Journal of Elementology ISSN 1644-2296

Nowakowska M., Ochmian I., Mijowska K. 2017. *The influence of street conditions on sea buckthorn fruit quality and content of micro- and macronutrients in berries and in soil.* J. Elem. , 22(1): 235-244. DOI: 10.5601/jelem.2015.20.1.871

ORIGINAL PAPER

THE INFLUENCE OF STREET CONDITIONS ON SEA BUCKTHORN FRUIT QUALITY AND CONTENT OF MICRO- AND MACRONUTRIENTS IN BERRIES AND IN SOIL

Małgorzata Nowakowska, Ireneusz Ochmian[1], Kamila Mijowska[1]

[1]Department of Horticulture
West Pomeranian University of Technology in Szczecin

Abstract

Sea buckthorn (*Hippophaë rhamnoides* L.) is grown in urbanized areas owing to its low habitat requirements, resistance to harsh urban conditions and spectacular appearance, especially in autumn and winter when the shrubs produce an abundance of orange berries. The climatic conditions of Szczecin are favourable for the cultivation of sea buckthorn, which can be encountered in various green areas and along streets of this city. Our aim was to identify the influence of street conditions on the content of macro- and micronutrients, also heavy metals, in soil and in berries and on the size and firmness of sea buckthorn fruits. The soils were characterized by similar low salinity (EC 0.31-0.41 mS cm^{-1}).The content of various elements in the soil and berries varied depending on a test site. The soil along a street had a lower nutrient content (P 74.8-98.1; K 99.6-162.7; Mg 38.4-55.1 mg kg^{-1}) than the orchard soil (P 123.3; K 284.7; Mg 72.7 mg kg^{-1}). The heavy metal content in the tested soils (Cd 0.083-0.296; Pb 17.2-31.3 mg kg^{-1}) was found to be much below the limits set in the relevant standards. The content of the tested elements in fruits was most often correlated with their soil content. Berries collected from shrubs which grew on a green strip separating roadway lanes contained much more lead (0.267--0.383 mg kg^{-1} DM), but significantly less cadmium (0.032-0.035 mg kg^{-1} DM) than berries collected in the orchard (Pb 0.231; Cd 0.040 mg kg^{-1} DM). Regardless of the location where the shrubs grew, the cadmium and lead content fell within the limit range set by the relevant standards. Berries picked from non-varietal shrubs growing along the road were smaller (mass of 100 berries 39-45 g) than berries picked from the cv. Hergo shrubs cultivated in the orchard (mass of 100 berries - 57 g). The highest firmness and resistance to puncture were displayed by the smallest berries harvested along the road at research station 1 and cv. Hergo berries. The soils located along the busy street were not contaminated with heavy metals. Besides, in each case the content of heavy metals in sea buckthorn fruits was much lower than allowed by the standards.

Keywords: berries, *Hippophaë rhamnoides***,** mineral composition, soils, urbanised area.

Ireneusz Ochmian, PhD, Department of Horticulture, West Pomeranian University of Technology in Szczecin, Słowackiego 17 str., 71-434 Szczecin, Poland, phone (+48) 91 449 61 61, e-mail: ochir@o2.pl

INTRODUCTION

Sea buckthorn (*Hippophaë rhamnoides* L.), which belongs to the oleaster family (*Eleagnaceae*), grows over a broad area. It occurs in East and Western Asia, from the Caucasus to the Carpathian Mountains, from the Alps to the Pyrenees, in the Black Sea basin and in Central and Northern Europe (Wang et al. 2011). In Poland, it grows in natural stands on the Baltic Sea coast. Sea buckthorn is a xerophyte, i.e. it has good tolerance of drought, soil salinity and air pollution, and it is a sunlight loving plant. It prefers light permeable calcareous soils, but can also thrive on clayey cliffs, dunes and slopes (Sabir et al. 2003). The shrubs can stand extreme temperatures ranging from -43°C to 40°C and are resistant to drought; the majority of sea buckthorn populations can be found in areas with the annual precipitation ranging from 400 to 600 mm, but the plant requires watering in regions with lower precipitation (Li, Schroeder 1996).

