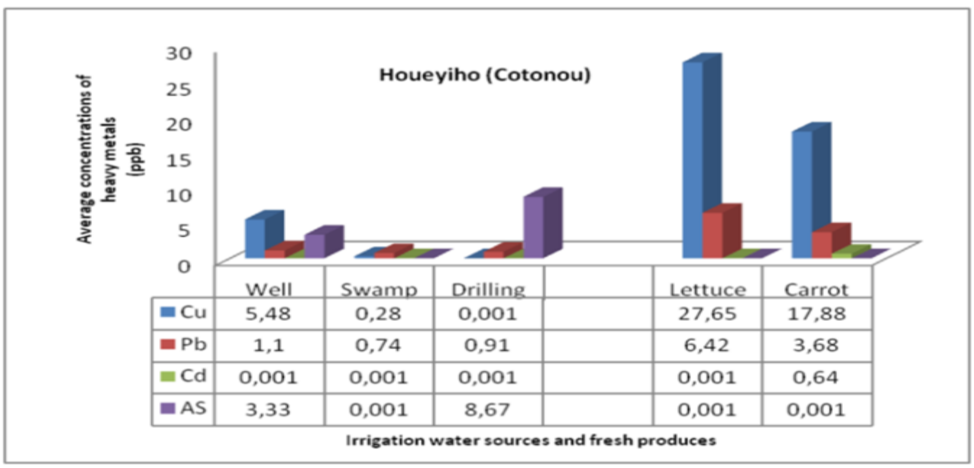
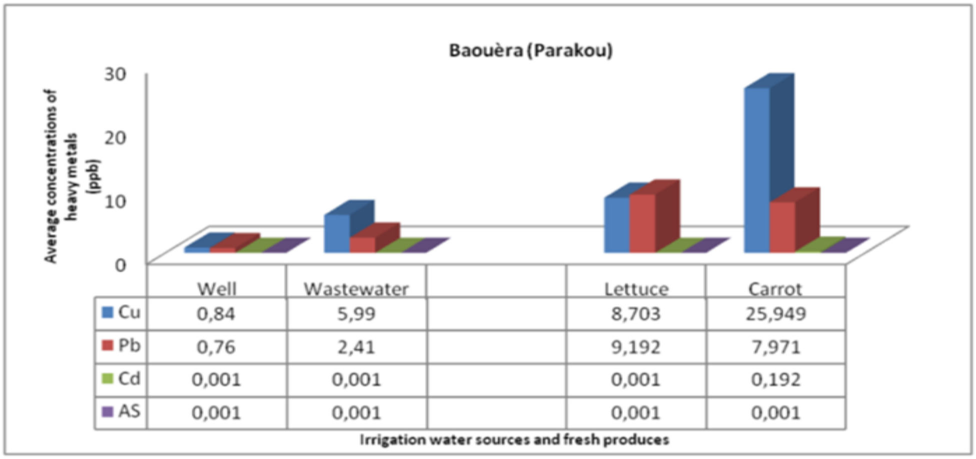


2b



2c

Figure 2: Average concentrations of heavy metals in irrigation water sources and fresh produces in Nkolondom (2a), Houeyiho (2b) and Baouèra (2c).

3.6 Total and Faecal coliforms contamination of irrigation waters

Analysis of faecal microorganisms in irrigation water sources revealed the presence of microbial pathogens. Based on the irrigation water source, there was a significant difference in the concentrations of faecal ($p=0.006$) and total ($p=0.006$) coliforms found in the three study sites. The highest concentrations of faecal coliforms were found in well waters whereas drilling waters were found to be less contaminated in faecal pathogens. The average amounts of faecal and total coliforms found in the vegetable farm of Nkolondom were 100±82 CFU/100ml and 3467±170 CFU/100ml respectively (**table 3a**). This vegetable farm was less contaminated with faecal microorganisms than that of Baouèra and Houeyiho. However, in Benin almost all water sources used for irrigation (well, wastewater and swamp) had harmful concentrations of faecal coliforms (>1000 CFU/100ml). The level of contamination in water sources at Houeyiho ranges as follows: well>swamp>drilling with the corresponding faecal contaminations values of 3470±201 CFU/100ml in well waters, 1670±416 CFU/100ml in swamp and 0.67±1.15 CFU/100ml in drilling waters respectively (**table 3b**). In Baouèra vegetable growing site, well water (22533±1543 CFU/ml) was more contaminated than wastewaters (2,633±499 CFU/ml) collected from municipal drainage systems serving as irrigation system (**table 3c**).

3.7 Total and Faecal coliforms contamination of fresh produces

Fresh produces are more contaminated with faecal microbial pathogens than irrigation water sources and this is also the trend recorded with the heavy metal analysis. Generally, all the fresh produced analysed were found to contain harmful concentrations of faecal and total coliforms

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when compared to the WHO threshold standards. The levels of faecal and total coliforms contamination were significant based on the type of fresh produce (p=0.014), with lettuce being the most contaminated farm produce. Lettuce (266.67±152.75 CFU/g) was more contaminated with faecal coliforms than celery (150±70.71 CFU/g) in Nkolondom vegetable farm (**table 3a**) Lettuce is also more contaminated with faecal coliform than carrot in Benin with the concentrations of 2,200±1,550 CFU/g (lettuce) and 66.70±11.50 CFU/g (carrot) in Houeyiho; and 2233.33±895.67 CFU/g (lettuce) and 267±47.11 CFU/g (carrot) in Baouèra (**tables 3b, 3c**).

