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Component Analysis and Determination of Heavy Metal Accumulation in *Euphorbia macroclada* Boiss (Nigde, Turkey)

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This study reports the heavy metal concentration of the plant macroclada boiss belonging to the Euphorbia type. Twenty stations which have different distances and different heights to the highway were chosen for this study from the separation of Nigde-Adana D750 highway Ali Hoca and Maden Village to Maden Village (Nigde, Turkey). The Cd, Cr, Cu, Ni and Pb concentrations of the sediment and plant samples got from those stations were studied through the ICP-OES technique. According to the arithmetic mean of the chemical analyses results, the highest values are Cr, Pb, Cu, Ni and Cd in earth; Ni, Cr, Cu, Pb and Cd in plants. The maximum values were shown in Cd: S1; Cr: S3; Cu: S10; Ni: S1; Pb: S3 stations in the earth and in Cd:S1; Cr: S1; Cu: S1; Ni: S1; Pb: S1stations in the plants. A high relationship level was defined between Cd *vs.* Cr, Ni, Pb; Cr *vs.* Ni, Pb and Ni *vs.* Pb in the earth and between Cd *vs.* Cr, Cu, Pb; Cr *vs.* Cu, Ni, Pb; Cu *vs.* Pb and Ni *vs.* Pb in the plants. According to the component analysis, the first factor is Cd, Cr, Ni, Pb and the second factor is Cu. On the other hand, the only factor represented the whole in the plants. The Model Summary analysis results in the earth is R^2 = 0,909 %, in the plant R^2 = 0,907 % and the samples were explained on a relatively high level. It was thought that the origins of the heavy metals showing positive high level relation are the same and the analysis area of Nigde-Adana D750 intercity highway are affected negatively due to the traffic.

Key Words: Heavy metal, Component analysis, Multivariate statistic, Macroclada boiss., Euphorbia, Nigde.

INTRODUCTION

Euphorbiaceae is a large family of flowering plants with 300 genera and around 7,500 species. This family occurs mainly in the tropics, with the majority of the species in the Indo-Malayan region and tropical America a good second. There is a large variety in tropical Africa, but it is not as abundant or varied as in these two other tropical regions. However, Euphorbia also has many species in non-tropical areas such as the Mediterranean Basin, the Middle East, South Africa and southern USA. The leaves are alternate, seldom opposite, with stipules[1-3]. As can be expected from such a large family, there is a wide variety in the structure of the flowers. They can be monoecious or dioecious. The stamens (the male organs) can number from 1 to 10 (or even more). The female flowers are hypogynous, i.e., with a superior ovary[4-8]. Euphorbia spp. have been the source of a large number of biologically active compounds, including skin irritant, tumor promoting and proinflammatory[9,10]. Some species of Euphorbia have been used as medicinal plants for the treatment of skin diseases, gonorrhea, migraine and intestinal parasites and as wart cures. Euphorbia spp. have been used in Turkish folk medicine for rheumatism, swelling and especially as a wart remover; however, they cause inflammation and diarrhea[11,12].

Studies of the heavy metal present in soil and plants is an important subject. A study shows the effects of natural and anthropogenic heavy metal contamination. Genetic relationships described in statistical[13-16].

EXPERIMENTAL

Nigde-Adana D750 highway represent approximately 13 km-highway from Ali Hoca and Maden Village crossroad to the hillsides of Maden Village (Nigde, Turkey). The samples for plant and earth were picked as 20 earth samples and 20 plant samples in total from the locations in 1.5 km on the edge of the highway. Maden Village which is from the province of Nigde district of Ulukisla draws attention through its natural beauties. The road which is the working area is very important due to connecting to famous Ali Hocali village, to the place of

TABLE-1
RESULT OF CHEMICAL ANALYSIS (MACROCLADA BOISS)

