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THE EFFECTS OF AIR POLLUTION ON FOREST ON SUNDIKEN MASSIF (NORTH OF ESKİŞEHİR/ TURKEY)

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ABSTRACT

Sündiken Massif is located between a latitude of 39°06′-40°09′ north and a longitude of 29°58′-32°04′ east. The massif, laying east-west direction, has reached an elevation of 1818 m on Kızıldağ Hill. It's length is 60 km on east-west direction and width is about 20-25 km from north to west. Sakarya river, forming north border of the massif, supplies water for Sarıyar, Gökçekaya, Yenice which are very important hydroelectric plants. Sündiken is rising upright like a big wall along two sides of the river and the dams. A considerable amount of woody production has been made from forests, consist of calabrian pine, scotch pine, Anatolian black pine and junipers. The forests covering the mass also protect the soils from erosion and dams from silting.

Çayırhan thermoelectric power plant, 24 km at a distance to east part of the mass and 48 km to west of it, is located on north east of the massif. It consists of 4 units, two of them has 150 MW and the others have 160 MW, 620 MW capacity in totally. Besides it has a heating centre for the buildings of it. Each unit has a desulphurisation unit in the plant. But it is known that they are not being put into use according to frequency of operation.

In this research, carried out on Sündiken Massif, it was determined that the concentrations of sulphur in needle were between 2050-3224 ppm, 2330-3445 ppm, 2481-3672 ppm for calabrian pine, 1080-2080 ppm, 1241-2190 ppm, 1367-2540 ppm for black pine and 1110-2049 ppm, 1510-2308 ppm, 1710-2474 ppm for scotch pine according to age of needle respectively. Although these amounts might not be fatal but would cause to decrease of increment. Presence of yellow stains on the needles has also attracted attention and pointed out air pollution result from SO_2 .

This subject was investigated and presented because it has constituted an interesting model from the point of view of a thermoelectric power plant-forest and forest-hydroelectric power plant relations and a risk which air pollution result from a thermoelectric power plant would effect hydroelectric power plant indirectly exists.

Key Words: Air pollution, Thermoelectric power plant, hydroelectric power plant, forest, dam.

1. INTRODUCTION

Gases emitted from lignite fired power plant's stacks without cleaning has damaged to forests in Turkey. Sulphur di okside in flue gases is the most harmful gas for forest trees. The half life of SO_2 is 24 hours. SO_2 combining with moisture and ozone in the atmosphere converts into H_2SO_3 and H_2SO_4 and also leads to acidic rains. Ozone in atmosphere forms with the aid of NO_x and CO present in stack gases abundantly. SO_2 uptaken through stomata on leaves or needles of trees converts into H_2SO_3 and H_2SO_4 and ruins the chlorophyll cells. Destruction of chlorophyll in leaves and needles effects photosynthesis negatively and decreases photosynthesis products. Consequently trees could make more narrow tree rings and there have been a decrease in wood production.

2. THE OBJECTIVES OF THE STUDY

There has been a thermal power plant, 24-48 km at a distance to north-west part of sündiken massif, with 620 MW (4 unit) installed capacity. It has also four flue gas treatment plants (Map/Cross 1). In spite of these treatment plants pronounced yellow stains have been occurred on the needles of pines on Sündiken Mountain. Especially these yellow stains are more pronounced on pine needles on the north side of the mountain. To determine sulfur accumulation caused these stains needle samples from north and south exposure of the mountain at 100 m elevation intervals were collected and analyzed. The needle samples were collected as 1,2 and 3 year old on October 2002 and July 2003. The study was conducted as two cross section by A. Çömez and E.Tuncer.

