Journal of Animal and Veterinary Advances 8 (12): 2719-2726, 2009
ISSN: 1680-5593

Determination of Some Chemical Properties of Common Cattail (*Typha latifolia* L.)

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Abstract: This study was carried out to determine macro, micro and heavy metals in the root, stem and leaves of common cattail (*Typha latifolia* L.) between the years of 2005-2006. The study was conducted by collecting plant samples on monthly basis. Plant samples were collected from two different regions (Lakes A and B) in Kahramanmaras province of Turkey. The study was conducted under laboratory conditions. Among macro elements of the plant, potassium was mostly concentrated in the stem whereas sodium and calcium were mostly concentrated in the leaves. Magnesium was mostly concentrated in the root. Among the micro elements, zinc, iron and copper were mostly concentrated in the root whereas manganese was mostly concentrated in the leaves. Among heavy metals, nickel, lead and cadmium were mostly concentrated in the root.

Key words: Chemical properties, common cattail (*Typha latifolia* L.), heavy metals, macro elements, micro elements, leaves, stem, root

INTRODUCTION

Aquatic weeds are widely distributed in irrigation channels and the areas with high underground water level in the world and in Turkey. *Typha latifolia* L., which is one of these aquatic weeds, is a perennial aquatic weed widely distributed in Turkey. Typha genus is distributed in irrigation systems in Turkey alone or together with other aquatic weeds, particularly with the *Phragmites* genus. *Typha latifolia* L. is a commonly distributed perennial aquatic weed in Turkey. The plant is rich in nutritious substances and grows in tropic and mild regions, slow running water, marshes, water-sheds, lakes and channels. In Turkey common cattail was identified in Thrace, Northeastern Turkey and Central Anatolia (Altinayar, 1998).

Heavy metal contamination is one of the serious environmental problems threatening agricultural factors in water or land ecosystems, human and animal health (Srivastav *et al*., 1994; Lasat, 2002; Fediuc and Erdei, 2002; Overesch *et al*., 2007). Some aquatic plants have the ability of removing heavy metal and nutritional in their environments (Dunbabin and Bowmer, 1992). Common cattail plants have a high capacity of uptaking heavy metals (McNaughton *et al*., 1974).

Mungur *et al*. (1998) analyzed micro, macro elements and heavy metals in the root, stem and leaves of common cattail and determined the distribution of these in the roots, stem and the leaves and assessed the environmental effects of these substances. At the end of the study the researchers found that common cattail removed 81.7-91.8% Cu, 75.8-95.3% Pb, 82.8-90.4% Zn from the water. In their studies Zhihong *et al.* (1998) reported that in *Typha latifolia*, Zn was mostly concentrated in the stem, Pb and Cd were mostly concentrated in the root.

The purpose of this study was to analyze macro (K, Ca, Na, Mg), micro elements (Zn, Fe, Cu, Mn) and heavy metals (Pb, Ni, Cd) concentrated in root, stem and leaves of common cattail (*Typha latifolia* L.), to identify the quantity of these elements and metals in the organs of the plant and to determine the differences between the plant organs and to make comparisons according to months and regions.

MATERIALS AND METHODS

Study area: The study was carried out between 2005-2006 in Evri (Lake A) (37°16'43.95"K-37°07'24.03"D) and Kumasir Lakes (Lake B) (37° 30'31.37"K- 36°53'49.10"D) in Kahramanmaras province of Turkey with the purpose of determining macro, micro and heavy metals in the root, stem and leaves of common cattail (*Typha latifolia* L.) collected from these two lakes.

Evri Lake, named as Lake A, is located at an altitude of 548 m and has an area of approximately, 2 ha. Kumasir Lake, named as Lake B, is located at an altitude of 456 m and has an area of approximately, 9 ha. Both lakes are

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natural lakes and there are rural settlements around the lakes. The waters of these lakes are used in agricultural irrigation. In addition, both lakes are mainly dominated by common cattail.

Material: Plant species collected on monthly basis for a 12 month period were cleaned in the laboratory. The root, stem and leaves were separated. First, the wet weights of the plants were determined and after keeping the plants in incubator at 65°C for 48 h, dry weights of the samples were determined. Then, the samples were grinded in the mill and kept at -20°C temperature in the freezer, until the time of analysis.

The pH and salt content of 2 different spots we determined for *Typha latifolia* samples (Lakes A and B) were monitored for 12 months. The pH values of the water samples of the area was determined using pH meter and salt values were determined by salt-meter and temperature values were measured in the field using a thermometer. The plant (root, stem and leaves) collected from two different lakes were analyzed according to wet burning method and macro element (K, Ca, Mg, Na), micro element (Zn, Fe, Cu, Mn) and heavy metal (Pb, Ni, Cd) contents of the root, stem and leaves of *Typha latifolia* were identified.

