

Agricultural Production Status of Hevsel Gardens

Süleyman Kızıl and Neşe Üzen

Introduction

- 1 The Hevsel Gardens have played an important role in the nutrition of the population of Diyarbakır, from the city's establishment to the present day. The agricultural production areas of the Hevsel Gardens, which are the focus of this study, cover an area of approximately 300-350 hectares within the boundaries of Diyarbakır districts including Sur, Alipaşa and Fatihpaşa neighbourhoods. Poplar tree production covers some 100-150 hectares of this land located close to the river bed while the remaining section hosts mostly vegetable production and orchards restricted to a small area.
- 2 The concentration of the population in cities puts pressure on agricultural production areas. Due to this pressure, agricultural production areas overlap with urban infrastructures. Nutrition habits have an important role in the memory of societies. In this regards local markets have important functions.
- 3 The women-farmers of the Hevsel gardens sell the products in the *Aşefçiler Çarşısı*, a very old traditional and local market place. It is very important to preserve this tradition as it is a cultural legacy of the city. Preservation of this tradition depends on the upkeep of healthy soils, the upholding of ecological farming and a local consumption.
- 4 This study aims to carry out heavy metal analyses of the soils, of the agricultural irrigation water and of some products of the Diyarbakır's Hevsel Gardens. Furthermore, we seek to determine the agricultural potential and the socio-economic conditions of the farmers in this area.

Materials and Method

- 5 The land of Hevsel Gardens, located on the right bank of the Tigris River, is slightly inclined towards the stream banks (% 0-2 slope) and present a thick free soil. This fertile

soil, suitable for all types of plants cultivation, is more than 90 cm deep. It is a first-class agricultural land, classified by the relevant administration as “Agricultural Land” and in the “deep profile soil group” (Anonymous 1994).

Table 1. Results of the analysis on the soil of Hevsel Gardens production site

Location	Depth	Texture	EC (%)	(CaCO ₃) (%)	pH	Organic Matter (%)	P ₂ O ₅ (kg/da)	K ₂ O (kg/da)
1	0 – 30	Clay loam	0.05	13.3	7.78	2.35	17.3	208
1	30 – 60	loam	0.04	12.5	7.84	2.44	18.7	182
2	0 – 30	loam	0.12	5.7	7.76	1.45	20.9	76
2	30 – 60	Loamy sand	0.04	7.2	7.80	0.58	8.75	30
3	0 – 30	clay	0.06	3.8	7.72	4.00	25.5	382
3	30 – 60	clay	0.29	3.8	7.70	2.38	16.5	267
4	0 – 30	clay	0.06	3.4	7.40	2.73	24.7	237
4	30 – 60	clay	0.06	4.9	7.52	2.73	24.7	293
5	0 – 30	Clay loam	0.05	4.9	7.49	2.55	28.1	280
5	30 – 60	loam	0.05	4.2	7.58	1.68	16.5	175

- 6 In order to determine the general characteristics of the land, soil samples were taken from different locations in the study area and from two different depths (surface and underground) (Table 1). Soil samples were analyzed in the Soil Analysis Laboratory of Diyarbakır Directorate of Provincial Food, Agriculture and Livestock. To irrigate their crops, the farmers of the gardens use natural springs (Hz. Süleyman spring, Benusen spring, Anzele spring) as well as wastewater coming from domestic raw sewages. Samples were taken from these water sources and analysed. In addition to the soil, dill, rocket and stinger plants growing in Hevsel Gardens were sampled as well and these samples were dried at 70°C for 48 hours. Heavy metal analyses of soil, water and plant samples were made using a Perkin Elmer Optima 7000 DV (PerkinElmer, Inc., Shelton, CT, USA) device.
- 7 Moreover, a survey based on a precise questionnaire was carried out in order to determine the agricultural and socio-economic structure of the farmers producing in Hevsel Gardens.

Research and Discussion

Soil Analyses Results of Hevsel Gardens

- 8 Results of the soil analyses of Hevsel Gardens are shown in Table 1. According to these results, water saturation varies from 52% to 81%. The texture of the soil samples are sand, clay, clay-loam. The high water ratio in the samples is due to the high humidity ratio of the soil at the time of sampling (15 January 2015). The salt amount in the soil samples varies between 0.04%-0.29%. Total salt amount may vary according to the sampling date (Table 2).