3. RESULTS

(1) As seen from Table 1 sulfur contents of pine needles on north exposure are higher than those of south.
(2) Cool/cold and moist air accumulated over Sakarya river especially at nights has caused an evident air pollution effects. The air can not flow along the river easily due to Sakarya is a folded river (Map/Cross1). Air mass cooled and become heavy on the valley-sides has gone down to the Sakarya valley as mountain breezes and become calm there at nights (Map/Cross 1. and Table 1, Figure 1)
(3) Higher sulfur accumulation was determined on pine needles on north side of the mountain at "middle mist zone"(700-800 m) and "upper mist zone" (1300-1400 m) and on the south exposure at a mist zone (1300-1400 m) forming from time to time.
(4) It is a critical point that sulfur content in 1 year-old pine needle collected on July 2003 is less than one on October 2002. This difference indicates that sulfur accumulation in the needles has continued on July, August, September and October too. An other word, there is an air pollution occurred in the summer, not in winter for heating purpose. This air pollution has originated from Çayırhan thermal power plant, moved to the north side of Sündiken mountain by north-east wind.

(5) Air pollution from heating and industry in Eskişehir has no effective influence on Sündiken mountain. Winds from the north-east has moved polluted air, originated from Eskişehir and it's environment, to the south-west direction. There is no important settlement area on the north and north-east of Sündiken mountain.

4. DISCUSSION

(1) Pronounced yellow stains on the pine needles observed on territory show the effects of SO_2.
(2) Sulfur contents of Calabrian pine needles affiliated with effects of air pollution are seen in Figure 2. Sulfur contents of Calabrian pine needles influenced by air pollution as very severe and sever vary a wide range because of ecological sensitivity. In shallow or stony soil, drought or cold (upper mountainous areas) cites, less amount of sulfur contents would affect the pine needles more severely. As the cite conditions become convenient more amount of SO_2 will be needed to occur sever effect.
(3) An amount of 1800-2000 ppm sulfur contents in needles from the north side of Sündiken mountain points out severe influence.

5. CONCLUSION

According to evaluation on high sulfur contents in pine needles on Sündiken mountain in spite of flue gases treatment plants of Çayırhan thermal power plant it can be concluded that:
(1) flue gases treatment plants of Çayırhan thermal power plant couldn't be always worked.
(2) even if the treatment plants works it has low capacity and flue gases release without treated has affected the forests.
(3) When taking into consideration that a longer time working program has been implemented for the plant (from 4630 hour to 6511 hour in 2002) and lignite using in the plant has been increased from 5000 ton/day to 7000 ton/day, it is realized that leakage of untreated flue gases has been increased.
(4) Sulfur content of pine needles so high that can destroy the chlorophyll. Destruction of chlorophyll causes decrease of wood production.
(5) Both forest districts and farmers owing land harming from flue gases of Çayırhan thermal power plant along the Sakarya valley has a right to want a compensation.

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Table 1. Sulfur contents in needles from north and south exposures of Sündiken Mountain