Wet destruction with $HNO_3/HClO_4$: Destruction procedures based on the use of a mixture of HNO_3 and $HClO_4$ are often used for plant analysis (Schierup and Larsen, 1981; Kufel, 1991; Stoltz and Greger, 2002). Ten millilitres of concentrated HNO_3 (ultrapure 65%) and 1 mL of 70% $HClO_4$ were added to 1.00 g plant sample and the suspension was allowed to stand overnight at room temperature. The sample was then heated for 1 h at 120°C and then at 175°C, until about 2 mL of acid remained. The temperature was then further increased to 225°C for 10 min. After cooling, the suspension was filtered (S and S, blue ribbon, Schleicher and Schuell) in a 50 mL volumetric flask and diluted to the mark.

Chemical analyses: In all of the extracts, K, Ca, Mg, Na, Cu, Fe, Mn, Zn, Cd, Pb and Ni contents were measured using flame atomic absorption spectrometry (Perkin Elmer AAS-3110, USA).

Statistical analyses: For comparison of means, the data were examined statistically using one-way Anova followed by Duncan multiple comparison test ($p<0.05$) (SAS, 1999). The method detection limit of each procedure was calculated as three times the standard deviation of the blanks.

RESULTS AND DISCUSSION

Properties of study area: The pH, salt concentration and temperature of Lake A ranged from 6.67-7.7, 0.14-0.42 and 8-24°C, respectively, while pH, salt concentration and temperature of Lake B ranged from 6.58-7.69, 0.14-0.5 and 7-24°C, respectively.

Ph value is suitable for irrigation water, however % salt content of the water belongs to low and moderate salinity class. The increase of salinity in the water restricts natural life, plant development in the water and utilization of the lake for irrigation purposes (Tok, 1997).

Dry Matter (DM) content of root, leaves and stem of *Typha latifolia*: The DM (%) content of *Typha latifolia* plant collected from Lake A and Lake B for one year was determined in the laboratory and the results are presented in Fig. 1.

As can be seen from Fig. 1, the leaves of *Typha latifolia* had the highest DM content in January. The DM contents measured in the root, leaves and stem of the plant in lakes A and B in other months were close to each other. However, generally the leaves had the highest DM content when different organs of the plants were analyzed.

Macro elements contents of root, leaves and stem of *Typha latifolia*: Macro elements content of Root, Leaves and Stem of Typha latifolia are given in Fig. 2-5.

There was a significant difference between lakes in terms of the macro elements of *Typha latifolia* such as K, Na, Ca and Mg.

On the other hand, there was no significant ($p>0.05$) difference between leaves obtained from two lakes in terms of Na.

When, whole parts of plant was taken into consideration, there are significant ($p<0.05$) differences among months.

When, Fig. 2-5 are analyzed in terms of macro elements; in average of 12 months, in Lake A, potassium (K) had the highest concentration in the root, stem and leaves (10758,21 mg kg^{-1} in the root, 12720.48 mg kg^{-1} in the stem, 11568.261 mg kg^{-1} in the leaf), followed by sodium (Na) (5779.46 mg kg^{-1} in the root, 6287.77 mg kg^{-1} in the stem, 5538.47 mg kg^{-1} in the leaf); calcium (Ca) (307.49 mg kg^{-1} in the root, 583.43 mg kg^{-1} in the stem and 541.45 mg kg^{-1} in the leaf) and magnesium (Mg) (9.91 mg kg^{-1} in the root, 22 mg kg^{-1} in the stem and 10.42 mg kg^{-1} in the leaf). In the root, potassium (12491.7 mg kg^{-1}), calcium (429.69 mg kg^{-1}) and magnesium values (14.87 mg kg^{-1}) were found to be the

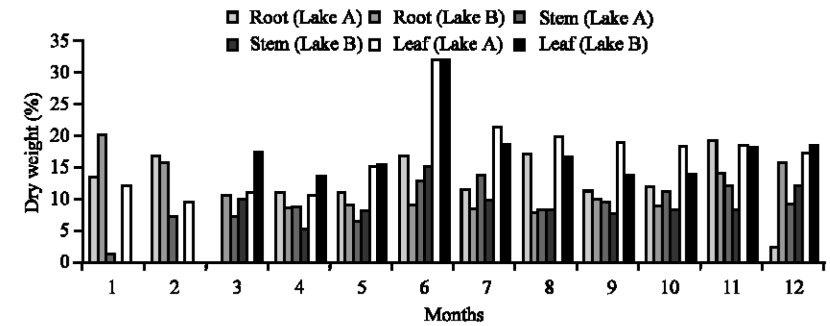

Fig. 1: Dry matter content (%) of *Typha latifolia* plant collected from 2 different regions (Lake A and Lake B) in different organs (Root, Stem and Leaf)