Table 2. Heavy metal content of the soil samples taken from different locations and depths in Hevsel Gardens (mg/kg $\pm$ % RSD)

	1		2		3		4		5	
	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
Cd	0.25 ± 0.66	0.25 ± 0.26	0.025 ± 3.30	0.10 ± 4.47	0.5 ± 0.38	0.18 ± 2.37	0.12 ± 1.34	0.2 ± 0.97	0.06 ± 2.98	0.12 ± 2.71
Co	7.0 ± 0.42	6.5 ± 0.46	16.8 ± 0.72	11.8 ± 1.06	9.5 ± 0.22	8.4 ± 0.15	7.1 ± 0.67	11.4 ± 0.23	6.8 ± 0.29	8.4 ± 0.40
Cr	22.0 ± 0.68	18.3 ± 0.49	37.8 ± 0.49	35.3 ± 1.43	4.3 ± 0.26	26.9 ± 0.36	14.2 ± 0.88	23.8 ± 0.45	16.1 ± 0.89	18.4 ± 1.65
Cu	39.3 ± 0.01	43.8 ± 1.61	74.0 ± 1.08	50.3 ± 1.08	17.8 ± 1.00	40.6 ± 0.51	49.6 ± 1.28	72.6 ± 0.60	34.4 ± 0.50	44.8 ± 0.84
Mn	236.3 ± 0.64	214 ± 0.19	356.3 ± 0.42	572.3 ± 0.23	666.0 ± 0.31	308.0 ± 0.26	400.5 ± 0.27	315.6 ± 0.11	145.8 ± 0.23	168.4 ± 0.61
Ni	30.5 ± 1.47	27.0 ± 0.60	61.8 ± 0.77	56.0 ± 0.68	52.8 ± 0.80	50.1 ± 0.78	24.2 ± 0.42	38.4 ± 1.00	26.7 ± 0.10	30.8 ± 0.71
Pb	35.3 ± 0.26	41.5 ± 0.51	7.0 ± 0.33	5.75 ± 0.78	13.3 ± 0.35	39.2 ± 0.89	28.7 ± 0.16	42.6 ± 0.51	15.3 ± 0.51	19.8 ± 0.29
Se	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Zn	36.5 ± 0.24	33.0 ± 0.56	37.8 ± 0.51	24.0 ± 0.38	42.8 ± 0.23	38.2 ± 0.40	27.5 ± 0.51	43.4 ± 0.92	19.2 ± 0.67	20.8 ± 0.92
Fe	13162 ± 0.42	13297 ± 0.08	12945 ± 0.20	19102 ± 0.57	512.3 ± 0.14	19635 ± 0.02	9585 ± 0.07	8376 ± 0.37	11250 ± 0.18	12486 ± 0.24

* Tr : trace

- 9 In general, the pH of the soil ranges from 7.40 to 7.84. There is no lime problem in the soil, the lime content (CaCO_3) varies from 3.42% to 13.3%. The soil of Hevsel Gardens is in low or medium class in terms of lime content. The organic material of the soils varies from 0.58% to 4.00% and the soil is in medium-rich organic material in terms of soil content. Hevsel Gardens' soil is rich in terms of phosphor and potassium when compared to international standards (Güzel *et al.* 2002).

Heavy Metal Content of the Soil

- 10 The most important toxic heavy metals in the Hevsel Gardens soils are cadmium, lead, nickel, arsenic and copper. Presence of these heavy metals is increased by the use of industrial fertilizers such as the mineral phosphorus one, in addition to natural phosphorus coming from sewage irrigation process. The range values of some heavy metal retained in the soil display the following boundaries: 0.2-1.0 mg/kg for Cd, 10 mg/kg for Co, 70-100 mg/kg for Cr, 20-30 mg/kg for Cu, 1000 mg/kg for Mn, 50 mg/kg for Ni, 10-30 mg/kg for Pb, 0.5 mg/kg for Se and 50 mg/kg for Zn (Alloway 1993; Güzel *et al.* 2002).

