RESEARCH ARTICLE **(Open Access)**

Assessment of Habitats Area and Nickel Hyperaccumulator Plant *Alyssum* Genus in Albania

ERIDANA ÇUNI[1], ERTA DODONA[1], PETRIT HARASANI[2], FATBARDH SALLAKU[1], SEIT SHALLARI[1*]

[1] Faculty of Agriculture and Environment, Agricultural University of Tirana, Tirana, Albania

[2]Polis University, Tirana, ALBANIA

Abstract

Developed soils on serpentine rocks occupies a large area in Albania which contains huge reserves of, nickel, chromium and cobalt. The purpose of our study was to identify the species, the habitats of metal's hyperaccumulator *Alyssum* genus in Albania and to analyze the metals content in soils and plants too. There are accomplished several field trips investigated the mine, ultramafic and mafic soil in different areas of Albania. The soil samples and plants are taken randomly in each habitat for chemicals analyzes and species identifications. The sample of *Alyssum* sp. was identified according to the Flora Europea.*Alyssum murale*wasrepresented by three different varieties. *Alyssum murale*; var. *chlorocarpum*was was represented in 11 habitats in south and southeast Albania. *Alyssum murale*var. *chalcidicum* was identified in three habitats and *Alyssum murale* var. *subvirescens* also was identified in two habitats. *Alyssum markgrafii*was represented only in one habitat in North Albania. Soil and plant samples were analyzed for total Ca, Co, Cr, Mg and Ni. Based on results, each site exhibited a high concentration of one or more metals. The nickel content in soils varied between 1050 and 5650 mg kg^{-1}dry matter. The soils pH values varied from 6.12 to 8.12. The nickel content in plant of *Alyssum murale* varies from 6900 to 18300 $mgkg^{-1}$ dry matter. The nickel content in plants of *Alyssum markgrafii* is from 13770 to 22640 mg kg^{-1} dry matter. These results confirmed that hyperaccumulator*Alysum* sp. is developed as one endemic plant on Albanian serpentine soils. *Alyssum murale*is represented in four location and 16 habitats by three different varieties. *Alyssum markgrafii* is represented only in one isolated habitat in North Albania.

Keywords: Serpentine, hyperaccumulator plants, *Alyssum sp.*, soil.

1. Introduction

The most hyper accumulate Ni plants are found on serpentine soils. Approximately 300 taxa containing up to 3% mg Ni kg^{-1} DM have been identified worldwide as Ni hyperaccumulators **[3, 4, 5]** *Alyssum* genus is one of the most popular hyperaccumulator plants identified in Albania **[9]**. Other studies showed the presence of hyperaccumulatorspecies in the serpentine area in Albania **[9, 1]**. It's intersted to use those plants in bioremediation technologies **[2]**. Serpentine soil concept means soils developed on the rocks which are characterized by a high content of metals (Ni, Co, Cr), by a high ratio of Mg/Ca and very low content of N, P and K.Based in this fact, serpentine isconsidered more as one environmental concept or a special environment which affects the development of flora and fauna species. **[9, 10]** .here are accomplished several field trips investigated the mine, ultramafic and mafic soil in different area of Albania (Figure 1).

2. Material and Methods

During the expedition, the soil samples (0-20cm) and plants are taken randomly in each habitat for chemicals analyzes and species identifications. The objectives were to determine the areas of metal's hyperaccumulator plants in Albania, to identify the plants species and to analyze the Ni content in soil and plants as well and pH in soils too. More than ten plant species were collected at each habitat at different times (May, June, July and August 2014-2015). The plants samples were dried first on the filter paper. The herbarium with all the exemplars represents the plant in different phases from all the area investigated. The identification of species was done according to the Flora Europaea **[13, 14, 15, 16, 17]** and Albanian flora **[6].** For the identification it was used the dycotomic

*Corresponding author: Seit Shallari; E-mail: seitshallari@gmail.com
(Accepted for publication on December 15, 2015)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

method. Soil samples from the rhizosphere (the upper horizon) of each habitat was collected at the depth of 0-20 cm. Five soil samples (2cm core diameter) were sampling randomly in the location and bulked to produce a composite sample of 50-100g. The soil was dried at 105^0C for 24 hours and sieved through a 1 mm screen.

