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WASTE MANAGEMENT, WATER POLLUTION, AIR POLLUTION INDOOR CLIMATE

Proceedings of the 2nd International Conference on
WASTE MANAGEMENT, WATEaR POLLUTION, AIR POLLUTION, INDOOR CLIMATE (WWAI'08)

Corfu, Greece, October 26-28, 2008

Energy and Environmental Engineering Series
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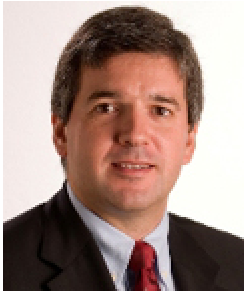
Urban Pollution and the Impacts in Urban Kitchen Gardens Sustainability



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Abstract: The environmental dimension is a key factor in a city sustainable development and must be incorporated in the planning process of the dense and complex urban areas. Nowadays particular emphasis is given to the problems of water, soil and air pollution in urban context. However, those evaluations not always motivate the indispensable environmental and social conscience to mitigate the origin of the pollution problems. So, in some cases the public health is in risk, mainly when the presence of preoccupying levels of contamination can be identified in soils and plants.

In Portuguese cities, and around the world, people are making small but significant changes to help sustain our ecosystem every day. In that context, the kitchen garden is gaining renewed interest as one component of the movement towards local, fresh, and seasonal foods. But the urban pollution is a preoccupant threat to the sustainability and viability of kitchen gardens as domestic production areas of food with appropriate quality.

In a recent research work in the city of Braga, in the Northwest part of Portugal, a serious problem of contamination was detected and compromises the environmental viability of kitchen gardens in the urban area. The research identify that the lettuces produced in the urban area of the city, usually included in the inhabitants food diet, accumulates significant levels of cadmium, lead and zinc. Also the analytical results of soils samples reveal high values for those metals. The lettuce and soils samples from several urban kitchen gardens present cadmium, lead and zinc concentrations levels higher than the standard limited fixed by the European Commission Regulation. The concentrations levels are also higher than the samples from kitchen gardens in rural neighbourhood areas.

Understanding the interrelations between urban pollution and the sustainability of urban kitchen gardens is essential to the cities planning process. Healthier and better planned cities must integrate social and ecological conscience for more sustainable attitudes and behaviours.

Urban Pollution and the Impacts in Urban Kitchen Gardens Sustainability

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Abstract: - A sustainable city must incorporate the environmental dimension in the development of the dense and complex urban area. To reach that, the urban agriculture and the green spaces with multiple uses, such as urban kitchen gardens, must be incorporated in the cities sustainable development model. In Portugal, Braga is a good example of those cities where the preservation of rurality tradition is important in the urban development, for the city presents an eminent agricultural involving landscape that coexists with the urban centre activities. Nowadays, city centre kitchen gardens represent the remaining portions of the agricultural life once intensely lived. However, Braga also presents typical environmental problems of large cities, such as the significant increase of mobility and road traffic, which puts the viability of the urban kitchen gardens health at risk.

The present work describes the methodology used in a monitoring process in order to analyse the environmental condition of Braga urban kitchen gardens. Soil and lettuce samples from eight different sites had been analysed taking into account their chemical composition. The analysis results show viable problems for the urban kitchen gardens as agricultural spaces that produce food with an appropriate quality for a nutritious diet. The results reveal preoccupying levels of contamination and pollution of heavy metals such as Cadmium, Lead and Zinc.

Key-Words: Sustainable City; Urban Pollution; Urban Agriculture, Urban Kitchen Gardens

1 Introduction

The environmental dimension is a key factor in a city sustainable development and must be incorporated in the planning process of the dense and complex urban areas. Nowadays, particular emphasis is given to the problems of water, soil and air pollution in an urban context. However, those evaluations do not always motivate the indispensable environmental and social conscience to mitigate the origin of the pollution problems. So, in some cases public health is at risk, particularly when the presence of preoccupying levels of contamination can be identified in soils and plants.

In Portuguese cities, and around the world, people are every day making small but significant changes to help to sustain our ecosystem. In that context, the kitchen garden is gaining renewed interest as a component of the movement towards local, fresh, and seasonal foods. But urban pollution is a preoccupying threat to the sustainability and viability of kitchen gardens as domestic production areas of food with appropriate quality.

