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A Research on Nutrients of Algae in the Wetland Areas of Van Province

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Abstract: This research was done in order to determine the amount of certain nutrients in algae in the wetland areas of Van Province. Ten sampling stations with different characteristics, including natural lakes, rivers and reeds were chosen. In this study, we have identified *Spirogyra* spp., *Microspora* spp. and some mixed diatom groups (*Nitzschia* spp. taxons), *Cladophora fracta*, *Ulothrix zonata*, *Cladophora glomerata*, *Hydrodictyon reticulatum*, *Mougetia* spp. and *Zygnema* spp. in the selected locations. In the species of algae which were determined at the stations in this research, the rates of the lowest and highest values for Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Crude Fibre (CF), ash and Nitrogen Free Extract (NFE) were determined respectively as 93.20-99.36, 3.10-20.27, 0.04-1.03, 3.77-28.95, 29.20-87.76, 3.59-38.82%. The lowest and highest amounts in the samples of the stations for Calcium (Ca), Phosphorus (P), Nitrogen (N), potassium (K), sodium (Na), Magnesium (Mg), iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) were determined, respectively as 29.16-779.73, 0.21-9.64, 0.42-3.24, 5.12-125.97, 2.92-78.88, 13.73-29.77, 4.96-28.33, 0.07-2.60, 0.01-0.05 and 0.01-0.17 mg/kg.

Key words: Algae, nutrient content, Van Province, sampling stations, wetland areas, natural lakes

INTRODUCTION

Studies on the availability of new feed and food resources in the world have been conducted intensively on the likelihood of food and feed supply of algae (Anonymous, 2015). Terrestrial and freshwater algae have been the subject of researchas much as marine algae for animal feeding. Today, approximately 70 species of algae are used as fertilizers, medicines, nutrients, nutrient additives and animal feed (Henrikson, 1989).

Algae are one of the nutrients that have the richest biological value of vegetable protein in nature. The protein content of algea can be up to 65% which is about twice that of the closest rival soybean. Algae are also rich sources of vitamins and calcium. Because of these properties, it is thought that algae may have an important place in animal feeding in the future (Anonymous, 2015).

Various feeding studies have shown that many algal species have high values for fish, pigs, sheep and goats and cattle as protein supplements (Indergaard and Mlnsaas, 1991).

MATERIALS AND METHODS

Experimental materials: The research material was obtained from the wetland areas of Van Province of Turkey (Fig. 1). The material consisted of macro-structure freshwater algae which were obtained from wetlands (stations) in Caldyran Plain Wetland, Catak White Water Stream, Gevas Donemec Delta, Lake Ercek Wetland, Ercis Celebibaoy Reeds, Gorundu Wetland of Gevas, Lake Kaz Stream (dirty) of Caldyran, Lake Kaz Stream (fresh water) of Caldyran, Muradiye Water fall, Lake Turna during three different periods (May, July and September).

Sampling process was carried out by taking approximately 8 kg of wet sample with equal amounts of each station at five different points. The collected samples were let to dry at room temperature (Table 1).

Analysis methods: Analysis of DM, CP, EE, ash and NFE were performed according to Williams (1984). The crude

Table 1: Types of sampling stations and stations

Station	Position	Habitat type
1	Caldran Plain Wetland	Inland marsh ecosystem (Palustrine)
2	White Water Stream (Catak)	River-size ecosystem (Riverine)
3	Donemec Delta (Gevas)	River-size ecosystem (Riverine)
4	Lake Ercek Wetland (Tusba)	Inland marsh ecosystem (Palustrine)
5	Celebiba Reeds (Erci)	Inland marsh ecosystem (Palastrine)
6	Gorundu Wetland (Gevas)	Inland marsh ecosystem (Palastrine)
7	Lake Kaz Stream (Dirty (Caldran)	River-size ecosystem (Riverine)
8	Lake Kaz Stream Clean (Caldran)	River-size ecosystem (Riverine)
9	Muradiye Waterfall (Muradiye)	River-size ecosystem (Riverine)
10	Lake Turna (Tusba)	Lake ecosystem (Lacustrine)

