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EFFECTS OF AIR POLLUTION ON SULPHUR ACCUMULATION IN SOME TREE LEAVES IN THRACE - TURKEY

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Abstract. Rapid increasing of the world population and energy demand of the industrialisation caused an incredible use of fossil fuels. This use created the today's main environmental problem "air pollution" by emission of the SO_2, NO_x, and CO_2. The harmful effect of air pollution is not only a problem in the areas where the fossil fuels are intensively used but also is the main problem in agricultural and forested area. In fact, air pollution and forest decline can be seen in the Thrace part of Turkey. This part of Turkey having a large cultivated area in the central plateau surrounded with forested mountain ranges in the north and the south. Polluted air coming from Central and Northern European countries by prevailing winds, especially affects the north-west part of Turkey. This study focused on to find out the size of the problem on especially forest cover of the region by delimitation of sulphur accumulation in the tree leaves. Results showed that values of sulphur content in the samples are very high, and the continuity of the pollution will create the destroying of the plant cover and soil and water resources.

Keywords: air pollution, sulphur concentration of needles, forest decline.

AIMS AND BACKGROUND

Air pollution as a well-known concept originates from burning fossil fuels (coal and petroleum, etc.). Air pollutants primarily consist of gases like SO_2, NO_x, Cl_2, F_2, O_3, atmospheric partcles, dusts less than 10 μ, hydrocarbons (CH and PAN), waste gases from different emission sources. These pollutive materials affect living organisms and trees by several ways. This effect is mainly attributed to the air pollution of the chlorophyll tissue of trees. This destruction causes decreasing of carbohydrate synthesis which is required for respiration and growth of trees. In dry air conditions, these pollutive materials accumulate on the leaves of the trees as dry deposition. In wet or moist air conditions, these gases are converted into acids and cause acid rains on the earth surface and plant covers. Acid rains can create a spoiling process in the soil profile by leaching the top soil. This leaching decreases the base saturation and causes decomposition of clay minerals, then, soil reaction falls down to aluminium buffer level.

The effect of air pollution on trees and other plants is different depending on atmospheric moisture conditions. Pollutants as gases in dry air are taken into plant

tissues with CO_2 through the respiratory pores. In the initial phase of the carbohydrate ($C_6H_{12}O_6$) synthesis, water is ionised in chlorophyll and one atom of oxygen is released. This oxygen is used for the synthesis of carbonic acid with CO_2 from air and H_2O from the soils. By this process like initial synthesis process, gases reaching to chlorophyll are converted into acids (H_2SO_3, H_2SO_4, HNO_3, HF, HCl). The presence of O_3 in the air surrounding of the leaves, encourages this converting processes. This occurrence of acids causes a destruction in chlorophyll tissues. Depending upon this destruction's level plants make less increment or die[1-5].

In moist air conditions, these gases from the pollutants accumulate on the leave surfaces and on contacting water molecules, can cause drastic and fatal effects on the leaves, like burning, brown spots and drying. Especially, PAN (peroxyacetylnitrate) which occurs by means of the combination of NO_x+O_3+CH is very effective.

During wet air conditions, these pollutants can be converted into acid forms in air and acid rains occurr. By the rain and snow particles these acids reach the top soil and leaching processes begin. Decreasing of the soil pH reaction to the aluminium buffer level can damage plant roots[1,6-14].

EXPERIMENTAL

The Regulation related with "Protection of Air Quality" in Turkey issued in 1986 is based on the Air Pollution standards related with human health:

	1 h	Short period	Long period	Winter season
On the country basis SO_2 $\mu g/m^3$	900	400	150	250
In the industrial areas SO_2 $\mu g/m$	900	400	200	-
Natural protection areas SO_2 $\mu g/m^3$	-	-	60	-

These values are fatal for all of the forest trees which are under the effect of SO_2. The values which the forest trees can resist may be accepted as follows[2,17]:

In the sensitive and poor ecosystems (dry and very cold conditions, stony or shallow soil)	30 $\mu g/m^3$
In good ecosystems	50-80 $\mu g/m^3$
For the sensitive tree species	50 $\mu g/m^3$
For the medium level sensitive tree species	80 $\mu g/m^3$
For the less sensitive tree species	120 $\mu g/m^3$
WHO	20 $\mu g/m^3$

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SITE PROPERTIES OF THE AREA UNDER STUDY

Location. Thrace is located in between Black sea, Marmara and Aegean sea in the north-west part of Turkey (Map 1). This part of Turkey having a large cultivated area in the central plateau surrounded with forested mountain ranges in the north and the south.

Climate. Climatic data of the study are shown in Table 1.