Table 3a: Faecal and total coliforms levels in irrigation water sources and Fresh produces in Nkolondom.

Nkolondom (Yaoundé)			
Coliforms **(Log 10** *CFU/100*	Irrigation water sources (*mean value±SD*)	Fresh produces (*mean value±SD*)	
	River	Lettuce	Celery
Faecal Coliforms	2.000 ± 1.914	4.426 ± 4.097	4.176 ± 3.699
Total Coliforms	3.540 ± 2.230	5.630 ± 4.667	5.538 ± 4.653

Table 3b: Faecal and Total coliforms levels in irrigation water sources and Fresh produces in Houeyiho.

Houeyiho (Cotonou)					
Coliforms **(Log 10** *CFU/100 ml or g***)**	Irrigation water sources (*mean value±SD*)			Fresh produces (*mean value±SD*)	
	Well	Swamp	Drilling	Lettuce	Carrot
Faecal Coliforms	3.540 ± 2.303	3.222 ± 3.619	-0.174 ± 0.061	5.342 ± 5.190	3.824 ± 3.061
Total Coliforms	4.256 ± 4.301	5.098 ± 4.674	2.380 ± 1.400	6.538± 5.107	6.111 ± 5.316

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Table 3c: Faecal and total coliforms levels in irrigation water sources and Fresh produces in Baouèra.

Baouèra (Parakou)				
Coliforms (**log 10** *CFU/100 ml or g*)	Irrigation water sources (*mean value±SD*)		Fresh produces (*mean value±SD*)	
	Well	Wastewater	Lettuce	Carrot
Faecal Coliforms	4.352 ± 3.176	3.420 ± 2.698	5.348 ± 4.952	4.427 ± 3.673
Total Coliforms	3.279 ± 3.146	3.756 ± 1.903	6.290 ± 6.328	5.090 ± 5.117

3.8 Quality of irrigation water, harvested fresh produces and human health

In order to evaluate the socio-economic and health impact of farm produces on farmers and potential consumers, information was gathered on risks awareness, the rate of consumption of fresh produce; and these factors were correlated with the level of contaminants. Data collected from the questionnaires administered revealed that farmers from Houeyiho (90%), Nkolondom (70%) and Baouèra (30%) are regular consumers of fresh produces. Further study showed that 76.2 %, 66.7% and 66% of market gardeners from Nkolondom, Houeyiho and Baouèra respectively recognised the potential contamination in these farm products. Interestingly, 53.33% of market gardeners in Baouera do not eat their produces because they are aware on the potential health risks associated. They also confirmed about the poor quality of waters they use to irrigate vegetables. In contrast, there was not any significant association among the risk information of contaminants and the consumption of fresh produces in other investigated sites. In fact, even if these last sites had harmful level of coliforms, their level of contamination was significantly lower than that of the Bouera site according to both irrigation water sources ($F = 18.78$; $P = 0,003$) and the corresponding fresh produces ($F = 5.16$; $P = 0.049$). Market gardeners from Baouera may therefore don`t care about the health risks of the consumers of the fresh produces they cultivate. The main health problems registered in the three study sites include malaria, thyphoid fever, amoeba, cholera. Different physical issues and symptoms were also recorded such as back pain, headache, vomiting, diarrhoea, cough, spots all over the body and athletic foots which varied across the study sites (**table 4**). Although, other sources of health problems were gathered when administering the questionnaire such as drudgery (67-90%) working environment (7-50%) irrigation water (23-40%) and inhalation or contact with pesticides/fertilizers and only between 33-80% of farmers visit the hospital while 57-80% make use of local medicine for treatment and just a few visit the pharmacy for drugs.

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Table 4: Origin, distribution and precautions against diseases in market gardeners

QUESTIONNAIRE CHARACTERISTICS		Nkolondom		Baouèra		Houeyiho	
		N	F (%)	N	F (%)	N	F (%)
Regular consumption of fresh produce in market gardeners	YES	21	70	9	30	27	90
	No	9	30	21	70	3	10
Frequent diseases/symptoms found in market gardeners	Malaria	12	40	16	53.3	19	63.3
	Stomach ache	12	40.0	14	46.7	9	30
	Headache	13	43.3	14	46.7	20	66.7
	Diarrhoea	6	20	10	33.3	0	0
	Tiredness	22	73.3	14	46.7	20	66.7
	Typhoid fever	10	33.3	7	23.3	1	3.3
	Athletic foots	12	40	6	20	8	26.7
	Back pain	7	23.3	3	10	4	13.3
	Cough	8	26.7	9	30	7	23.3
	Cold	6	20	11	36.7	8	26.7
	Cholera	1	3.3	5	16.7	1	3.3
	Vomiting	2	6.7	2	6.7	6	20
	Spots	1	3.3	2	6.7	1	3.3
Precautions took for treatment	Hospital	24	80	10	33.3	14	46.7
	Infusion	17	56.7	26	86.7	23	76.7
	Market drugs	9	30	6	20	6	20
	Pharmacy	7	23.3	9	30	3	10
Origin of diseases/symptoms	Drudgery	27	90	20	66.7	27	90
	Environment	15	50	6	20	2	6.7
	Irrigation water	12	40	10	33.3	7	23.3
	Pesticides	9	30	1	3.3	6	20
	Fresh produce	5	16.7	4	13.3	0	0
	Other	2	6.7	10	33.3	4	13.3

Values are expressed as number of cases (N) with frequencies (F) in percentage (%).