More than ten plant species were sampled randomly from each habitat. Plants samples were dried at 105^0C for 24 hours. Sample of 0.5g (soil and plant) were digested with 6 ml HNO_3, 6ml HF and 2ml $HClO_4$; the final solution was in 50% HCl (v/v) and it was used for the determination of Ni concentration. Concentration of Ni, in the soil and plant solution was determined by the flame atomic absorption spectrometry (using PyeUnicam SP-9AAS). The pH was determined in a soil/water solution with the ratio of 1:2.5 and the pH meter used was a wtw Microprocessor pHmeter.Samples of *Alyssum Murale* which were identified according to the Flora

Europea and Albanian Flora (in Albanian language Flora e Shqiperise), represented three different varieties of *Alyssum murale*; var. *chlorocarpum* was represented in five location or habitats (Bitincka, Korca, Pogradec, Prrenjas and Librazhd) and 11 sub-habitats in south and southeast Albania. *Alyssum murale* var. *chalcidicum* was identified in Bitincka, Pogradec and Vanshkjez. *Alyssum murale* var. *subvirescens* also was identified in Mborja and Drenova (two sub-habitats in Korca region).*Alyssum markgrafii* is represented only in Gjegjan, one habitat in North of Albania. The fruit's size of *Alyssum murale* varies in different habitats from 0.8 to 1.5 mm. *Alyssum markgrafii* has the biggest fruits up to 1.8 mm. The plants growth (the height of stems), depends from soils condition and varies from 55 to 93 cm.

3. Results and Discussions

Habitats and sub-habitats of Alyssum genus description

Habitat of Bitincka (HB: 40°38'47.80"N: 20°58'58.54"E) is located in south-eastern of Albania at 700-1100m above sea level (table 1). There are serpentine sites, which had been mined for Ni and Co. In this region were localized deposits of nickel-silicate and iron-nickel. The Ni cores contain significant amounts of Fe and Co. Some Ni mines are starting in this site. *Alyssum murale* var. *chlorocarpum* was identified in the sub-habitat EM (40°38'45.64"N: 20°59'23.67"E). *Alyssum murale* var.*chalcidium* was represented in sub-habitats WM (40°38'52.62"N: 20°59'21.46"E).

Table 1. The coordinates of habitats and sub-habitat of *Alyssum* genus in Albania

Habitat 's coordinates	Sub-habitat's coordinates			
HB 40°38'47.80"N 20°58'58.54"E	EM 40°38'45.64"N 20°59'23.67"E	WM 40°38'52.62"N 20°59'21.46"E	BM 0°38'38.34"N 20°59'15.64"E	AV 40°38'35.87"N 20°58'55.31"E
HK 40°36'51.66"N 20°46'39.54"E	KD 40°34'59.31"N 20°46'58.98"E	KM 40°35'14.82"N 20°46'38.79"E	KD 40°39'0.79"N 20°48'36.80"E	KP 40°41'16.32"N 20°50'27.90"E
HP 40°54'10.44"N 20°39'32.33"E	NH 40°59'58.08"N 20°38'6.20"E	NMe 40°59'38.10"N 20°38'1.90"E	NL 40°59'44.71"N 20°37'57.34"E	QA 41°3'52.39"N 20°36'45.88"E
HPr 41° 4'5.68"N 20°33'5.97"E	NL 41° 4'9.58"N 20°33'30.98"E	KO 41° 3'59.59"N 41° 3'59.59"N	FI 41° 4'5.67"N 20°32'21.80"E	
HL 41°10'59.82"N 20°18'59.40"E	HM 41°10'17.43"N 20°20'6.29"E	NT 41°11'24.30"N 20°18'37.02"E	NM 41°11'3.04"N 20°19'15.47"E	
HVR				
HGP 41°56'40.44"N 20° 0'26.93"E				

Habitat of Korça (HK: 40°36'51.66"N: 20°46'39.54"E) is located in southeastern of Albania at 700-1000m above sea level, around this city (figure 1). In this area there are determined four sub-habitats of *Alyssum Murale*, KD sub-habitat (40°34'59.31"N: 20°46'58.98"E), KM sub-habitat (40°35'14.82"N: 20°46'38.79"E), KD sub-habitat 40°39'0.79"N: 20°48'36.80"E), KD sub-habitat (40°39'0.79"N:

20°48'36.80"E), and KP sub-habitat (40°41'16.32"N: 20°50'27.90"E). There are serpentine soils in this region, rich in Ni, Cr, and Co. It is identified *Alyssum murale* var.*subvirescens* in KD sub-habitat and KM sub-habitat. *Alyssum murale* represents the dominant species in the soil uncultivated by other plants.