Nutrient-rich sea buckthorn berries are food for birds, especially fieldfares. However, the use of berries from urban areas is controversial due to the pollution in urban areas (Hajduk, Kaniuczak 2014, Leake et al. 2009). The pollution accumulation level in plants is varied and largely depends on a plant species and a growing site (Säumel et al. 2012). Heavy metals are a great hazard to health. Lead causes damage to the nervous, reproductive and cardiovascular systems, and disrupts the haemoglobin biosynthesis (Sengar et al. 2008), whereas cadmium impairs vitamin D metabolism and causes damage to kidneys and bones (Cosio et al. 2004). Industrial pollution is the main source of environmental contamination. Major Pb contamination sources in the environment are metal smelters and other industrial plants, lead arsenate pesticides and phosphate fertilisers (Nicholson et al. 2003). Not long ago, lead pollution was also linked to the use of leaded petrol (with the addition of tetraethyl lead), which used to be a significant factor due to the constantly increasing traffic intensity. However, the use of leaded petrol has been banned in developed countries (Żak, Konieczyński 2008). Industrial and agricultural development causes widespread Cd contamination of agricultural soils and the soil-plant environment, mainly due to industrial emissions (Dong et al. 2007).

The advantages of sea buckthorn, such as high ornamental value, resistance to urban conditions and useful, nutrient-rich berries, may support its broader application in green areas, assuming that berries from urban areas are not contaminated and therefore not harmful to the avifauna.

The aim of the research was to determine the influence of street conditions on the content of mineral ingredients in berries and in soil, and on the size and firmness of sea buckthorn fruits. The impact of a street with heavy traffic on the degree of contamination by heavy metals in soil and fruits was compared to a situation where shrubs grew in an orchard.

MATERIAL AND METHODS

Characteristics of the area of research and plant material

The studies were carried out in the Department of Horticulture of the West Pomeranian University of Technology in Szczecin, between 2012 and 2014. The research was conducted in Szczecin, where sea buckthorn is rarely planted near streets, despite the fact that the climatic conditions for its cultivation are favourable. In Szczecin, the average annual air temperature is 8.6°C; July is the warmest month with the multi-year average temperature of 17.8°C, and January is the coldest month, with the average temperature of -0.6°C. The average annual precipitation is 538 mm, and the highest precipitation is recorded in July (75 mm). Szczecin lies in subzone 7A (Heinze, Schreiber 1984).

Considerable differences in the weather were observed between the individual years of our study, and significant deviations of the recorded values from the mean multi-year period values were noted. The year 2012 was characterized by lower temperatures in the spring as compared to 2014 and 2013. The temperatures were much higher in the fruit ripening months as compared to the multi-year period. Precipitation varied over the years and in individual months. Exceptionally little precipitation was observed in 2012, especially in the fruit ripening period, that is in August and September.

Female shrubs (not belonging to a specific cultivar) growing on a strip separating lanes of one of Szczecin's main exit roads were selected for the study. Południowa Street is an urban section of National Road No. 13, distinguished by high traffic intensity KR5 (*State report*… 2012). The carriageways of the street, each with two traffic lanes, are separated by a 3-metre wide median strip with a lawn and sea buckthorn shrubs, which grow in rows along an 800-metre section of the street. Stands 1 and 3 were situated at the ends of the street, in the vicinity of Hackena and Uniwersyteckie Roundabouts, while stand 2 was situated halfway along the street. Shrubs of the cultivar Hergo were cultivated in the Orchard Research Station in Ostoja, which belongs to the Department of Horticulture of the West Pomeranian University of Technology in Szczecin (stand 4).

Methods

Soil in which the shrubs grew was sampled for analyses along a straight line perpendicular to the street, at a distance of 0.5 m from the edge of the carriageway. Soil samples were also taken from rows in the orchard where sea buckthorn shrubs grew. Aggregated soil samples were prepared from the soil material collected with an Egner sampling stick from the humus level (0-30 cm).

Berries chosen for the analysis were harvested at the end of September, when they were fully ripe. Berries were weighed on a RADWAG WPX 4500 electronic scales (0.01 g accuracy). The diameter and firmness of berries were measured with a non-destructive computerized device FirmTech 2 (BioWorks, USA). The firmness for 100 randomly selected berries from each specimen was expressed as a gram-force compressing the berry surface by 1 mm. Punctures were made using a plunger with a diameter of 3 mm.