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Fig. 1: Workspace and sampling stations

fibre analyzes of the feeds were performed using ANKOM 200 Fiber Analyzer (ANKOM Technology Corp. Fairport, NY, USA). The 9 elements, macro (P, K, Ca, Mg) and micro (Fe, Mn, Cu, Na, Zn) were analyzed in the samples of algae in total. The total nitrogen ratio was determined via. the Kjeldahl method and the other elements were determined by reading via the ICP9AES (Varian 9 Vista) device. Macrominerals and trace elements were determined by Instrumental Neutron Activation Analysis (INAA) and by Inductively Coupled Argon Plasma-Atomic Emission Spectroscopy (ICP-AES). The latter has been used to quantify metals not measurable or minimally measurable by INAA (Cd, Cu, Mg, Mn, Pb). For INAA analysis, the TRIGA Mark 2 reactor of the ENEA-Casaccia Laboratories (Rome, Italy) has been used. Diagnosis of algae was done morphologically with light microscope. The determination books used for the diagnosis of algae are Prescott (1973), John *et al.* (2002), Bold and Wynne (1985), Czurda (1932), Desikachary (1959), Elster and Ohle (1982), Round *et al.* (1990) and Smith (1920, 1950). Research data were obtained in ten stations and at three different periods.

Statistical methods: In the statistical analysis of the data obtained in the study, the SAS 9.4 package program was be used (2016). A General Linear Model (GLM) analysis of the differences between the group's mean values w was be used in the Duncan multiple comparison test todetermine whether the differences between groups are significant. The following mathematical model was be used to evaluate the data obtained without working:

$$Y_{ij} = \mu + a_i + b_j + e_{ij}$$

Where:
Y_{ij} = i 'st area j'.st observation value of turnover
μ = Population average
a_i = i' st amount of effect of the region
b_j = j' st amount of influence in the period
e_{ij} = Chance-related error

RESULTS AND DISCUSSION

The species and nutrient analysis results of the algae obtained from the stations are summarized in the following charts (Table 2-6).

As a result of this study, *Spirogyra* spp., *Microspora* spp., *Nitzschia* spp., *Cladophora fract*, *Ulothrix zonata*, *Cladophora glomerat*, *Hydrodictyon reticulatum*, *Mougetia* spp. *ve Zygnema* spp. algae species were identified in the wetland areas of Van Province (Table 4).

In many studies it has been reported that the nutrient content of algae changes according to periods Wassink *et al.* (1953), Milner (1976), Gerloff and Skoog (1954), Fleurence (1999), Cirik *et al.* (2010) and Turan *et al.* (2015). However, no difference was observed between the periods (Table 3) in terms of nutrients in this study ($p<0.05$). The reason why there are no differences in terms of nutrients between periods is that the station averages of the period's were taken as period average.

As seen in Table 4, the differences between the stations (Table 4) were found to be significant ($p<0.05$) in terms of the Dry Matter (DM) quantities of the algae in the study area. In terms of DM, the results obtained in this study are similar to the amounts of DM determined by

Athukorala *et al.* (2003) for algae but higher than those of many feed materials used in animal feeding (Aksoy *et al.*, 2000; Sauvant *et al.*, 2004; Ergun *et al.*, 2007).

It has been determined that the CP values (Table 4) of algal samples obtained in the areas of Van Province are quite low compared to some literature reports (Cleland and Hardin, 1957; Kumta and Harper, 1962; Takeuchi *et al.*, 2002). It can be said that the reason for low CP ratio is due to the difference in algal species (Fleurence, 1999). Marsham *et al.* (2007) obtained CP rates between the

Table 2: Freshwater algae species detected at stations

Species	Food ingredients									
Spirogyra spp.	1	2					7			
Microspora spp.	1	2			5		7			
Karyþyk diatom (*Nitzschia* spp. aoyrlykta)	1		3	9						
Cladophora fracta (bol miktarda)		2		3		6		8	9	10
Ulothrix zonata		2								
Cladophora glomerata (bol miktarda)			3					8		
Hydrodictyon reticulatum (yooun)					5					
Mougetia spp.					5		7			
Zygnema spp.							7			

