ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 09, Issue, 01, pp.7258-7262, January, 2018

RESEARCH ARTICLE

ASSESSMENT OF HEAVY METALS POLLUTION IN WATER AND LETTUCE SAMPLES AT OUAGADOUGOU AND ITS SUBURBAN, BURKINA FASO

***Moumouni Derra, Dr. Ousmane I. Cisse, Dr. Luc T. Bambara, Karim Kabore and Pr. François Zougmoré**

Laboratory of materials and Environment, Physics Department, Training and Research Unit Exact and Applied Science, University of Ouagadougou, Burkina Faso

ARTICLE INFO

Article History:
Received 24th October, 2017
Received in revised form
18th November, 2017
Accepted 06th December, 2017
Published online 31st January, 2018

Key words:

Heavy metals, Concentration, Contamination, Pollution, Bioaccumulation.

ABSTRACT

The aim of this work was to assess the heavy metal environmental pollution in Ouagadougou and its suburban, in order to evaluate the risks on the population health. Lettuce samples, tap and surface waters sample were analyzed to determine the total heavy metal content. The Inductive Coupled Plasma-Spectrometry was used to analyze the samples. The concentration of Cr and Ni at Boulbi were 37.94ppm and 11.00ppm respectively and 8.19ppm of Pb in Baskuy sample. The Cr concentration in Boulbi lettuce was very high than the toxicity thresholds fixed by WHO and concentration of Ni was within the toxicity rang fixed by WHO. The higher value of Pb can lead to health risk due to the bioaccumulation effect. The concentration of Al, Ba, Cu, Fe, As and Cr were low et less than the standards set by WHO. In addition, Massili water was more polluted than Loumbila dam water. Massili water contains Co which is not found in Loumbila dam water. In addition, the concentration of Fe and Mn in water exceeded the recommended standards for irrigation water. The results of this study showthe presence of heavy metals in water and lettuce, andthe degree of risk of consumer.

INTRODUCTION

Heavy metals play a very important place in human life. Indeed it plays an essential role in many domains. In literature, several authors tell us that heavy metals from the point of view of their properties are components of a wide variety of products. Thus some heavy metals such as lead, arsenic, selenium, cadmium, mercury, selenium, chromium, cobalt and strontium are found in many levels of human activity such as metallurgy, chemistry, health (pharmaceuticals), energy, agriculture etc. (Di Benedetto, 1997, Poupon, 2007, Grosman*et al.,* 2009). After use, these products are sometimes abandoned in the environment without respecting the rules in this area. Their impact on the environment negatively affects consumer products (water, milk, fruit, lettuce etc.) when we know that heavy metals can by often very complex mechanisms ending up in the food chain and drinks. Therefore human health is threatened because some of these metal even a tiny amount constitutes a danger to bind their toxic properties. Thus depending on their physiological and toxic effects one can classify the heavy metals in two groups of biological standpoint. This is essential or trace elements and toxic metals (Kadouche, 2013). However even the metal that will reveal their properties dangerous to health are very useful to man in certain areas of science. View the multitude of heavy metals in the environment and the fact that they are present most often has the state of traces it is difficult to dose its. Thus measurements of the methods are many and the choice depends on the purpose of the analysis (Di Benedetto, 1997). The main purpose of this work is to highlight the existence of heavy metals in our environment in the characterizing and quantifying them in order to assess their impact on the environment and therefore the human exposure degree. To achieve this, we levied the samples of water and plants in Ouagadougou (capital city of Burkina Faso) and its suburban to analyze their total levels of heavy metals with ICP-MS (inductive coupled plasma-mass Spectrometry).

Corresponding author: **Moumouni Derra,**
Laboratory of materials and Environment, Physics Department, Training and Research Unit Exact and Applied Science, University of Ouagadougou, Burkina Faso.

Pollution of environment

A significant amount of heavy metals is introduced into the environment through the intermediary of natural and human sources. In terms of human activity, the contamination has many origins such as the burning of fossil, industrial residues, the exhaust gases of vehicles, the incineration, the mining activity, agriculture and liquid and solid wastes etc. (Pujol *et al.,* 1999, Sirven, 2006). This type of pollution is involved in a much shorter time scale on the order of the decade or even less (Bliefet, *et al.,* 2001). The pollution from natural origin, it may come from volcanoes hot springs the activity of erosion infiltration etc. which essentially are the natural source of contamination of soil metals (Sirven, 2006).