Dry matter content was determined after drying berries at 105°C. The estimation of the content of minerals in dry weight was carried out in accordance with the Polish Standard (PN) using certified reagents. After mineralization in H_2SO_4 (96%) and HCl (70%), N was determined in the soil, while P, K, Ca and Mg were measured in the berries. In the soil, K and P were determined by extracting in $C_6H_{10}CaO_6$, while Ca, Mg by extracting in $C_2H_3O_2NH_4$. Micronutrients were determined after mineralization in HNO_3 (65%) and $HClO_4$ (70%) in a ratio of 1:1 for soil and 3:1 for fruit samples. Total nitrogen concentration was determined by the Kiejdahl distillation method using a Gerhardt 30. The content of potassium and calcium was measured with atomic emission spectrometry, whereas the magnesium content was assessed with flame atomic absorption spectroscopy using an iCE 3000 Series. Phosphorus content was determined with the Barton method at a wavelength of 470 nm, on a Marcel s 330 PRO spectrophotometer. The content of microelements was assayed using an iCE 3000 Series (IUNG 1972). The pH of the soil (in 1 mol KCl) and electric conductivity (EC) were measured potentiometrically with an ELMETRON CX 742 device. Soil density was determined by a cutting ring, and field water capacity was assessed by gravimetry at pF 2. The textural composition of soil was determined using the laser method. All the tests were performed each year in three replications.

The experimental treatments were arranged in a randomized complete block design with three replicates. The experimental unit consisted of a plot with 5 plants. The results were subjected to statistical analysis using Statistica 10 (Statsoft, Poland). The values were evaluated by the Tuckey test and differences at $P < 0.05$ were considered significant.

RESULTS AND DISCUSSION

The soil from the sites located on the lane separating the street lanes, based on the textural composition test, was defined as sandy loam (Table 1), with the bulk density of up to 1.67 Mg m^{-3} and a high pH value (Table 2). The soil in the orchard was agricultural soil with a natural profile, developed from silt loam, with a considerably lower density of 1.12 Mg m^{-3}, a lower pH value and a higher water capacity. It also contained much more organic matter – 31.4 g kg^{-1} of soil. Regardless of a site, the soils were characterised by similar low salinity – EC 0.31-0.41 mS cm^{-1} (Table 2).

In comparison to the optimal mineral content of soil by Sadowski et al. (1990), the soil in which the shrubs grew, irrespective of a site, was charac-

Table 1

Textural composition of the soils in which the shrubs of sea buckthorn were growing

Growing stand	Content of fraction (mm)							Soil type
	sand				total	silt	clay	
	1.0-0.5	0.5-0.25	0.25-0.10	0.10-0.05	1.0-0.05	0.05-0.002	<0.002	
	content (%)							
1*	2.2	14.0	23.2	15.5	54.9	41.4	3.7	sandy loam
2	4.1	19.7	27.4	14.1	65.2	32.0	2.8	sandy loam
3	3.1	15.3	22.5	15.2	56.1	40.3	3.6	sandy loam
4	3.9	14.6	11.2	14.6	44.2	51.2	4.6	silt loam

* 1-3 stand beside the road – non-varietal shrubs; 4 orchard – cultivar Hergo shrubs

Table 2

Physical properties of soils in which the shrubs of sea buckthorn were growing

Growing stand	Field water capacity (% ww^{-1})	Organic matter (g kg^{-1})	Bulk density (Mg m^{-3})	pH (in KCl)	EC (mS cm^{-1})
1*	22.4*a***	15.6*b*	1.67*c*	7.5*b*	0.38*a*
2	19.7*a*	12.3*a*	1.42*b*	7.5*b*	0.31*a*
3	21.8*a*	13.5*a*	1.51*b*	7.6*b*	0.41*a*
4	33.8*b*	31.4*c*	1.12*a*	6.2*a*	0.34*a*

* for explanation, see Table 1;
** Means followed by the same letter do not differ significantly at $P = 0.05$ according to Tuckey multiple range test.

