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Determination of Heavy Metal Levels in Some Moss Species Around Thermic Power Stations

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Abstract: In our studry, the chemical analysis related to the heavy metal pollution in some mosses grown near the thermic power stations which built close to Muğla and its environs, was carried out.

Key Words: Determination, thermic power station, moss, heavy metal, pollution.

Termik Santraller Civarındaki Bazı Karayosunlarında Ağır Metal Birikiminin Saptanması

Özet: Çalışmamızda Muğla ve civarında kurulmuş olan termik santrallerin yakınlarında bulunan karayosunlarında kimyasal analizlerle ağır metal kirliliği tesbit edilmiştir.

Anahtar Sözcükler: Tesbit, termik santral, karayosunu, ağır metal, kirlilik.

Introduction

As it is known environmental problems are among daily life problems in Turkey as in the world the last 20 years. Problems such that-caused by the destruction of forests, erosion, rapid increasing of population, distorting urbanization and decreasing green areas, distortion of shores, chemicals used in industry, nuclear energy and thermic power stations are the ones that their solutions are searched not only in our country but also in all over the world. Air, water and soil pollution related to the industrialization and urbanization are above the biological tolerance limits. Especially the overlapping of the settlements and industrial areas has been the reason for increasing air pollution in recent years.

Heavy metals, such as zinc, lead, copper or nickel, are extremely toxic in very small amounts. When one or more of these elements in present in the environment at high concentrations, living organisms are subjected to strong natural selection for tolerance. Environmental contamination by metals exerts physological presures that are clearly too severe for survival of most species by means of phenotypicplasticity or physiological acclimation, rather than genetic adaptaion.

Mosses are used as bioindicators in some various ecological studies for recent thirty years. It is known that especially mosses and lichenes are sensible to air pollution. On the contrary to vascular plants mosses have no cuticula and epidermal layer differentiation. Carpet shaped mosses have usually no organs for the uptake of mineral constituents from the soil, and the contact between the moss individual and its substrate mostly poorly developed. Carpet shaped mosses usually absorb minerals by their whole surface because they have no carrying systems **(Rühling**

& Tyler 1973, 1984; Grodzinska & Godzik 1991). Rasmussen (1977) has already discussed the advantages of using bryophytes for monitoring heavy metal contamination from the atmosphere. Both bryophytes and lichenes retain heavy metals directly from precipitation, as well as from dry particulate matter, owing to their lack of cuticule and large capacity for cation exchange. According to Goncalves, Boaventura and Mouvet (1990) aquatic mosses are biological indicators; they are important bioaccumulators for pollutants and they indicate the pollution. There is a growing literature on the use of aquatic bryophytes to monitor heavy metals. Their ability to accumulate these metals coupled with the broad geographical and ecological distributions of some species and their relative lack of seasonality suggest that at least in temperature regions, they have greater potential as monitors than any other group of aquatic plant. Mosses can accumulate metals without choice, they are always green, they can be picked up all year round and they have a large geographical distribution. So they are considered as ideal plants in determining heavy metal accumulation. Since they reflect the environmental pollution, mosses have been mostly used in determining pollution levels in forests, cities and industrial areas both in local and regional levels.

In this study, the research on heavy metal accumulation levels on mosses around Yatağan thermic power station near Muğla and Kemerköy and Yeniköy thermic power stations near Ören, and the research on pollution around thermic power stations and coal stock areas caused by chimney gas, ashes have been aimed.

Material and Method

The quantity of heavy metal build up on twelve kinds of mosses which collected near three termic power stations which had been built around Muğla-the area of our study-has been determined. The specimens of mosses picked have been pointed by the collected number of researcher as in the following;

Ö.229............. Bryum capillare var. capillare

Ö.217............. Tortula princeps

Ö.220............. Homalothecium sericeum

Ö.173............. Funaria hygrometrica

Ö.242............. Tortula princeps

Ö.244............. Barbula vinealis var. cylindrica

Ö.254............. Leucodon sciuroides

Ö.196............. Bartramia stricta

Ö.204............. Pleurochaeta squarrosa

Ö.205............. Scorpiurium circinatum

Ö.206............. Rhyncostegium riparioides

Ö.211............. Leucodon sciuroides.