In a recent research work in the city of Braga, in the Northwest part of Portugal, a serious problem of contamination was detected and in fact it compromises the environmental viability of kitchen gardens in the urban area. The research identified that the lettuces produced in the urban area of the city, usually included in the inhabitants' food diet, accumulate significant levels of cadmium, lead and zinc. The analysis results of soils samples reveal high values of those metals. The lettuces and soils samples of several urban kitchen gardens present cadmium lead and zinc concentration levels which are higher than the limited standard fixed by the European Commission Regulation. The concentration levels are also higher than the samples of rural neighbourhood areas kitchen gardens.

Understanding the interrelations between urban pollution and the sustainability of urban kitchen gardens is essential to the cities planning process. Healthier and better planned cities must integrate social and ecological conscience for more sustainable attitudes and behaviours.

2 Urban Kitchen Gardens

The kitchen garden constitutes a surrounded land parcel, of small extension, where vegetables, ornamental plants, plants and fruitful trees are cultivate. In general, urban kitchen gardens are usually small and in interstitial spaces between buildings and streets of the cities. The main objectives of kitchen gardens are: to produce self-supplying food; to increase the income and greater balance of the family budget; to supply fresh products and to promote organic agriculture and healthy products; to recycle organic residues (composting); to promote social integration; to reinforce the social inhabitants relations by allowing an easier access to the products that are offered and changed among neighbours and relatives; to support recreation activities, leisure and distraction moments as anti-stress therapy; to preserve rural cultural inheritance; to defend agrobiodiversity and to keep the plants genetic diversity and varieties [8, 12].

The urban kitchen gardens represent a basic element to consider in the urban space for they congregate key features of sustainable development: social justice, a balanced economic development and environmental protection. In this direction, it is considered that urban kitchen gardens can significantly contribute for the sustainable development of any city.

However, although there are some benefits and uses concerning urban kitchen gardens, they can also contain some problems of contamination and pollution. As it is reported by Varennes [11], contamination is an accumulation of one or more substances that would not normally be present, or at least would exist in a lower level, and pollution means that the presence of those substances can cause serious problems to the organisms, as it is the case of the presence of heavy metals (a group of elements in which the five atomic density is superior g/cm3 and that is normally associated to problems of contamination and toxicity) in the local agricultural cultures. Normally metals come from the emission of pollutants from diverse sources, such as the intense use of motorised vehicles; the deposit of constructions residues; the exploitation of contaminated residual and pluvial waters; the domestic and industrial sources. Thus, the concern associated with the contamination and pollution of the local agricultural cultures with heavy metals exists due to the risks that the extreme concentration of metals cause to public health because they can be accumulated in the eatable part of the plants in the human diet. However, as the metal absorption of the plants is changeable, it allows adapting the choice of the agricultural cultures concerning the level and the type of contamination. Generally, the biggest amounts of heavy metals are exactly accumulated in plants leaves, being the lettuce a good example, for it is considered a main metal accumulative in its aerial part, that is, in leaves [3]. However, soil metal absorption can also be significant in urban areas because soils are exposed to a permanent contamination due to the combustion gases of motorised vehicles. Other soil sources of contamination are the fuel industries, fuel storage and the escapes of the sewer and septic systems. As referred by DGA [2, 7] heavy metals are the most common contaminants in urban soils.

The risk for public health of contamination of urban kitchen gardens happens because the main source of exposition to heavy metals is food, and the concentration of heavy metals increases due to its accumulation in the food chain [6]. Thus, heavy metals elements have the characteristic to cause damages (intrinsic factor that the danger of the substance represents) and the reduction of exposition is the only effective way to diminish the risk for public health and the environment [4]. Being this exposition associated in general to the geographic location, it is considered potentially bigger in the centre of urban areas. So it is pertinent to evaluate the sustainability and the environmental viability of urban kitchen gardens in cities centres.

3 Material and Methods

3.1 Study area

The municipality of Braga is situated in the Northwest part of Continental Portugal (Figure 1) with an area of 183km² and 164,193 inhabitants, in 2001 [5], being densely populated 896 inhabitants/km². The municipality presents an important urban centre, the third most important city of Portugal, with an area of 32km² and 100,000 inhabitants, in 2001 [9] and, therefore, the population density was around 3,100inhabitants/km².

In the city of Braga there is a significant amount of kitchen gardens, all over the urban area. The biogeophysiques and social characteristics are a few reasons for that: mild climate; long days of sun; water and soil availability; fertile soil; young and dynamic population who is thirsty for fresh, safe and fast products.