terized by a high content of phosphorus (74.8-123.3 mg kg^{-1} – optimum 20-40 mg kg^{-1}), potassium (99.6-284.7 mg kg^{-1} – optimum 50-80 mg kg^{-1}) and magnesium (38.4-72.7 mg kg^{-1} – optimum 25-40 mg kg^{-1}). As concluded in the research, the street soil, despite being exposed to pollutants, had lower levels of cadmium (0.083-0.130 mg kg^{-1}), lead (17.2-23.0 mg kg^{-1}) and manganese (19.9-31.3 mg kg^{-1}) than the orchard soil (Table 3). According to CHUDECKA (2013), the Zn, Pb and Cu content in urban soils decreases with the increasing distance from carriageways. Soils have the ability to accumulate heavy metals, and the distance from the source of pollution has impact on their quality (JAWORSKA, DĄBKOWSKA-NASKRĘT 2012). The Pb, Cd, Zn, Cu content determined in the analyzed soils is much lower than the values of soil quality standards in Poland (*Regulation on the Minister* ... 2002), and falls in the lower range of concentrations identified by HAJDUK and KANIUCZAK (2014).

Table 3

Chemical composition of soils in which the shrubs of sea buckthorn were growing

Growing stand	Total content (mg kg^{-1})			
	P	K	Ca	Mg
1*	98.1*b***	162.7*b*	682*b*	49.2*b*
2	74.8*a*	99.6*a*	788*b*	38.4*a*
3	75.2*a*	151.9*b*	736*b*	55.1*b*
4	123.3*c*	284.7*c*	452*a*	72.7*c*

	Total content (mg kg^{-1})					
	Fe	Mn	Zn	Cu	Cd	Pb
1	112.4*b*	23.5*a*	22.4*a*	8.41*b*	0.083*a*	23.0*b*
2	108.0*b*	19.9*a*	42.5*b*	4.39*a*	0.093*a*	20.6*ab*
3	135.2*c*	31.3*b*	26.9*a*	5.88*a*	0.130*b*	17.2*a*
4	83.4*a*	57.3*c*	37.0*b*	7.52*b*	0.296*c*	31.3*c*

*, ** for explanation, see Table 2

According to the Report of the Chief Inspectorate of Environmental Protection (*State report*… 2012), 97% of agricultural areas in Poland are characterized by a natural, slightly elevated content of heavy metals.

It was found that the macronutrient content in the analyzed berries from the shrubs growing at the three street stands and in the orchard was within the following ranges: from 1.73 to 3.46 for nitrogen, from 1.08 to 2.15 for phosphorus, from 5.63 to 14.82 for potassium, from 0.63 to 0.92 g for magnesium and from 0.48 to 0.65 g kg^{-1} of berries for calcium. The highest N, P, K content was determined in berries collected in the orchard (Table 4). The content of the individual macronutrients was similar to the results obtained by Gut et al. (2008), except the potassium content, which was at a higher level, comparable to the concentration found in berries collected in the orchard. Our analysis of the results revealed that in the majority of cases, berries collected in the orchard contained higher quantities of the tested micronutrients. The content of these micronutrients was highly varied in berries collected in the green strip separating the street lanes. The micronutrient content in the tested berries from plants growing in the street stands and in the orchard falls within the following ranges: from 30.8 to 137.2 mg for iron, from 9.40 to 19.8 for manganese and from 0.75 to 1.33 mg for zinc and from 1.93 to 3.72 mg in kg of berries for copper. The highest quantities of Fe, Mn, Cu, similarly to the macronutrients, were found in berries collected in the orchard (Table 4). The content of P, Ca, Mg, Mn, Zn, Cu in berries depended on the content of these elements in soil, which was confirmed by a high and significant correlation between them. The content of harmful heavy metals in berries was varied and it depended on a growing site (Table 4). The content of lead in berries at the street stands was from 0.267 to 0.383 mg kg^{-1} DM (after recalculation into

Table 4

Chemical composition of berries of sea buckthorn

Growing stand		Total content (g kg^{-1})				
		N	P	K	Ca	Mg
1*		1.73*a***	1.08*a*	5.63*a*	0.48*a*	0.63*a*
2		2.75*bc*	1.74*bc*	11.44*b*	0.51*a*	0.69*a*
3		2.32*b*	1.53*ab*	9.17*b*	0.65*a*	0.88*b*
4		3.46*c*	2.15*c*	14.82*c*	0.62*a*	0.92*b*
Correlation coefficients	soil-fruit	-	0.58***	-0.66	0.64***	0.79***
	leaf-fruit	-	0.87***	0.67***	0.79***	0.91****