They were collected in the following areas;

Ö. 229, Ö, 217, Ö. 220: Around Ören-Yeniköy thermic power station in Yeniköy.

Ö. 173, Ö. 242, Ö. 244, Ö. 254: Around the thermic power station in Yatağan and accross Yatağan-Eskihisar coal mine.

Ö. 196, Ö. 204, Ö. 205, Ö. 206, Ö. 211: Around Ören-Kemerköy thermic power station in Kemerköy.

Measurements made have been studied in two terms as Autumn and Spring, and their averages are presented as **Table (1-2)**. Values of studied elements (Cu, Zn, Cd, Pb, Ni) are presented on **Figure (1-5)**.

Table 1. Seasonal station variables of heavy metal levels which some moss flora species were found to contain in the study area.

SPECIES	ST		Cd	Pb	Cu	NI	Zn
		AUTUMN	0.450	11.800	10.075	95.875	40.500
	1	SPRİNG	0.590	15.630	14.980	134.200	42.870
		AVERAGE	0.520	13.715	12.527	115.037	41.685
Tortula princeps							
		AUTUMN	0.000	1.625	6.575	6.225	26.500
	2	SPRİNG	0.850	2.300	10.125	4.900	53.000
		AVERAGE	0.472	7.838	12.082	5.512	39.750
Funaria hygrometrica		AUTUMN	0.200	6.025	23.250	12.275	112.500
	2	SPRING	0.310	7.050	34.200	13.550	208.500
		AVERAGE	0.225	6.537	28.725	12.912	160.500
Bryum capillare var. capillare		AUTUMN	0.000	4.575	31.925	321.525	85.750
	1	SPRING	0.180	8.185	38.955	250.275	113.750
		AVERAGE	0.090	6.380	35.440	285.900	99.750
Barbula vinealis var. cylindrica		AUTUMN	0.200	6.300	15.825	10.675	45.000
	2	SPRING	0.220	6.690	20.385	11.850	50.185
		AVERAGE	0.210	6.495	18.105	11.262	47.592
Barbula vinealis var. cylindrica		AUTUMN	0.450	1.200	16.475	37.525	44.000
	3	SPRING	0.770	1.600	19.447	42.525	46.620
		AVERAGE	0.610	1.400	17.961	40.025	42.310

Table 2. Seasonal station variables of heavy metal levels which some moss flora species were found to contain in the study area.

SPECIES	IST		Cd	Pb	Cu	NI	Zn
		AUTUMN	0.200	1.250	7.925	98.175	43.250
	1	SPRİNG	0.150	2..200	11.000	88.155	46.870
		AVERAGE	0.175	1.725	9.402	93.165	45.000
Tortula princeps							
		AUTUMN	0.450	74.675	17.378	12.850	73.250
	2	SPRİNG	0.518	129.475	18.315	15.150	98.275
		AVERAGE	0.320	102.075	17.845	14.000	85.762
Funaria hygrometrica	3	AUTUMN	0.200	65.325	10.575	21.525	67.750
		SPRING	0.280	165.320	13.315	20.150	85.650
		AVERAGE	0.240	115.322	11.945	20.837	76.700
Bryum capillare var. capillare	3	AUTUMN	0.000	94.650	12.325	24.050	50.000
		SPRING	0.000	89.850	48.325	22.850	56.250
		AVERAGE	0.000	92.250	30.325	23.450	53.125
Barbula vinealis var. cylindrica	3	AUTUMN	0.200	0.050	21.825	26.025	48.500
		SPRING	0.750	6.440	24.650	30.750	78.400
		AVERAGE	0.475	3.245	23.327	28.387	63.450
Barbula vinealis var. cylindrica	3	AUTUMN	0.450	9.025	9.900	17.725	56.500
		SPRING	0.440	6.500	17.925	17.422	61.765
		AVERAGE	0.445	7.762	13.912	17.523	59.132