According to Braga Master Plan [1] the predominant soils type in Braga is Cambisols, which represent recent soil from materials carried by water, wind or gravity, and with a minimum of eluviations. In Braga, this type of soils is typical from Dystric Cambisols, from metamorphic schist rocks, and Humic Cambisols, from igneous granite rocks, with the predominance of the last ones. So, the predominance of acid soil ($pH \leq 5$) is natural.

3.2 Monitoring program

The methodology proposed by Pinto [9, 10] to evaluate the viability of urban kitchen gardens, as food producers for the human diet, is supported in a campaign to monitor eight kitchen gardens in Braga (Figure 1). So, five kitchen gardens for sampling points were chosen in Braga central urban area and other three in the periphery area, in zones with lower levels of contamination and pollution potentiality.

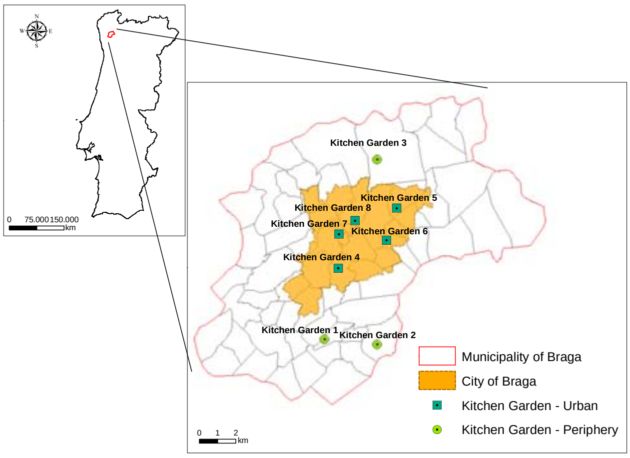

Fig.1: Map of the studied area and sampling sites

The urban kitchen gardens sampling points chosen were done having as their basis on the following choice criteria: in a central urban area with motorised traffic; in a periphery area with less motorised traffic; in both kitchen gardens with chemicals absence in agriculture process. On the other hand, the chosen plant/vegetable must: be much consumed in the human diet; have a favourable growth in the climate of Braga; a good bioindicator. Also, the choice of the soil sample must be restricted to the existing one in each kitchen garden. A representative number of samples of the agricultural culture and soil for kitchen garden must also be taken into account. As well, the heavy metals of the chemical analysis must be: associated to problems of contamination and toxicity; bioacumulator, that is, the organisms are not capable to eliminate them; easily accumulated in plants or vegetables; easily accumulated in soils; potentially emitted by urban pollution sources.

3.3 Plant selection and analyses

The vegetable used species was the lettuce Ball of Butter (Lactuca sativa L. to var. capitata L.), a domestic lettuce or lettuce of kitchen gardens, with smooth leaf, very plump, tender, with a favoured growth in the spring. This type of lettuce has great consumption in the diet of Braga inhabitants. The leaves, the vegetable aerial part, are the consumed part. The catch-crop of the Ball of Butter lettuce was made in the last month of the winter trimester – March, and after twelve weeks of growth, in the beginning of June, the lettuce was harvested. Two lettuce samples were collected in each kitchen garden, totalising fifteen lettuce samples (in one of the urban kitchen garden only one lettuce sample was possible to get).

The accumulation of high amounts of metals in the lettuce leaves can occur from different sources, such as: the atmospheric particle deposition and dusts essentially provoked by the gases from atmospheric pollution - motorised vehicles and industries; the absorption of elements contained in the soil; from waste and sewage disposal contaminated into the soil; the irrigation with contaminated water; acid rain; the removal of soil with contaminated debris of civil construction and industries.

Each lettuce sample was considered as a simple sample, having been analysed individually. The physical preparation of lettuce samples involved their washing with fresh water followed by drying in greenhouse at the temperature of 50ºC. After the drying process, the vegetal material was worn out (<0.5mm), in order to get one subsample for chemical study. The subsamples were kept in polystyrene bottles. The chemical attack was made by the method of incineration for saw dries. The samples (fifteen lettuce samples and one standard certified reference: BCR 62) were submitted to calcinations process at 480ºC. Following, the samples were solubilised in nitric acid.

The used analytical methods in lettuce samples had been the Spectrometry of Emission with Plasma Inductive to measure Zinc concentration and the Spectrometry of Atomic Absorption with Graphite Chamber to measure Cadmium and Lead concentration.