- 11 The amount of Lead (Pb) present in the soil samples varies according to the depth. It was determined that the Pb content of samples taken from a depth of 30-60 cm is higher than Pb amount in samples taken at ground surface. This shows that Pb element moves downwards in the soil, washed down both by irrigation and rain waters. Unfortunately the plants' root system is particularly active at this depth which may cause lead accumulation in the plants. Pb content in the soil samples has been found at both depths in sample 1 and above the boundary values in samples 3 and 4. Such concentration is not unusual considering the close urban environment with its manifold emissions sources in addition to the use of waste water as agricultural irrigation water.
- 12 Results obtained from the study show that there is no Cu, Cd, Co, Zn and Cr pollution in the soil of Hevsel Gardens according to allowed limits for agricultural soil (Table 2).

Heavy Metal Content of the Irrigation Water

- 13 Old records indicate that the city's waste water used to reach the Hevsel gardens already more than a century ago. Documents dated from 1893 (Ref ?), show the complaints and actions filed by farmers who thought that preventing waste water's irrigation for health risk's prevention and sanitary reasons hindered production in the gardens. Today, the irrigation needs of the agricultural areas in the Hevsel Gardens are provided by five supplies. Four are clear waters coming from: Hz. Süleyman Spring, Benusen spring, Anzele spring, natural spring water while the fifth one is domestic waste water (Figure 1).

Figure 1. Sources of some irrigation waters used in agricultural production



- 14 Cadmium concentration in agricultural soils and irrigation waters can be problematic if it rise above the allowable maximum define by health authorities. In Turkey, the allowable

range limits is between 0.01 and 0.05 mg/kg (Anonymous 1991). In the Hevsel Gardens' sources, the Cd contents vary as follows: 0.00872 mg/kg in the Hz. Süleyman spring; 0.00028 mg/kg in the Benusen spring; 0.04936 mg/kg in the domestic waste water; 0.06146 mg/kg in the natural spring water and 0.00535 mg/kg in the Anzele spring. Among the irrigation waters, the Cd content is found just above the boundary value only in natural spring water (Table 3).

Table 3. Trace element and metal contents of agricultural irrigation waters in Hevsel Gardens

Location	Heavy metals (mg/kg)								
	Ni	Zn	Se	Pb	Cu	Fe	Cr	Cd	Mn
Hz. Süleyman spring	0.0015	0.0089	Tr	0.0045	0.0052	0.0134	0.05	0.0087	0.0392
Benusen (Spring)	0.0009	0.0057	Tr	0.0006	Tr	0.0002	0.0379	0.0003	0.0002
Domestic waste water	0.001	0.0031	0.0001	0.0089	0.0079	0.0028	0.012	0.0494	0.0537
Spring water	0.0032	0.009	0.0034	0.0032	0.0109	0.0049	0.0166	0.0615	0.0042
Anzele spring	0.0002	0.0032	Tr	0.0109	0.0058	0.0046	0.0137	0.0054	0.0068

* Tr : trace

Heavy Metal Content of Some Products

- 15 Nickel (Ni) content in cultivated plants is comprised between 0.1-1.0 mg/kg at normal dry weight (Güzel *et al.* 2002). Taking these boundary values into consideration, there is no problem in the rocket, dill and stinger plants with regard to Ni contents. The Iron (Fe) amount in the leaves vary from 10 to 1000 mg/kg according to dry material calculation principle. The sufficient Fe amount is generally between 50 and 250 mg/kg (Smith *et al.* 1984). The values in dill plant are slightly above the boundary values (1192 mg/kg).
- 16 The Manganese (Mn) intake varies in plants according to soil reaction (pH) values. For example, while the Mn content of plants growing on a soil whose pH is comprised between 6.9-8.0, varies from 6 to 185 according to dry material calculation principle, the Mn content of the same plants growing in forest soil with a pH of 4.5-5.4 varies between 72 and 1200 mg/kg (Bergmann 1992). Concerning the Mn contents analyzed in the plants growing in the Hevsel Gardens, lack of Mn is noticed only in stinger plants. Mn amounts in dill and rocket plants are within acceptable boundaries (Table 4).