Heavy metals contamination

The human contamination by heavy metals can be accidental or controlled. However the omnipresence of metals in the environment would have less consequence if it was not associated to a direct or indirect risk of contamination of living beings. The man who can be found at all echelons of heavy metals distribution cycle in the environment can absorb by different ways with likely consequences on his health (Dietrich, 1998). Thus man may be contaminated by ingestion, inhalation or absorption (Di Benedetto, 1997).Indeed the heavy metals present in the environment (water, air, soil etc.) can by sometimes complex cycles be in a vegetable step of our food chain and cause contamination of the human oral (Kadouche, 2013). The passage of heavy metal in a food chain is become dangerous by the phenomenon of bioaccumulation which is the process of accumulation of a substance in all or part of a living organism via the food chain or ecosystem (Bouchouata *et al.,* 2012, Kebir, 2012).

Hazards related to heavy metals

For man the problematic of heavy metals is major because it affects all the characteristics of life. Indeed the heavy metals can cause degeneration of the cell. Thus they can lead to the pathologies that can affect a man's physical integrity and / or mental. Indeed some metals have teratogenic effects and others may even lead to fertility problems (Dietrich, 1998).

MATERIALS AND METHODS

Sampling sites

The samples were collected at Ouagadougou, Loumbila, Massili and Boulbi. Seven (7) samples (lettuce and water) were collected in seven (7) different sites: three (3) in Ouagadougou, two (2) in Loumbila, one (1) in Massili and one (1) in Boulbi.

Table 1. Sampling sites with sample nature

Site	Geographic location	Nature of sample
Hôpital Yalgado	Ouagadougou	lettuce
Baskuy	Ouagadougou	Lettuce
Boulbi	P.O	Lettuce
Loumbila dam	P.O	water
Loumbila ENEP/tap	P.O	water
Secteur 10/tap	Ouagadougou	water
Massili	P.O	water

P.O: Peripheries of Ouagadougou

MATERIALS

Plastic containers were used to collect samples of water and plastic bags for plants samples. The appropriate laboratory equipment was used to prepare and analyze the different samples.

METHODS

Dissolution of the samples in the laboratory

Samples setting procedure depends on its nature (water, plant, soil, etc.). In our case, the samples were only water and plants. The plant samples were mineralized.

Preparation of samples of water to analyze Protocol

- Appropriate water sample and filter it
- Appropriate 10ml of the filtered water and add 0,02ml of nitric acid (HNO_3^-)
- Analyze mixed solution with the ICP-MS

Protocol Preparation of samples of plants to be analyzed

- Appropriate the sample (leaves, roots, etc.) and dry it
- Pulverize the dry sample to make a powder
- Appropriate 1g of this dry powder
- Add 10ml of very concentrated H_2SO_4
- Heat mildly on a hotplate while agitating from time to time until total dissolution of the powder in the solution (about 10 to 15minutes)
- Add 10ml of distilled water and heat the whole mildly during 5 to 10 minutes
- Transfer the all in a vial sized up of 100ml and complete with the distilled water (one will take care to rinse the beaker before completing)
- Let to decant well and appropriate the filtrate to analyze with the ICP-MS.

Analytical technique

Measurement techniques of heavy metals quantities of materials are numerous. The choice of one of them depends on the operation you want to do with the result (Di Benedetto, 1997). In our case after the preparation of the samples we used ICP-MS for the determination of heavy metals. This reference technique has the advantage of several metals has dosed once. In addition, it provides reliable results. The technique of ICP-MS (Figure 1) can be summarized as follows:

Introduction system and the plasma torch

The prepared sample (liquid) is introduced in the system by a levy which is automatic needle. Then it leads to using a peristaltic pump to the nebulizer. It continues in the torch in the form of aerosol by pumping through the nebulizer. At this level (torch) the sample is mixed has a steady stream of argon ionizes a very high temperature (5000 10000ºK). This argon plasma allows atomizing to excite and ionize the elements that are in the aerosol. Thus there is formed an electrically neutral plasma combining electrons and ionized elements (Bouhnik-Le *et al.*, 2001; Mahesh *et al.*, 2012).

Interface and focusing system

The interface allows the transfer of a representative sample of the ion plasma to a vacuum chamber. The ions are then focused there. The transfer of ions to the quadrupole and the detector is pumped from atmospheric pressure torch part (Bouhnik-Le *et al.*, 2001; Mahesh *et al.*, 2012).