Moss specimens collected from the fields and brought to laboratory have been dried in 85° C etüvs. Then a sample weighted as 1.0±0.1 grams had been put into 50 ml. erlens. 15 ml. $HNO3$ is pured on the sample. Next day, it is heated about 8 hours at 50°-60 °C. After cooling, 4 ml. $HClO4$ is added in each sample, and then heated about 4 hours at 100-110 °C. It is heated upto 190-200 °C after putting off the clocks glass on the erlens. After the precipitate at the bottom of the erlens is cooled, 10 ml. concentrated HCl and approximately 30 ml. pure water are added. Then it is again heated at 90-95 °C and the compounds are dissolved in 2-3 hours. The solution filtered by black filter paper is poured into pyrex glass ware and the pure bidestillated water is added upto the marked level. The heavy metal determination in the specimens solution that became ready to be measured after a series of chemical procedure has been read by GBC

904PBT model atomic absorbtion spectrofotometer. Cooling of floor has been obtained by using of Deterium lamp. As a result values have been counted as µg.g-1 dry weight (ppm).

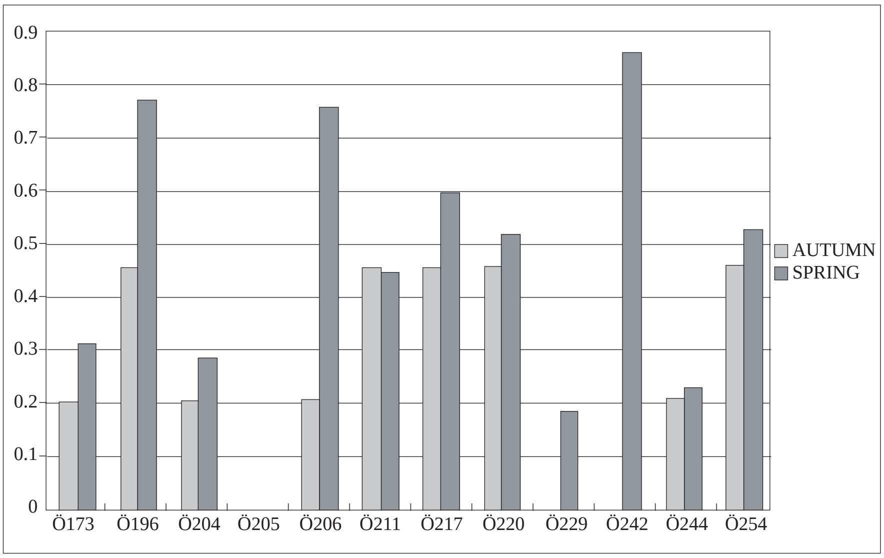

Figure 1. Levels of Cd

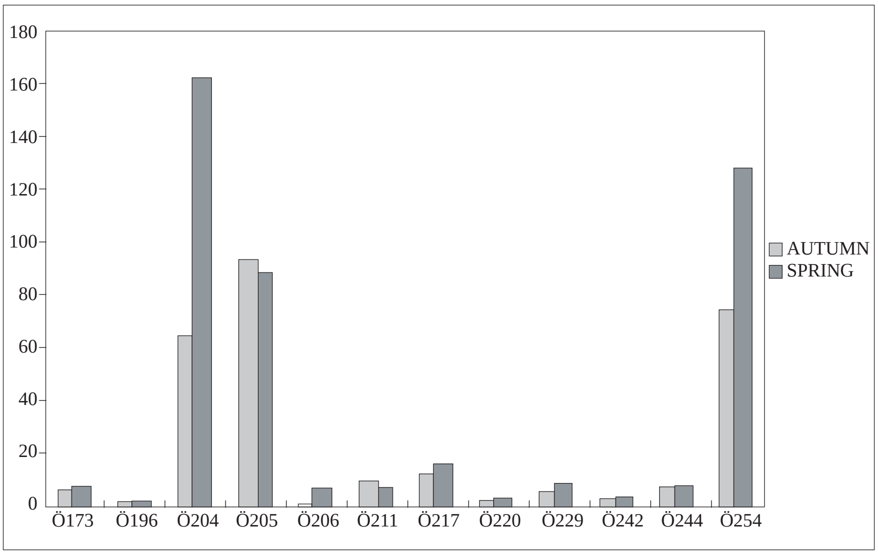

Figure 2. Levels of Pb

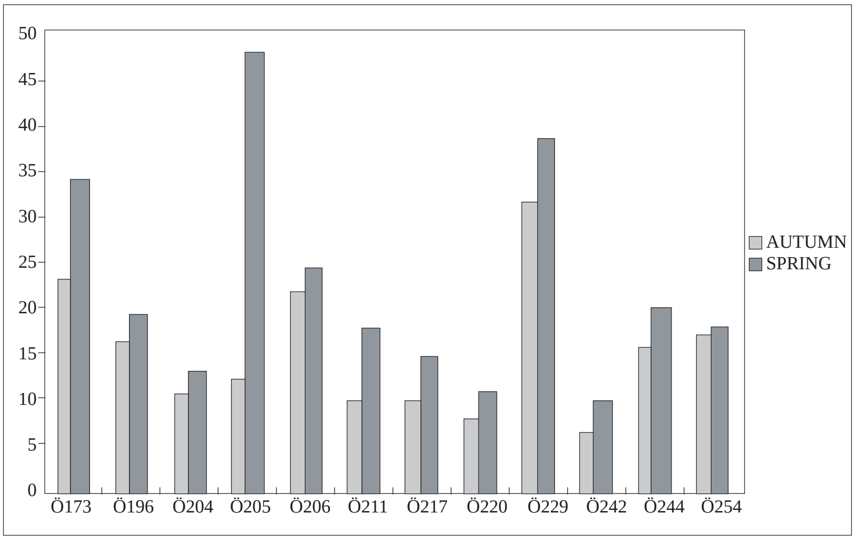

Figure 3. Levels of Cu

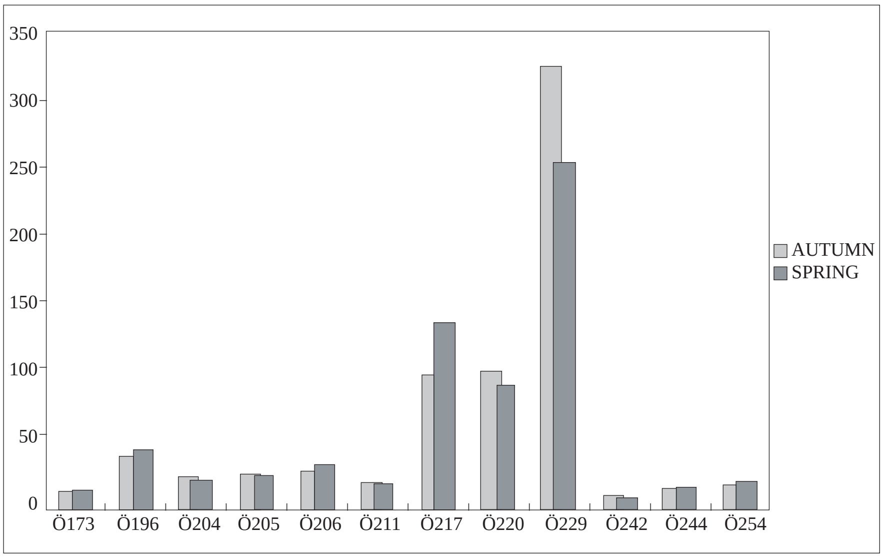

Figure 4. Levels of Ni

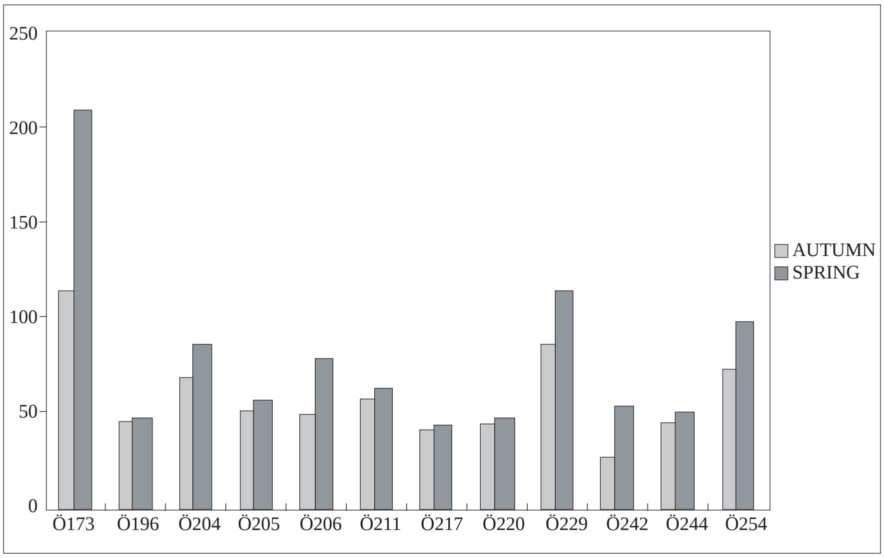

Figure 5. Levels of Zn

Results and Discussion