NORTH EXPOSURE														SOUTH EXPOSURE											
1 . CROS SECTION AFTER A. ÇÖMEZ								II. CROS SECTION AFTER E.TUNCER						1 . CROS SECTION AFTER A. ÇÖMEZ								II. CROS SECTION AFTER E.TUNCER					
ZONE	ELEVATION (m)	SPECIES	NEEDLE FORMING YEAR	NEEDLE AGE	OCT. 2002 S ppm	JULY 2003 S ppm	NEEDLE AGE	SPECIES	NEEDLE AGE	OCT. 2002 S ppm	JULY 2003 S ppm	NEEDLE AGE	ZONE	ELEVATION	NEEDLE FORMING YEAR	SPECIES	NEEDLE AGE	OCT. 2002 S ppm	JULY 2003 S ppm	NEEDLE AGE	SPECIES	NEEDLE AGE	OCT. 2002 S ppm	JULY 2003 S ppm	NEEDLE AGE
PINUS SYLVESTRIS ZONE	1700	P. sylvestris	2003			1904	1	P. sylvestris			1390	1	PINUS SYLVESTRIS ZONE	1700	2003	P. sylvestris			1803	1	P. sylvestris			1610	1
			2002	1	2049	2258	2		1	1650	1780	2			2002		1	1904	2005	2		1	1650	1760	2
			2001	2	2308	2366	3		2	1810	1950	3			2001		2	2021	2157	3		2	1790	1910	3
			2000	3	2474				3	1980					2000		3	2227				3	2180		
		P. nigra	2003	1			1	P. nigra				1			2003	P. nigra				1	P. nigra			1260	1
			2002	1			2		1			2			2002		1			2		1	1650	1710	2
			2001	2			3		2			3			2001		2			3		2	1740	1920	3
			2000	3					3						2000		3					3	2030		
	1600	P. sylvestris	2003			1666	1	P. sylvestris			1350	1	PINUS SYLVESTRIS-PINUS NIGRA ZONE	1600	2003	P. sylvestris			1710	1	P. sylvestris			1110	1
			2002	1	1710	1760	2		1	1380	1510	2			2002		1	1803	1904	2		1	1390	1550	2
			2001	2	1904	2021	3		2	1610	1860	3			2001		2	1955	2005	3		2	1580	1900	3
			2000	3	2049				3	1910					2000		3	2207				3	1980		
		P. nigra	2003				1	P. nigra			1410	1			2003	P. nigra			1543	1	P. nigra			1270	1
			2002	1			2		1	1520	1610	2			2002		1	1573	1635	2		1	1390	1490	2
			2001	2			3		2	1620	1880	3			2001		2	1710	1872	3		2	1650	1740	3
			2000	3					3	1930					2000		3	1904				3	1740		
	1500	P. sylvestris	2003			1717	1	P. sylvestris			1700	1	PINUS NIGRA ZONE	1500	2003	P. sylvestris				1	P. sylvestris				1
			2002	1	1803	1948	2		1	1790	1810	2			2002		1			2		1			2
			2001	2	2150	2258	3		2	1850	2030	3			2001		2			3		2			3
			2000	3	2380				3	2130					2000		3					3			
		P. nigra	2003				1	P. nigra			1080	1			2003	P. nigra			1573	1	P. nigra			1610	1
			2002	1			2		1	1390	1520	2			2002		1	1635	1710	2		1	1640	1690	2
			2001	2			3		2	1560	1650	3			2001		2	1775	1824	3		2	1890	1890	3
			2000	3					3	1760					2000		3	1971				3	1960		
	1400	Psylvestris	2003			1873	1	P. sylvestris			1310	1		1400	2003	P. sylvestris				1	P. sylvestris				1
			2002	1	1948	2123	2		1	1430	1560	2			2002		1			2		1			2
			2001	2	2157	2279	3		2	1560	1710	3			2001		2			3		2			3
			2000	3	2366				3	1830					2000		3					3			
		P. nigra	2003					P. nigra			1150	1			2003	P. nigra			1710	1	P. nigra			1230	1
			2002	1					1	1560	1610	2			2002		1	1775	1904	2		1	1230	1310	2
			2001	2					2	1740	1810	3			2001		2	1921	2056	3		2	1410	1540	3
			2000	3					3	2180					2000		3	2174				3	1570		
PINUS SYLVESTRIS-PINUS NIGRA ZONE	1300	P. sylvestris	2003			1356	1	P. sylvestris			1700	1		1300	2003	P. sylvestris				1	P. sylvestris				