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4. DISCUSSION

Human population has increased rapidly in Africa over the last decades which have led to high rate of unemployment and starvation (UNFP, 1994). This situation has made Africans to turn into agricultural activities to serve as a quick alternative with subsidence allowance to the white collar jobs. Among these activities is the production of market gardening crops (Temple and Moustier, 2004). Demography of market gardeners in Yaoundé revealed that both male and female share the same interest for market gardening activities (**table 2a**). However, most of the market gardeners in Benin are male and just like other Africa countries women in Benin are often involved in marketing of fresh produces (Temple et al., 2008; Keraita et al., 2008). As women sell the fresh produces at the road sides in the downtown and suburbs areas where the traditions considered the men as the head of the family and believe to have done their part by harvesting the produce. The greater proportion of 31-60 years old adults involved in vegetable farming in the study sites show that market gardening activity is more of adults affairs than young ones. Allagbé et al. (2014) described that young people of 21-40 years old were more implicated in market gardening in Benin. This group may have stand as co-workers to help as relatives or serving as a temporary workers. In fact, as the most active group of the society, young adults of less than 30 years are scholars or students or are involved in second-stage professional activities (dressmakers, builder, shoe-maker, carpenter, and so on) where only few of them are involved in day to day farming activities. The high rate of adults above 30 years old in market gardening can be attributed to the status of unemployment in the society with sometime no professional experience and also because they have to fetch for their families. In fact, according to the information on the matrimonial status and the number of children, we noticed that most market gardeners were married in Nkolondom, Houeyiho and Baouèra and have higher number of children (≥ 4) compared to the unmarried groups. (**table 2a**). This information therefore elucidates their high engagement in rapid development agriculture which procures rapid revenue. Furthermore, the great number of children recorded in each market gardener household may highlight the popular character of the surveyed cities and the non-respect of the standards of family planning both in Cameroon and Benin (UNFP, 1994).

River was the only water source used for irrigation in the vegetable quarter of Nkolondom in Yaoundé (Cameroon). This is in line with the results described by Temple and al. (2008). They described that the vegetable site of Nkolondom is crossed by the Ntsas River which is supplied by various hill's water sources in Yaoundé. As most market gardening activities in Yaoundé are carried out on dregs, the use of water from river can be attributed to the study period (end of November) which is during the long drying season in Yaoundé and during which dregs are always dried up. According to Kuitcha et al. (2008), this use of river water stands is the main alternative for people who do not have access to the main water supplies (camwater, drilling,

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well) in Yaoundé. In contrast to Yaoundé, four sources of waters used for irrigation (well, wastewater, drilling and swamp) were found in Benin study sites (**table 2b**). The differences irrigation water sources can be linked to the economic level and geographical position of each study site in the Republic of Benin. The vegetable site of Houeyiho (Southern-Benin) is located on dregs with a humid soil and near the Atlantic Ocean. Whereas the vegetable site of Baouèra is located in Northern-Benin which is a dry region. This could be the reason there was great dependence on wastewaters for irrigation of fresh produces in this area (Gmmell and Schmidt, 2010; Singh et al., 2010). Communities lacking access to potable waters may not have an alternative to using wastewaters as they constitute a feasible way ensuring crop outputs (Raschid et al., 2005). These wastewaters have higher nutrient values and may therefore reduce the effect and expenses on fertilizers in market gardening activities (Gmmell and Schmidt, 2010; Raschid et al., 2005; Van der Hoek et al., 2002). Gardeners are more interested in the use of motor-pump as an alternative to the traditional watering can both in Cameroon and Benin but could not be easily purchased due to its financial cost. However, the fact that tourniquets were only found in Houeyiho vegetable site can be the reason why market gardeners from this site are more professional than their peers from Baouèra in Parakou and even those from Nkolondom in Yaoundé.

It was noticed that market gardeners in Cameroon and Benin are involved in the cultivation of different fresh produces. They are usually involved in rapid development fresh produces which provide them with substantial revenues. Carrot was completely absent in the vegetable site of Nkolondom whereas it was among the main cultivated vegetables in Houeyiho and Baouèra. Nevertheless, carrot is well cultivated in other areas of Cameroon as Foumbot and Bafoussam, which are the main suppliers of fresh produces in cities and markets (Tarla et al., 2015). Celery on the other hand was less cultivated in Benin than Cameroon. The explanation given to these by some market gardeners is the lack of experience on carrot cultivation and culinary habits in the use of celery in Benin. In fact, most farmers are only involved in the cultivation of traditional vegetables found in their region. According to Temple and Moustier (2004), and as observed in our study sites, the interest of market gardeners for one crop over another depend on many factors including the society's culture, the cultivation practice, the merchant value, the cost of the crop, the live cycle of crop, the sensitivity of the crop to pests, the demand of fertilizers during cultivation practice, and the healthy state of farmers (which can influence the daily number of crop watering).

