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Assessment of Heavy Metals Pollution in Surfaces and Underground Irrigation Waters at Ouagadougou, Boulbi and Tanghin-Dassouri

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Abstract : The aims of this study was to characterize and to quantify the heavy metals pollution in surface and underground waters used for the irrigation. This work permitted to value the degree of sanitary risk that the populations incur. The heavy metals concentration, gotten with the ICP-MS, show that some samples were polluted in Mn and in Se: concentrations of Mn in sample E1and those of Se in samples E2, E5, E7, and E8 were above the recommended limit. The use of these waters resources, without treatment, for the irrigation could generate serious consequences for the human health.

Keywords: Concentration, heavy metals, pollution, norms, WHO, p.p.b.

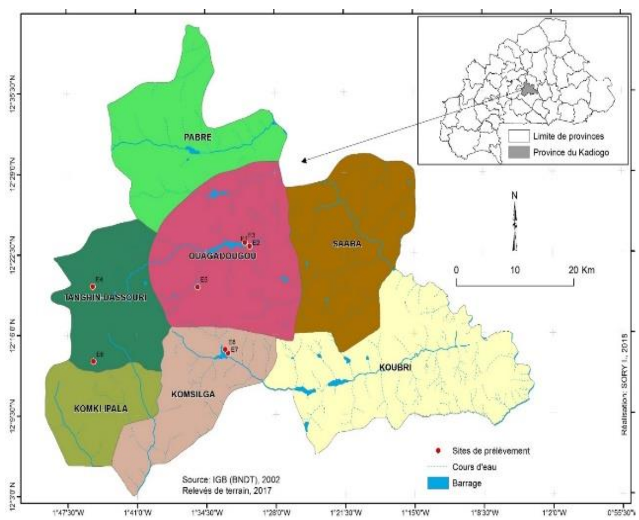
1. Introduction

Several studies (M. Gérard Miquel, 2001; Tanouayi G. et al, 2002 ; Assemblée parlementaire européen, 2011) showed that the heavy metals in the environment is a threat for the human and animal health. The heavy metal from natural processes (change of the rock mother, volcano, marine surf, …) or anthropiques (urban waste, mine, industry,…) can move in waters resources intended to the irrigation and/or to the consumption (Berrow, M.L. and al., 1991). The use of the contaminated water in agriculture can contribute strongly to affect the food chain through soils (Annabi A.B. and al., 2007; Bouchouata O. and al., 2011). In the practice, the water resources used in the market gardening are of various sources: surface waters (dam, retained of water, river, laugh, etc.), underground waters (generally of the wells) and sometimes same of the treated or no treated domestic or industrial waste water (A. YATRIBI and al., 2000). The diversity of waters resources doesn't only have that of the advantages for the market gardening; it also increases the risk of contamination of the environment and the man by the heavy metals. The used of water in market gardening in the Kadiogo district at Burkina without knowing the quality of the water can be the cause of environment and vegetable pollution. The present work, deals with the assessment of the degree of heavy metals pollution in irrigation waters of some market gardening sites of Ouagadougou. This study also contributes to put in place a data base of heavy metal concentration in irrigation water at Burkina. The study was interested in four (04) sites: two (02) in Ouagadougou (CHU-Yalgado Ouedraogo, Pissy), Boulbi and Tanghin-Dassouri. Four (4) samples of underground waters and four (4) other of surface waters were sampled to characterize and to quantify the concentrations of mercury (Hg), of manganese (Mn), of lead (Pb), of cadmium (Cd), antimony (Sb), of selenium (Himself), of tin (Sn) and of zinc (Zn).

2. Material and method

2.1. Geographical situation of the sites

UNISTRONG GPS was used for sampling sites localisation and ArcGis 10.3 software was used to make the map (fig. 1).



Legend: E1: CHU-well; E2: CHU-surface; E3: Dam nº3; E4: Pissy-Well; E5: Pissy-Dam; E6: Tanghin-Dassouri-Well; E7: Boulbi-Well; E8: Boulbi-Dam.

Figure 1: Geographical localization

2.2. preparation of the samples and analytic method

Sampling: The sampling took place between December 2016 and January 2017. The irrigation water was collected in polyethylene bottles. At the sampling site, the bottles were rinsed twice with the water to be sampled prior to filling. The water samples were acidified on site, with nitric acid (IGCC/UNIDO/UNDP/UNEP/GEP/NOAA/NEPAD, 2009). The samples were analysed one week after sampling in the

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worry to minimize the loss of elements especially those of volatile nature as mercury (Hg).
Preparation of the samples: To the laboratory, the sample were filtered. Then, 10ml of each samples was diluted with 0,02 ml of nitric acid (HNO_3).
Dosage: The ICP-MS (**Inductive Coupled Plasma-Spectrometry mass,** mark Perkin Elmer, model: ELAN 9000) was used to characterize and to quantify the heavy metals concentration. These analyses were achieved in the BUMIGEB (Mines and Geology Office of Burkina). according to the water analysis protocol.