Table 4. Heavy metal content of some products (mg/kg $\pm$ % RSD)

	Dill	Rocket	Stinger
Cd	0.2 $\pm$ 0.40	0.4 $\pm$ 0.36	0.2 $\pm$ 0.11
Co	1.6 $\pm$ 0.01	0.6 $\pm$ 0.40	1.0 $\pm$ 0.67
Cr	4.4 $\pm$ 0.91	1.2 $\pm$ 0.72	2.2 $\pm$ 1.94
Cu	8.4 $\pm$ 0.55	4.0 $\pm$ 0.09	7.4 $\pm$ 1.80
Mn	53.6 $\pm$ 0.28	12.8 $\pm$ 1.00	2.1 $\pm$ 3.24

Ni	7.0±0.16	2.4±1.28	4.2±2.01
Pb	6.6±0.50	3.0±1.48	1.6±7.36
Se	Tr*	1.2±21.11	Tr
Zn	13.8±1.09	9.8±1.51	6.8±0.38
Fe	1169±0.36	192.2±0.17	449±0.87

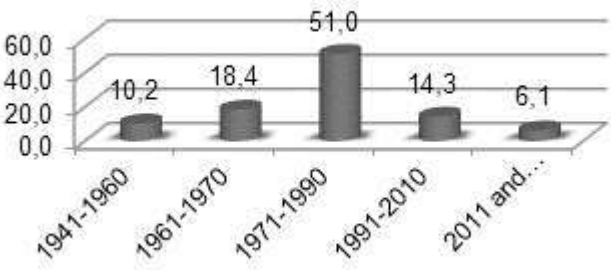
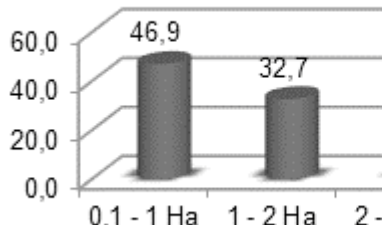
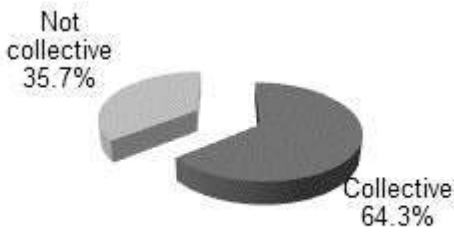
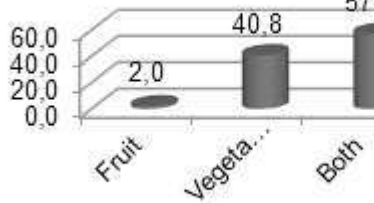
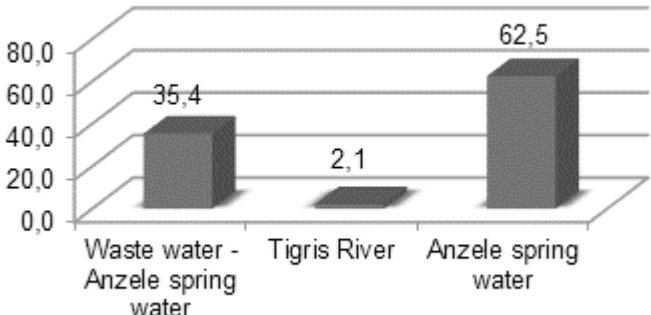
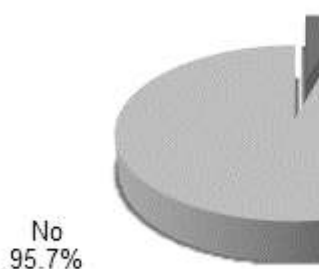
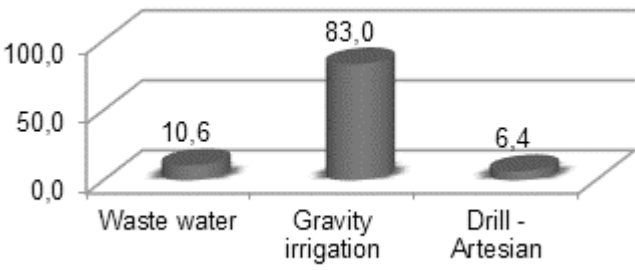
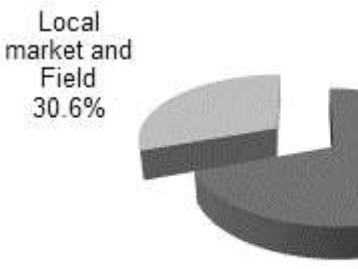
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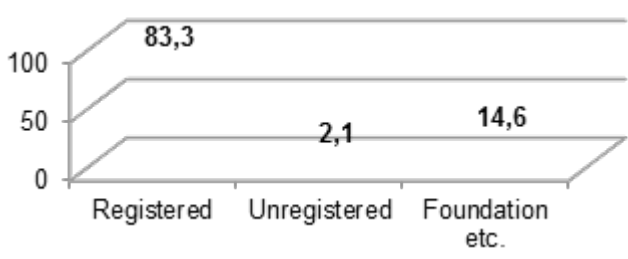
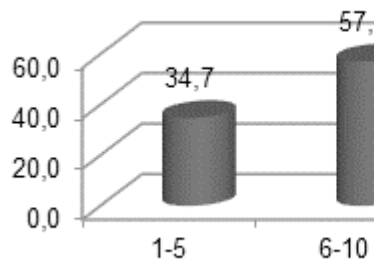
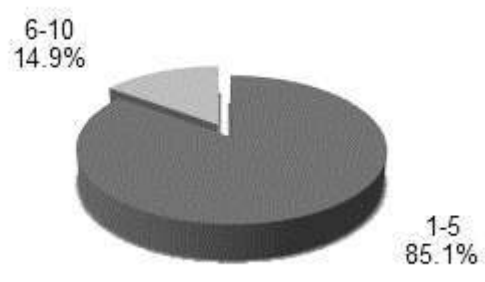
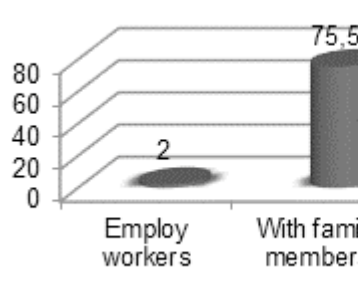
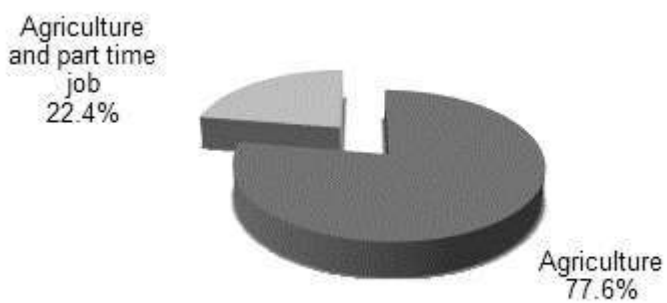
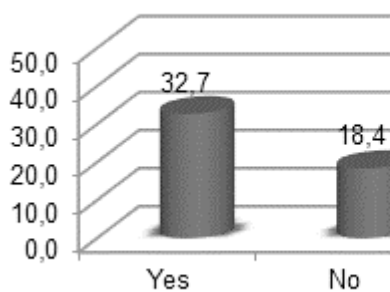
- 17 Zinc (Zn) contents of cultivated plants vary between 20 and 100 mg/kg, the critical level is accepted as 10-15 mg/kg in most cereals and 20-30 mg/kg in dicotyledonae (Kacar and Katkat 2006). Zn content of the analysed plants is between boundary values.
- 18 The copper (Cu) need of plants is generally low. According to dry material calculation principle, Cu amount varies from 5 to 15 mg/kg. Toxic effect can be seen when the Cu amount is above 15-30 mg/kg (Robson and Reuter 1981). According to the analysis of the Cu contents of the plants samples, while the Cu content of dill and stinger plants is within normal limits; in rocket plants, it is below the boundary values even though close to normal (4.0 mg/kg). (Table 4)
- 19 Copper level is determined as low in rocket plants and sufficient in dill and stinger plants. While iron is at a sufficient level in rocket, it is excessive in dill and stinger plants. Manganese levels are insufficient in rocket and stinger plants, but sufficient in dill plant. Zinc is at an insufficient level in all three plants. The cobalt content in plants is not at a threatening level for human health. This is also valid for manganese, i.e. the manganese level of maximum 53.6 mg/kg does not threaten human health (Deveci 2012).