Sample no	Soil samples (mg/kg)					Plant samples (mg/kg)				
	Cd	Cr	Cu	Ni	Pb	Cd	Cr	Cu	Ni	Pb
S1	3.54	91.64	21.15	18.48	51.12	1.02	5.46	3.02	7.54	1.13
S2	3.24	91.54	18.62	16.65	52.18	0.98	5.21	2.98	6.57	0.98
S3	2.75	91.87	21.15	17.25	51.39	0.65	4.35	2.99	6.12	1.02
S4	2.96	88.62	20.56	16.32	48.89	0.77	3.54	2.87	5.65	0.98
S5	2.78	87.64	21.89	15.48	47.69	0.78	3.65	2.54	4.48	0.88
S6	2.80	88.89	20.99	15.93	46.64	0.52	3.36	2.60	5.54	0.64
S7	2.92	89.92	22.14	16.42	47.79	0.92	2.14	2.43	4.04	0.78
S8	2.89	85.47	21.65	14.28	43.35	0.64	1.74	2.51	4.56	0.89
S9	2.73	90.12	23.36	15.59	42.89	0.56	2.01	2.12	3.66	0.65
S10	2.88	86.70	28.84	16.00	44.57	0.78	1.98	1.98	4.56	0.45
S11	2.87	80.14	22.65	15.56	43.77	0.56	2.15	2.01	5.54	0.56
S12	2.79	78.87	25.90	14.28	42.58	0.69	1.47	0.00	5.01	0.77
S13	2.69	82.29	26.68	14.98	40.12	0.46	1.73	0.00	4.56	0.56
S14	2.54	80.00	26.65	13.35	38.56	0.33	2.21	0.87	5.45	0.47
S15	2.46	76.14	20.00	14.59	39.87	0.29	1.56	0.65	4.12	0.00
S16	2.30	72.56	23.34	13.34	37.54	0.36	1.89	0.73	4.25	0.25
S17	2.41	74.53	21.85	12.41	35.56	0.41	1.54	0.36	3.89	0.00
S18	2.12	77.89	23.38	11.68	36.54	0.45	1.65	0.58	4.01	0.12
S19	1.98	76.42	22.14	12.25	34.4	0.23	0.00	0.38	4.58	0.00
S20	1.54	70.23	20.12	11.20	37.64	0.21	1.29	0.41	4.65	0.00

TABLE-2
RESULTS OF CHEMICAL ANALYSIS OF SOIL AND PLANT SAMPLES SIMPLE STATISTICAL EVALUATION

Soil	Minimum	Maximum	Mean	Std. deviation	Plants	Minimum	Maximum	Mean	Std. deviation
Cd	1.54	3.54	2.6595	0.44328	Cd	0.21	1.02	0.5805	0.24332
Cr	70.23	91.87	83.0740	6.98624	Cr	0.00	5.46	2.4465	1.38234
Cu	18.62	28.84	22.6530	2.58190	Cu	0.00	3.02	1.6015	1.12960
Ni	11.20	18.48	14.8020	1.94725	Ni	3.66	7.54	4.9390	0.99264
Pb	34.40	52.18	43.1545	5.54296	Pb	0.00	1.13	0.5565	0.38194

Darbogaz and Yedi göller region on Toros Mountains and with its organic cherries.

Earth samples were taken systematically from 20 stations in total starting from the crossroad of Ali Hocali and Maden Village on Nigde-Adana D750 highway to the highway edges in Maden village. The samples were taken 0-10 centimeter depth of the earth. The coordinates for the samples were determined through the GPS device in Garmin brand. A sample shovel made from a hard plastic was used in taking the samples and the samples were saved in a plastic bag of one kilogram. The sample bags were cared to be sterilized. The collected samples were dried at 105 ºC during 24 h in drying ovens and passed from the 2 mm plastic mesh and separated from the pebbles. The samples were homogenized and brought in the dimension of 2 mm. The concentrations of Cd, Cr, Cu, Ni and Pb from the heavy metals on the samples made suitable for the analysis were defined *via* ICP-OES technique from the type of milligram/kilogram (mg/kg). All the analyses were made through Perkin Elmer brand Optima 4300 DV model ICP-OES. The samples of macroclada boiss plant belonging to Euphorbia type were collected from the places which take place on the analysis area and are near to the earth samples collected systematically. The samples represent the whole of the origins, bodies and branches. The processes which will cause contamination on the collected samples were avoided. The collected samples were dried under the laboratory conditions and then burned in the muffule furnaces and turned into ashes. The analyses were done on those ashes. The analyses on the plant samples are the same with the techniques for the earth samples[17-19].