3. Results and discussions
3.1. results
3.1.1. determination of the physicochemical parameters
The physical-chemistry parameters have been measured in situ with an electronic multimeter. The temperature (T), the potential hydrogen (PH), the electrical conductivity (EC) and the concentration of total dissolved solid (TDS) were measures for each samples (cf. table 1).

Table 1: Physical-chemistry parameters of the waters samples

Samples	T (°C)	PH	EC (µs)	TDS (p.p.m)
E1	24,5	7,07	323	161
E2	24	6,92	321	160
E3	28,8	8,01	372	186
E4	28,5	5,97	1582	792
E5	26,7	6,80	435	219
E6	28,6	5,28	56	27
E7	27,4	6,01	129	64
E8	27,6	8,96	163	83
E9	35	6,5 à 8,4	12 (25°C)	7680
E10	-	6,5 à 9,5	2500	-

E9: **Norms for irrigation water (Morocco) and E10: Norms for drinking water (WHO; EU)**

3.1.2. determination of the heavy metals concentrations
Figure 2 shows the concentrations of heavy metals for different studied sites. Table 2 shows the averages and extremums values (max and min) of heavy metal concentration in water samples and compare to the norms for irrigation water (Moroccans and Canadians) and for the drinking water (EU, 1998; WHO, 2006).

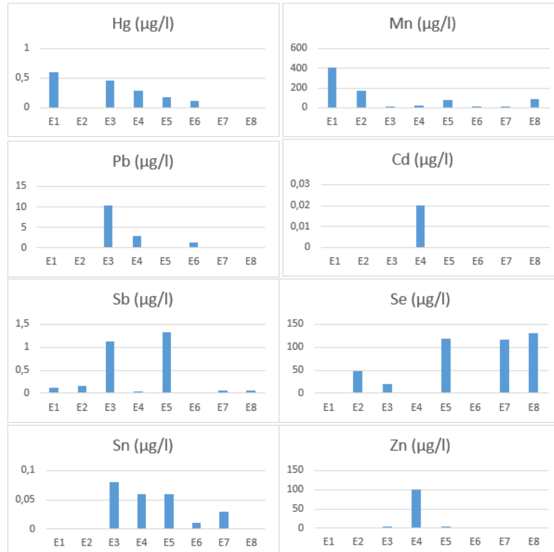

Figure 2: Concentration of the heavy metals in waters samples

Table 2: Averages and extremums of heavy metal in water

	Concentration (µg/l)	Hg	Mn	Pb	Cd	Sb	Se	Sn	Zn
This study	Mean	0,205	100,978	1,889	0,003	0,361	54,180	0,030	14,054
	Min	0,000	9,450	0,000	0,000	0,020	0,000	0,000	0,000
	Max	0,600	407,200	10,460	0,020	1,330	130,980	0,080	99,720
	Standart Deviation	0,184	94,709	2,421	0,004	0,432	51,053	0,028	21,417
Canadian Irrigation water		-	-	200	5	-	20	-	1000 - 5000
Morocco Irrigation water		1	200	5000	10	ND[1]	20	ND	2000
Norms for drinking water		1	50	10	3 à 5	5 à 20	10	NF	3000

The heavy metal concentration in well waters and surface water (dams) are showed in table 3 and figure 3.

Table 3: Averages concentration of heavy metal in well and dam waters

Type of water	Concentration	Hg	Mn	Pb	Cd	Sb	Se	Sn	Zn
Well water	**Mean**	**0,250**	**113,780**	**1,088**	**0,005**	**0,060**	**29,158**	**0,025**	**25,710**
	Min	0,000	9,450	0,000	0,000	0,020	0,000	0,000	0,000
	Max	0,600	407,200	3,000	0,020	0,120	116,630	0,060	99,720
	Standard deviation	0,195	146,710	1,088	0,008	0,030	43,736	0,020	37,005
Dams water	**Mean**	**0,160**	**88,175**	**2,690**	**0,000**	**0,663**	**79,203**	**0,035**	**2,398**
	Min	0,000	15,660	0,000	0,000	0,050	19,350	0,000	0,000
	Max	0,460	173,590	10,460	0,000	1,330	130,980	0,080	4,890
	Standard deviation	0,160	42,708	3,885	0,000	0,563	45,858	0,035	2,398

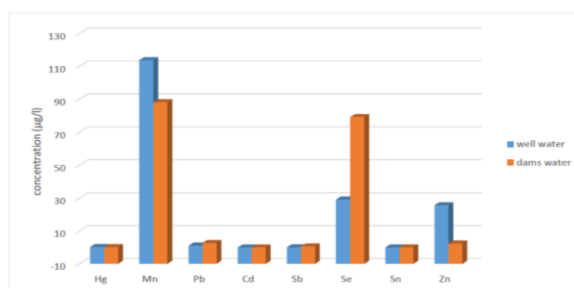

Figure 3: Mean concentration of the heavy metals in the well waters and dams

3.3. discussions
The physico-chemical parameters and the concentration of heavy metal show that the waters quality varies from one site to

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other. In more, the heavy metal concentration depends to the site.

3.3.1. The physico-chemical parameters

The temperature of water varies from 24 to 28,8 ºC. In all water samples, the temperature was less than the fixed norm that is of 35 ºC for the irrigation water (Maroc, 2007).