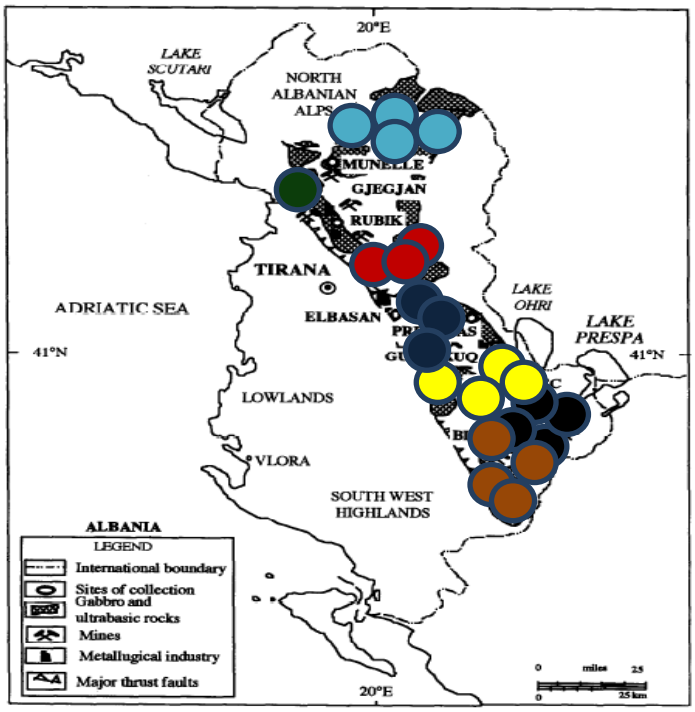

Figure 1. Maps of Albanian serpentine soil and site of soil and plant collection

Habitat of Pogradec (HP: 40°54'10.44"N: 20°39'32.33"E)is locatednear the Ohrid Lake and there were identified four sub-habitats, Near the Hotel (NH). Near the Memorial (NMe), Near the Linivillage (NL) and Qafethane(QA) at 300-500 m above sea level. It is also a serpentine soil with a very high content in Fe, Ni and Co silicates. Up to 2% Ni it has been recorded in the iron type laterites of Librazhd-Pogradec region. A metal industry of Ni, Fe and Co had been operating for several years and was dismantled in 1990.Close to this site (less than 30km), are also, Cr mines (Pojske) and Fe-Ni-Co mines (Guri i Kuqi, Red Stone). It is identified *Alyssum murale* var. *chlorocarpum* in Qafethanesub-habitat and Near the Hotel and *Alyssum murale* var. *chalcidicum*Near the Memorial and Near the Lini village respectively.

Figure 2. *Alyssum murale* var. *chlorocarpum*, sub-habitat of Qafethane

Habitat of Prrenjas (HPr: 41°4'5.68"N: 20°33'5.97"E). In this region we have identified three sub habitats of *Alyssum murale*(table 2); Near the Lake (41°4'9.58"N: 20°33'30.98"E), Kotodesh(41°3'59.59"N: 41°3'59.59"N) and Farmer Nickel Industry (41°4'5.67"N: 20°32'21.80"E).Two habitats, Near the Lake and the Farmer Nickel Industry are respectively in the Est and West of the Prrenjas town. Kotodesh is another one in front of

Prrenjas town and near the Kotodesh village at 300-400 m above sea level. The parent material is rich in Fe, Ni, Cr and Co. The Fe-Ni-Co mines had operated in this region for several years. A local metal company in Prrenjas and in Elbasan smelter has treated the mineral ores. Habitat of Librazhd (HL: 41°10'59.82"N: 20°18'59.40"E) is located in South Albania around the town with the same name. There are located three sub-habitats, Hotelisht (HO), Near the Town (NT) and Near the Memorial (NM). There are serpentine soils with deposits of nickel-silicate and iron-nickel similar to Prrenjas site. In this habitatit is identified *Alyssum murale* var. *chlorocarpum*.