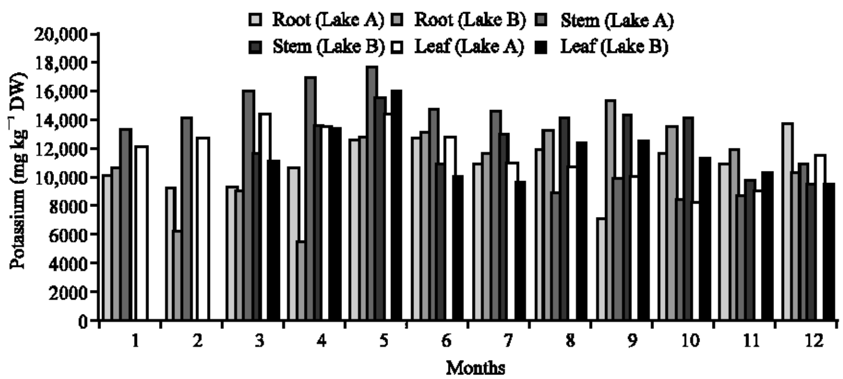

Fig. 2: Potassium (K) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

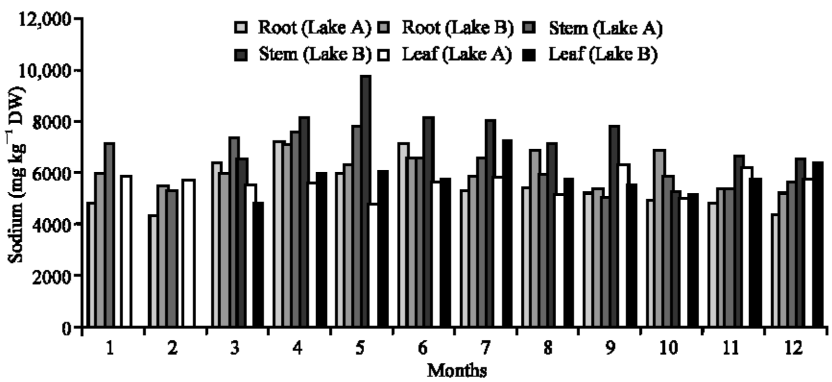

Fig. 3: Sodium (Na) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

highest in June; while, sodium values were found to be the highest (7167.74 mg kg^{-1}) in April. In the stem, potassium, sodium, calcium and magnesium values were found to be the highest in May (17579.03, 7754.39, 903.70 and 12.78 mg kg^{-1}, respectively). In the leaf, it was found that potassium had the highest concentration in March and May (14254.7 mg kg^{-1}), sodium had the highest concentration in September (6218.44 mg kg^{-1}), calcium had the highest concentration in December (699.09 mg kg^{-1}) and magnesium had the highest concentration in February (14.24 mg kg^{-1}).

In average of 12 months, in Lake B, potassium (K) had the highest concentration in the root (10953.33 mg kg^{-1} in the root, 10592.35 mg kg^{-1} in the stem and 9574.46 mg kg^{-1} in the leaf), followed by sodium (Na) (5974.12 mg kg^{-1} in the root, 6110.89 mg kg^{-1} in the stem, 9615.66 mg kg^{-1} in the leaf); Calcium (Ca) (348.98 mg kg^{-1} in the root, 364.04 mg kg^{-1} in the stem and 419.46 mg kg^{-1} in the leaf) and Magnesium (Mg) (15.98 mg kg^{-1} in the root, 11.75 mg kg^{-1} in the stem and 13.23 mg kg^{-1} in the leaf). In the root, highest potassium value was identified in September (15161.30 mg kg^{-1}), the