For the pH, the value varies between 5,28 and 8,96. However, the norm recommended for the irrigation water must be consisted between 6,5 and 8,4 and for the drinking water is between 6,5 and 9,5. So, the study shows that the pH of the samples E4 (pH=5,97), E6 (pH=5,28) and E7(pH=6,01) were acidic and out of norm.

The decrease of pH in these waters can entails increase the solubility of the heavy metals and their mobility (Moran and Wentz, 1974; Nordstrom and al., 2000). what increases the risk of toxicity. The pH of sample E8 (pH=8,96) is slightly above the norm recommended for the irrigation. Studies (Balistrieri et al., 1984; Zhu et al., 1993) concluded that an increase of the pH encourages the metallic adsorption on the reducible fraction of the sediments (oxides of iron and manganese), after exchange of the metallic cations with the H^+ ions on some sites of surface.

For the Electric conductivity, on all sites, the value was between 56 µs (28,6°C) to 1582 µs (28,5°C). The temperatures for all sample were high than the advisable norm who is 12 µs at 25°C for the irrigation. Therefore, the conductivity increases when the temperature increases, this phenomenon explains itself by the fact that the mobility of ions increase because of the viscosity reduction. What increases the risk of toxicity as confirms already by the pH.

The concentration of totals dissolved solid were varies from 27 to 219 p.p.m and were less than the limit (7680 p.p.m).

3.3.2. appreciation of heavy metals concentration

Mercury (Hg): the minimal concentration was determined in samples E7 and E8 (0,00 p.p.b). The highest concentration of mercury was determined in sample E1 (0,60 p.p.b). the concentration of mercury in all samples were less than the recommended limit for irrigation and consumption waters.

Manganese (Mn): The minimal concentration of manganese has been observed in sample E6 (9,45 p.p.b) and the maximal in sample E1 (407,20 p.p.b). The toxicity limit for irrigation and drinking water are 200 p.p.b and 50 p.p.b respectively. The minimal and maximal value were met in underground waters (well). The sample E1 come from the well behind the Yalgado Ouedrago Teaching Hospital. it can be having the pollution of the watertable in Mn, by the hospitable activities through the channel of evacuates waters rejected by the hospital. Also the concentration of rejected waters was 173,59 p.p.b close to the limit (200 p.p.b).

The concentration of Mn in the samples E5 (79,70 p.p.b) and E8 (83,75 p.p.b) were relatively less than the limit of irrigation water but high than the limit of drinking water.

Lead (Pb): The Lead concentrations in the samples E1, E2, E7 and E8 were 0,00 p.p.b. The maximal value was determined in the sample E3 (10,46 p.p.b) that is a surface water. The total absence of Pb in E1 and E2, that were no far from the E3, the contamination may have a punctual or local origin. If it was soil or the hospitable activities, one would have noted a presence, of lead in the samples E1 and E2. This suspected contamination can be an atmospheric nature and/or can cause by the dismissals of used objects (battery, etc.) or the wear of the vehicles tires that is often meets in the dam during the rainy season (Murakami et al., 2004; Zhang et al., 2009). Nevertheless, all concentrations were lower than the norm of irrigation that is 5000 p.p.b.

Cadmium (Cd), Antimony (Sb) and Tin (Sn): According to their speciation, the Cadmium (Cd), the antimony (Sb) and the tin (Sn) have more toxicities (Matias M.S., 2008). Exception of Sn who’s the limit has not been indicated, the concentration of Cd and Sb in the water samples were less than the norms for irrigation and drinking water.

Selenium (Se): At low dose, the Selenium has numerous properties. Several studies already put in inscription its anti-oxidize action. It also plays a role in the stimulation of immunity, for organism detoxification, or to warn the cardiovascular illnesses and certain cancers (Marlene Callejas, 2009). In the case of this study, the concentration of selenium in samples E2 (47,34 p.p.b), E5 (119,14 p.p.b), E7 (116,63 p.p.b) and E8 (130,98 p.p.b) were high than the limit recommended for the irrigation that is of 20 p.p.b. In more, the waters of samples E1, E4 and E6 are used for the consumption by the market gardeners and their families, the selenium concentration was nil. The concentration of sample E7 was 11,5 times bigger than the limit fixed for the drinking water.

Zinc (Zn): the concentrations of zinc were less than the limit recommended for the irrigation and drinking water.

The waters from the sample E1 was polluted in manganese (Mn), also samples E2, E5, E7 and E8 were polluted in selenium (Se), that can lead to a problem of public health since they contribute strongly to the contamination of the vegetal via soil (Tanouayi G. and al, 2015).

In a general manner, the well waters were more polluted in manganese, mercury, cadmium and zinc that the waters of surface. On the other hand, the concentration of lead, antimony and selenium in waters of surface were higher than their concentration in underground waters (well).

4. Conclusion

The results of this study show that the concentrations of Hg, Cd, Zn, Pb, Sb and Sn, were conform to the Moroccan norms for the irrigation. However, the concentrations of manganese (Mn) and selenium (Se) were high on some sites. The results of this study show that a regular follow-up of these resources in waters is indispensable.

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