Table 1. Some climatic data of meteorological stations in Thrace

Annual climatic data	Edirne 48 m	Kesan 185 m	Hayrabolu 15 m	Kirklareli 232 m	Luleburgaz 46 m	Pinarhisar 190 m	Tekirdag 4 m	Demirkoy 300 m	Corlu 183 m	Bahcekoy Istanbul 129 m
Mean *t* (°C)	13.5	14.4	13.3	13.2	13.1	13.2	13.8	12.0	12.6	12.8
Mean max. *t* (°C)	19.1	19.5	19.3	18.4	19.2	18.7	17.6	17.3	17.7	17.8
Mean min. *t* (°C)	8.0	9.0	8.3	8.4	7.0	7.8	10.3	7.4	8.0	9.0
Mean precip. (mm)	599.3	648.8	618.7	575.8	614.5	630.1	590.5	818.8	577.1	1074.4
Mean rel. hum. (%)	70	77	74	73	71	77	75	72	74	83
Mean misty (days)	29.8	8.8	16.7	12.0	19.9	14.5	5.8	18.6	16.7	19.0
Prev. wind	N	N	N	ENE	E	E	NE	NE	NE	NE

Vegetation. Main tree species forming large stands on the north are oak (*Quercus* sp.) and beech (*Fagus orientalis* L i p s k y.), Calabrian pine (*Pinus brutia*) on south mountainous areas. These areas also contain Crimean pine (*Pinus nigra*), fir (*Abies bornmülleriana*), maritime pine (*Pinus pinaster*), stone pine (*Pinus pinea*), cedar (*Cedrus libani*), etc.

Air pollution in Thrace. SO_2 concentrations of air in winter season at some urban areas between 1994-1998 in Thrace are shown in Table 2.

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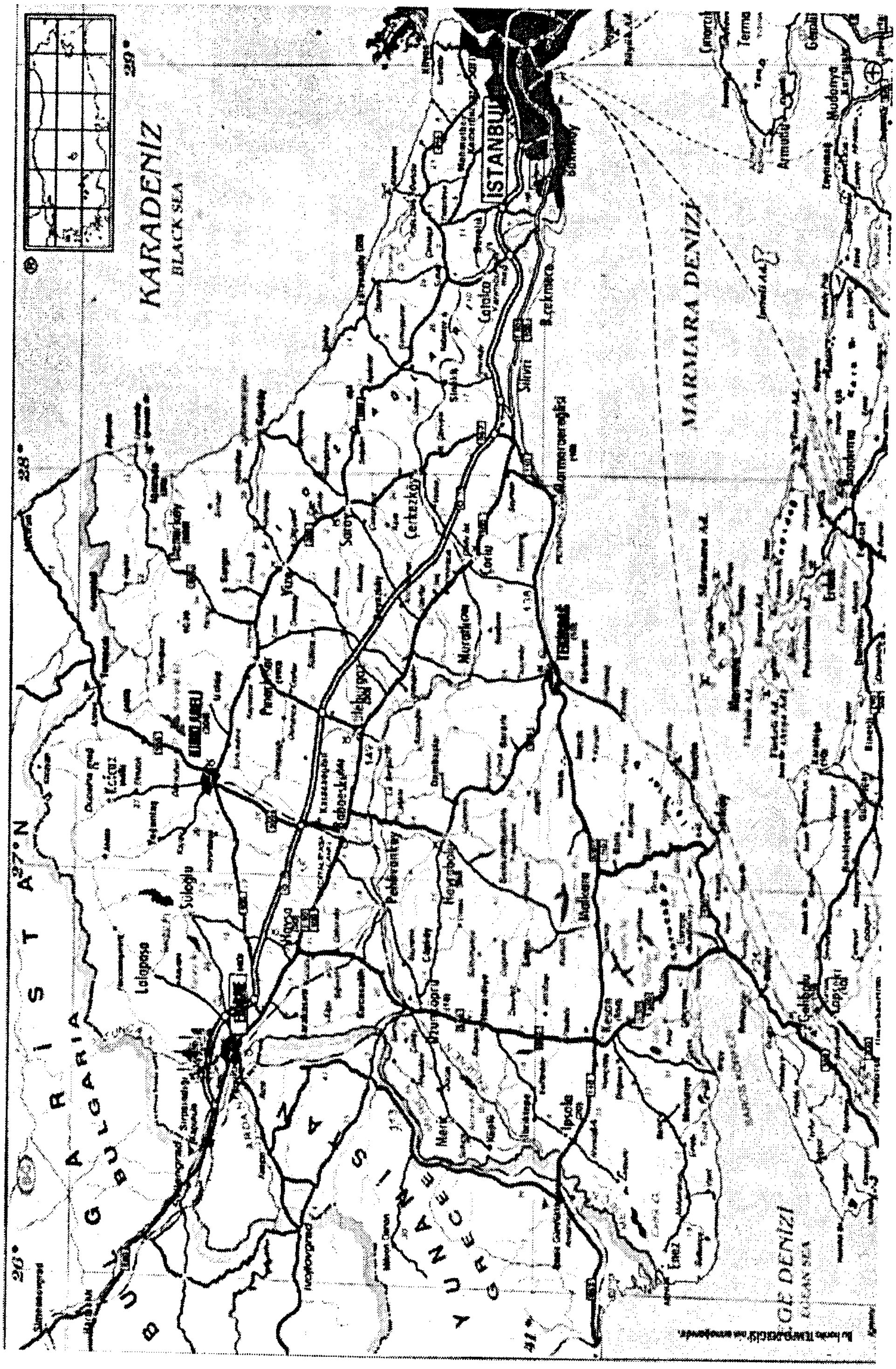