3.4 Soil analyses

Each soil sample was considered as a simple sample, having been individually analysed. The physical preparation of the soil samples involved drying them in greenhouse at the temperature of 40ºC, followed by milling them at 200 mesh in Agate mill. After the milling process the samples were homogenised, in order to get one subsample for geochemical study. These subsamples were kept in polystyrene bottles. The chemical attack was made by the method of alkaline fusing. Some aliquot of the different samples were prepared (eight soil samples, one certified reference standard - NRCC MESS-3, and one standard reference AC-E) and a solvent, metaborato of lithium, was added. All the samples were submitted to fusing at 1000ºC. The casting samples were solubilised in nitric acid.

The concentration of Zinc in soil samples was measured by Spectrometry of Emission with Plasma Inductive and the concentration of Cadmium and Lead in soil samples were measured by Spectrometry of Atomic Absorption with Graphite Chamber.

4 Results and Discussion

For the lettuce samples analytical results interpretation had been used as reference, for Cadmium and Lead, the concentrations limit fixed by the EU Regulation n.º1881/2006, respectively 0.20mg/kg and 0.10mg/kg. Concerning Zinc there is no legislation and the reference of Varennes [11], who refers that the Zinc normal contents in plants vary between 25 and 150mg/kg, was used. So, in the study the concentration limit of Zinc was 150mg/kg.

For the soil samples analytical results interpretation had been used as reference, for Cadmium, Lead and Zinc, the concentrations limit fixed in Portuguese regulation Portaria n.º176/96 to acid soil (pH $\leq$ 5), was respectively 1mg/kg, 50mg/kg and 150mg/kg .

The Cadmium (Ca), Lead (Pb) and Zinc (Zn) samples analytical concentrations results and respective concentrations limit to lettuce and to soils are presented in Table 1 and 2.

Table 1: Cd, Pb and Zn concentration in lettuce samples

Lettuce Sample		Cd (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Concentration Limit		0.20	0.10	150
Kitchen Garden 1 Periphery	Lettuce 1.1	0.16	0.08	93
	Lettuce 1.2	0.21	<0.04	188
Kitchen Garden 2 Periphery	Lettuce 2.1	0.12	<0.04	37
	Lettuce 2.2	0.14	<0.04	35
Kitchen Garden 3 Periphery	Lettuce 3.1	0.34	0.94	131
	Lettuce 3.2	0.35	0.96	103
Kitchen Garden 4 Urban	Lettuce 4.1	0.07	0.91	172
Kitchen Garden 5 Urban	Lettuce 5.1	0.13	0.70	81
	Lettuce 5.2	0.21	0.99	70
Kitchen Garden 6 Urban	Lettuce 6.1	0.39	0.42	83
	Lettuce 6.2	0.59	0.56	151
Kitchen Garden 7 Urban	Lettuce 7.1	0.06	8.62	77
	Lettuce 7.2	0.05	3.44	76
Kitchen Garden 8 Urban	Lettuce 8.1	0.38	2.68	128
	Lettuce 8.2	0.39	4.04	158

The analytical results for the lettuce (Figure 2, 3 and 4) and soil samples (Figure 5, 6 and 7) reveal the existence of several concentrations above the limit for Cadmium, Lead and Zinc, in urban and periphery kitchen gardens. In urban kitchen gardens the concentration values are substantially higher than in not urban kitchen gardens. Also, the possible translocation of those metals between soil and lettuce was still evident, in the scope of the interrelation established in the soil-plant system.

Table 2: Cd, Pb and Zn concentration in soil samples

Soil Sample		Cd (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Concentration Limit		1	50	150
Kitchen Garden 1 Periphery	Soil 1	<0.17	110	254
Kitchen Garden 2 Periphery	Soil 2	<0.17	70	174
Kitchen Garden 3 Periphery	Soil 3	0.70	532	483
Kitchen Garden 4 Urban	Soil 4	<0.17	81.6	239
Kitchen Garden 5 Urban	Soil 5	0.17	171	215
Kitchen Garden 6 Urban	Soil 6	0.17	137	221
Kitchen Garden 7 Urban	Soil 7	0.27	672	386
Kitchen Garden 8 Urban	Soil 8	2.93	1183	946

