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Distribution of Epiphytic Lichens and Air Pollution in the City of Trabzon, Turkey

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In this study the distribution of epiphytic lichen species in connection with air pollution has been investigated in Trabzon city. Three zones in the study area based on the distribution of 29 epiphytic lichen taxa were described. The first one is a lichen desert zone which covers a narrow band in the city center. The others are struggle zone and normal zone. The struggle zone covers a quite large area in the city and the normal zone lies to the South of the city.

The lichens were defined to have been sensitive against air pollution by Nylander (Nash 1976). Air pollution affects not only trees but also lichen species on their bodies. In addition sometimes wholesale destruction of normal communities by heavy "dry" and "wet" sulphur dioxide pollution concentrations result in their replacement by certain algae and some lichens in resistance against air pollution (Purvis et al., 1994). It was understood that some lichen species accumulated heavy metals and radioactive substances (Sloof and Wolterbeek, 1992). In Turkey some studies have been conducted by taking into account of epiphytic lichen species to determine air pollution resulting from sulphur dioxide (John 1989, Özdemir 1992). The main purpose of this paper is to determine map of the pollution in Trabzon-Turkey using lichens and to give some clues to city planers.

MATERIALS AND METHODS

The lichen samples were gathered from 33 different stations between between January and December 2004 in the city of Trabzon. Figure 1 shows the position of the investigated lichen sites in the city of Trabzon province.

A stereo microscope, a light microscope and the usual spot tests and reference books were used in the identification of the samples (Purvis et al., 1994, Poelt 1981, Wirth 1995). After being identified the lichen species as herbarium specimens were stored in the herbarium of the Biology Department, Giresun Science and Art Faculty, Karadeniz Technical University.

Central population of Trabzon being one of the coastal province of Eastern Black

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Sea region was approximately 215, 000 according to the cencus in 2000. Average height of settlement regions is 30 metres (Fig. 1). There are official institutions and high buildings consisting of a large number of apartment houses in the center and many houses with one or two-floors are built in the outer parts of thecenter. There are, however, a lot of multi-storey houses especially towards the mountains in new settlement regions in south and south-west directions. Air pollution results from heating, industrial institutions and traffic. In Trabzon, mesoclimate affected from the sea is seen (Kılıçoğlu 1986). Annual average precipitation is 831 mm and the most rainfall is in December. Annual average temparature is 14.6°C. Figure 2 shows that dominating wind is in south and south-west directions in December, in south-west direction in April, in South direction in June and North-west direction in other month (Meteoroloji 1994). In 1995–2004 monthly average sulphur dioxide measures are given in Tab. 1 (Directorship of environment province health 2004).

Table 1. Sulphur dioxide concentrations in the atmosphere between 1995–2004 in Trabzon city ("–" indicates unmeasured).

	Sulpur dioxide concentration ($\mu g/m^3$)									
	Year									
Months	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
J	77	57	58	67	72	63	63	85	73	109
F	70	109	65	77	68	76	57	86	59	77
M	52	73	61	74	48	68	60	72	66	72
A	37	43	41	34	39	60	41	71	72	67
M	25	21	25	27	29	32	43	33	34	56
J	19	21	22	22	27	22	23	25	41	39
J	20	20	20	22	27	27	27	–	–	36
A	–	20	23	24	23	27	29	–	–	34
S	25	20	22	26	32	29	29	–	–	–
O	25	26	26	28	–	38	34	–	–	–
N	68	64	75	33	50	67	44	–	–	81
D	94	53	70	73	82	53	63	80	86	98

RESULTS AND DISCUSSION

Struggle zone is present in outparts of that region called a lichen desert covering a narrow area in the city center and industrial region (Fig. 1). After lichen desert epiphytic lichen species in struggle zone were defined more common on the bodies of decidious trees such as apsen, poplar and willow (Tab. 2).