		total content (mg kg^{-1})					
		Fe	Mn	Zn	Cu	Cd	Pb
1		45.3*a***	13.3*b*	7.51*a*	3.58*c*	0.032*a*	0.369*b*
2		78.5*b*	9.40*a*	11.87*bc*	2.46*b*	0.035*b*	0.267*a*
3		30.8*a*	16.5*bc*	9.19*ab*	1.93*a*	0.034*ab*	0.383*b*
4		137.2*c*	19.8*c*	13.34*c*	3.72*c*	0.040*c*	0.231*a*
Correlation coefficients	soil-fruit	0.13	0.94****	0.91***	0.78***	-0.29	-0.45
	leaf-fruit	0.69***	0.18	0.97****	0.81***	0.87****	0.93***

*, ** for explanation, see Table 1, 2, *** – significant dependence (0.05), **** – highly significant dependence (0.01)

FW from 0.045 to 0.067 mg kg^{-1}). The lead content in fruits collected in the orchard, where there were no urban pollutants, was 0.231 mg kg^{-1} DM (after recalculation into FW 0.031 mg kg^{-1}). The allowable lead content in small fruits is set at 0.20 mg kg^{-1} FW in the *European Commission Regulation…* (2006). After calculating the lead content in the sea buckthorn fruits to fresh weight amounts, the results were much below the upper threshold provided in the standard. The lead content in sea buckthorn berries can be even higher. For example, it was determined at 0.57 mg kg^{-1} by Egorova, Neverowa (2013). Less cadmium (0.032-0.035 mg kg^{-1} DM – after recalculation into FW 0.006 mg kg^{-1}) was in berries of plants which grew in the strip separating the street lanes than in berries collected in the orchard (0.04 mg kg^{-1} DM – after recalculation into FW 0.005 mg kg^{-1}). These values fall within the upper range (0.05 mg kg^{-1} FW) defined in the mentioned *European Commission Regulation…* (2006). The influence of a cultivation site on the heavy metal content was also confirmed by Bednarek et al. (2010) and Bi et al. (2010). Lower mobility of metals in the soil solution and their sorption by plants are influenced by higher pH values.

The research showed that the size of berries and their chemical composition depended on the location of shrubs. The mass of 100 berries was significantly lower if they were picked on the stands beside the road, where they weighed between 39.6 to 45.2 g. The largest berries were picked in the orchard: 100 berries weighed 57.8 g, and their length was 11.35 mm (Table 5).

Table 5

The size and firmness of berries of sea buckthorn depending on the place of cultivation

Growing stand	Mass of 100 berries (g)	Dry matter (%)	Axis diameter			Axis length	
			berries diameter (mm)	firmness (G mm^{-1})	puncture (G mm^{-1})	length of berries (mm)	firmness (G mm^{-1})
1*	39.6*a***	18.2*c*	8.23*a*	144*c*	83*c*	10.44*a*	98*b*
2	45.2*b*	16.9*b*	9.06*b*	93*a*	58*a*	10.81*a*	64*a*
3	42.6*ab*	17.3*bc*	8.51*ab*	117*b*	71*b*	10.63*a*	79*a*
4	57.8*c*	13.5*a*	9.86*c*	136*c*	89*c*	11.35*b*	105*b*

* For explanation, see Table 1;
** Means followed by the same letter do not differ significantly at $P = 0.05$ according to Tuckey multiple range test.

According to Kawecki et al. (2010), berries of sea buckthorn (not belonging to a specific cultivar) weigh approx. 0.4 g, whereas berries of horticultural varieties are heavier, up to 0.9 g. Firmness is one of the indicators of berry quality; it also describes the resistance of berries to punctures while they are picked, stored or transported. An increased number of punctures may result from agricultural practice, but it is also a cultivar-specific feature (Rab, Ul-Haq 2012). The most firm and resistant to puncture were the smallest berries picked at stand 1 and berries from the cultivar Hergo picked in the orchard. The research shows that the size of a berry may be negatively correlated with its firmness (Ochmian et al. 2009*a*, 2010). The relatively low firmness of the berries of sea buckthorn is comparable to easily punctured berries of blue honeysuckle (Ochmian et al. 2009*b*).