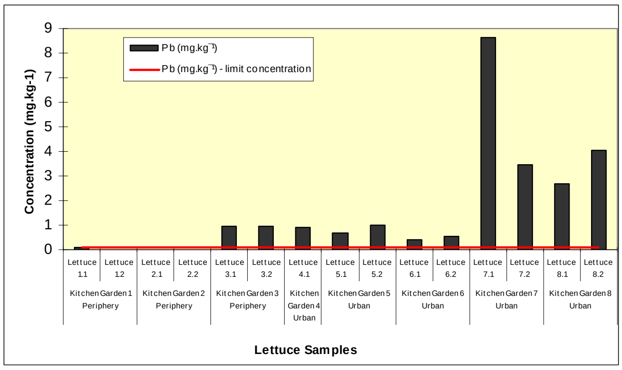

Fig.2: Pb concentration in lettuce samples

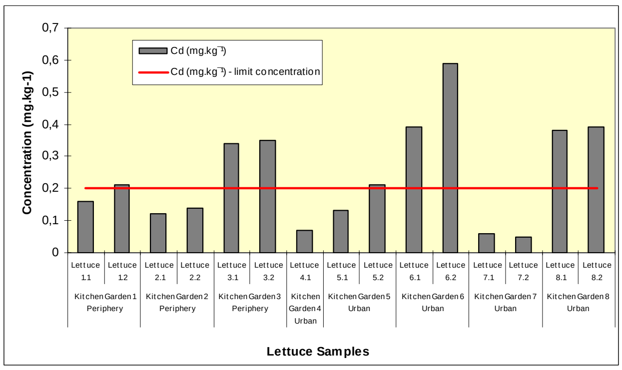

Fig.3: Cd concentration in lettuce samples

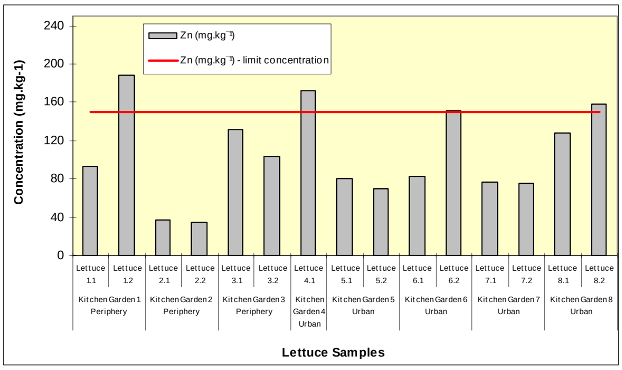

Fig.4: Zn concentration in lettuce samples

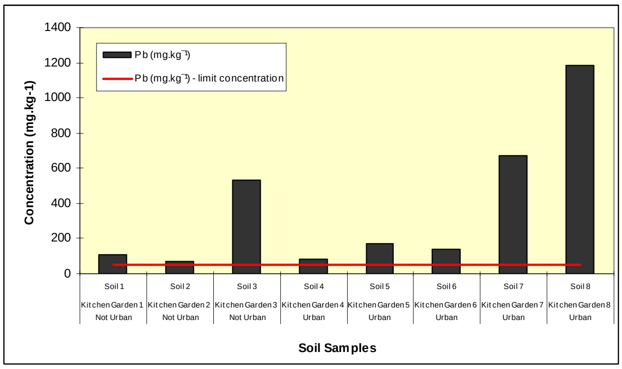

Fig.5: Pb concentration in soil samples

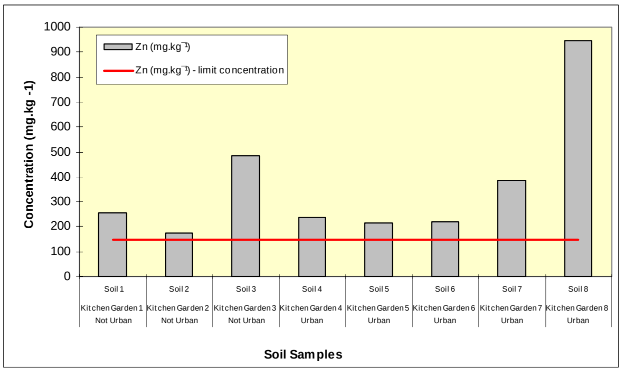

Fig.6: Zn concentration in soil samples

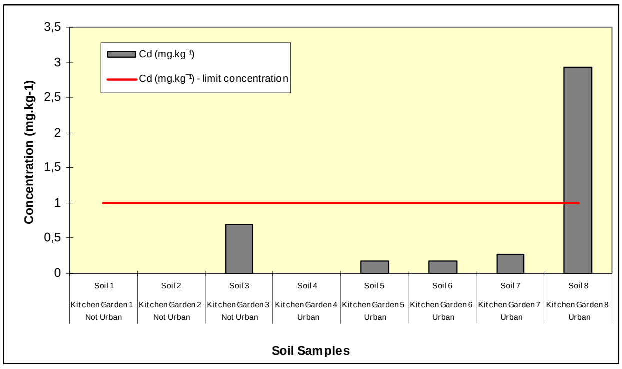

Fig.7: Cd concentration in soil samples

Cadmium is the element that in minor number of samples, and significant reduced form, the concentration limit was exceeded, but its possible translocation in kitchen garden number 8 was inferred, for the soil and lettuce samples had exceeded the concentrations limit. It is however mentioned that the Cadmium presence in soil samples is less significant than in lettuce samples. Its presence above the concentration limit was collected in eight lettuce samples, of which three in two not urban kitchen gardens (kitchen gardens 1 and 3) and five in three urban kitchen gardens (kitchen gardens 5, 6 and 8) and only in one urban kitchen garden soil (kitchen garden 8).

Lead is the element that in further number of samples and more significant form, the concentration limit was exceeded, but its possible translocation in some samples was inferred. It is mentioned that its presence, although being sufficiently significant in all of them, is more significant in soil samples and not in lettuce samples. Its presence above the concentration limit in all eight soil samples and in eleven lettuce samples, one in not urban kitchen garden (kitchen garden 3) and nine in five urban kitchen gardens (kitchen gardens 4, 5, 6, 7 and 8), is distinguished.

Zinc also exceeds several times, and in a significant figure the concentration limit, and its possible translocation in some samples was also inferred. It is mentioned that the Zinc presence, although also being significant in all of them, is more significant in soil samples than in lettuce samples. Its presence above the concentration limit in all of the eight soil samples and in four lettuce samples, from which one in one not urban kitchen garden (kitchen garden 1) and three in three urban kitchen gardens (urban kitchen gardens 4, 6 and 8), is distinguished.

It was verified that the five urban kitchen gardens are more affected by the heavy metals presence. So, the levels of contamination and pollution for identified metals can be related with the different and more numerous emitting sources of pollution in urban area but also with the possible translocation established in the soil-plant system. In this context, the lettuce, when accumulating metals above the respective concentration limit, can cause serious problems of toxicity.