Struggle zone begins after Toygaroğlu and Havacı Mete street in Hızırbey district, Ahmet Can street and İnönü main road, administration of justice, Girl health private high school, Monopoly in Gülbaharhatun district, Zağnos street, Russian consulship, Mimar Sinan street, Culture center in Ortahisar district, Zafer and Çukur Hamdi street, Fatih Turkish Bath and Muhittin mosque in Zafer district, Boztepe street in Yenicuma district, Governership, Nemlioğlu and Tekke mosque street, Fatih park in Gazipaşa district, Çömlekçi street III, Yan and Mektep street and Municipility marriage Office in Çömlekçi district and lying towards and

Table 2. Numerical distribution of lichen species defined on trees

Lichen	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Arthonia dispersa				1										
Arthonia sp.														1
Arthothelium ruanum														1
Arthothelium sp.														1
Caloplaca cerina	1	9	2		3	1								
Caloplaca Cerinella	1	4	3		8			1						
C. citrina	1	7	1		4	3				1				
C. holocarpa		12			10	5								
Caloplaca sp.		5												
Candelariella aurella		9	1	3	9	2		1						
C. vitellina	7	2	2	6	4			1	1		1	1		
Evernia prunastri					1		2	1	2				1	
Graphis scripta		4												
Flavoparmelia caperata		3					6							
Lecania sp.		1			1									
Lecanora carpinea		1			3	2								
L. dispersa	2	3	1	1	2	1								
Lecanora sp.	1		1		2									
Lecidella elaoechroma		2		1										
Parmelia sulcata							5							
Phaeophyscia orbicularis		2		3	1								3	
Physcia adscendens		20	18	2	11	3		2						
P. tenella	1	10	3	2	3									
P. stellaris		6			4									
Punctelia subrudecta							4							
Ramalina pollinaria		1					1							
R. farinacea		2					2							
Xanthoria parietina		30	10		9	2				3	7	1		
X. candelaria		2	1		2									

A: *Acer*, B: *Populus*, C: *Aesculus*, D: *Tilia*, E: *Robinia*, F: *Salix*, G: *Quercus*, H: *Pinus*, I: *Cedrus*, J: *Acacia*, K: *Ficus*, L: *Cercis*, M: *Picea*, N: *Fraxinus*

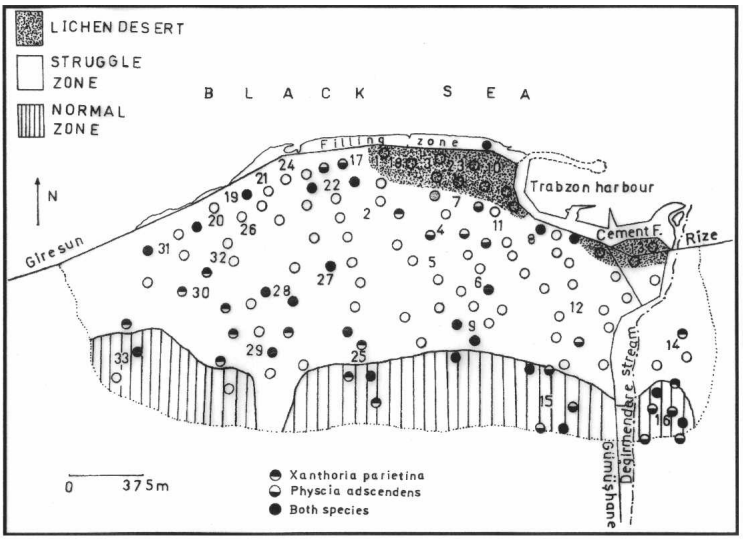

Figure 1. Lichen distribution zones and distribution of *Xanthoria parietina* and *Physcia adscendens.*

Mektep street and Municipility marriage office in Çömlekçi district and lying towards south of the city. In addition a part area in the South of Erdoğdu II district is situated in struggle zone. Normal zone has been found to begin far from the city center in spite of the fact that green areas and tree communities in the central Trabzon begin from the shore and are associated together new settlements regions in south and south-west directions. Normal zone begins after Dereboyu district, Fatih industrial, Kalkınma district, ammunition store and towards the end of Evrendede street in Boztepe district, Bahçecik mosque, Balerko buildings at the end of Köseoğlu street in Erdoğdu III district, Sağlık meslek Highschool and lichen desert includes city center except lichen desert and also green areas reaching the mountains in south and South-west directions. The species that are not resistant to air pollution such as *Evernia prunastri, Ramalina farinacea* and *Ramalina pollunaria* have been seen far from the city despite the fact that green areas and trees are very abundant and near the city. We can say these species chose places away from the city center to find suitable substrata despite the fact that fertilized agricultural fields are widespread and near the city center.