As a result of our Cu and Zn values have been found very high on ***Funaria hygrometrica*** which had been collected the area Yatağan thermic power station (Table 1-2). While Cu concentration value is varies between 23.250 µg.g-1 and 34.200 µg.g-1, Zn concentration value is in between 112.500 µg.g-1 and 208.500 µg.g-1. adaptation to environmental contamination by heavy metals in cryptogramic plants is not well understood. Bryophytes occur in a diversity of metal contaminated environments including mine tailings, urban areas and on soils polluted by metal smelters, and there is some evidence that metal tolerant ecotypes occur. Increased ability to tolerate copper and zinc in **Funaria hygrometrica**. In contrast **Shaw & Albright (1990)** found no evidence that an urban population of **Bryum argenteum** was more tolerant of copper, zinc, lead or cadmium then were suburban or rural populations, although internasl concents of the metals differed greatly among them. Heavy metals, such as zinc, lead, copper, or nickel, are extremly toxic in very small amounts. When one or more of these elements is present in the environment at high concentrations, living organisms are subwected to strong natural selection for tolerance **(Shaw & Albright, 1990)**. The use of bryophytes is a highly suitable method in assesing temporal, regional and local trends in heavy metal deposition patterns. Even **Grodzinska's (1990)** results, (Cu 6.01 µg.g-1, Zn 23.80 µg.g-1), **Hylocomium splendes** that accumulates most heavy metals, are pretty low according to our study. **Barbula vinealis var. cylindrica,** which was picked up around the same thermic power station, has the lowest value of Cd (Average 0.210 µg.g-1). The highest value has been determined in Zn as (Average 47.502 µg.g-1). However, in spring time the thermic power station, has the lowest value of Cd (Average 0.210 µg.g-1). The highest value has been determined in Zn as (Average 47.502 µg.g-1). However, in spring time