Irrigation water quality is of great importance because products exposed to contaminated water may put consumers at risks of getting involved in some health problems. As the international trade of agricultural products is growing, the export of contaminated fresh produces could assist the spread of contaminants into areas where such contaminants have not been recorded or least

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pronounced (Gmmell and Schmidt, 2010). We investigated the quality of water used for irrigation in study sites of Cameroon and Benin. Overall, the concentrations of heavy metals found in waters used for irrigation varied according to water source and study site. Heavy metal concentrations reported were very low (compared to the WHO threshold limits) and not directly harmful to human (Akrong et al., 2012; Cornish et al., 1999). River from Nkolondom was the least contaminated with heavy metals among the irrigation water sources investigated in the three study sites. This is different from the previous studies by Defo et al. (2015) in the Ntem River in Yaoundé, and Tarla et al. (2015) in surface waters of western highlands in Cameroon. This can be as a result of low anthropogenic activities in our study area (Temple et al., 2008). Overall in Benin (Houeyiho and Baouèra), Cu and Pb were more accumulated in surface or sky-opened waters (well, swamp, and wastewater) than in deeper-water (drilling) as described by Mustapha and Adeboye (2014) and Tom et al. (2014). This can be attributed to the origin of these metals (Defo et al., 2015; Mustapha and Adeboye, 2014; Sekemo et al., 2011) and the filterable nature of the soil (Atidegla et al., 2011). In fact, Cu and Pb are usually found in the atmospheric air and are provided by aerosols and engine' smokes such as vehicles, planes and motor-pumps in the vegetable fields (Koumoloua et al., 2013; Scott et al., 2010; Sekara et al., 2005). They can therefore easily lay on the surface of waters. In contrast, Arsenic was found to be more concentrated in drilling in Houeyiho. This vegetable farm is located in the landing-ground of the international airport in Cotonou and is frequently vaporized by smokes from planes. In addition, this farm serves as a deposit site for dusts used to make compost which are serious contaminant materials (Soclo et al., 1999). Cadmium and Arsenic are usually found in the deeper-ground across the mining sites from mineral deposit but are also present in the atmosphere from tobacco' smokes or at the surface of the soil form batteries (Farooq et al., 2008; Smedley and Kinniburgh, 2002). Unavailability of mining stations in the study areas could justify why they were found at very low concentrations in this study which also highlights their low and non-toxic levels in the irrigation water sources in Cameroon and Benin. However, a previous study in the same vegetable farm of Houeyiho described a higher proportion of heavy metals (Koumoloua et al., 2013). The difference in heavy metal concentrations in water sources may be attributed to the method used and the presence of interference metals such as Iron and Zinc which may antagonistically increase or decrease the levels of metals of interest (Cu, Pb, Cd and As) in environmental samples (ADEME, 1998). Atomic Absorption Spectrophotometry technique (AAS) was used for metal analysis in this previous study as against the advanced Metalyser Pro HM3000 machine (Trace2O, Berkshire, 2014, UK) used for analyses in this present study. The Metalyser Pro HM3000 machine is fast and very precise, and does not promote interferences metals during analyses. The levels of metals below the threshold standards could suggests that the critical charge of these metals are not yet saturated in the soil with the soil still playing its buffer effect by decreasing the concentrations of metals that could reach the ground water

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ADEME (1998) and Agbossou et al. (2003). The health risks associated with heavy metals in irrigation water sources appear to be existent. Market gardeners should therefore be educated to avoid the use of contaminated waters during their market gardening activities as these waters may contaminate vegetable produces.

Excess of heavy metals in edible vegetables may pose health threats to the general population. This study was carried out to monitor the metals concentrations in fresh produces. The fresh produces investigated were found to be contaminated with heavy metals with different concentrations based on the vegetable type. As found with irrigation water sources, Cu and Pb were the main contaminants of fresh produces both in Cameroon and Benin. Pb has always been described as the most dangerous metal in vegetables (Tom et al., 2014). Fresh produces often contain more heavy metals than irrigation waters because several factors such as climate, atmospheric depositions and volcanic activities, erosion of parent rocks, concentrations of heavy metals in soil, the nature of soil, use of manures, fertilizers and pesticides, and the degree of maturity of the plants at the time of harvest have been considered as origins for fresh produce contaminations (Tom et al., 2014; Khan et al., 2013; Atidegla et al., 2011; Sekemo et al., 2011; Farooq et al., 2008). An average Cd concentration of 0.64±0.06 ppb was obtained in carrot in Houeyiho which was reported to be almost absent in irrigation water sources. Although, this concentration is lower than what was obtained by Al-Chaarani et al. (2009) in Jordan and Lugwisha and Othman (2014) in Tanzania. In fact, Cd stands as a mobile element that is easily absorbed by root plants and transported to shoots where it is uniformly distributed in plants (Sekara et al., 2005). In contrast to Cd, levels of As obtained in irrigation water sources were almost at zero level (<0.001 ppb) in fresh produces. This is different from what was reported in Koumoloua et al. (2013) who described the presence of As in vegetables in this same study site of Houeyiho. According to the level of contamination of each vegetable, lettuce had the highest levels of metals (Cu and Pb) than celery and carrot in Nkolondom and Houeyiho. This difference in metal accumulation between lettuce and carrot is similar to results obtained by Gnandi et al. (2008) in Togo. And according to Agbossou et al. (2003), this could be attributed to the fact that leafy vegetables are more susceptible to uptake contaminants than the root vegetables. In contrast, carrot was more contaminated with metals than lettuce in Baouèra. This phenomenon may therefore depend on the bioavailability of the metal in the soil and the type of culture (Islam et al., 2007). In addition, the high contamination level of lettuce can be related to the great development rate of lettuce and the increasing use of pesticides during the market gardening practices (ADEME, 1998). Even the concentration of heavy metals did not reach their threshold limits (according to the WHO standards), it is important to note that the low amounts found constitute a health risk for potential consumers (Orisakwe et al., 2012; Islam et al., 2007; WHO, 1992). Continuous consumption of unsafe concentrations of heavy metals through foodstuffs may lead to chronic accumulation in the kidney and liver of humans, causing disruption of

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numerous biochemical processes, and leading to cardiovascular, nervous, kidney and bone diseases (Kihampa et al., 2011; Lawal and Audu, 2011; Jarup, 2003).