Table 3: Nutrients of freshwater algae according to periods*

Food ingredients	Period	Period	Period
DM (%)	97.07±0.71	96.91±0.87	97.31±0.56
CP (%)	10.12±1.83	12.23±1.80	11.69±1.40
EE (%)	0.59±0.10	0.67±0.12	0.51±0.12
CF (%)	19.05±0.10	21.03±2.35	20.27±2.50
ASH (%)	47.56±6.60	43.32±6.04	50.39±5.66
NFE (%)	19.24±3.84	19.10±3.83	14.10±2.06
N (%)	1.62±0.29	1.93±0.30	1.87±0.22
Ca (mg/kg)	72664.10±16491.84	80970.90±26102.55	74380.00±23820.58
K (mg/kg)	10887.09±3544.33	14068.70±4045.75	13321.60±2902.12
Mg (mg/kg)	4310.70±634.05	4855.00±443.40	6005.00±817.92
Na (mg/kg)	5489.53±1970.15	5870.44±1553.63	7757.66±3111.17
P (mg/kg)	625.50±265.85	1821.80±1068.71	706.15±298.29
Fe (mg/kg)	2848.05±683.39	2491.72±730.35	3512.18±951.42
Mn (mg/kg)	207.82±48.82	228.27±76.24	623.57±356.83
Cu (mg/kg)	4.99±0.99	6.41±1.18	5.11±1.12
Zn (mg/kg)	224.24±215.87	11.13±2.89	16.45±8.99

*As averages of samples obtained from all stations

Table 4: Nutrient quantities of algae obtained from stations

Food ingredients	DM (%)	CP (%)	EE (%)	CF (%)	ASH (%)	NFE (%)
1	97.46±0.57^{b}	13.30±0.96^{bc}	1.03±0.20^{a}	27.02±3.63^{ab}	29.20±5.26^{d}	26.40±0.94^{b}
2	99.00±0.25^{ba}	13.87±4.13^{b}	0.52±0.15^{bcd}	15.10±3.50	51.76±8.73^{b}	17.89±2.04^{bc}
3	99.36±0.15^{a}	12.40±1.61^{bcd}	0.58±0.09^{abc}	20.31±5.96^{abc}	48.76±9.44^{bc}	17.17±2.80^{bc}
4	98.65±0.37^{ba}	10.72±1.57^{bcd}	0.50±0.24^{bcd}	18.66±1.05^{bc}	29.27±9.66^{d}	38.82±10.47^{a}
5	99.14±0.16^{a}	7.89±1.30^{de}	0.42±0.09^{cd}	19.66±1.37^{abc}	55.83±1.86^{b}	14.84±1.38^{c}
6	95.94±0.51^{c}	6.70±0.59^{de}	0.69±0.04^{abc}	21.39±1.25^{abc}	53.88±1.36^{b}	12.73±1.23^{cd}
7	95.21±0.32^{c}	11.02±0.52^{bcd}	0.94±0.25^{ab}	18.69±0.37^{bc}	45.93±2.65^{bcd}	17.73±1.31^{bc}
8	94.69±0.39^{c}	20.27±1.73^{a}	0.78±0.17^{abc}	27.65±3.09^{ab}	31.38±4.52^{cd}	13.93±1.65^{cd}
9	98.32±0.19^{ba}	3.10±0.50^{e}	0.04±0.00^{d}	3.77±0.31^{d}	87.76±1.34^{a}	3.59±1.56^{d}
10	93.20±1.07^{d}	14.17±1.79^{b}	0.42±0.04^{cd}	28.95±0.89^{a}	37.13±2.80^{bcd}	11.68±0.74cd

Table 5: Quantities of Nitrogen (N), Calcium (Ca), potassium (K), Magnesium (Mg) and sodium (Na) in algae obtained from stations