RESULTS AND DISCUSSION

The results of the earth and plant samples taken from the stations have been shown in Table-1. The contents of the heavy metals (Cd, Cr, Ni, Pb and Cu) started with the highest values as from the intercity roads and as it became far away the anomaly values were observed to be decreased. In different studies, it was stated that there was metal pollution on the earth on the edge of the highway[20,21]. The maximum values were shown in Cd: S1; Cr: S3; Cu: S10; Ni: S1; Pb: S3 stations in the earth and in Cd: S1; Cr: S1; Cu: S1; Ni: S1; Pb: S1stations in the plants. However, the Cu values in the earth had a different division from the other. It can be thought that the Cu values in the earth were under a different effect.

The chemical analysis of the earth and the plant samples were analyzed statistically on a simple level (Table-2). The statistical studies help in understanding the heavy metal anomalies[22-26]. According to the arithmetic mean of the chemical analysis results, the highest values were Cr, Pb, Cu, Ni and Cd in the earth. And also, they were Ni, Cr, Cu, Pb and Cd in the plants and the order of importance was defined according to the analyzed heavy metal abundance. The Cr in the earth and the Ni in the plant had the highest values and the Cd had the lowest values in both earth and plant.

The correlation relation in the earth and plants was analyzed (Table-3). Different relation levels were defined between

TABLE-3
CORRELATION ANALYSIS

Soil	Cd	Cr	Cu	Ni	Pb	Plants	Cd	Cr	Cu	Ni	Pb
Cd	1					Cd	1				
Cr	0.817(**)	1				Cr	0.734(**)	1			
Cu	-0.017	-0.124	1			Cu	0.749(**)	0.784(**)	1		
Ni	0.899(**)	0.880(**)	-0.123	1		Ni	0.510(*)	0.789(**)	0.541(*)	1	
Pb	0.816(**)	0.887(**)	-0.308	0.915(**)	1	Pb	0.845(**)	0.772(**)	0.787(**)	0.627(**)	1

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed)

TABLE-4
PRINCIPAL COMPONENT ANALYSIS

Soil component	Initial Eigen values			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.639	72.776	72.776	3.639	72.776	72.776
2	1.019	20.385	93.161	1.019	20.385	93.161
3	0.185	3.696	96.857			
4	0.101	2.030	98.887			
5	0.056	1.113	100.000			
Plants component	Initial Eigen values			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.869	77.375	77.375	3.869	77.375	77.375
2	0.591	11.827	89.202			
3	0.271	5.425	94.626			
4	0.161	3.219	97.846			
5	0.108	2.154	100.000			

Extraction method: Principal component analysis

the elements. The positive high relationship (r^2 = less than 0.10) level was defined between (Cd *vs.* Cr, Ni, Pb; Cr *vs.* Ni, Pb and Ni *vs.* Pb) in the earth. In the plants, the positive high relationship level was defined between (Cd *vs.* Cr, Cu, Pb; Cr *vs.* Cu, Ni, Pb; Cu *vs.* Pb and Ni *vs.* Pb). Cu one of the heavy metals in the earth differed from the plants and did not had a positive high relationship level with the other heavy metals. In different studies, the heavy metals showing a positive high relationship are thought to be the same in their origins[24,26]. Similar results were gained in the analysis area.

According to the hierarchical cluster analysis, 2 groups were composed specifically in the earth and plant samples. Location bunches are similar in the earth and the plants. It also has suitability within itself in the analysis of the earth and the plants. So, it is thought that the locations are under similar environmental effects. Suitability was also observed among bunches. The locations of the samples near to the intercity road were separated from the other locations (Fig. 1).