the value in **Homalothecium sericeum** which spreads over largely, comes up to 98.275 µg.g-1. Regional variations in the concentratios of heavy metals, found in **Homalothecium sericeum** in this study, reflect the fall-out from an atmospheric poll to which long-range transport and local supply contribute. The reason for that the other species are acrocarp mosses. In Ören, Yeniköy thermic power station the lowest Cd value has been obsorved in **Bryum capillare var. capillare** as average 0.09 µg.g-1. This rate is pretty low according to Poland, Iceland and Scandinavian countries. Yearly nickel concentrations taken from thermic power station have been determined as 93.165 µg.g-1 in **Homalothecium sericeum, 115.037** µg.g-1 in **Tortula princeps,** 285.900 µg.g-1 in **Bryum capillare var. capillare.** These values has been found pretty high according to the results taken from Southern Spitsbergen **(Grodzinska & Godzik, 1991).**

In Ören / Kemerköy thermic power station there could be found no Cd data in **Scorpiurium circinatum**. On the other hand Pb, Cu, Ni, Zn values have been found high. In the other species similar results have been also confirmed (Table 3-4).

Table 3. According to Research Data, Annual Average Value of the Heavy Metal Concentration in Pleurocarp Mosses is Shown on the Following Table. (µg/g Dry weight based).

Species	Cd	Pb	Cu	Ni	Zn
Homalothecium sericeum	0.252	51.900	13.743	53.582	66.441
Pleurochaeta squarrosa	0.240	115.322	11.945	20.837	76.700
Scorpiurium circinatum	--------	92.250	30.325	23.450	53.125
Rhyncostegium riparioides	0.475	3.245	23.237	28.387	63.450
Leucodon sciuroides	0.445	7.762	13.912	17.573	59.132

Table 4. Heavy Metal Conceration Levels of Pleurocarp Mosses.