5 Conclusion

Urban pollution and the impacts in urban kitchen gardens sustainability are a problem in major cities. In that context, this work presents the results from a study carried out in the city of Braga, where sampling points allow to identify a serious problem of soils and

vegetables (plants) contamination but, above all, a problem of urban pollution is verified:
i) tracer of Cadmium, Lead and Zinc in all lettuce and soil samples;
ii) concentrations of Cadmium and Lead tracer in lettuce samples from urban kitchen gardens above the limit;
iii) concentrations of Lead and Zinc tracer in soil samples from urban kitchen gardens above the limit;
iv) the predominance of concentrations above the limit and Lead concentrations that grow in the lettuce and soil samples of urban kitchen gardens;
v) the presence of Cadmium, Lead and Zinc in a little significant number of lettuce samples of not urban kitchen gardens in concentrations above the limit;
vi) the presence of Lead and Zinc in concentrations above the limit in all soil samples of not urban kitchen gardens;
vii) the possible translocation of Cadmium, Lead and Zinc in the lettuce samples for the interrelations established between soil and plant.

It was therefore detected that the environmental viability of kitchen gardens in the city centre area is compromised, over all for kitchen gardens are spaces to grow vegetables to the human diet. As the chemical analytical results show, the intolerable values of heavy metal concentration in plants must report that the risks for public health are high.

Therefore, it was verified that the evaluation of the environmental viability of urban kitchen gardens constitutes an adjusted model to identify pollution problems in cities.

Acknowledgments

The authors are thankful: to the eight proprietors of the kitchen gardens sampling points, who had collaborated throughout three months, and without their confidence and aid it would not have been possible to materialise this study; to the City council of Braga, for having supplied essential information; to the University of Minho, nominated to the Departments of Civil Engineering and Land Sciences for the financial and laboratories resources. The authors also thank to Dr. Cíntia Regalo for her useful and kind assistance in the revision of this paper.

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