According to the component analysis, 2 (two) groups were composed. The first factor is represented by Cd, Cr, Ni, Pb and the second one by Cu element. According to the results of the principal component analysis (PCA), 2 (two) groups were defined. The first factor explains 72.776 % of the total variance with a high eigen value of 3.639 (Table-4). The first factor is represented by Cd, Cr, Ni, Pb. The second factor explains 20.385 % of the total variance with an eigen value of 1.019 (Table-4). According to the results of the Principal component analysis (PCA), 1 (one) group was defined. The factor explains 77.375 % of the total variance with a high eigen value of 3.869 (Table-4). The first factor is represented by Cd, Cr, Cu, Ni, Pb (Table-5). The first factors in both of them had similar rates. The fact that the second factor was not seen in

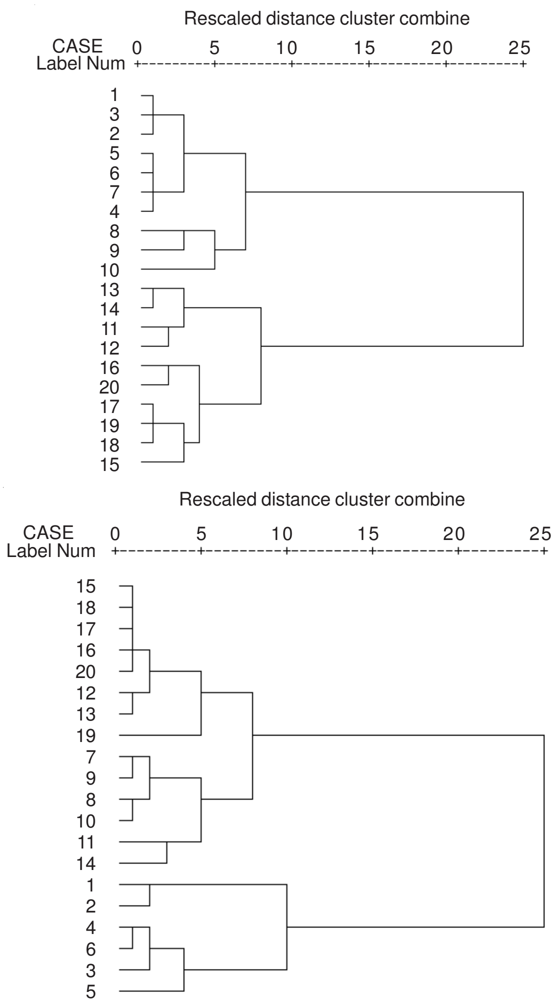

Fig. 1. Hierarchical cluster analysis

TABLE-6
MODEL SUMMARY AND ANOVA TABLES OF REGRESSION DATA

Soil model	R	R square	Adjusted R square	Std. error of the estimate	Plants model	R	R square	Adjusted R square	Std. error of the estimate
1	0.909(a)	0.827	0.781	3.27092	1	0.907(a)	0.823	0.775	0.65534

Soil model		Sum of squares	df	Mean square	F	Sig.	Plants model		Sum of squares	df	Mean square	F	Sig.
1	Regression	766.859	4	191.715	17.919	0.000(a)	1	Regression	29.865	4	7.466	17.384	0.000(a)
	Residual	160.483	15	10.699				Residual	6.442	15	0.429		
	Total	927.342	19					Total	36.307	19			

the plants is related with the fact that the copper existed in the plant in the same portions as the other heavy metals and had similar features.

TABLE-5
COMPONENT MATRIX (a)

	Soil Component		Plants Component	
	1	2		1
Cd	0.920	0203	Cd	0878
Cr	0.941	0066	Cr	0928
Cu	-0.207	0975	Cu	0883
Ni	0.970	0081	Ni	0779
Pb	0.61	-0130	Pb	0921

Extraction method: Principal component analysis. Soil: (a) 2 components extracted. Plants: (a) 1 component extracted

The results of the Model Summary analysis in the earth were $R^2 = 0.909$ % and the results of the model summary analysis in the plant were $R^2 = 0.907$ %. The explanatory power of the regression analyses for model summary was $R^2 = 100$ %. According to ANOVA, 20 descriptive variables (Pb, Cu, Cd and Ni) had a high explanatory power for the variation of Cr element. According to the analysis results, the model summary and Anova had the same feature in the earth and the plant samples. The analysis results have the utmost explanatory feature in both of them. The accuracy degree of the chemical analysis results in the inspection area reached the highest level. The number of the sample was understood to be sufficient according to these results (Table-6).

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