Stations	N (%)	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	Na (mg/kg)
1	1.13±0.15^{bc}	41080.00±11374.24^{c}	9064.00±3326.74^{bc}	3568.00±300.30	19726.67±4416.88^{a}
2	2.22±0.66^{b}	49120.00±26797.87^{c}	14580.00±4483.93^{bc}	5066.67±212.36	7144.00±450.14^{b}
3	1.98±0.26^{bcd}	28366.67±4895.64^{c}	23335.67±10561.62^{ab}	5090.67±564.37	4934.67±2279.72^{b}
4	1.72±0.25^{bcd}	7290.00±3642.10^{c}	6632.33±2172.06^{c}	6340.67±3040.79	16959.67±4712.05^{a}
5	1.26±0.21^{cde}	64010.00±3850.41^{c}	6621.33±1006.19^{c}	4970.00±254.48	4050.33±242.59^{b}
6	1.07±0.09^{de}	177200.00±4744.47^{ab}	9945.33±82.75^{bc}	5889.33±715.19	730.53±100.45^{b}
7	1.07±0.09^{de}	129600.00±9860.53^{b}	16061.33±5466.62^{bc}	4671.67±292.25	3494.33±551.94^{b}
8	3.24±0.28^{a}	49823.33±11242.11^{c}	31493.33±5035.03^{a}	3432.00±587.31	2064.67±438.62^{b}
9	0.42±0.07^{e}	194933.33±39392.74^{a}	1279.63±422.17^{c}	5765.33±1341.68	1593.90±799.95^{b}
10	2.27±0.29^{b}	18626.67±4659.56^{c}	8378.33±2058.58^{bc}	7441.33±1184.50	3026.67±792.89^{b}

Table 6: Amounts of Phosphorus (P), iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) in the algae obtained from the stations

Stations	P (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
1	122.77±829.72	1894.33±512.67^{cd}	137.59±48.87	8.31±0.58^{b}	758.87±704.47
2	979.33±488.76	4924.67±1029.75^{abc}	145.10±32.53	11.71±0.31^{a}	20.60±7.63
3	324.33±193.17	5257.33±785.40^{ab}	142.83±14.12	8.71±2.16^{ab}	11.64±4.37
4	292.65±105.54	1793.37±1070.91^{cd}	48.47±25.42	4.94±1.65^{cd}	50.02±3.38
5	53.33±24.10	3051.00±1417.50^{bcd}	1618.03±1079.48	4.20±0.83^{cd}	7.52±1.90
6	234.42±40.30	356.92±38.80^{d}	69.17±52.92	1.58±0.08^{d}	7.42±0.87
7	4308.67±3434.51	1875.25±476.86^{cd}	214.83±63.15	2.58±0.51^{cd}	9.83±0.58
8	2408.83±245.31	989.83±304.96^{d}	257.58±100.38	3.67±1.04^{cd}	4.67±1.16
9	318.58±133.03	7083.33±1519.60^{a}	651.17±101.08	3.73±0.66^{cd}	10.02±5.23
10	368.58±190.58	2280.43±1131.83^{bcd}	247.43±3786	5.62±1.14^{bc}	3.80±1.83

$^{a-d}$The difference between the periods that take different letters within the same station (column) is significant ($p<0.05$)

range of 6.9% (*Corallina officinalis*) and 31.8 (*Polysiphonia* spp.) on his study of 11 different species. It is seen that the CP values of algae obtained from the study area are similar to protein rates of marine macro-algae (Athukorala *et al*., 2003; Matanjun *et al*., 2009). It is seen that the CP amounts of the region algae generally have an CP content of medium quality meadow dry grass (Table 4), except Lake Kaz (fresh water) samples. It has been determined that the samples obtained from Lake Kaz (fresh water) contain CP close to legume forages (Aksoy *et al*., 2000; Sauvant *et al*., 2004; Ergun *et al*., 2007).