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Table 2. SO_2 concentrations of air in winter season at some urban areas between 1994-1998 in Thrace (μg/m³)

Location	Years				
	1994	1995	1996	1997	1998
Istanbul	253	189	135	110	88
Tekirdag	57	174	-	53	-
Edirne	153	174	289	154	193
Kýrklareli	73	50	44	42	36

Air quality of Black sea atmosphere. Ion and element concentrations of aerosols in Black sea atmosphere are shown in Table 3.

Table 3. Ion and element concentrations of aerosols in Black sea atmosphere[15] (μg/m³)

Parameters	West Black sea	East Black sea
SO_4	9.1 ± 2.6	4.3 ± 1.6
NO_3	3.1± 0.8	2.1 ± 0.8
Cl	1.4 ± 1.7	3.8 ± 2.0
Na	1.4 ± 1.2	3.9 ± 2.9
K	0.33 ± 0.07	0.11 ± 0.10
Ca	0.77 ± 0.88	-
Mg	0.34 ± 0.27	-
Fe	0.42 ± 0.23	0.29 ± 0.19
Al	0.54 ± 0.24	± 0.22

Tree leaves were collected as 62 sampling plots and 156 leave samples from each plot. Sulphur contents of the needles were determined by gravimetric barium sulphate method.

RESULTS AND DISCUSSON

Sulphur concentrations of leaves are given in Table 4. Thrace is surrounded by cool and humid Black sea in the north, and dry and warm Mediterranean sea in the south. The mountain ranges in the north and south create a climate difference. Inner Thrace has a continental climate that is hot and dry in summer and cold in winter. This mountainous areas especially have sensitive ecological ecosystems. Misuse of land, overgrazing, and disturbing of the natural plant cover are also main factors in the occurring of this declining. Therefore, air pollution effects in these sensitive ecosystems cause a rapid changing in the ecological balance.

Forest decline in Thrace is under the effect of polluted air coming from Middle European countries and Russia. Nearly all the leaves analysed in laboratory have acidic burn trace, but acute damage events have not been yet in mass

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level. This occurrence can be explained by the high level of sulphur concentration in the leaves, acid rains and mist problem in the studied area.

As a comparison some measurements of the sulphur concentration in the needles of the affected calabrian pine trees in the surrounding area of the Yatagan Thermal Power Plant show values of 1276-10 680 ppm[16], 1630-4000 ppm[18], 1602-3682 ppm[13] sulphur concentration.

On the other hand, the study carried out on the Calabrian pine stands in surrounding of Yenikoy Thermal Power plant shows that the sulphur concentrations in the needles varied between 1127-9481 ppm[19]. It has been found that the sulphur concentration in one and two years old needles in unpolluted regions ranked from 1142 ppm to 1418 ppm[16], respectively.

The result for Yatagan and Yenikoy region can be easily explained by emission sources present in the area. Conversely, the high level of sulphur concentration in Thrace can be explained by polluted air movement from industrial centres to the region.