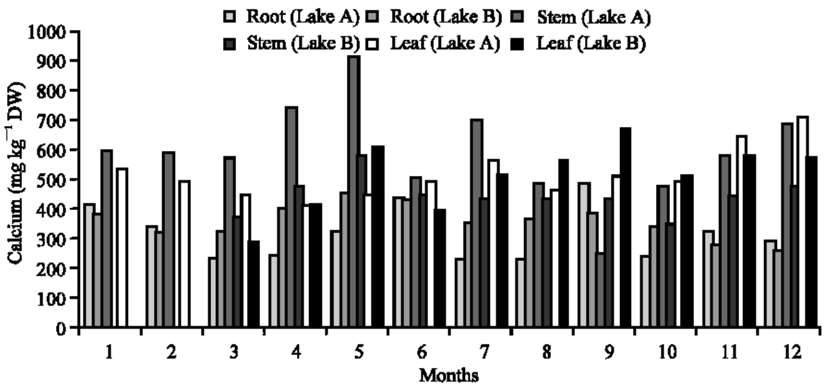

Fig. 4: Calcium (Ca) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

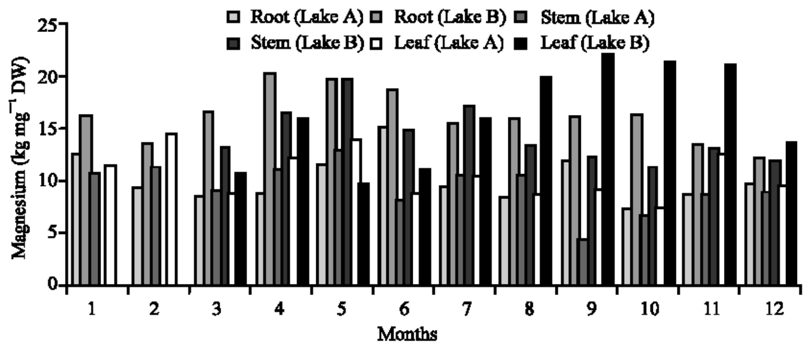

Fig. 5: Magnesium (Mg) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

highest nitrogen and magnesium value was identified in April (6997.08 and 19.98 mg kg^{-1}, respectively) and the highest calcium value was identified in May (446.74 mg kg^{-1}). In the stem, the highest potassium value was identified in September (16143 mg kg^{-1}); while the highest sodium, calcium and magnesium values were identified in May (9663.65, 572.91 and 19.49 mg kg^{-1}, respectively). In the leaves, the highest potassium concentration was identified in May (15866.47 mg kg^{-1}); while the highest sodium concentration was identified in June (7199.74 mg kg^{-1}), the highest calcium and magnesium concentrations were identified in September (664.99 and 21.78 mg kg^{-1}, respectively).

In the study, in general terms, among macro elements K was mostly identified in the stem; while Na and Ca values were mostly identified in the leaves and Mg values were mostly identified in the roots. To use *Typha latifolia* plant as animal feed, the critical values of 3% in calcium, 1% in magnesium, 3% in potassium and 1% in sodium should not be exceeded (Alpaslan *et al*., 2004). Consumption of *Typha latifolia* plant containing macro elements above these quantities by the animals results in toxic effect. According to the analyses, macro elements contained by the leaves and stem of *Typha latifolia* plant do not exceed this critical value, thus toxic effect is not the case for the animals.

Micro elements in root, leaves and stem of *Typha latifolia*: When compared in terms of the regions (Lakes A and B), it was found that in the root, there was no significant ($p>0.05$) difference between Zn values and there was a significant ($p<0.05$) difference among Fe, Cu and Mn values. In the stem, there was no significant ($p>0.05$) difference between the regions. In the leaves, there was significant ($p<0.05$) difference between Zn and Cu values. In addition, there was significant ($p<0.05$) difference between Fe and Mn values.

When, micro elements concentrated in root, stem and leaves of *Typha latifolia* plant in lakes A and B were analyzed according to the months, it was found that there was a statistically significant difference for each element; while, the difference in terms of Copper (Cu) in the root and stem was not found to be significant ($p<0.05$) according to the months.

Figure 6-9 indicate, micro quantities (dry matter mg kg^{-1}) observed in different organs of common cattail plant for 12 months.

When, Fig. 6-9 are analyzed in terms of micro elements; in the average of 12 months, in Lake A, Manganese (Mn) was found to have the highest concentration in the root, stem and leaves (41.48 mg kg^{-1} in the root, 83.17 mg kg^{-1} in the stem, 120.84 mg kg^{-1} in