As seen in Table 4, the difference between the stations was found to be significant with regard to EE ($p<0.05$). It is observed that the algae obtained from the stations contain lower levels of EE than the alga samples obtained from other studies (Cleland and Hardin, 1957; Kumta and Harper, 1962). Species of algae in studies where high oil ratios have been determined are *Chlorella pyrenoidosa*, *Scenedesmus obliquus*, *Chlorella ellipsoida*, *Seongiococcum* excentricum (Cleland and Hardin, 1957; Kumta and Harper, 1962). It has been observed that the study area algae with low EE ratios contained similar proportions of EE content to *E. cottonii*, *C. lentillifera*, *S. polycytum* species which were studied by Matanjun *et al*. (2009). EE rates were found to be lower than the EE rates of many feed ingredients whereas they were close to the EE limit values determined for Hungarian vetch, wheat straw and chickpea straw (Sauvant *et al*., 2004; Gungor *et al*., 2008; Canbolat, 2012).

The difference between CF (crude fibre) rates between stations is significant ($p<0.05$). The CF values of the algae obtained from the stations were found to be lower than those of the *Laminaria longicruris*, *Fucus vesiculosus*, *Rhodymnenia palmata*, *Porphyra laciniata*, *Chondrus crispus* and *Gigartina mamillosa* species studied by Butler (1931), whereas they were found to be close to the crude fibre ratios of *E. cottonii*, *C. lentillifera* and *S. polycytum* species studied by Matanjun *et al*. (2009). In a study conducted by Marsham *et al*. (2007) on different species, they report crude fibre ratios at the range of 1.1-24.7%. The CF (Crude Fibre) ratios of study area algae were found to be close to CF ratio of good quality alfalfa hay (Gungor *et al*., 2008) but lower than the other roughage which these researchers studied. Excluding algal samples from Muradiye Waterfall Station, the CF (Crude Fibre) rates of algae obtained from other stations are close to the CF (Crude Fibre) rates of good quality roughage (Sauvant *et al*., 2004; Ergun *et al*., 2007).

The difference between the HK (ash) rates between stations was found to be significant ($p<0.05$). The variation in the amounts of ash (3.75-46.19%) in algae reports is considerably wide (Hori *et al*., 1990; Takeuchi *et al*., 2002; Matanjun *et al*., 2009). Ruperz (2002) reports that their ash values are 20.6-21.1% in edible brown marine algae and 30.1-39.3% in edible red marine algae. The ash rates of alga samples obtained in this study were found to be higher than the ash rates of legume forages and wheat forages used in animal feeding (Aksoy *et al*., 20001; Sauvant *et al*., 2004; Ergun *et al*., 2007).

Differences between stations (Table 4) were found to be significant ($p<0.05$) with regard to Nitrogen Free Extract (NFE). In the study conducted by Wong and Cheung (2000) on *H. japonica*, *H. charoides* and *U. lactuca* species, Nitrogen Free Extract (NFE) ratios were reported between 4.28 and 22.8. In this study, the Nitrogen Free Extract (NFE) ratios obtained from algae are similar to those obtained from the study by Wong and Cheung (2000). The amount of NFE (Nitrogen Free Extract) obtained from the study area is lower thanlegume forages but higher than the NFE (Nitrogen Free Extract) amounts of hay (Ergul, 1993; Sauvant *et al*., 2004; Sehu *et al*., 1998).

Differences in the amounts of Nitrogen (N) between the stations were found to be significant ($p<0.05$). Variations similar to those observed in the N (Nitrogen) ratios of study-area algae were also, observed in other studies (Fleurence, 1999). As a matter of fact, Marsham *et al*. (2007) have found that the lowest N ratio of 11 different species which they studied is 0.48% in *Fucus serratus* species and the highest value is 8.16% in *Porphyra* spp. Milner (1976) reported the highest N (Nitrogen) content for Spirulina with 14.11% in the rewieved literature. The amounts of N (Nitrogen) in area algae are generally medium quality meadow dry grass except for Lake Kaz (freshwater) samples (Table 4). N (Nitrogen) ratios of the samples from Lake Kaz (freshwater) are close to the ratios of legume forages (Aksoy *et al*., 2000; Sauvant *et al*., 2004; Ergun *et al*., 2007).