According to the Cressoniere's regulation, water used for irrigation of market gardening crops should be safe of any parasitological infestation (Circular note, 1978). In poor sanitation urban areas, microbial agents have been found among the wide contaminants of water sources including those used for irrigation of fresh produces (Scott et al., 2010). Irrigation is known to be common in our environment and vegetables grown in these areas are often eaten raw. High level of microbial contamination in waters used to irrigate these vegetables is raising concerns in the public health (Keraita et al., 2008; Gmmell and Schmidt, 2010). In this study, analysis of faecal microorganisms in waters used for irrigation showed that all water sources are contaminated with microbial pathogens but at different degrees. Study sites in Baouèra and Houeyiho in Benin had higher microbial pathogens than the vegetable site of Nkolondom in Cameroon. Overall, the average levels of faecal coliforms found were lower than that of total coliforms in our three study sites. This shows that faecal materials do not constitute the only origin of microbial agents in waters used for irrigation (Shuval et al., 1986). In Benin, almost all water sources used for irrigation had harmful concentrations of faecal coliforms (>1000 CFU/100 ml), with the study site of Baouèra being the most contaminated. The level of contamination of irrigation water sources in Houeyiho is as follows: well>swamp>drilling (**table 3b**). This high contamination level of well and swamp with microbial agents can be related to the nature of surface waters compare to drilling which is known as an underground water. In fact, all faecal materials released (e.g. from poultry manure) in the environment can be transported directly to surface waters (Akrong et al., 2012). The use of poultry manure and fertilizers is very common in all the study sites and could contribute to the contamination levels of irrigation waters. Our data showed that water from well is more harmful than municipally wastewaters in Baouèra (**table 3c**). In contrast, Gemmell and Schmidt (2010), and Shuval et al. (1986), described higher concentrations of coliforms in wastewaters. This high contamination level of well waters may be attributed to the nature of stable waters compared to draining waters. According to Akrong et al. (2012), high levels of coliforms in stream and drain water sources could be attributed to the discharge of untreated domestic effluents from surrounding houses. This is not always true as we obtained the lowest levels of total and faecal coliforms in river in Yaoundé. Our results therefore could be as a result of the flowing nature of wastewaters, in which high levels of heavy metals found is not suitable for the development of microbial pathogens. On the other hand, rivers usually get waters from different origins and this can impact its nature. The nature of water sources can thereafter impact the living conditions of microbial organisms which require specific parameters (pH, Temp, humidity, salinity, etc.) to grow. It is important to study the different species of microorganisms to determine the exact microbial flora

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of waters used for irrigation in the study sites. This information will help to specifically evaluate the impact of these contaminants on both the environment and human health.

Fresh produces in this study had greater levels of faecal microbial pathogens than irrigation waters. In spite of being leafy vegetables, lettuce was more adequate for microorganism's development than celery. The survival of pathogens on plants is influenced largely by ecological factors including weather conditions (warmth, exposure to sunlight and humidity) (Beuchat et al., 2002). In contrast to the highest level of faecal coliforms obtained in lettuce both in Houeyiho and Baouèra, Agbossou et al. (2003) obtained more faecal coliforms in carrot in the vegetable farm of Houeyiho which could be because of the difference between the edible parts of these two crops. As the edible part of carrot is underground and too confined, it is less adequate to the development of microorganisms. In contrast, the leaves of lettuce are in direct contact with microbial pathogens present in water and air at the surface of the soil (Gmmell and Schmidt, 2010; Keraita et al., 2008). Also, the rough surface of lettuce leaves constitutes an adequate milieu for the microorganisms to avoid the sun. The vegetable farm of Baouèra had the highest concentrations of faecal coliforms in fresh produces as found in irrigation waters. In fact, people in Baouèra usually defecate in the vegetable farm in contrast to Houeyiho where there is a well-constructed toilet for market gardeners. In addition, the study site of Houeyiho is well structured and organized with a general cleaning day of the site. However, the amounts of coliforms found in Houeyiho could also be attributed to the dusts stocked in this site for compost. As with waters used for irrigation, the amounts of total coliforms obtained show that instead of faecal microbial agents, there are other possible microorganisms in the edible parts of fresh produces. These organisms should therefore be quantified and specified as some may pose greater problems to a person with health challenges (Akrong et al., 2012). The consumption of these produce could constitute a potential microbial health risk for consumers. There is therefore a necessity to accentuate the sanitary education of marked gardeners in order to increase the hygiene of vegetable sites, the quality of resulting produces and the safety of potential consumers.