CONCLUSION

The soils lying along a busy street were not contaminated with heavy metals. The determined level of contamination is considered to be the natural content. Also, the soil salinity was very low, comparable to the soil salinity in the orchard. The content of micro- and macronutrients in sea buckthorn fruits depended on the quantity of these elements in the soil. Also, the growing place of shrubs had influence on the berry quality. A significant correlation was found between the P, Ca and Mg content in soil and fruits. In the majority of cases, berries collected in the orchard contained higher amounts of the analyzed micro- and macronutrients. Fruits obtained from shrubs growing along the street with heavy traffic contained more lead than fruits from shrubs growing in the orchard. Berries collected from shrubs which grew in the strip separating the street lanes contained less cadmium. However, in each case, the content of heavy metals in sea buckthorn fruits was consistently much lower than allowed by the standards.

REFERENCES

Bednarek W., Tkaczyk P., Dresler S. 2010. *Cadmium and lead in soft fruit from integrated production*. Acta Agrophys., 15: 5-11. (in Polish) www.old.acta-agrophysica.org/artykuly/acta_agrophysica/ActaAgr_177_2010_15_1_5.pdf

Bi X., Ren L., Gong M., He Y., Wang L., Ma Z. 2010. *Transfer of cadmium and lead from soil to mangoes in an uncontaminated area, Hainan Island, China*. Geoderma, 155: 115-120. DOI: 10.1016/j.geoderma.2009.12.004

Chudecka J. 2013. *The content of Zn, Cu, Pb and salinity of soils of green areas located in the center of Szczecin*. Fol. Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 304(26): 5-12. (in Polish) http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-10a5e83c-2dcc-44db-988a-b97045ac44da/c/Chudecka.pdf

Cosio C., Martinoia E., Keller C. 2004. *Hyper accumulation of cadmium and zinc in Thlaspi caerulescens and Arabidopsis halleri at the leaf cellular level*. Plant Physiol., 134(2): 716-725. DOI: http://dx.doi.org/10.1104/pp.103.031948

Dong J., Mao W.H., Zhang G.P., Wu F.B., Cai Y. 2007. *Root excretion and plant tolerance to cadmium toxicity – A Review*. Plant Soil Environ., 53(5): 193-200. http://agriculturejournals.cz/publicFiles/00156.pdf

Egorova I.N., Neverova O.A. 2013. *Heavy metal concentration in the herbal medicinal products of Hippophae rhamnoides* L. *which grows on refuse dumps of the Kuznetsk Coal Basin Surface Mines*. World Appl Sci., J 27: 497-500.

European Commission Regulation No. 1881 / of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union L 364 of 20.12.2006.

Gut M., Gasik A., Mitek M. 2008. *Sea buckthorn - a pharmaceutical plant*. Przem. Spoż., 6: 36-38. (in Polish)

Hajduk E., Kaniuczak J. 2014. *Microelements in soils and in leaves of selected tree species in an industrial urban area*. J. Elem., 19(4): 1001-1019. DOI: 10.5601/jelem.2014.19.3.730

Heinze W., Schreiber D. 1984. *Eine neue Kartierung der Winterhärte-Zonen für Gehölze in Europa*. Mittelungen der Deutschen Dendrologischen Gesellschaft, 75: 11-56. http://www.gis.gov.pl/ckfinder/userfiles/files/Departament%20Bezpiecze%C5%84stwa%20%C5%BBywno%C5%9Bci%20i%20Zywienia/Prawo%20B%C5%BB/2006-1881_pl_zaniecz.pdf

IUNG. 1972. *Methods of laboratory tests in chemical laboratories*. Part II. *The study of plant material*. IUNG, Puławy, 25-83. (in Polish)

Jaworska H., Dąbkowska-Naskręt H. 2012. *Influence of the Głogów copper works on the content of mobile forms of copper and zinc in arable soils*. J. Elem., 17(1): 57-66. DOI: 10.5601/jelem.2012.17.1.05

Kawecki Z., Bieniek, A., Szałkiewicz M. 2010. *Common sea buckthorn in the agricultural landscape*. Acta Sci. Pol., Adm. Loc., 9: 45-53. (in Polish) http://dlibra.bg.uwm.edu.pl/Content/1431/Acta-Adm-Loc-9-3.pdf#page=45

Leake J., Adam-Bradford A., Rigby J.E. 2009. *Health benefits of 'grow your own' food in urban areas: implications for contaminated land risk assessment and risk management*. Environ. Health, 8(1): 6. DOI: 10.1186/1476-069X-8-S1-S6

Li T., Schroeder W. 1996. *Sea buckthorn (Hippophaë rhamnoides* L.*): A multipurpose plant*. HortTechnol., 4: 370-380.