The variation observed between the stations for Calcium (Ca) (Table 5) was found to be significant ($p<0.05$). Similar to this variation, Csikkel-Szolnoki *et al*. (2000) determined a variation in 13 different algal species (minimum *Heterosiphonia plumosa*, 15000 mg/kg and maximum *Boergeseniclla fruticulosa*, 144000 mg/kg). The amount of (*Corallina officinalis*) Ca (182000 mg/kg) determined in algae species that Marsham *et al*. (2007) stated that it has a low protein ratio is close to the values in Muradiye Water fall samples which is the highest value obtained in our study. The lowest Ca (Calcium) levels determined in the literature were reported by

MacArtain *et al*., (2007) in the species of *Himanthia elongata* as 30.0 mg/kg. This amount is lower than the Ca (Calcium) amount of algae in all stations. The amounts of Ca (Calcium) in algae obtained from the study area stations were determined higher than the amounts of barley, wheat, grain corn, cob corn, meadow and pasture grass, clover, trefoil, vetch, oat, sudangrass, barley straw, wheat straw, wheat, corn, sugar beet pulp and corn silage (160-1100 mg/kg) in the study by Alp *et al*. (2001).

The variation observed between the stations for Calcium (Ca) (Table 5) was found to be significant ($p<0.05$). The values obtained are within the wide variation of the researchers who study on algae. MacArtain *et al*. (2007) report that the average of K is 20123 mg/kg in *Laminaria digitata* and the average of K (potassium) for *Porphyra umbilicalis* is 342 mg/kg. *Chondrus* spp. Csikkel-Szolnok *et al*. (2000) report 50400 mg/kg as the highest algae potassium content and 7400 mg/kg for *Rhodothamniella floridula* as the lowest potassium value. The level of K (potassium) in Spirulina samples is reported as 870-935 mg/kg in the reports of Campanella *et al*. (1999). This value is lower than the K amounts of species obtained in the areas of Van Province. This value is also lower than the amounts which Alp *et al*. (2001) obtained from wheat, grain corn, cow corn, meadow and pasture grass, clover, trefoil, vetch, oat, sudangrass, barley straw, wheat straw, wheat, corn, sugar beet pulp and corn silage for K (potassium) (340-1810 mg/kg) (Sauvant *et al*., 2004).

The statistical difference (Table 5) between the Mg (Magnesium) amounts of the algae obtained from the stations was found not to be significant ($p<0.05$). Campanella *et al*. (1999) report 5440 mg/kg for brown algae as the lowest Mg amount (*Laminaria saccharina*) and 13100 mg/kg as the highest amount of Mg (*Dyctyota dichotoma*). Mg amounts of algea obtained from the study area are close to the findings of Campanella *et al*. (1999). MacArtain *et al*. (2007) report Mg amounts for different marine algae species as *Ascophyllum nodosum* 225000 Mg/kg, *Laminaria digitata* 403500 mg/kg, *Himanthalia elongata* 90100 mg/kg, *Undaria pinnatifida* 75700 mg/kg, *Porphyra umbilicalis* 108300 mg/kg, *Palmaria palmata* 97600 mg/kg, *Chondrus crispus* 573800 mg/kg, *Enteromorpha* spp. 455100 mg/kg. The amounts of Mg determined by MacArtain *et al*. (2007) for marine algae are much higher than those obtained from study area algae. Mg averages obtained from the stations in the study area were determined lower than the average value of 10900 mg/kg for mg which Csikkel-Szolnoki *et al*. (2000) reported for thirteen different red algae species. The mg amounts of algae obtained from the areas of Van Province are higher than the mg amounts of most forage crops (Ergul, 1993; Sehu *et al*., 1998; Alp *et al*., 2001; Sauvant *et al*., 2004).