Food materials Contaminated with heavy metals and microbial agents have become an inevitable concern. Heavy metals and microbial pathogens are among the many potential health risk factors which can build-up into market gardeners produces consume by people (Lugwisha and Othman, 2014; Orisakwe et 2012; Lawal and Audu, 2011; Jarup et al., 2003). Both waters used for irrigation and the resulting fresh produces analyzed in this study had non-toxic concentrations of heavy metals and harmful levels of faecal coliforms. The consumption of fresh produces (lettuce, carrot and celery) in Nkolondom, Houeyiho and Baouèra may therefore have impact on human health. This is similar to what was described early (CDC, 2009; Gillespie et al., 2004; Sivapalasingam et al., 2004). These described the outbreaks of food borne infections and showed that these outbreaks were associated with the consumption of raw vegetables or fruits. Whether

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people become infected or sick after eating contaminated fresh produces depends on a number of additional factors such as the minimal infectious dose for a particular microorganism or metal, the level of immunity and simultaneous contamination through other routes (Singh et al., 2010; Turkdogan et al., 2002; Shuval et al., 1986). Turkdogan et al. (2002) related high concentrations of heavy metals in fruits and vegetables to high prevalence of upper gastrointestinal cancer. other health challenges that could result due to food and/or water-borne contaminations include diarrhoea, vomiting, stomach ache, headache, cold, typhoid fever, etc. (**table 4**). All these diseases/symptoms were among the frequent health issues identified in the market gardeners in Nkolondom, Houeyiho and Baouèra. Further studies should be carried out to investigate the relationships between these diseases and the market farming activities, in order to come out with the risk factors of fresh produces on human health. Other health issues including athletic foots (**figure 3**) and spots were also found in some market gardeners and could be attributed to waters used for irrigation, ingestion, inhalation or contact with pesticides and fertilizers (Lugwisha and Othman, 2014; Orisakwe et al., 2012; Lawal and Audu, 2011; Jarup et al., 2003). In fact, frequent contact with heavy water contaminated irrigation waters during watering activities could be sufficient to split the foots and even the hands of gardeners. Due to the poor socio-economic level of farmers, we can infer that their visit to hospitals may be due to close proximity with health facilities and often because when the disease is at its severe stage (Gillespie et al., 2004). The risks observed were homogenous in both Cameroon and Benin, showing that the problem of heavy metals and faecal coliforms in fresh produces is not country specific but a general treat in Central and West Africa. Overall, this study has been able to provide awareness to market gardeners and consumers of fresh produces about the potential risks of market gardening activities, and highlight the need to develop potential strategies to eliminate postharvest metals and microorganisms in vegetables such as the washing method of vegetables before consumption.

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Figure 3: Impact of irrigation waters and presence of athletic foot in market gardeners.

5. CONCLUSION

This study revealed that water used for irrigation and fresh produces in Nkolondom (Cameroon), Houeyiho and Baouèra (Benin) contained heavy metals at a non-harmful degree, and unacceptably high loads of faecal coliforms which constitute a great health concern. This study also reveals a possible transfer of heavy metals and faecal microorganisms from irrigation waters to fresh produces. However, these findings are not sufficient evidence to state that humans are becoming ill as a result of consuming contaminated food produces, but are sufficient enough to highlight the risks associated with the market farming activities in Cameroon and Benin. These risks may be minimized through proper use of water, proper produce treatment as well as through safe market gardening practices.

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REFERENCES

ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie), 1998. Connaissance et maîtrise des aspects sanitaires de l'épandage des boues. P.22. Available at : www.ademe.fr (Accessed: 28 February 2015)

Agbossou, K.E., M.S. Sanny, B. Zokpodo, B. Ahamide and H.J. Guedegbe, 2013. Evaluation qualitative de quelques légumes sur le périmètre maraîcher de Houéyiho, à Cotonou au sud-Bénin. *BRAB.,* 42:1-12

Akomagni, A.L., 2006. Monographie de la commune de Cotonou. *Afrique Conseil.*, p.1-47

Akrong, O.M., A.J. Ampofo and A.K.S. Danso, 2012. The Quality and Health Implications of Urban Irrigation Water Used for Vegetable Production in the Accra Metropolis. *J. Environ. Prot.,* 3:1509-1518

Al-Chaarani, N., J.H. El-Nakat, P.J. Obeid and S. Aouad, 2009. Measurement of levels of heavy metal contamination in vegetables grown and sold in selected areas in Lebanon. *Jord. J. Chem.,* 4:303-315

Allagbé, H., M. Aitchedji and A. Yadouleton, 2014. Genesis and development of urban vegetable farming in Republic of Benin. *IJIAS.,* 7:123-133

Arora, M., B. Kiram, S. Rani, A. Rani, B. Kaur and N. Mittal, 2008. Heavy metal accumulation in vegetables irrigated with water from different sources. *Food. Chem.,* 111:811-815

Atidegla, C.S., K.E. Agbossou, J. Huat and G.R. Kakai, 2011. Contamination métallique des légumes des périmètres maraîchers urbains et péri urbains: Cas de la commune de Gran-Popo au Bénin. *Int. J. Biol. Chem. Sci.,* 5:2351-2361

Beuchat, L.R., 2002. Ecological factors influencing survival and growth of human pathogens on raw fruits and vegetables. *Microbes Infect.,* 4:413–423

CDC (Centers for Disease Control and Prevention), 2009. Investigation of an outbreak of Salmonella Saintpaul infections linked to raw Alfalfa sprouts, Update for May 8, 2009. *CDC, Atlanta, GA*. Available at: http://www.cdc.gov/Salmonella/saintpaul/ (Accessed 14 May 2015)

Chary, N.S., C.T. Kamala and D.S.S. Raj, 2008. Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicol. Environ. Saf.,* 69:513–524

Circular Note, 1978. Revision of the departmental sanitary regulation. *Cressoniere's regulation, France*