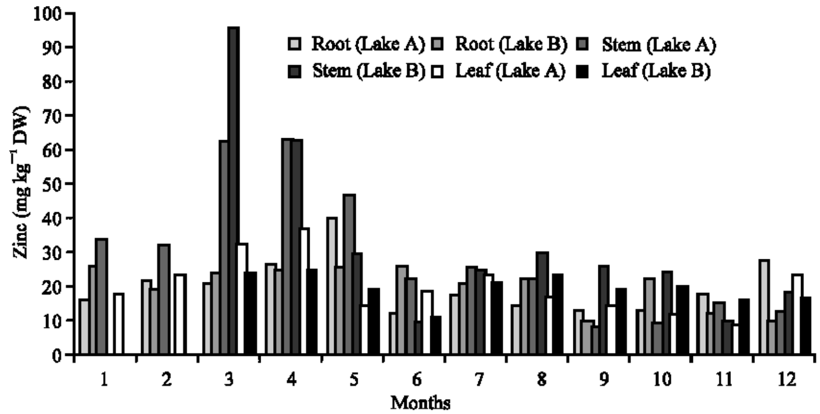

Fig. 6: Zinc (Zn) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

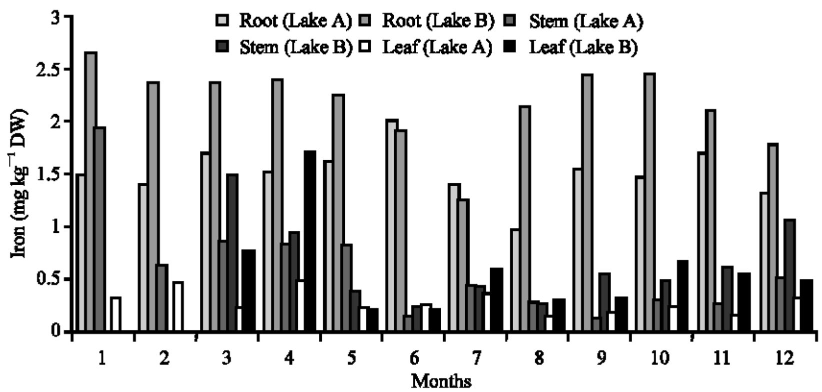

Fig. 7: Iron (Fe) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

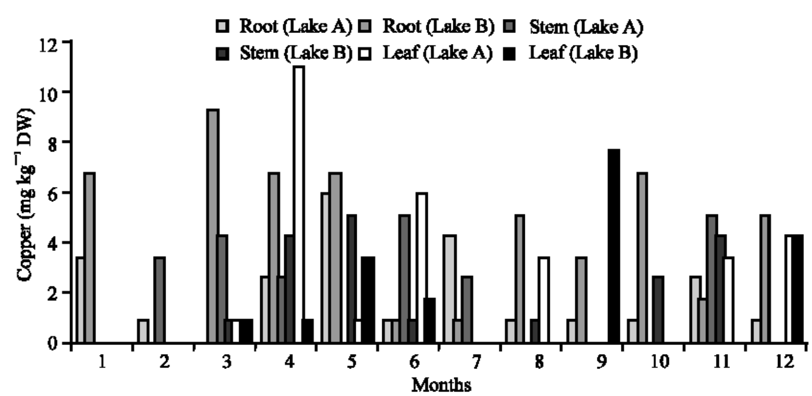

Fig. 8: Copper (Cu) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

the leaves) followed by Zinc (Zn) (19.54 mg kg^{-1} in the root, 28.93 mg kg^{-1} in the stem, 19.62 mg kg^{-1} in the leaves), Copper (Cu) (1.95 mg kg^{-1} in the root, 1.88 mg kg^{-1} in the stem, 3.43 mg kg^{-1} in the leaves) and iron (Fe) (1.50 mg kg^{-1} in the root, 25.48 mg kg^{-1} in the stem, 0.27 mg kg^{-1} in the leaves). In the roots, manganese and iron were found to have the highest concentration in June (59.50 and 2.00 mg kg^{-1}, respectively); zinc and copper were found to have the highest concentration in May (39.62 and5.83 mg kg^{-1}, respectively). In the stem, manganese was found to have the highest concentration in December (216.62 mg kg^{-1}), zinc was found to have the highest concentration in April (62.82 mg kg^{-1}), copper was found to have the highest concentration in June and

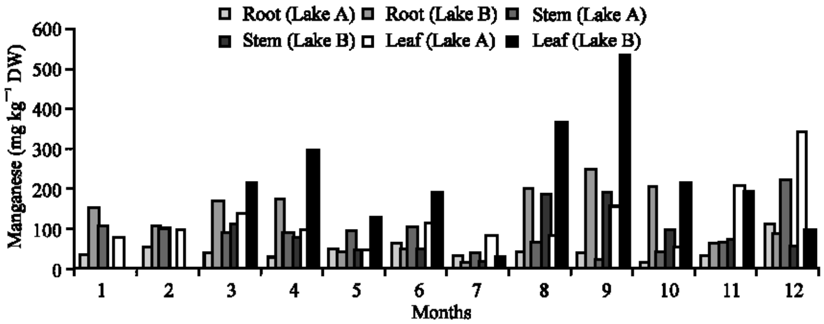

Fig. 9: Manganese (Mn) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

November (5.00 mg kg^{-1}) and iron was found to have the highest concentration in January (1.93 mg kg^{-1}). In the leaves, manganese was found to have the highest concentration in December (336.87 mg kg^{-1}), zinc, copper and iron were found to have the highest concentration in April (36.34, 10.83 and 0.47 mg kg^{-1}, respectively).