Nicholson F.A., Smith S.R., Alloway B.J., Carlton-Smith C., Chambers B.J. 2003. *An inventory of heavy metals inputs to agricultural soils in England and Wales*. Sci. Total Environ., 311(1): 205-219. DOI: 10.1016/S0048-9697(03)00139-6

Ochmian I. Grajkowski J. Skupień K. 2010. *Effect of substrate type on the field performance and chemical composition of highbush blueberry cv. Patriot*. Agric. Food Sci., 1: 69-80. http://ojs.tsv.fi/index.php/AFS/article/view/5973

Ochmian I., Grajkowski J., Skupień K. 2009*a*. *Influence of substrate on yield and chemical composition of highbush blueberry fruit cv. 'Sierra'*. J. Fruit Ornam. Plant Res., 17: 89-100. http://www.insad.pl/files/journal_pdf/journal2009/vol17%281%292009/Full9%202009_1_.pdf

Ochmian I., Oszmiański J., Skupień K. 2009*b*. *Chemical composition, phenolics and firmness of small black fruits*. J. Appl. Bot. Food Qual., 83: 64-69. http://pub.jki.bund.de/index.php/JABFQ/article/view/2128

Rab A., Ul-Haq L. 2012. *Irrigation intervals affect physicochemical quality attributes and skin cracking in litchi fruit*. Turk. J. Agric. For., 36: 553-562. DOI: 10.3906/tar-1108-11

Regulation of the Minister of the Environment of 9 September 2002, on standards for soil quality and land quality. Dz.U. 02.165.1359 4, October 2002. http://isap.sejm.gov.pl/DetailsServlet?id=WDU20021651359

Report of the Chief Inspectorate for Environmental Protection. 2012. *Monitoring of agricultural soil chemistry in Poland in 2010-2012*. Institute of Plant Cultivation, Fertilization and Soil Science in Puławy. http://www.gios.gov.pl/chemizm_gleb/index.php?mod=wyniki&cz=G, access 4.01.2016

Sabir S.M., Ahmed S.D., Lodhi N. 2003. *Morphological and biochemical variation in Hippophae rhammnoides ssp. turketanica, a multipurpose plant for fragile mountains of Pakistan*. S. Afr. J. Bot., 69: 587-592. http://www.cabdirect.org/abstracts/20043073131.html;jsessionid=4D1CA2E301D7255929673629496B210F

Sadowski A., Nurzyski J., Pacholak E., Smolarz K. 1990. *Identify the needs for fertilizing orchard plants*. II. *The rules, limits and nnumbers of fertilization*. Instruction SGGW, 3: 25.

Säumel I., Kotsyuk I., Hölscher M., Lenkereit C., Weber F., Kowarik I. 2012. *How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany*. Environ. Pollut., 165: 124-132. DOI: 10.1016/j.envpol.2012.02.019

Sengar R.S., Gautam M., Sengar R.S., Garg S.K., Sengar K., Chaudhary R. 2008. *Lead effects on physicobiochemical activities of higher plants*. Rev. Environ. Contam. Toxicol., 196: 73-93.

State report of the city of Szczecin. 2012. *Strategy Office of Szczecin*. www.um.szczecin.pl/raport2010-2011 - access 10.06.2014. (in Polish)

Wang Y., Jiang H., Peng S., Korpelainen H. 2011. *Genetic structure in fragmented populations of Hippophae rhamnoides ssp. sinensis in China investigated by ISSR and cpSSR markers*. Plant. Syst. Evol., 295(1-4): 97-107. DOI: 10.1007/s00606-011-0466-7

Żak M., Konieczyński J. 2008. *Comparison of benzene and its alkylated derivates profiles in car's fuels, engine exhaust gases and in air in the vicinity of communication arteries*. Arch. Environ. Protect., 34(2): 3-12. http://www.ipis.zabrze.pl/dokumenty/archives/roczniki/2008/2-1.pdf