Mass filter and detector

The mass filter separates the ions according to the mass / charge ratio according to their stability. After this separation the ions are detected and accounts by a multiplier of electrons (Bouhnik-Le *et al.*, 2001; Mahesh *et al.*, 2012).

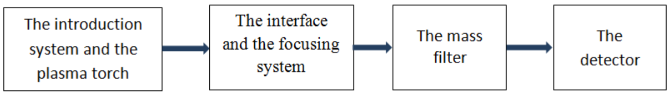

Figure 1. Diagram of a general ICP-MS

RESULTS AND DISCUSSION

The characterization and quantification of heavy metals were mainly limited to plants and drinking and surface water. For plants it is essentially acted lettuce. The plants samples were collected from three (3) sites: Behind YalgadoOuedraogo Teaching Hospital, near Baskuy dam and Boulbi.

The elements such as Ag, Hg, Co, Pb, Cr, As, Ni, Mo, and Cd were characterized and quantified. These results are presented in Table 2 and represented by digraphs in Figure 2. They also confirm the existence of heavy metals in vegetable crops (Bambara*et al.*, 2015). The study was based on drinking and surface waters. Thus the water valve / sect.10 and ENEP Loumbila have been used as drinking water and surface water were from the Loumbila dam and Massili stream. Ba, Cu, Fe, Cd, As, Co, Cr, Mn and Mo are the elements that were analyzed in the water samples. The heavy metal concentration in the drinking water results and those of surface water are shown in Tables 3 and 4 respectively. These results were presented in Figure 3 for drinking water and in Figure 4 for surface waters.

Results

Heavy metal concentration in Lettuce

Table 2. Heavy metal concentration in Lettuce from different sites (ppm or mg / kg)

Site Metal	Yalgado Hospital	Baskuy	Boulbi	Toxicitylimit
Ag	1.038007	7.690598	2.484243	-
Hg	5.728537	3.957884	2.903812	-
Co	2.452028	3.34889	5.922619	15-20
Pb	7.231244	8.194414	5.306855	12-300
Cr	23.35082	28.96394	37.944207	3
As	1.971766	5.41847	3.525779	40
Ni	4.773249	6.114163	10.996008	10-100
Mo	2.413343	2.331783	1.933292	-
Cd	0.265213	0.365671	0.219317	5

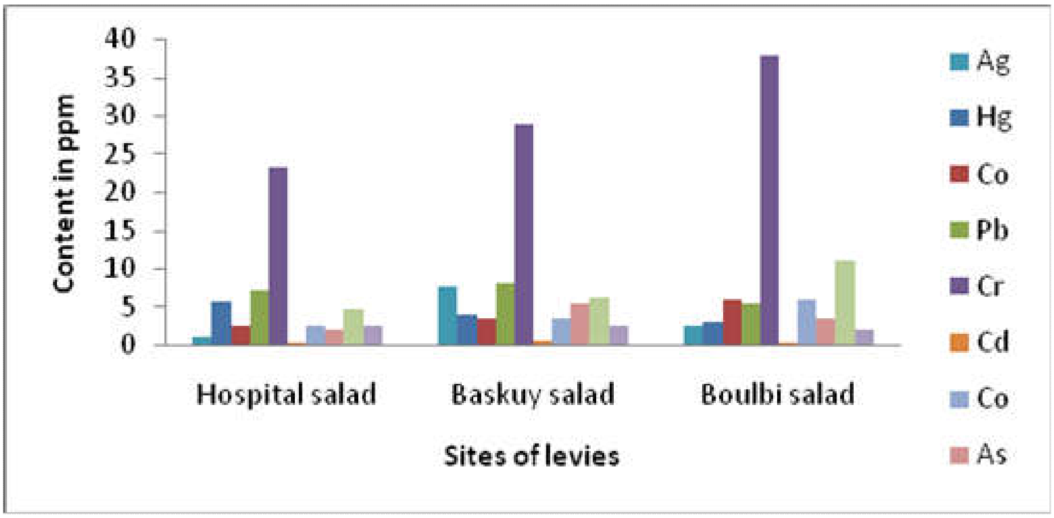

Figure 2. Heavy metal concentration in lettuce from three different sites

Heavy metal concentration in water samples

Table 3. Heavy metal concentration in water samples before and after treatment (ppm)