In average of 12 months, in Lake B, Manganese (Mn) was found to have the highest concentration in the root, stem and leaves (122.17 mg kg^{-1} in the root, 72.41 mg kg^{-1} in the stem, 184.67 mg kg^{-1} in the leaves); followed by Zinc (Zn) (37.03 mg kg^{-1} in the root, 27.09 mg kg^{-1} in the stem, 15.74 mg kg^{-1} in the leaves), Copper (Cu) (4.38 mg kg^{-1} in the root, 1.53 mg kg^{-1} in the stem, 1.53 mg kg^{-1} in the leaves) and iron (Fe) (2.17 mg kg^{-1} in the root, 0.53 mg kg^{-1} in the stem, 0.48 mg kg^{-1} in the leaves). In the roots, manganese was found to have the highest concentration in September (245.52 mg kg^{-1}), zinc and copper were found to have the highest concentration in March (231.36 and 9.17 mg kg^{-1}, respectively) and iron was found to have the highest concentration in January (2.64 mg kg^{-1}). In the stem manganese was found to have the highest concentration in September (183.93 mg kg^{-1}), zinc and iron were found to have the highest concentration in March (94.78 and 1.48 mg kg^{-1}, respectively) and copper was found to have the highest concentration in May (5.00 mg kg^{-1}). In the leaves, manganese and copper were found to have the highest concentration in September (528.34 and 7.5 mg kg^{-1}, respectively), zinc was found to have the highest concentration in April (23.86 mg kg^{-1}) and iron was found to have the highest concentration in October (0.66 mg kg^{-1}).

In terms of micro elements, to use *Typha latifolia* plant as animal feed, the critical values of 50 ppm in zinc, 150 ppm in iron, 10 ppm in copper and 100 ppm in manganese should not be exceeded (Alpaslan *et al*., 2004). According to the findings of this study, zinc contained by the stems of *Typha latifolia* plant growing in Lake A exceeded the critical value at 3 and 4 month; manganese exceeded the critical values at 1, 6 and 12 months. In Lake B, zinc exceeded the critical values at 3 and 4 month; manganese exceeded the critical values at 3, 8 and 9 months, so common cattails should not be used as animal feed. Manios *et al*. (2002) identified various elements concentrated in root, stem and leaves of *Typha latifolia* plant growing in wastewater and found that copper and zinc mainly concentrated in the root when compared to stem and the leaves. This result is consistent with the findings of the study.

Heavy metals in root, leaves and stem of *Typha latifolia*: When, the heavy metals (Ni, Pb and Cd) concentrated in the roots, stem and leaves of *Typha latifolia* plant growing in lakes A and B were compared, no significant ($p>0.05$) difference was found between the ones in root and stem, however there was significant ($p<0.05$) difference between Ni and Cd values in the leaves. Only the difference between Pb was not found to be significant ($p<0.05$).

Figure 10-12 indicates the quantities (dry matter mg kg^{-1}) concentrated in different organs of common cattail plant for 12 months.

When, Fig. 10-12 were analyzed in terms of heavy metals; in the average of 12 months, in Lake A, lead (Pb) was found to have the highest concentration in the root, stem and leaves (32.44 mg kg^{-1} in the root, 13.31 mg kg^{-1} in the stem, 15.80 mg kg^{-1} in the leaves); followed by Nickel (Ni) (10.49 mg kg^{-1} in the root, 7.91 mg kg^{-1} in the stem and 8.74 mg kg^{-1} in the leaves) and Cadmium (Cd) (3.56 mg kg^{-1} in the root, 2.68 mg kg^{-1} in the stem, 4.45 mg kg^{-1} in the leaves). In the roots, the highest lead values were identified in October (229.55 mg kg^{-1}), the highest nickel and cadmium values were identified in September (17.66 and 6.43 mg kg^{-1}, respectively). In the stem, the highest lead values were identified in September (49.90 mg kg^{-1}), the highest Nickel values were identified in January (16.56 mg kg^{-1}) and the highest cadmium values were identified in March (7.57 mg kg^{-1}). In the