			2002	1	1486	1536	2		1	1940	2090	2			2002		1			2					
			2001	2	1666	1717	3		2	2130	2230	3			2001		2			3					
			2000	3	1854				3	2310					2000		3								
		P. nigra	2003			1529	1	P. nigra			1470	1			2003	P. nigra			1623	1	P. nigra			1790	1
			2002	1	1623	1659	2		1	1650	1880	2			2002		1	1760	1854	2		1	1790	1840	2
			2001	2	1760	1854	3		2	2010	2150	3			2001		2	1904	2005	3		2	1890	1980	3
			2000	3	2056				3	2230					2000		3	2099				3	2130		
	1200	P. sylvestris	2003			1623	1	P. sylvestris				1		1200	2003	P. sylvestris				1	P. sylvestris				
			2002	1	1666	1717	2		1			2			2002		1			2					
			2001	2	1803	1904	3		2			3			2001		2			3					
			2000	3	2049				3						2000		3								
		P. nigra	2003			1270	1	P. nigra			1650	1			2003	P. nigra			1529	1	P. nigra			1300	1
			2002	1	1443	1573	2		1	1990	2110	2			2002		1	1565	1717	2		1	1330	1420	2
			2001	2	1623	1728	3		2	2130	2250	3			2001		2	1760	1804	3		2	1510	1520	3
			2000	3	1775				3	2290					2000		3	1854				3	1610		
PINUS NIGRA ZONE	1100	P. nigra	2003			1479	1	P. nigra			1510	1	OAK-JUNIPER-PINUS NIGRA ZONE	1100	2003	P. nigra			1277	1	P. nigra			1390	1
			2002	1	1580	1659	2		1	1570	1740	2			2002		1	1399	1435	2		1	1430	1490	2
			2001	2	1753	1854	3		2	1790	1940	3			2001		2	1486	1529	3		2	1510	1610	3
			2000	3	1955				3	2030					2000		3	1589				3	1620		
	1000	P. nigra	2003			1392	1	P. nigra			1880	1		1000	2003	P. nigra			1199	1	P. nigra			1270	1
			2002	1	1410	1486	2		1	2030	2120	2			2002		1	1325	1410	2		1	1350	1420	2
			2001	2	1498	1623	3		2	2170	2290	3			2001		2	1454	1540	3		2	1470	1530	3
			2000	3	1971				3	2380					2000		3	1573				3	1550		
	900	P. nigra	2003			1659	1	P. nigra			1740	1		900	2003	P. nigra			1119	1	P. nigra			1270	1
			2002	1	1803	1897	2		1	2080	2140	2			2002		1	1147	1241	2		1	1350	1460	2
			2001	2	2056	2150	3		2	2190	2290	3			2001		2	1270	1367	3		2	1490	1620	3
			2000	3	2207				3	2540					2000		3	1399				3	1650		
PINUS BRUTIA ZONE	800	P. brutia	2003			2157	1	P. brutia			2280	1													
			2002	1	2280	2365	2		1	2710	2820	2													
			2001	2	2496	2525	3		2	2980	3080	3													
			2000	3	2664				3	3100															
	700	P. brutia	2003			2387	1	P. brutia			2050	1													
			2002	1	2720	2756	2		1	2180	2330	2													
			2001	2	2929	2979	3		2	2430	2550	3													
			2000	3	3445				3	2600															
	600	P. brutia	2003			2174	1	P. brutia			2100	1													
			2002	1	2207	2366	2		1	2130	2330	2													
			2001	2	2441	2481	3		2	2440	2660	3													
			2000	3	2608				3	2710															
	500	P. brutia	2003			2474	1	P. brutia			2190	1													
			2002	1	2633	2698	2		1	2700	2870	2													
			2001	2	2864	2954	3		2	2910	3090	3													
			2000	3	2986				3	3120															
	400	P. brutia	2003			3044	1	P. brutia			2230	1													
			2002	1	3224	3382	2		1	2760	2970	2													
			2001	2	3445	3542	3		2	3050	3280	3													
			2000	3	3672				3	3390															