Cornish, A.G., E. Mensah and P. Ghesquire, 1999. Water Quality and Peri-Urban Irrigation: An Assessment of Surface Water Quality for Irrigation and Its Implications for Human Health in the Peri-Urban Zone of Kumasi, Ghana. *Report OD/TN 95, HR Wallingford Ltd, Wallingford*, p.44

Datta, S.P., D.R. Biswas, N. Saharan, S.K. Ghosh and R.K. Rattan, 2000. Effect of long-term application of sewage effluents on organic carbon, bioavailable phosphorus, potassium and heavy metal status of soils and content of heavy metals in crops grown thereon. *J. Indian. Soc. Soil. Sci.,* 48:836–839

Defo, C., K.P.B. Yerima, K.M.I. Noumsi and N. Bemmo, 2015. Assessment of some heavy metals in soil and groundwater in an urban watershed of Yaoundé (Cameroon-West Africa). *Environ. Monit. Assess.,* 187:DOI 10. 1007/s10661-015-4292-1

ISSN: 2455-6939

Volume:02, Issue:05

Farooq, M., F. Anwar and U. Rashid, 2008. Appraisal of heavy metal contents in different vegetables grown in the vicinity of an industrial area. *Pak. J. Bot.,* 40:2099-2106

Gemmell, E.M. and S. Schmidt, 2010. Potential links between irrigation water quality and microbiological quality of food in subsistence farming in KwaZulu-Natal, South Africa. *Current Research, Technology and Education Topics in Applied Microbiology and Microbial Biotechnology, A. Mendèz-Vilas (Ed.)*, p1190-1195

Gillespie, I.A., 2004. Outbreak of Salmonella Newport infection associated with lettuce in the UK. *Euro surveillance.,* 8:2562

Gleick, H.P., 2000. The Worlds Water 2000: The Biennial Report on Freshwater Resources. *Island Press, Washington DC*, p.315

Gnandi, K., K. Tozo, P.A. Edorh, H. Abi, K. Agbeko, K. Amouzouvi, G. Baba, G. Tchangbedji, K. Killi, P. Bouchet and K. Akpagana, 2008. Bioaccumulation de certains éléments métalliques dans les produits maraîchers cultivés sur les sols urbains le long de l'autoroute Lomé-Aného, Sud Togo. *Acta Bot. Gallica.,* 155:415-426

Islam, Eu., X-e. Yang, Z-l. He and Q. Mahmood, 2007. Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. *J. Zhejiang Univ. Sci. B.,* 8:1-13

Jarup, L., 2003. Hazards of heavy metal contamination. *Brit. Med. Bull.,* 68:167–182

Keraita, B., P. Drechsel and F. Konradsen, 2008. Using on farm sedimentation ponds to improve microbial quality of irrigation water in urban vegetable farming in Ghana. *Wat. Sci. Tech.,* 57:519-525

Khan, K., Y. Lu, H. Khan, M. Ishtiaq, S. Khan, M. Waqas, L. Wei and T. Wang, 2013. Heavy metals in agricultural soils and crops and their health risks in Swat District, northern Pakistan. *Food. Chem. Toxicol.,* 58:449–458

Kihampa, C., J.S.W. Mwegoha and S.R. Shemdoe, 2011. Heavy metals concentrations in vegetables grown in the vicinity of the closed dumpsite. *Int. J. Environ. Sci.,* 2:889-895

Kora, O., 2006. Monographie de la commune de Parakou. *Afrique Conseil,* p.1-44

ISSN: 2455-6939

Volume:02, Issue:05

Koumoloua, L., P. Edorha, S. Montchoa, K. Aklikokoub, F. Lokoc, M. Bokod and E.E. Creppye, 2013. Health-risk market garden production linked to heavy metals in irrigation water in Benin. *Compt. Rend. Biol.* 336:278-83

Kuitcha, D., K.B.V. Kamgang, N.L. Sigha, G. Lienou and G.E. Ekodeck, 2008. Water supply, sanitation and health risks in Yaounde, Cameroon. *Afr. J. Environ. Sci. Technol.,* 2:379-386

Lawal, A.O. and A.A. Audu, 2011. Analysis of heavy metals found in vegetables from some cultivated gardens in the Kano metropolis, Nigeria. *J. Environ. Chem. Ecotoxicol.,* 36:142-148

Lone, M.I., S. Saleem, T. Mahmood, K. Saifullah and G. Hussain, 2003. Heavy metal contents of vegetables irrigated by sewage/tube well water. *Int. J. Agric. Biol.,* 5:533-535

Lugwisha, E.H. and C.O. Othman, 2014. Levels of Selected Heavy Metals in Soil, Tomatoes and Selected Vegetables from Lushoto District-Tanzania. *Int. J. Environ. Monit. Anal.,* 2:313-319

Mallmann, W.L. and C.W. Darby, 1941. Uses of a lauryl sulphate tryptose broth for the detection of coliform organisms. *Am. J. Pub. Health.,* 31:127

Muchuweti, M., J.W. Birkett, E. Chinyanga, R. Zvauya, M.D. Scrimshaw and J.N. Lester, 2005. Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: implications for human health. *Agric. Ecosyst. Environ.,* 112:41-48.