Socio economical structure of Hevsel Gardens farmers

- 20 The survey covers 49 farmers parceled out over an area of approximately 250 ha. The number of buildings on the verge of Hevsel Gardens agricultural lands and established inside the agricultural boundaries is increasing day by day. Such pressure adversely affects the sustainable use of the gardens. In addition, there are summer houses, recreation and hiking places around the Hevsel Gardens. Preserving these areas against the increasing urban pressure is paramount. According to the survey, the ratio of actual farmers who were already producing between 1941 and 1960 is 1% only. In comparison, the ratio of those who started production between 1971 and 1990 is 51%. The agricultural production areas of Hevsel Gardens are rather scattered. The majority of the producers have pieces of land of 0-10 and 10-20 da. These landowners constitute 79.6% of total producers. Division of land due to Inheritance Law is considered as one of the reasons for this scattered structure (Figure 2).

Figure 2. Survey results of Hevsel Gardens producers

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Main source of producers income	Satisfaction status of producers														

- 21 In the following section, the term of fruit is used according to its botanical classification, meaning any carpel containing seeds, while the term of vegetable refers to any plant part consumed for food that is not a fruit or seed, but including mature fruits that are eaten as part of a main meal (Sinha *et al.* 2010).
- 22 Generally, plants whose fruits, leaves and roots are consumed by Diyarbakır's inhabitants are grown in the Hevsel Gardens (Figure 3). Vegetables whose fruits are consumed are tomato, pepper, aubergine, cucumber, zucchini, okra; vegetables whose leaves are consumed are cabbage, lettuce, spinach, rocket, purslane, parsley, dill, basil and mint;

cereal vegetables are green beans, onions, and vegetables whose shoots are eaten are scallion, leek and the primary vegetable whose root is eaten is turnip.

Figure 3. A view of production of some products in the field



- 23 Growing process of such diversified agricultural products needs irrigation water. Farmers state that they use irrigation water from Anzele, Hz. Süleyman spring and domestic wastewater. The topographical structure of Hevsel Gardens makes it possible to bring irrigation water to the plantations using the gravity irrigation method. Some farmers irrigate their crops from wells they have dug themselves.
- 24 Hevsel Gardens farmers sell their products in the Metropolitan Municipality Market. An improvement of the quality and development of marketplaces in the vicinity of the production areas may lead to an increase of diversity and marketable quality of the products, thus raising the added value. Some of the farmers already sell their products in a local market known as *Aşefçiler Çarşısı-Aşefçi Bazaar* (Figure 4).

Figure 4. Local market for products produced in Hevsel Gardens sold at *Aşefçi Bazaar*



- 25 Among the farmers, those possessing land of 0-10 da and 10-20 da are the majority. Small landowners families state that they can manage the workforce by themselves. Even though farmers whose land is around 0-10 da say that they are generally satisfied with their living standards, we observe that farmers owning larger fields, of some 40 da and more, are dissatisfied as they were expecting more profits. Indeed, demographic pressure and the need of a larger housing stock in Diyarbakır raised, for a while, their hopes to obtain building permits for their lands and became real estate owners. Such hopes, nourished by the lack of land property regulation implementation and campaigns initiated by fierce real estate companies, seems to have been cut short by the protection initiatives done in the frame of the UNESCO programme.
- 26 The population per family of Hevsel Gardens farmers varies from 3 to 15. The number of agricultural production workers in every family ranges from 1 to 6. In the farmer families, tasks other than agricultural production generating additional income are also performed. It is stated that the agricultural workforce consist mostly of women. In some cases, when families cannot provide the workforce by themselves, workers are brought in. In such cases again, women are the preferred source of the workforce.
- 27 The survey shows that agriculture is the most important means of earning a living for the people residing around the Hevsel Gardens. Approximately 78% of the farmers live solely from agriculture. Farmers engaged in additional work besides agriculture are around 72% (Figure 2).