Sites Métaux	Loumbila dam	Tap/ENEP Loumbila	Tap/Ouagadougou sect.10	limit content of drinking water
Ba	0.2064	0.4097	0.2528	700
Cu	0.1763	0.2645	0.2868	2000
Fe	0.5408	0.4341	0.7648	-
Cd	0	0	0	-
As	0.0009	0.0009	0.0011	10
Co	0	0	0	-
Cr	0.0074	0.0114	0.0087	50
Mn	0	0	0	400
Mo	0	0	0	70

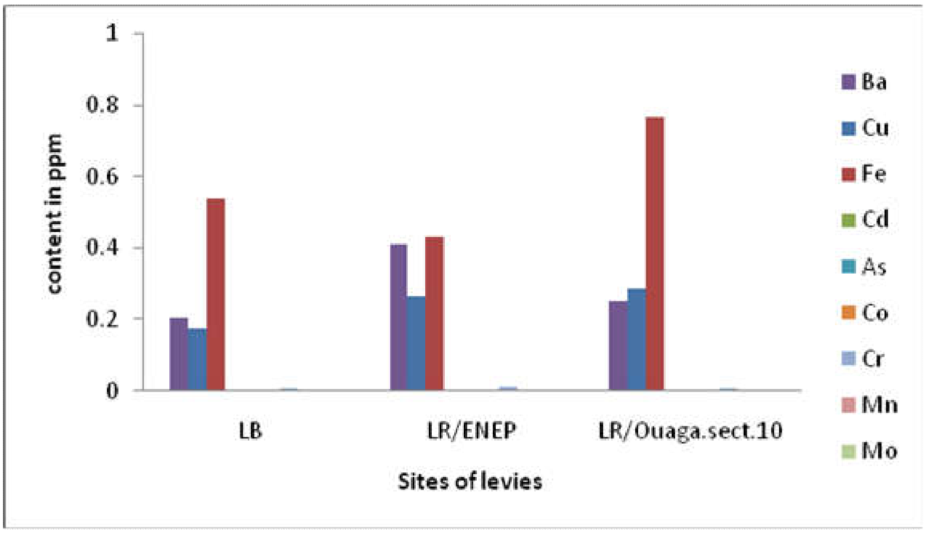

Figure 3. Influence of treatment on the metals concentration in the water

Table 4. Metals concentration in waters for two different surfaces (dam and stream)

Sites Métaux	Loumbila (dam)	Massili (stream)	Content limit for irrigation water (mg/l)
Ba	0.2064	0.3817	-
Cu	0.1763	0.2539	-
Fe	0.5408	13.8531	5
As	0.0009	0.0036	0.1
Co	0	0.0085	0.05
Cr	0.0074	0.0699	0.1
Mn	0	0.3962	0.2
Mo	0	0	-