Table 2. Habitats and sub-habitat with *Alyssum murale* and *Alyssum markgrafii* in Albania

Habitat	Sub-habitat	Species	Size of fruits (mm)	Height of stems (cm)
Bitincka	Est of mines	*Alyssum murale*var.*chlorocarpum*	1.2	50-70
	West of mines	*Alyssum murale*var.*chalcidium*	1.2	60-85
	Between the mines	*Alyssum murale*var. *chalcidium*	0.8	65-75
	Below the village	*Alyssum murale*var. *chalcidium*	1.1	60-80
Korca	Drenova	*Alyssum murale*var.*subvirescens*	1.4	55-75
	Mborja	*Alyssum murale*var. *subvirescens*	1.3	65-85
	Dishnica	*Alyssum murale*var. *chlorocarpum*	1.2	55-75
	Plasa	*Alyssum murale*var. *chlorocarpum*	1.5	50-75
Pogradec	Near the Hotel	*Alyssum murale*var. *chlorocarpum*	1.3	50-70
	Near the Memorial	*Alyssum murale*var. *chalcidium*	1.0	55-80
	Near the Lini	*Alyssum murale*var. *chalcidium*	1.0	50-70
	Qafethane	*Alyssum murale*var. *chlorocarpum*	1.1	55-75
Prrenjas	Near the Lake	*Alyssum murale*var. *chlorocarpum*	1.2	60-75
	Kotodesh	*Alyssum murale*var. *chlorocarpum*	1.5	60-80
	Farmer Industry	*Alyssum murale*var. *chlorocarpum*	1.3	55-75
Librazhd	Hotolisht	*Alyssum murale*var. *chlorocarpum*	1.1	55-65
	Near the Town	*Alyssum murale*var. *chlorocarpum*	1.2	75-93
	Near the Memorial	*Alyssum murale*var. *chlorocarpum*	1.5	45-75
Vanshkjez–Mirdite		*Alyssum murale*var. *chalcidium*	0.8	55-75
Gjegjan-Pukë		*Alyssum markgrafii*	1.9	60-85

Habitat of Vanshkjes-Mirditë (HVM) is located in the North of Albania at 200-300m above sea level in the Mirdita region. This site, where is presented *Alyssum murale* var. *chalcidicum,* is located near the Mati river. Ultrabasic and ultramafic rocks in the Mirdita region in Cr and Cu. Four mines, copper (Cu) – gold (Au), silver (Ag), are situated in the Rubic and Mirdita region. In this area is present the nickel hyperaccumulator plant *Alysummurale*.

Figure 3. *Alyssum murale* var. *chalcidicum*, Habitat of Vanshkjes, Mirdite.

Habitat of Gjegjan-Pukë (HGP) 41°56'40.44"N: 20° 0'26.93"E) is situated at the North of Albania at 400-600m above sea level. Silicate-type ores of this region consist of some laterites containing up to 2.6% Ni. The Ni content in soil is amount 1000mg kg -1 dray matter. *Alyssum markgrafi* is identified as a dominant plant species in the uncultivated area.

Figure 4. *Alyssum markgrafi* Habitat of Gjegjan-Pukë

Site clime data

The temperature parameter data for each location are shown in the table 3. The data's for the humidity and the sunshine duration are shown in table 4. These data are the means for 40 years from 1950 to 1990. The soil and atmospheric condition are very specifically for the growth of Alyssum murale and Alyssum markgrafii. The mean of temperature for the period April-September for all locations is 16-20^{0}C. During the winter the minimal absolute temperatures varies from 12.8^{0}C in Pogradec to 20.9^{0}C in Bitincka. In South Albania the annual atmospheric precipitation varies from 700mm in the Korca region to 1250mm in Prrenjas and Librazhd regions. In North of the country the atmospheric precipitation varies from 1600mm in Mirdita (Vanshkjez) to 1800mm in Gjegjan-Pukë. During the green period (April-September) the quantity of rainfall varies from 275mm (Korca), to 600mm (Gjegjan-Pukë). The minimum atmospheric humidity is about 40%.