Affixing the filters to the chimneies, using fuel-oil in good quality in the high tall buildings and in jop-sites, protecting tree communities and green areas may give appreciable results with regards to human-health.It was understood that sulphur dioxide measures in the study area were very low when comparing sulphur dioxide measures in the study area with measures obtained then in other studies in Turkey (John 1989, Özdemir 1992). We can say there is a lichen desert and struggle zone covering a wide area in the study area dispite the fact that here are no trees in some places of the city center or present trees have acidic

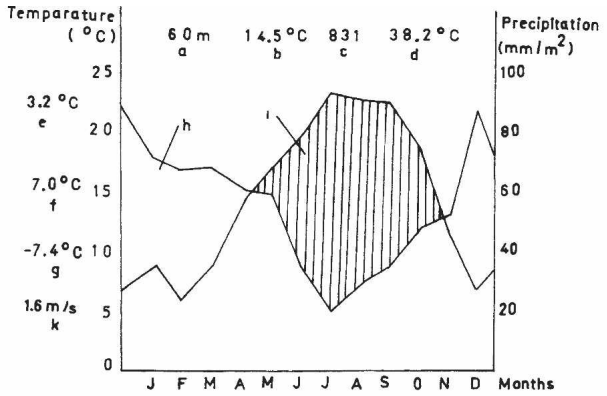

Figure 2. Climate diagram belonging to the study area

a:Height, b:Annual avarage temparature, c:Annual avarage total precipitation, d: Maximum absolute temparature, e: Maximum avarage temparature, f: Minimum avarage temparature, g: Minimum absolute temparature, h: Precipitation period, ı: Dry period, k: Avarage wind speed

bark and their bodies were coated by lime against harmful insect and not suitable substrata in the struggle zone. A total of 29 epiphytic lichen taxa was identified in the city of Trabzon and the forest near the city. Distribution of lichen species is given in Tab. 3. Lichens can grow much more time in suitable mesoclimate conditions and also in natural brooks or small and deep ditches. Along brooks the lichen flora is extremly rich on branches which extend above the surface of water, like Dereboyu, Karşıyaka and Boztepe districts.

Trees, having acidic bark resulting from air pollution, lose lichen communities on their bodies (Broad 1989). *Robinia pseudoacacia* L., *Acer negundo* L., *Aesculus hippocastanum* L., *Populus nigra* L., *Cedrus* spp., *Pinus* spp., *Cupressus* spp, *Salix* spp., *Fraxinus* spp and *Plathanus orientalis* are the most common trees in the city and its surroundings. In the city center, no epiphytic lichen species were seen since either there are not any trees or majority of present trees in some places has acidic bark and their bodies were coated with lime against harmful insect.

Epiphytic lichen species were also not seen in industrial region due to the fact that there are not any trees and there is a cement factory causing air pollution in industrial region towards the eastern end of the city. In cemeteries often exist large undisturbed lawns and threes where a few lichen can be observed except surroundings Boztepe, Kaymaklı and Çukurçayır districts. This is due to low altitude, high pollution and the negative effect of the typical city-climate. Fruticose lichen species are affected more quickly by air pollution since they have larger suface than the other lichen species (Nash 1976, Broad 1989, Galun 1989). In the study area *Ramalina* and *Evernia* species were seen far away from the city. *Cupressus sempervirens* L., *Robinia pseudoacacia* L., *Acer negundo* L., *Tilia*

Table 3. Station distribution of lichen species in the study area(*)