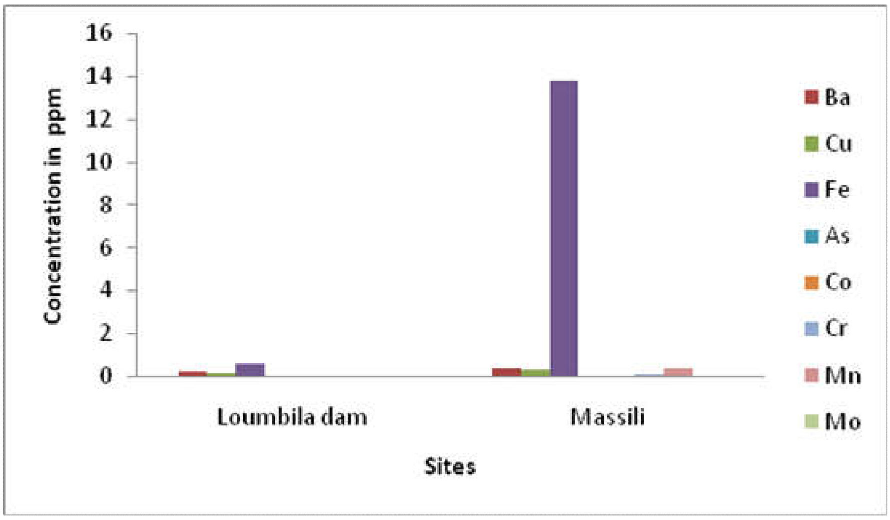

Figure 4. Comparison between metals concentration in dam and stream

DISCUSSION OF RESULTS

Heavy metal concentration in Lettuce

The concentrations of heavy metal in lettuce are show in table 2 and Figure 2. For lettuce: the choice of these 3 sites is justified by the fact that irrigation water differs from one site to another. Indeed the picked lettuce behind the Yalgado hospital is irrigated by the water coming directly from the hospital and wells therein. As for the outcome Baskuy lettuce, it is irrigated by dam water and Boulbi lettuce is irrigated by the stream water (Massili). The analysis reveals a various concentration of heavy metals in those lettuces and also a difference between the concentrations depending to the location. In addition, certain concentration of heavy metal exceeded the toxicity threshold fixed by the WHO. Indeed, the maximum concentration of Chromium (Cr) detected in plant was 37.94ppm found in Boulbi and the minimum was 23.35ppm in lettuce from Yalgado hospital. The toxicity threshold of this metal is exceeded in all three sites. For Nickel (Ni), the maximum concentration was 11.00ppm in plant from Boulbi and lowest concentration was 4.77ppm from the hospital site. The Ni concentration in Boulbi lettuce exceeded the toxicity threshold that is set at 10ppm. The highest concentration of silver (Ag) was detected in Baskuy lettuce (7.690598ppm) and its minimum content was in the hospital plant (1.038007ppm). For mercury (Hg) there is the maximum level on the hospital plant (5.728537ppm) and the minimum on Boulbi plant (2.903812ppm). For cobalt (Co) the maximum content was found in Boulbi (5.922619ppm) and the minimum on the hospital website (2.452028ppm). The maximum content of lead (Pb) is raised in Baskuy (8.194414ppm) and its minimum content is in Boulbi (5.306855ppm). For arsenic (As) the recommended content by OMS in plants is 0.43ppm then we face a maximum content of (5.41847ppm) in Baskuy and (1.971766ppm) for the minimum content on the site of the Yalgado hospital. However no content has reached the toxicity threshold is set at 40 ppm. In terms of molybdenum (Mo) the maximum level comes from the hospital (2.413343ppm) and the minimum Boulbi (1.933292ppm). In the case of cadmium (Cd) the maximum level is raised in Baskuy (0.365671ppm) and Boulbi site for the minimum value (0.219317ppmm). The concentration of Co, As, and Cd were less than the toxicity threshold set by WHO. However those of Cr, Ni and Pb were high. The concentration of Pb being close to the toxicity and those of Ni and Cr having initiates the toxicity threshold. These high recorded levels for Ni and Cr in Boulbi lettuce may be due to contamination of irrigation water and the cumulative effect of these items by the soil. Indeed this irrigation water comes from Massili which is a tributary of the Nakambe river (eg white volta). Contamination of this water may come from the fact that some industries dump their waste in the river without prior treatment. As for the concentration of Pb is so higher in Baskuy lettuce one can think of contamination linked to the soil and / or irrigation water. A more thrust study will situate us on the origin of this contamination.

Heavy metal concentration in tap water and dam of Loumbila

These sites were choosing because the Loumbila dam water is treated and used as drinking water at Ouagadougou and Loumbila. The results of the analyses show that the concentration of Co, Mn, Cd and Mo in the water samples were less than the detection limits of the system. However, the concentrations of Ba, Cu, As, Fe and Cr were low compare to the toxicity threshold. Thus these waters are safe for consumption. The concentration of Cu, Fe, Ba, Cr and As were low in the dam water and the results show the concentration of these metals were increased in the tap after treatment for drinking. This increase of the concentration may be due to the channeling system or piping. A more thrust study will situate us on the contamination when well even it is small (figure 3 and Table 3).

Heavy metal concentration in Massili water and Loumbila dam

We are interested in these sites because very often these surface waters are used for irrigation and its impact the plant contamination. In addition they are watering places for animals that can also be contaminated. The results of this study show that the Massili stream water was more concentrated than Loumbila dam water. The assay of samples from these sites show that Massili water is busier than Loumbila dam well even when it is a course of water that is renewed. Indeed the concentration of Ba, Cu, As and Cr are higher in Massili water than Loumbila dam water. Also, Massili water contains Co which is not found in the dam of Loumbila. In addition the concentration of Fe and Mn in the water exceeded the recommended standards for irrigation water (Figure 4 and Table 4). All these high levels of metals in the Massili water can be due to the industries action. They could also justify the contamination of lettuce from Boulbi mainly in Co Cr and Ni (Table 2).