Table 3. Temperaturesdata's

Temperatures data's (^{0}C)	HB	HK	HP	HPr	HL	HV	GP
Annual mean of minimal daily	4-8	4-8	4-8	4-8	4-8	4-8	4-8
Annual mean reduced sea level	4-6	4-6	4-6	4-6	4-6	4-6	4-6
Annual absolute maximal	35	37	39.6	40	40.5	38	34.6
Mean of the warm	16-20	16-20	16-20	16-20	16-20	16-20	16-20
Annual mean of maximal daily	14-18	14-18	14-18	14-18	14-18	14-18	14-18
Annual mean	10-14	10-14	10-14	10-14	10-14	10-14	10-14
Annual absolute minimal	-20.9	-24.8	-12.8	-15	-15.5	-17.8	-21

Table 4. Date of the atmospheric precipitation, relative humidity and the bright sunshine duration

Parameters	HB	HK	HP	HPr	HL	HV	GP
Atmospheric precipitation (mm)							
Annual mean total	900	700	800	1250	1250	1600	1800
Mean total in the warm period	350	275	325	450	450	500	600
Maximal absolute of total in 24h	98	77	77	102	125	181	191
Humidity (%)							
Mean relative humidity in January	70-75	70-75	70-75	70-75	70-75	60-65	65-70
Mean relative humidity in July	40-45	40	45-50	45-50	-50	40-45	-50
Bright sunshine duration h							
January (court day)	100-125	100-125	100-125	75-100	75-100	100-125	75-100
July (length day)	325-350	325-350	325-350	300-325	300-325	325-350	300-325

Soil pH and Ni content

In the table 5 are shown the nickel concentration in soil and plant samples and the value of soil's pH.. Nickel content was analyzed in soil samples collected on the twenty habitats or seven locations (table 3). Nickel concentration in soils of serpentine and industrial sites was very high up to 5650 mg kg^{-1} dry matter (Bitincka). The nickel content in soils varied between 1005 (Vanshkjez) and 5650 mg kg^{-1} dry matter. The highest values were observed at the sample from the spoil mine of Bitincka, The sample from Prrenjas exhibited again the highest concentration in Ni (1890-2900 mg kg $^{-1}$ dry matter). The soils pH values varies from 6.54 in Prrenjas, (sub-habitat Near the Lake), to 8.12 in Pogradec (sub-habitat Near the Hotel). The soil pH values in North Albania decrease, *i.e* .in Gjegjan-Pukë the values varies between 5.6 to 6.02.The nickel content in plant of *Alyssum murale* varies from 6900 at Prrenjas (sub-habitat-Farmer Nickel Industry) to 18300 mgkg^{-1}dry matter was observed in plants from Pogradec (Near the Memorial) The nickel content in plants of *Alyssum markgrafii* collected in Gjegjan-Pukë is from 13770 to22640 mg kg $^{-1}$ dry matter.

Table 5. Concentration of nickel in soils and plants of Alyssum sp., and soils pH

Locality	Sub habitat	Ni soil	Ni plant	pH (H_2O)
		mg kg $^{-1}$ DM (means value n = 5)		
Bitincka	Est of mines	3000	11208	7.78
	West of mines	2485	13225	7.21
	Between the mines	5650	9560	7.91
	Below the village	1680	8970	8.08
Korca	Drenova	2280	8967	7.83
	Mborja	1750	9200	7.42
	Dishnica	1005	10758	7.01
	Plasa	1140	8110	7.66
Pogradec	Near the Hotel	2490	8690	8.12
	Near the Memorial	1856	18300	6.78
	Near the Lini village	2159	14180	6.69
	Qafethane	1950	9850	7.01
Prrenjas	Near the Lake	2900	11160	6.54
	Kotodesh	1890	12800	6.89
	Farmer Industry	2900	6900	7.45
Librazhd	Hotolisht	1600	9800	7.02
	Near the Town	1350	12500	7.41
	Near the Memorial	1200	8945	7.65
Vanshkjez	Vanshkjez	1050	11980	6.20
Gjegjan	Gjegjan (n=5)	1879	22640	6.12

3. Conclusions

There is a considerable area of serpentine soils in Albania that creates conditions for the growth of Ni hyperaccumulatorspecies represented by *Alyssum murale* and *Alyssum margrafii*. In this study we identified six areas as habitats of *Alyssum murale* and one habitat of*Alyssum markgrafii*. *Alyssum murale* habitats are located from North East to the South East of Albania and represented by 19 sub-habitats and three*A. murale* varieties (*chlorocarpum, chalcidium, subvirescens*). *Alyssum markgrafii*has been identified only in Gjegjanhabitat in North East Albania. The soil where the hyperaccumulatorplant *A. murale* dhe *A. markgrafii* murals were growth, are rich in Ni, Cr and Co and are poor in P and Ca. The content of Ni in soil varies from 1050 -5650 mgkg^{-1} dry matter. While the content in plantvaries from 6900 to 18300 mgkg^{-1} dry matter up to 22640 mg kg^{-1} dry matter for *A. markgrafii*. Hyperaccumulator plants can extract Ni from soil containing high metal for soil remediation or metal phytomining.