The differences between the amounts of sodium (Na) in the station samples (Table 4) were found to be significant ($p<0.05$). The data on the Na contents of the algae provide a great variation as in some of the other minerals. One of the data on low Na amounts belongs to *Kappaphycus* spp. (23.4 mg/kg) (Rajasulochana *et al*., 2010). Csikkel-Szolnoki *et al*. (2000) report an average of 42700 mg/kg for red algae and 36400 mg/kg for brown algae. These values are higher than the amounts of Na (sodium) determined in the study. The Na values of algae obtained from Lake Kaz-Freshwater and Muradiye Waterfall were similar to the Na contents of Campanella *et al*. (1999) for 5 different Spirulina samples (1230-2090 mg/kg) while the Na values of samples obtained from other stations were higher than these values. The Na values of algae obtained from the study area were determined higher than the Na values of the feeds obtained by Ergun *et al*. (2007) and Sauvant *et al*. (2004).

The difference observed between the stations for the amounts of P (Phosphorus) (Table 3) was found to be significant ($p<0.05$). The P (Phosphorus) amount range obtained by Mahre *et al*. (2014) for macroalgae species *Alaria esculenta*, *Laminara digitata*, *Laminara hyperborea*, *Fucus vesiculosus*, *Pelvetia canaliculata*, *Cladophora rupestris*, *Enteromorpha intestinalis*, *Ulva lactuca*, *Palmaria palmata*, *Vertebrata lanosa* is between 500 and 15000 mg/kg. In the literature reviewed, Rajasulochana *et al*. (2009) reported that *Kappaphycus* spp. was determined 12.24 mg/kg as the lowest amount of P (Phosphorus). Findings obtained in this study are within the limits of the literature findings 53.33 mg/kg which is the lowest P (Phosphorus) value in the study, obtained from the Celebibaoy Reeds is higher than the determined P (Phosphorus) value of 19.5 mg/kg for *Kappaphycus* spp. (Rajasulochana *et al*., 2010). The amounts of P (Phosphorus) in the stations of white water (979.33 mg/kg), Lake Kaz (dirty water) (4308.67 mg/kg) and Lake Kaz (fresh water) (2408.83 mg/kg) were determined higher than P (Phosphorus) amounts (90-440 kg/kg) of feed and forage crops which were obtained by Alp *et al*. (2001) while P (Phosphorus) values of other regions were determined similar to P (Phosphorus) values of these feeds.

The difference between the iron (Fe) amounts of the algae obtained from the study stations (Table 6) was found to be significant ($p<0.05$). The extreme values obtained by Mahre *et al*. (2014) for macroalgae species

Alaria esculenta, *Laminara digitata*, *Laminara hyperborea*, *Fucus vesiculosus*, *Pelvetia canaliculata*, *Cladophora rupestris*, *Enteromorpha intestinalis*, *Ulva lactuca*, *Palmaria palmata* and *Vertebrata lanosa* are between 58 and 10000 mg/kg. Campanella *et al*. (1999) determined for Spirulina in 5 different specimens as 195 mg/kg for the lowest amount of Fe and as 1119 mg/kg for the highest amount of Fe. Variation similar to the variation in the amounts of Fe was also observed in the Fe amounts of alga samples obtained from the stations of this study. Alp *et al*. (2001) determined that the amounts of Fe that they found in 16 different feeds were 45.79 mg/kg for one corn and the highest amount of Fe for vetch was 146.93 mg/kg. These amounts are lower than the Fe amounts of algaeobtained from the areas of Van Province. The amounts obtained in this study were higher than those of many feeds obtained by Ergun *et al*. (2007) but were lower than wet-milled corn embryo flour, dry-milled corn embryo flour, clover-like flour, blood flour, chicken flour, dried corn distillation product and meat meal. The Fe average (989.83 mg/kg) of Lake Kaz (fresh water) was found to be close to dried tomato paste (900 mg/kg) but it was higher than other feeds (Sauvant *et al*., 2004).