Conclusion

This study allowed us to evaluate the environmental pollution of heavy metals in Ouagadougou (capital of Burkina Faso) and its suburban. Thus it brings to light the risks to consumer health. Indeed Ni and Cr in lettuce from Boulbi have critical risk levels threaten the health of consumers. As for the other trace elements in lettuce despite their concentration, when acceptable even though a regular monitoring is necessary given that the cumulative effect of these metals in soils may result in the long crop contamination from these sites. For drinking water constant monitoring will also identify a possible contamination linked to the pipeline system that may occur. Some precautions should be taken to avoid contamination of surface water that usually used for irrigation and for drinking water sources.

Acknowledgements

Mr. Derra thanks the PIMASO project for the scholarship that allowed him to deepen his knowledge on the subject with his stay in the Republic of Cote d'Ivoire (RCI). I thank the BIMUGEB, giving the opportunity to do my analysis by ICP-MS. Also, I thank Prof KAMAGATE Bamory and Prof GONE N'Droh for accepting me in there Laboratory. The authors also thank in advance the anonymous evaluators with their remarks comments and guidance probably allows it to improve this article.

REFERENCES

Bambara, T. L., Kabore, K., Derra, M., Zoungrana, M., Zougmoré, F., Cisse, O.2015. Assessment of heavy metals in irrigation water and vegetables in selected farms at Loumbila and Paspanga, Burkina Faso, IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 4 Ver. II (Apr. 2015), PP 99-103 www.iosrjournals.org

Bliefet, C.,Perraud, R.2001. Chimie de l'environnement. Air, eau, sol, déchets. De Boeck université, paris Bruxelles, 1ère édition, 2001. p

Bouchouata, O., Ouadarri, H., Abidi, A. E. L., Morhit, M. E. L., Attarassi, B., Energie, M. De, & Eau, D. 2012. Bioaccumulation des métaux lourds par les cultures maraîchères au niveau du Bassin de Sebou (Maroc). Bulletin de l'Institut Scientifique, Rabat, Section Science de La Vie, 34(2), 189–203.

Bouhnik-Le, C. M., Patrice, P., Serrat E., Gruau G. 2001. Validation d'un protocole permettant le dosage simultané des cations majeurs et traces dans les eaux douces naturelles par ICP-MS. Rennes : Géosciences Rennes, 2001. 84p. Cahiers techniques de Géosciences Rennes, 1. ISBN 2-914375-01-8

Di Benedetto, M. 1997. Méthodes Spectrométriques D'Analyse et de Caractérisation, Dossier SAM, Axe « Génie des Procédés », Centre SPIN, Ecole des Mines de Saint-Etienne ; p49.

Dietrich, K. S. 1998. Les métaux lourds et leurs effets sur la santé. Conférence à l'école polytechnique de Zürich, 1998 ; p20

Grosman, M., Picot,A.2009. Mercury Strongly under suspicion, Environmental factors and Alzheimer's disease; vol.1, 2009; p.12-21.

Kadouche, S.2013. Utilisation des biomateriaux pour le traitement des eaux. Université Mouloud Mammeri Tizi Ouzou, faculté des sciences, departement de chimie, 2013 ; p176.

Kebir, T.2012. Eude de contamination, d'accumulation et de mobilité de quelques métaux lourds dans des légumes, des fruits et des sols agricols situés près d'une décharge industrielle de l'usine Alzinc de la ville de Ghazaouet ; Thèse ; Université Abou Bekr Belkaid-Tlemcen-Faculté des sciences, 2012, p282.

Mahesh, B., Baburao, C., Bhargavi, S., Sreekanth, N., and Sreenu, D.2012. inductively coupled plasma mass spectrometry (icp-ms), international journal of research in pharmacy and chemistry; 2012, 2(3), 671-680p.

Poupon,J. 2007. l'exposition au mercure en 2007 : toxicité et prise en charge, Vol.2007 ; (2007); p.51-56.

Pujol,J. L.,Dron,D.1999. Agriculture , monde rural et environnement : qualité oblige. Courrier de L'environnement de l'INRA n°37, 1999, p.52–56.

Sirven, J. B.2006. Détection de métaux lourds dans les sols par spectroscopie d'émission sur plasma induit par laser (LIBS) ; thèse ; Université de Bordeau I. 2006, p 253.

****