4. References

1. Bani A., Pavlova D., Echevarria G., Mullaj A., Roger D. Reeves, Morel J.L., and Sulçe S., 2010. **Nickel hyperaccumulation by the species of Alyssum and Thlaspi (Brassicaceae) from the ultramafic soils of the Balkans**. Botanica Serbica , Vol. 34 Issue 1, p3-14. 12p.
2. Bani A., Echevarria G ., Sulçe S., Morel J.L ., Mullai A., 2007. **In-situ phytoextraction of Ni by a native population of Alyssum murale on an ultramafic site (Albania)**. Plant and Soil,Volume 293, Issue 1, pp 79-89.
3. Brooks R.R., Leej., Reeves R D. et Jaffret., 1977. **Detection of nickeliferous rocks by analysis of herbarum specimens of indicator plants**. Journal of Geochemical Exploration, 7 : 49 -47.
4. Brooks R.R. et Radfordc.C., 1978. **Nickel accumulation by European species of the genus Alyssum**. Proc. R. Soc. Lond., B. 200 : 217-224.
5. Brooks R.R., Morrison R.S., Reeves R.D., Dudley T. R. et Akman Y ., 1979. **Hyperaccumulation of nickel by Alyssum Linnaeus (Cruciferae)**. Proc . R. Soc. Lond., B. 203 : 387-403.

6. **[6].** Demiri. M., 1983. **Flora ekskursioniste e Shqiperise**. Shtepia Botuese e Librit Shkollor Tirane: 986p
7. Reeves R.D., 1988. **Nickel and zinc accumulation bun species of Thlaspi L., Cochlearia L, and other genera of the Brassicaceaae**. Taxon, 37 : 309-318.
8. Reeves R.D., Macfarlane R.M. et Brooks R.R., 1983 b. **Accumulation of nickel and zinc by Western North American genera containing serpentine - tolerant species**. American Journal of Botany, 70: 1297-1303.
9. Shallari S, 1997. **Disponibilité du nickel du sol pour l'hyperaccumulateur Alyssum murale**. Ph. D. These. Institut National Polytechnique de Lorraine, Nancy, Francë. 105p.
10. Shallari S., Schwartz C., Hasko A., Morel J.L., 1998. **Heavy metals in soils and plants of serpentine and industrial sites of Albania**. Science of The Total Environment, Volume 209, Issues 2–3, 19 January 1998, Pages 133–142.
11. Shallari S., Echevarria G., and Morel J.L., 1999. **Where do plants take up their nickel from?** Proc. Extended Abstracts from the 5th Intern. Conference on the Biogeochemistry of Trace Elements (Vienna, Austria July 11-15, 1999). International Society for Trace Element Research, Vienna. p. 526-527
12. Shallari S., Echevarria G., Schwartz C., and Morel J.L.. 2001 **Availability of nickel in soils for the hyperaccumulator Alyssum murale Waldst. & Kit**. South African Journal of Science, Serpentine ecology, Special issue. 568-570.My Citations
13. Tutin T.G., Heywood V.H., Burges N.A., Valentine D.H., Walters S.M. et Webb D.A., 1968. **Flora Europaea**. Vol. 1. Cambridge University Press, 464p.
14. Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. et Webb D.A., 1968. **Flora Europaea**. **Vol. 2**. Cambridge University Press, 455p.
15. Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. et Webb D.A., 1972. **Flora Europaea**. **Vol. 3**. Cambridge University Press, 370p.
16. Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. et y D.A., 1976. **Flora Europaea**. **Vol. 4**. Cambridge University Press, 505p.
17. Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. et Webb D.A., 1980. **Flora Europaea. Vol. 5**. Cambridge University Press, 452p.
18. Tyler L.D., et Mcbride M.B., 1982**. Influence of Ca, pH and humic acid on Cd uptake. Plant and Soil**, 64: 259-262.
19. Vergnano Gambi O., y R. et y L., 1982. **Nickel, chromium and cobalt in plants from Italian serpentine areas**. Acta Ecologica, 3:.