Species	Heavy Metal Deposition Level
Homalothecium sericeum	Zn>Ni>Pb>Cu>Cd
Pleurochaeta squarrosa	Pb>Zn>Ni>Cu>Cd
Scorpiurium circinatum	Pb>Zn>Cu>Ni>Cd
Rhyncostegium riparioides	Zn>Ni>Cu>Pb>Cd
Leucodon sciuroides	Zn>Ni>Cu>Pb>Cd

As it has been already known bryophytes are seperated into two morphological groups as **Acrocarp and Pleurocarp** mosses. As a result of our study as pleurocarp mosses grow parallel to substratum it has been observed that they have much more ability to absorb heavy metals. According to this the heavy metal levels of acrocarp mosses are displayed in Table 5-6.

Table 5. According to Research Data, Annual Average Value of the Heavy Metal Concentration in Acrocarp Mosses is Shown in the Following Table (Dry weight μg/g).

Species	**Cd**	**Pb**	**Cu**	**Ni**	**Zn**
Tortula princeps	0.472	7.838	12.082	60.300	40.717
Funaria hygrometrica	0.255	6.537	28.725	12.912	160.50
Bryum capillare var. capillare	0.090	6.380	35.440	285.90	99.750
Barbula vinealis var. cylindrica	0.210	6.495	18.105	11.262	47.592
Bartramia stricta	0.610	1.400	17.961	40.025	42.310

According to these results it has been observed that heavy metals cause the decreasing of the sporphyta density. Different levels of heavy metals on mosses are caused by biological and ecological factors such as environmental parameters and the spring time progress. Heavy metal concentration levels in some moss species spreading largely over the area are as: Tortula princeps, Bryum capillare Ni>Zn>Cu>Pb>Cd; Funaria hygrometrica, Barbula vinealis var. cylindrica Zn>Cu>Ni>Pb>Cd; Bartramia stricta, Rhyncostegium riparioides and Leucodon sciuroides Zn>Ni>Cu>Pb>Cd; Homalothecium sericeum Zn>Ni>Pb>Cu>Cd; Pleurochaeta squarrosa Pb>Zn>Ni>Cu>Cd; Scorpiurium circinatum Pb>Zn>Cu>Ni>Cd.

Species	Heavy Metal Deposition Level
Tortula princes	Ni>Zn>Cu>Pb>Cd
Bryum capillare var. capillare	Ni>Zn>Cu>Pb>Cd
Funaria hgrometrica	Zn>Cu>Ni>Pb>Cd
Barbula vinealis var. cylindrica	Zn>Cu>Ni>Pb>Cd
Bartramia stricta	Zn>Ni>Cu>Pb>Cd

Table 6. Heavy Metal Concenration Levels of Acrocarp Mosses.

References

1. Goncalves, E. P. R., Boaventura, R. A. R., Mouvet, C., 1990. Sediments and Aquatic Mosses as Pollution Indicators for Heavy Metals in the Ave River Basin (Portugal). The Science of the Total Environment, 114: 7-24.
2. Grodzinska, K., Szarek, G., Godzık, B., 1990. Heavy Metal Deposition in Polish National Parks-changes during ten years-Water, Air and Soil Pollition 49: 409-419.
3. Grodzinska, K., Godzık, B., 1991. Heavy Metal and Sulphur In Mosses From Southern Spitsbergen. Polar Research 9(2): 133-140.
4. Rasmussen, L., 1977. Epiphytic Bryophytes As Indicators of the Changes In The Back Ground Levels of Airborne Metals From 1951-1975. environmental Pollution 14: 37-45.
5. Rühling, A, Tyler, G., 1973. Heavy Metal Deposition in Scandanavia. Water, Air and Soil Pollution 2, 445-455.
6. Rühling, A, Tyler, G., 1984. Recent Changes in the Deposition of Heavy Metals in Northern Europe. Water, Air and Soil Pollution 22, 173-180.
7. Shaw, A. J., Albright, D. L., 1990. Potential for The Evolution of Heavy Metal Tolerances in Bryum argenteum a Moss. II. Generalized Tolerances Among Diverse Populations. The Bryologist 93(2): 187-192.