Differences in the Manganese (Mn) amounts of the algae obtained from the study area were not found to be significant (Table 6). Rajasulochana *et al*. (2010) obtained 0.44 mg/kg for the Mn value of *Kappaphycus* spp. This amount is the lowest observed value of algae in the literature reviewed. Campanella *et al*. (1999) obtained a range of 52.3-64.7 mg/kg of Mn for 5 algal species. Mahre *et al*. (2014) obtained the amount range of 3.1-130 mg/kg for the Mn amounts of ten different species. The Mn amounts of Celebibao Reeds and Muradiye waterfall samples are higher than the values given in the reviewed literature. Mn amounts of other station algae except these two stations are in accordance with the literature. Alp *et al*. (2001) reported that the highest amount of Mn from the sixteen forage crops was observed as 128.74 mg/kg for the vetch feed whereas the highest Mn value in the study of Ergun *et al*. (2007) was observed as 100 mg/kg for wheat bran, wheat-short, wheat embryo flour and bonkalit. If the Mn average (48.47 mg/kg) of Lake Ercek Wetland and the Mn average (69.17 mg/kg) of Gorundu Wetland are excluded these values are lower than Mn amounts of the algae obtained within the areas of Van Province.

Differences in the amount of Copper (Cu) in algal specimens obtained from ten different study stations (Table 6) were found to be significant ($p<0.05$). Mahre *et al*. (2014) report that the Cu amount range for some macro-alga species ranges from 1.6-17.0 mg/kg. The data obtained from the stations are higher than the amount of Cu (0.897 mg/kg) which Rajasulochana *et al*. (1990) obtained for *Kappaphycus* spp. but lower than the Cu values (12.3-69.6 mg/kg) which Campanella *et al*. (1999) obtained form 5 different samples for Spirulina. These amounts were obtained among the lowest (wheat straw 0.9 mg/kg) and the highest (23.85 mg/kg) amounts of Cu values which Alp *et al*., (2001) observed in wheat, grain corn, cow corn, meadow and pasture grass, clover, trefoil, vetch, oat, sudangrass, barley straw, wheat straw, wheat, corn, sugar beet pulp and corn silage. Ergun *et al*. (2007) report that the lowest value for Cu is 3 mg/kg for corn and yellow corn and the highest value is 88 mg/kg for the safflower pulp.

Differences in the amounts of Zinc (Zn) in wetland algae within the areas of Van Province were found not to be significant ($p<0.05$). Campanella *et al*. (1990) determined the Zn amounts for Spirulina in 5 different specimens as 240.0, 18.5, 14.2, 16.8 and 9.42 mg/kg. If the amount of Cu obtained from caldyran plain wetland is excluded, the amounts of Cu obtained from other stations are in accordance with the values reported by Campella *et al*. (1990). Mahre *et al*. (2014) report that the amounts of Cu are 8-49 mg/kg. When these values are taken into account, the amount of Cu in the samples obtained from the Caldyran Plain Wetland is high. When Caldyran Plain Wetland is excluded, the Zn values obtained are similar to the values reported by Alp *et al*. (2001) while they are lower than many of the values which Ergun *et al*. (2007) report.

CONCLUSION

In this study, ash amounts of algae obtained within the areas of Van Province were found high. In this respect, it is necessary to do further researches on the macro and micro mineral structures of the regional algae and to find out the possibilities of meeting the mineral matter needs of animals via. these algae. In terms of CP, another CP parameter studied, it has been determined that CP ratios of wetland algae were not very high when Lake Kaz (freshwater) station was excluded (CP 20.27%). It has been determined that macro and micro minerals are high due to the fact that the algea of Lake Kaz fresh water (*Cladophora fracta* and *Cladophora glomerata*) which has the highest CP ratio (20.27%) in the region, contains CP close to good quality alfalfa hay. For this reason, it has been concluded that further researches on two types of species, *Cladophora fracta* and *Cladophora glomerata* which were adapted to the region, must be carried out and that these two species must be produced and their contribution to the economy of the region and the country must be provided.

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