Lichen
Arthonia dispersa: 17
Arthonia sp.: 33
Arthothelium ruanum: 17
Arthothelium sp: 33
Caloplaca cerina: 2, 6, 14, 15
Caloplaca cerinella: 6, 16, 20, 22, 27, 30, 31
Caloplaca citrina: 2, 5, 6, 7, 8, 9, 12, 21, 25, 26, 28, 31
Caloplaca holocarpa: 4, 11, 12, 22, 25, 29, 31, 32, 33
Caloplaca sp.: 15, 25
Candelariella aurella: 9, 21, 22, 27, 28, 33
Candelariella vitellina: 9, 17, 21, 22, 24, 26, 28, 29, 32
Evernia prunastri: 9, 29
Flavoparmelia caperata: 15, 16, 29, 31, 33
Graphis scripta: 9, 14, 29
Lecania sp.: 14
Lecanora sp.: 6, 14, 25
Lecanora carpinea: 12, 14, 15, 16, 25, 31
Lecanora dispersa: 19, 22, 24, 27, 28, 29, 30, 32
Lecidella elaoechroma: 15, 16
Parmelia sulcata: 9, 25, 30
Phaeophyscia orbicularis: 9, 14, 15, 16, 22, 29
Physcia adscendens: 4, 6, 7, 8, 9, 15, 16, 17, 19, 20, 22, 25, 27, 28, 29, 31, 33
Physcia tenella: 8, 9, 14, 15, 16, 25, 27, 28, 30, 31, 33
Physcia stellaris: 9, 14, 15, 16, 29
Punctelia subrudecta: 9, 25, 30, 32
Ramalina farinacea: 9, 15, 16, 25
Ramalina pollinaria: 9, 25, 29
Xanthoria candelaria: 6, 11, 21, 29, 31
Xanthoria parietina: 2, 6, 8, 9, 14, 15, 16, 19, 20, 22, 25, 27, 28, 29, 30, 31, 32, 33

*Station number shown in map and Table 3.

1.Pazarkapı district (Reşadiye and Maraş street), 2. Gülbaharhatun district (Reşadiye and Martyr Refik Can street), 3. Kemerkaya district (Kunduracılar and Maraş street), 4. Cumhuriyet street, Boztepe and long street), 5. Zafer district (Martyr Refik Can street), 6. Yenicuma district (Yenicuma and Boztepe street), 7. Gazipaşa district (Gazipaşa, Boztepe and Park street), 8. Çömlekçi district (State highway street), 9. Boztepe district (Evrendede, Karmevki, Boztepe, Iran and Hospital street), 10. İskenderpaşa district (Sümer and Taşbaşı street), 11. Esentepe district (Seyran and Martyr Ayhan İnce Kara street), 12. Değirmendere district (Anatolia and State highway street), 13. Industry district (State highway street), 14. Kalkınma district (Anatolia street), 15. Kaymaklı district (Erzurum street), 16. Dereboyu district (Anatolia street), 17. Hızırbey district (Reşadiye street), 18. Çarşı district (Kemeraltı, Semerciler and Maraş street), 19. Yeni district (Hasan Saka and Fatih Dranas street), 20. Fatih district (Fatih, Ayasofya and Dr. İbrahim Okman street), 21. Kurtuluş street (Maraş street), 22. Governership (Hamamcı and Mumcular street), 23. City center (Atatürk's area), 24. Yalı district (Maraş street), 25. Bahçecik district (Buzludere street), 26. İnönü district (Yavuz Selim's Boulevard and İnönü street), 27. Erdoğdu district I (Demircioğlu and Martyr Osman Ertosun street), 28. Erdoğdu II (Kisarna street), 29. Erdoğdu district III (Köseoğlu street and Buzludere boulevard), 30. Aydınlıkevler district, 31. Toklu district, 32. Yeşiltepe district, 33. Karşıyaka district.