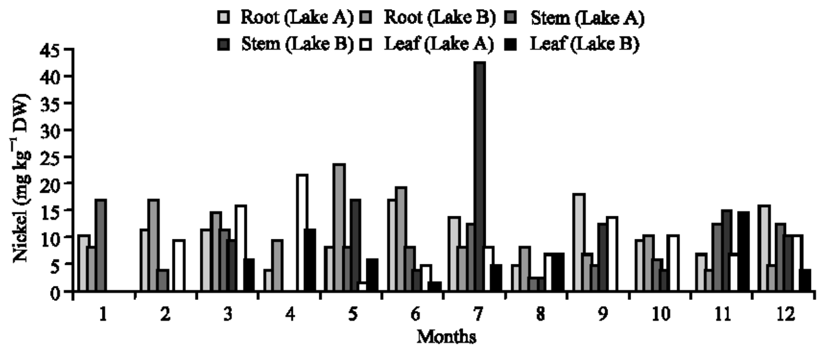

Fig. 10: Nickel (Ni) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

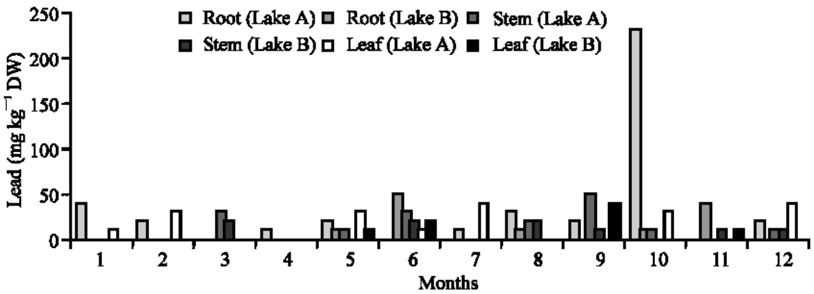

Fig. 11: Lead (Pb) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

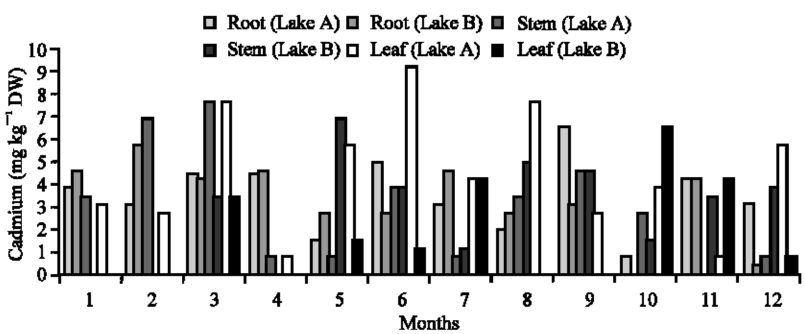

Fig. 12: Cadmium (Cd) content (dry matter mg kg^{-1}) in different organs of *Typha latifolia*

leaves, the highest lead values were identified in July and December (39.92 mg kg^{-1}), the highest nickel values were identified in April (20.98 mg kg^{-1}) and the highest cadmium values were identified in June (9.08 mg kg^{-1}).

In average of 12 months, in Lake B, lead (Pb) was found to have the highest concentration in the root and leaves (10.81 mg kg^{-1} in the root and 6.65 mg kg^{-1} in the leaves); followed by nickel (Ni) (10.76 mg kg^{-1} in the root and 4.32 mg kg^{-1} in the leaves) and Cadmium (Cd) (3.25 mg kg^{-1} in the root and 1.80 mg kg^{-1} in the leaves). In the stem, nickel (Ni) was found to have the highest concentration (9.38 mg kg^{-1}) followed by lead (Pb) (7.49 mg kg^{-1}) and Cadmium (Cd) (2.78 mg kg^{-1}). In the roots, the highest lead values were identified in June (49.90 mg kg^{-1}), the highest nickel values were identified in May (23.18 mg kg^{-1}) and the highest cadmium values were identified in February (5.68 mg kg^{-1}). In the stem, the highest nickel values were identified in July (41.95 mg kg^{-1}), the highest lead values were identified in March, June and August (19.96 mg kg^{-1}) and the highest cadmium values were identified in May (6.81 mg kg^{-1}). As for the leaves, the highest lead values were identified in September 39.92 mg kg^{-1}), the highest nickel values were identified in December (14.35 mg kg^{-1}) and the highest cadmium values were identified in October (6.43 mg kg^{-1}).

Manios *et al.* (2002) identified various elements found in root, stem and leaves of *Typha latifolia* plant growing in wastewater and found that copper, lead and cadmium were mainly concentrated in the root when compared to stem and the leaves. Similarly, Zhihong *et al.* (1998) identified higher concentrations of lead and cadmium in the roots of common cattail. These results are consistent with the findings of our study.

CONCLUSION

In this study, the analysis of plant samples collected from 2 different regions (Lakes A and B) indicated that among macro elements, potassium was mainly concentrated in the stem; sodium and calcium were mainly concentrated in the leaves and magnesium was mainly concentrated in the root. Among micro elements, zinc, iron and copper were mostly concentrated in the root, while manganese was mostly concentrated in the leaves. Various researchers have reported that common cattail can be used as animal feed. It was concluded that common cattail in the study did not exceed critical values particularly in terms of macro elements, however it can lead to toxic effect in some animals in terms of micro elements and attention should be paid before the utilization of the plant. In addition, it was found that among heavy metals, nickel, lead and cadmium were mostly concentrated in the root and it was concluded that the plant can remove these elements by its roots in contaminated waters.