Mustapha, I.H. and B.O. Adeboye, 2014. Heavy metals accumulation in edible part of vegetables irrigated with untreated municipal wastewater in tropical savannah zone, Nigeria. *Afr. J. Environ. Sci. Technol.,* 8:460-463

Mutune, A.N., M.A. Makobe and M.O.O. Abukutsa-Onyango, 2014. Heavy metal content of selected African leafy vegetables planted in urban and peri-urban Nairobi, Kenya. *Afr. J. Environ. Sci. Technol.,* 8:66-74

Orisakwe, E.O., K.J. Nduka, N.C. Amadi, O.D. Dike and O. Bede, 2012. Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern, Nigeria. *Chem. Cent. J.,* 6:2-7

Raschid, S.L., R. Carr and S. Buechler, 2005. Managing wastewater agriculture to improve livelihoods and environmental quality in poor countries. *Irrig Drain* 54:S11-S22

Rattan, R.K., S.P. Datta, P.K. Chhonkar, K. Suribabu and A.K. Singh, 2005. Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater-a case study. *Agri. Ecosyst. Environ.,* 109:310–322

Rompré, A., P. Servais, J. Baudart, deR. Marie-Rene and P. Laurent, 2002. Detection and enumeration of coliforms in drinking water: current methods and emerging approaches. *J. Microbiol. Meth.,* 49: 31–54

Schikora, A., A. Carreri, E. Charpentier and H. Hirt, 2008. The dark side of the salad: Salmonella typhimurium overcomes the innate immune response of Arabidopsis thaliana and shows an endopathogenic lifestyle. *PLoS ONE.,* 3:e2279

Scott, C.A., N.I. Faruqui and S.L. Raschid, 2010. Wastewater use in irrigated agriculture: Confronting the Livelihood and Environmental Realities. *CABI Publishing*; *Wallingford, UK.*

Sêkara, A., M. Poniedziaek, J. Ciura and E. Jêdrszczyk, 2005. Cadmium and Lead Accumulation and Distribution in the Organs of Nine Crops: Implications for Phytoremediation. *Pol. J. Environ. Stud.* 14:509-516

Sekomo, C.B., E. Nkurang, D.P. Rousseau and P.N. Lens, 2011. Fate of heavy metals in an urban natural wetland: The Nyabugogo Swamp (Rwanda). *Wat. Air. Soil. Pollut.,* 214: 321–333

Shackleton, C.M., M.W. Pasquini and A.W. Drescher, 2009. African indigenous vegetables in urban agriculture. *Earthscan, London*

Shuval, H.I., A. Adin, B. Fattal, E. Rawitz and P. Yekutiel, 1986. Wastewater irrigation in developing countries: health effects and technical solutions. *Washington DC, World Bank Technical Paper* No.51

Singh, A., R.K. Sharma, M. Agrawal and F.M. Marshall, 2010. Risk assessment of heavy metal toxicity through contaminated vegetables from wastewater irrigated area of Varanasi, India. *Trop. Ecol.,* 51: 375-387

Sivapalasingam, S., C.R. Friedman, L. Cohen and R.V. Tauxe, 2004. Fresh produce: a growing cause of outbreaks of foodborne illness in the United States, 1973 through

1997. *J. Food. Prot.,* 67:2342-2353

Smedley, L.P. and G.D. Kinniburgh, 2002. A review of the source, behaviour and distribution of arsenic in natural waters. *Appl. Geochem.,* 17:517–568

Soclo, H.H., M. Aguewe, B.C. Adjahossou, T. Houngue and A.H. Azontonde, 1999. Recherche de compost type et toxicité résiduelle au Bénin. *TSM.*, 94:68-76

Tarla, D.N., V.M. Bantar, M.Y.C. Mfopou, D. Fotio and D.A. Fontem, 2015. Determination of Heavy Metal Concentration in Surface Waters of the Western Highlands of Cameroon. . *JGEESI.,* 2: 46-53

Temple, L., S. Marquis and S. Simon, 2008. Le maraîchage périurbain à Yaoundé est-il un système de production localisé innovant ? *Economies et Sociétés*, *Agroalimentaire.,* 30:2309-2328

Temple, L. and P. Moustier, 2004. Les fonctions et contraintes de l'agriculture périurbaine de quelques villes africaines (Yaoundé, Cotonou, Dakar). *Cah. Agric.,* 13:15-27

Tom, M., T.D. Fletcher and D.T. McCarthy, 2014. Heavy Metal Contamination of Vegetables Irrigated by urban Stormwater: A Matter of Time? *PLoS ONE* 9:e112441

Turkdogan, M.K., F. Kilicel, K. Kara and I. Tuncer, 2002. Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey. *Environ. Toxicol. Phar.,* 13:175-179

United Nations Fund for Population (UNFP), 1994. Human development world report. *Economica, Paris*, 239 p

Van der Hoek, W., M. Ul Hassan, J.H.J. Ensink, S. Feenstra, S.L. Raschid, M.S. Safraz, R. Aslam, R. Hussain and Y. Matsuno, 2002. Urban Wastewater: a valuable resource for agriculture, a case study from Haroonabad, Pakistan. *Research Report 63. IWMI: Colombo, Sri Lanka,* p1-20

WHO (World Health Organization), 1992. Cadmium, Environmental Health Criteria. vol.134, *Geneva, Switzerland*.

Yadav, R.K., B. Goyal, R.K. Sharma, S.K. Dubey and P.S. Minhas, 2002. Post-irrigation impact of domestic sewage effluent on composition of soils, crops and ground water - a case study. *Environ. Int.,* 28:481–486.

Zavadil, J., 2009. The effect of municipal wastewater irrigation on the yield and quality of vegetables and crops. *Soil Water Res.,* 4:91-103