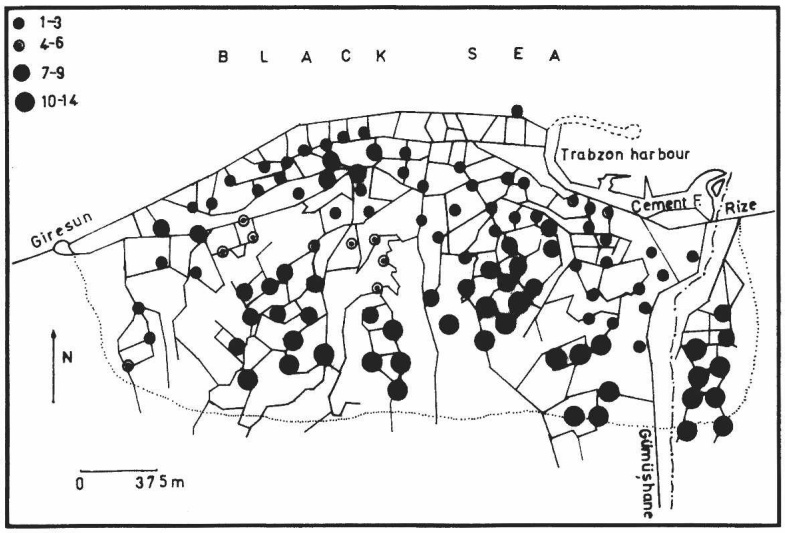

Figure 3. Variation of species number in stations as regards air pollution.

platyphyllos Scop., *Pinus* spp., *Populus nigra* L., *Fraxinus exelsior* L., *Salix babylonica* L. are seen more commonly in the struggle zone. In the struggle zone *Xanthoria parietina* and *Physcia adscendens* are the most common lichen species and these relatively resistant species penetrate far extending into the city (Seaward 1987). In the study area *Xanthoria parietina* loses its apothecia gradually becoming in small pieces until 2–4 mm towards lichen desert from struggle zone. Thallus, which reachs up to 2–5 cm towards the exit of struggle zone, has apothecia. In the same way *Physcia adscendens* is steril and in like-a very small piece and thallus gradually becomes down to 3–4 mm a small piece towards lichen desert from struggle zone. This species grows healty gradually towards the exit of struggle zone and mostly exists together *Xanthoria parietina* (Fig. 1).

Change of species number depended on air pollution in all of the localities in the study area is given in Figure 3. It shows a distinct pauperization of the lichen vegetation in the north, left side of the city center and front sides of the cement factory. In south and south-west parts of struggle zone of new settlement region green areas tree communities and are seen abundantly. The houses with a garden in one-floor, stables, poltries and sown fields being fertilized in this region cause bodies of trees to be very rich in terms of nitrogen. It was defined that nitrophil species such as *Caloplaca, Phaeophyscia* and *Lecania* grow in this region (Wirth 1980, Broad 1989). In addition causing air polution and sulphur dioxide in the atmosphere results from struggle zone of city center population density, cement factory, especially the weather windless and a large number of official institution and buildings in the setlement regions. It can be said that species growing on substrata in this conditions such as *Xanthoria parietina*, *Caloplaca holocarpa* and *Physcia adscendens* are enduring air pollution and dusty substrata by corresponding to the literature findings (Wirth 1980). The improved living

conditions in lawns can be seen beside on otherwise evenly high sulphur dioxide rate. Preservation, enlargment and creation of new priaries are necessary. In valleys aisles of low air temperature are pointed out by some lichens in terms of which cold and clean air exist in the city. Lichens are able to warn us not to use up under any circumstances these aisles for building areas.

Hygric conditions of the air can be improved by small priaries or lawns and also by lichens can be in and around parks. Higher number of species and the occurance of foliose lichens give clues to special fields with climatically especially favorable conditions. Thus the affects of high sulphur dioxide levels sometimes are covered by favorable climatical conditions. It therefore is necessary to reduce the sulphur dioxide emissions drastically. It is also be studied to what extend lichens in valleys and up to which altitude are influenced and wether aisles of low temperature due exist, which can be discovered by occurance of lichens. Such clues could also be useful for city planers.

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