REFERENCES

Alpaslan, M., A. Gunes and A. Inal, 2004. Gubreleme calismalarinda bitki analizlerinin yeri ve farkli bitkiler icin bitki besin maddesi kritik duzeyleri, 3. Ulusal Gubre Kongresi, Tokat. http://tmyo.gop.edu.tr/gubre_kongresi.doc.

Altinayar, G., 1998. Su yabanci otlari. T.C. Bayindirlik ve Iskan Bakanligi Devlet Su Isleri Genel Mudurlugu, Isletme ve Bakim Dairesi Baskanligi, Ankara.

Dunbabin, J.S. and K.H. Bowmer, 1992. Potential use of constructed wetlands for treatment of industrial wastewaters containing metals. The Sci. Total Environ., 111: 151-168. DOI: 10.1016/0048-9697(92)90353-T.

Fediuc, E. and L. Erdei, 2002. Physiological and biochemical aspects of cadmium toxicity and protective mechanisms induced in *Phragmites australis* and *Typha latifolia* L. J. Plant Physiol., 159 (3): 265-271.

Kufel, I., 1991. Lead and molybdenum in reed and cattail: Open versus closed type of metal cycling. Aquatic Bot., 40 (3): 275-288. DOI: 10.1016/0304-3770(91)90063-B.

Lasat, M.M., 2002. Phytoextraction of toxic metals: A review of biological mechanism. J. Environ. Quality, 31 (1): 109-120. http://jeq.scijournals.org/cgi/content/full/31/1/109.

McNaughton, S.J., T.C. Folsom, T. Lee, F. Park, C. Price, D. Roeder, J. Schmitz and C. Stockwell, 1974. Heavy metal tolerance in *Typha latifolia* without the evolution of tolerant races. Ecology, 55: 1163-1165. DOI: 10.2307/1940369.

Manios, T., E.I. Stentiford and P.A. Millner, 2002. The effect of heavy metals on the total protein concentration of *Typha latifolia* L. plants, growing in a substrate containing sewage sludge compost and watered with metaliferus water. Environ. Eng., 37 (8): 1441-1451. DOI: 10.1081/ESE-1200013268. http://www.teicrete.gr/WML/PDF-files/5.pdf.

Mungur, A.S., R.B.E. Shutes, D.M. Revitt and M.A. House, 1998. An assessment of metal removal by a laboratory scale wetland. Water Sci. Technol., 35 (5): 125-133. http://www-32.cis.portlandcs.net/wst/03505/wst035050125.htm.

Overesch, M., J. Rinklebe, G. Broll and H.U. Neue, 2007. Metals and arsenic in soils and corresponding vegetation at Central Elbe river floodplains (Germany). Environ. Pollut., 145 (3): 800-812. DOI: 10.1016/j.envpol.2006.05.016.

SAS Institute, 1999. SAS System for Windows Release 8.01. SAS Inst., Cary, NC.

Schierup, H.H. and V.J. Larsen, 1981. Macrophyte cycling of zinc, copper, lead and cadmiumin the littoral zone of a polluted and non-polluted lake; 1, Availability, Uptake and Translocation of Heavy Metals in *Phragmites australis* (Cav.) Trin. Aquatic Botany, 11: 197-210. DOI: 10.1016/0304-3770(81)90061-9.

Srivastav, R.K., S.K. Gupta, K.D.P. Nigam and P. Vasudevan, 1994. Treatment of chromium and nickel in waste-water by using aquatic plants. Water Res., 28 (7): 1631-1638. DOI: 10.1016/0043-1354(94)90231-3.

Stoltz, E. and M. Greger, 2002. Cottongrass effects on trace elements in submersed mine tailings. J. Environ. Quality, 31 (5): 1477-1483. http://jeq.scijournals.org/cgi/content/full/31/5/1477.

Tok, H.H., 1997. Cevre kirliligi, Trakya Universitesi Tekirdag ziraat Fakultesi Toprak Bolumu, Tekirdag. s:329.

Zhihong, Y., A.J.M. Baker, M.H. Wong and A.J. Willis, 1998. Zinc, lead and cadmium accumulation and tolerance in *Typha latifolia* as affected by iron plaque on the root surface. Aquatic Bot., 61 (1): 55-67. DOI: 10.1016/S0304-3770(98)00057-6.