Table 4. Sulphur concentrations of needles

Sample plot No	Location of sample plots	Tree species	Needle age S (ppm)			
			1	2	3	4
1	Corlu-Belek Kiþlasi	*Pinus brutia*	1360	3379		
2	Corlu-Mezarlik	*Pinus brutia*	3572	4342		
3	Corlu-Sancar Kiþlasi	*Pinus nigra*	1979	2352	5800	
4	Corlu-Sancar Kislasi	*Pinus brutia* (Young)	3245			
5	Cerkezkoy Lisesi	*Pinus nigra*	2143	4328	4550	
6	Cerkezkoy Trakya-Iplik	*Pinus nigra* (Young)	1611	1780	3215	
7	Saray Eski Kisla	*Pinus nigra*	1621	2597	3380	
8	Yarbay Hamdi Bey Kislasi	*Pinus nigra*	2545	3010	3435	3600
9	Vize-Goztepe	*Pinus nigra*	3037	3105	3200	
10	Yenice	*Pinus nigra*	2345	3250	3325	
11	Vize- Poyrali Sehitligi	*Pinus nigra*	4754	5424	6485	
12	Pamir Kislasi Luleburgaz	*Pinus nigra*	1180	2325	4800	
13	Luleburgaz Orman Fidanligi	*Pinus nigra*	1099	2093		
14	Luleburgaz Orman Fidanligi	*Pinus nigra* (Young)	1390	2720	3092	3120
15	Luleburgaz Devlet Hastahanesi	*Pinus nigra*	2088	3450	4080	
16	Alpullu Seker Fabrikasi	*Pinus nigra*	1320	1690	3998	
17	Babaeski	*Pinus nigra*	1072	2980	3100	
18	Babaeski-Havsa Mezarlik	*Pinus brutia*	3560	4053		
19	Babaeski-Havsa Mezarlik	*Pinus nigra*	2780	3256		
20	Havsa	*Pinus nigra*	3366	3682	3695	
21	Edirne Karayollari	*Pinus brutia*	3435			
22	Edirne Mezarlik	*Pinus nigra*	1965	2102	3147	
23	Edirne Mezarlik	*Pinus brutia*	1780			
24	Edirne Orman Isletmesi	*Pinus brutia*	1445	3091		

to be continued

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Continuation of Table 4

			1	2	3	4
25	Edirne-Kapikule Cikisi	*Pinus nigra*	1621	2597	3380	
26	Edirne-Kapýkule Cikisi	*Pinus brutia*	1861			
27	Kapikule-Kartaltepe Mensucat	*Pinus nigra*	2940	3395	4163	
28	Uzunkopru-Bulbuldere Ormani	*Pinus nigra*	1566	2970	3100	
29	Pasayigit	*Pinus nigra*	2100	2885	2970	
30	Kesan	*Pinus brutia*	2300	2425		
31	Malkara	*Pinus brutia*	2762	3450		
32	Tekirdag	*Pinus brutia*	1340			
33	Tekirdag Ataturk Ormani	*Pinus nigra*	1187	1772	1845	
34	Tekirdag Ataturk Ormani	*Pinus brutia*	2215			
35	Igneada	*Cedrus libani*	2058			
36	Igneada	*Pseudotsuga*	2196	2607		
37	Igneada	*Quercus*	2140			
38	Igneada	*Pinus nigra*	2003	2140	2320	
39	Igneada	*Pinus pinea*	2200	2374		
40	Igneada	*Pinus brutia*	2291			
41	Igneada	*Pinus pinaster*	2600	2800	2975	
42	Bulgar siniri	*Pinus pinaster*	2500	2612	2800	3120
43	Demirkoy ustu camlik 310 m	*Pinus nigra*	1800	1920	2125	2500
44	Boztas Piknik Yeri 290 m	*Abies bornmulleriana*	2572	2855	2945	
45	Sarapneltepe 310 m	*Quercus* spp.	2676			
45	Sarapneltepe 310 m	*Pinus nigra*	1500	1650	1825	
47	Sarapneltepe 310 m	*Pinus sylvestris*	1547	1600		
48	Manastirtepe Hamdibey ustu 500	*Pinus nigra*	1045	1485	1650	1865
49	Asker Koprusu 280m	*Saricam*	1310			
50	Asker Koprusu 280 m	*Pinus sylvestris*	1850	2145	2550	
51	Kadinkule 620 m	*Pinus nigra*	1745	2346	2485	
52	Kadinkule 620 m	*Fagus orientalis*	2495			
53	Yesilce ustu 420 m	*Quercus* spp.	2600			
54	Yesilce ustu 420 m	*Pinus nigra*	2672	2900		
55	Yoguntas-Polos 350m	*Pinus nigra*	2500	2850	2900	3200
56	Karahamza-Tavsantepe 430 m	*Pinus nigra* (Young)	2200	2445	2645	
57	Karahamza-Tavsantepe 430 m	*Pinus nigra*	2300	2385	2400	
58	Topcular 600 m	*Pinus nigra*	2200	2450	2525	3450
59	Terzidere 600 m	*Pinus nigra*	2325	2542	2845	3125
60	Yellibayir 400 m	*Pinus nigra*	1985	2185	2800	
61	Demircihalil dogusu 350 m	*Cedrus libani*	1400	1950		
62	Demircihalil dogusu 350 m	*Pinus nigra*	2200	2485	2845	3200

CONCLUSIONS

The results show that the leave samples from different tree species in Thrace have high sulphur concentrations, and these areas suffer from air pollution problem. Additionally, in the future, acidification of the forest, water ecosystems and agricultural areas in the region can be expected.

Being a global problem, acid rains and acidification of ecosystems are waiting an international cooperation to sustain air quality and to control the sources of pollution.

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