Conclusions and Recommendations

- 28 Vegetables with fruit and green leaves, consumed fresh without being processed, and largely preferred by consumers as they are easily found and cheap are more prone to water-related pollution than other types of food, depending on the quality of irrigation water used in the land on which they are grown. Occurrence of foodborne diseases as a result of consuming these types of food is high. Therein, the Hevsel Gardens present high public health risk. As seen in certain examples that can occur in developed countries as well, there have been cases of death due to the outbreak of *Escherichia coli* in plants whose leaves are consumed, such as lettuce and spinach. The basic reason for this is irrigation with surface water that is mixed with domestic waste water.
 - 29 The Hevsel Gardens is also one of the areas where the female workforce is best used. In this regard, it has an important social role. A high number of the farmer families earn their living from other professional activities. However, it seems possible to increase farmers' income by creating added value in their production. For this purpose, the production of both already grown product and alternative product should be encouraged. For example, dried tomatoes, peppers, aubergines, okras are products with high added value.
 - 30 The products grown in the Hevsel Gardens reflect local tastes and incentives to sell them in local markets such as the *Aşefçiler Çarşısı* should be offered. *Aşefçiler Çarşısı* is a local market where feminine labour has become the norm, an example to be encouraged by local administrations in similar places to maintain the traditional culture.
 - 31 Construction should not be allowed in the agricultural production areas of the Hevsel Gardens, and expansion of residents in this area should be prevented. In this way, the first class agricultural land can be protected against domestic waste and construction.
 - 32 Routine analyses should be made to detect risk-causing elements in irrigation water, soil and plants and the relevant public institutions should be warned to take the necessary measures.
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ABSTRACTS

Hevsel gardens date back to the foundation of the city of Diyarbakir and has an important role in feeding of local people. These gardens remind us of a rich past agricultural history that binds us to the future along with role of women in agriculture marketing of these products in local markets. This study reports land structure of Hevsel gardens, state of land use and heavy metals status of these soils, irrigation water used in agricultural production and some crops growing in the area. This study also evaluates socio economic conditions of farmers working in these gardens and determines some economic characteristics. The results obtained from this study, showed nominal amount of heavy metal contents in soil, water and plants that are below threat level for human consumption, however these analyses should be repeated regularly. It would be useful to promote cultivation of ornamental plants, seedlings/saplings production nurseries and building greenhouses in the area.

Hevsel Bahçeleri Diyarbakır şehrinin kuruluşundan günümüze kadar halkın beslenmesinde önemli bir role sahip olmuştur. Bu bahçeler tarımsal kültür hafızasının geleceğe taşınması, tarımda kadının rolü ve yerel pazarların oluşmasında da oldukça önemlidir. Bu çalışma ile Hevsel Bahçelerinin arazi yapısı, arazi kullanım yeteneğine göre durumu, toprak, tarımsal üretimde kullanılan sulama suyu ve yetiştirilen bazı ürünlerin içerdiği ağır metal içeriklerinin belirlenmesi amaçlanmıştır. Bununla birlikte bu bahçelerde üretim yapan üreticilere yönelik yapılan bir anket ile üreticilerin sosyo-ekonomik özelliklerinin belirlenmesine çalışılmıştır. Araştırmadan elde edilen sonuçlar, örneklerin alındığı dönem itibari ile ağır metal içeriklerinin toprak, su ve bitkide insan sağlığını tehdit eden boyutlarda olmadığı, ancak bu çalışmaların düzenli olarak tekrarlanması ve sulama suyu temininin kolaylaştırılmasına gerek duyulduğu belirlenmiştir. Bununla birlikte, söz konusu alanda, süs bitkileri, fide/fidancılık ve seracılık çalışmalarının teşvik edilmesi yararlı olacaktır.

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