REFERENCE: Results in MS Thesisis of A.Çömez and E. Tuncer 2004 were collected and arrenged.

EXPLANATION:

1. The needles,1 year-old in autumn-2002, , are the 2 year-old needles ,passed the winter, on July-2003. The needles, 2 year-old in autumn-2002, are the 3 year-old needles, passed the winter, in July-2003. The needles, 3 year-old in autumn-2002, was shedded in winter of 2002-2003. The needles, 1 year-old on July-2003, are the needles which begin to grow in April, May or June as related to elevation. These needles have lower sulfur content.
2. A considerable amount of sulfur content has accumulated in the needles in summers too. It has pointed that sulfur deposition derives from air pollution throughout the year, not air pollution related to heating in winter.
3. With the condensed air mass (mist) settled in Sakarya Valley the air pollution (like SO_2) increases on the mist zones over high slopes.
4. Higher sulfur contents on the north slopes than south ones points that the polluting resource effecting the Sündiken mountain is Çayırhan thermal power plant.
5. Excess of yellow stains is in line with the sulfur contents of the needles.

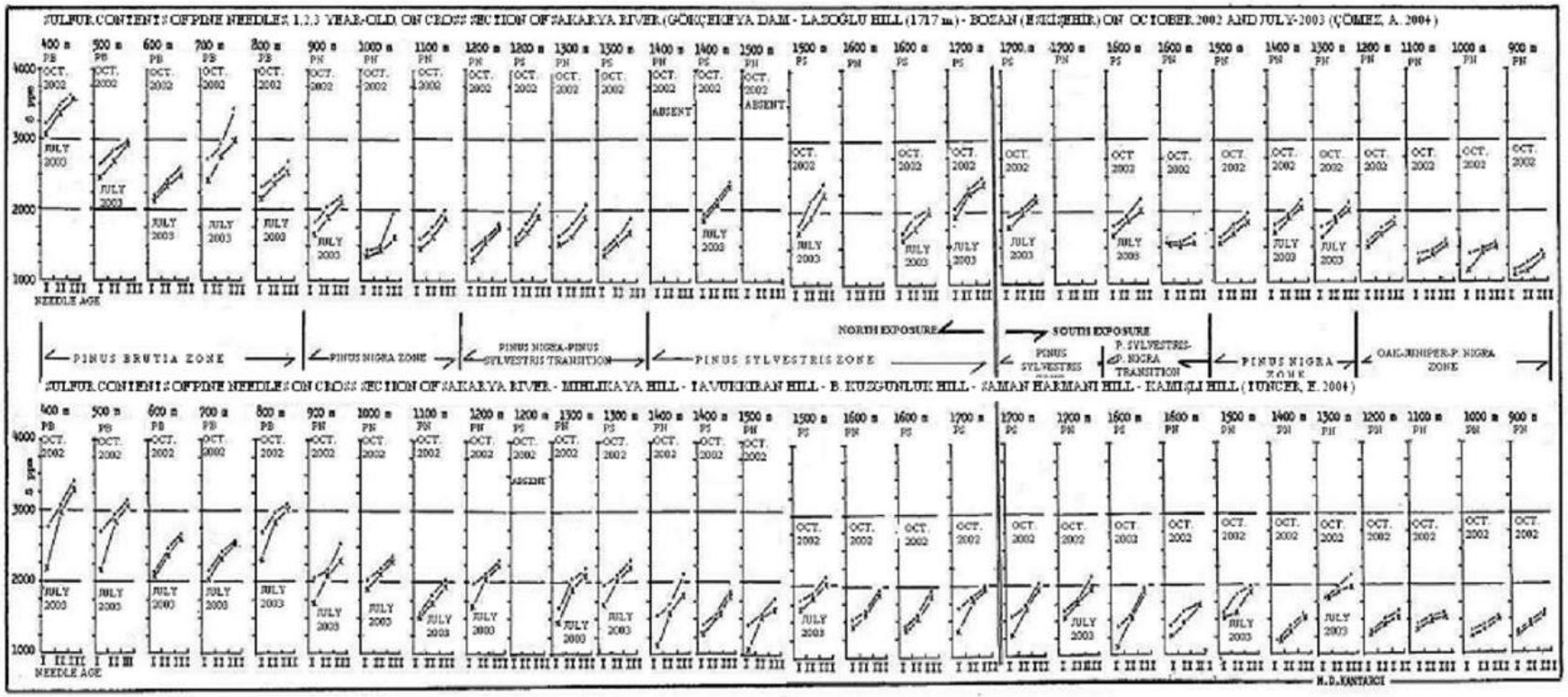
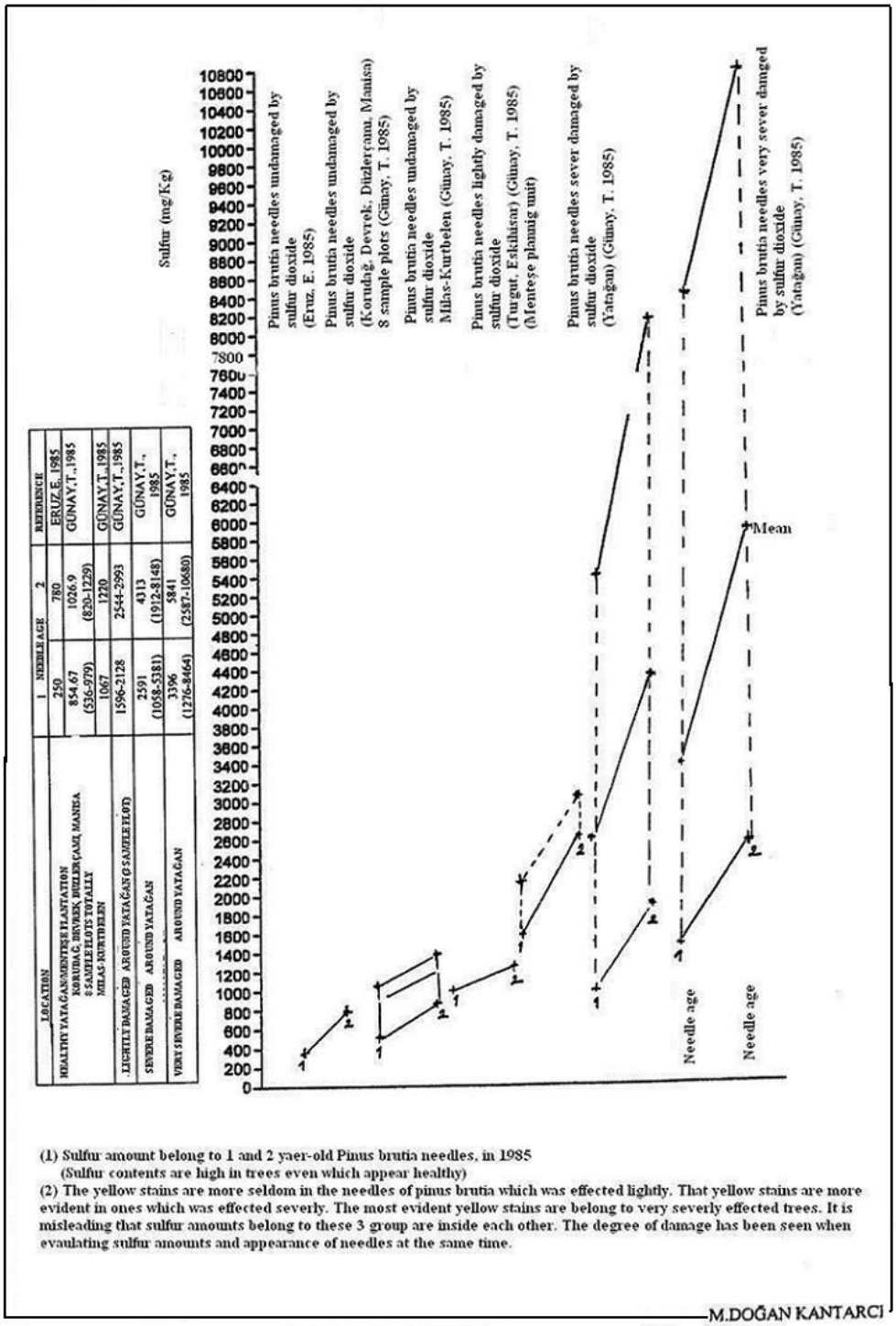


Figure 1. Changes in sulfur contents of Pinus brutia, Pinus nigra, Pinus sylvestris needles, 1, 2, 3 year-old, on north and south exposure of the Sündiken massif according to elevation and seasons (October-2002 and July-2003).

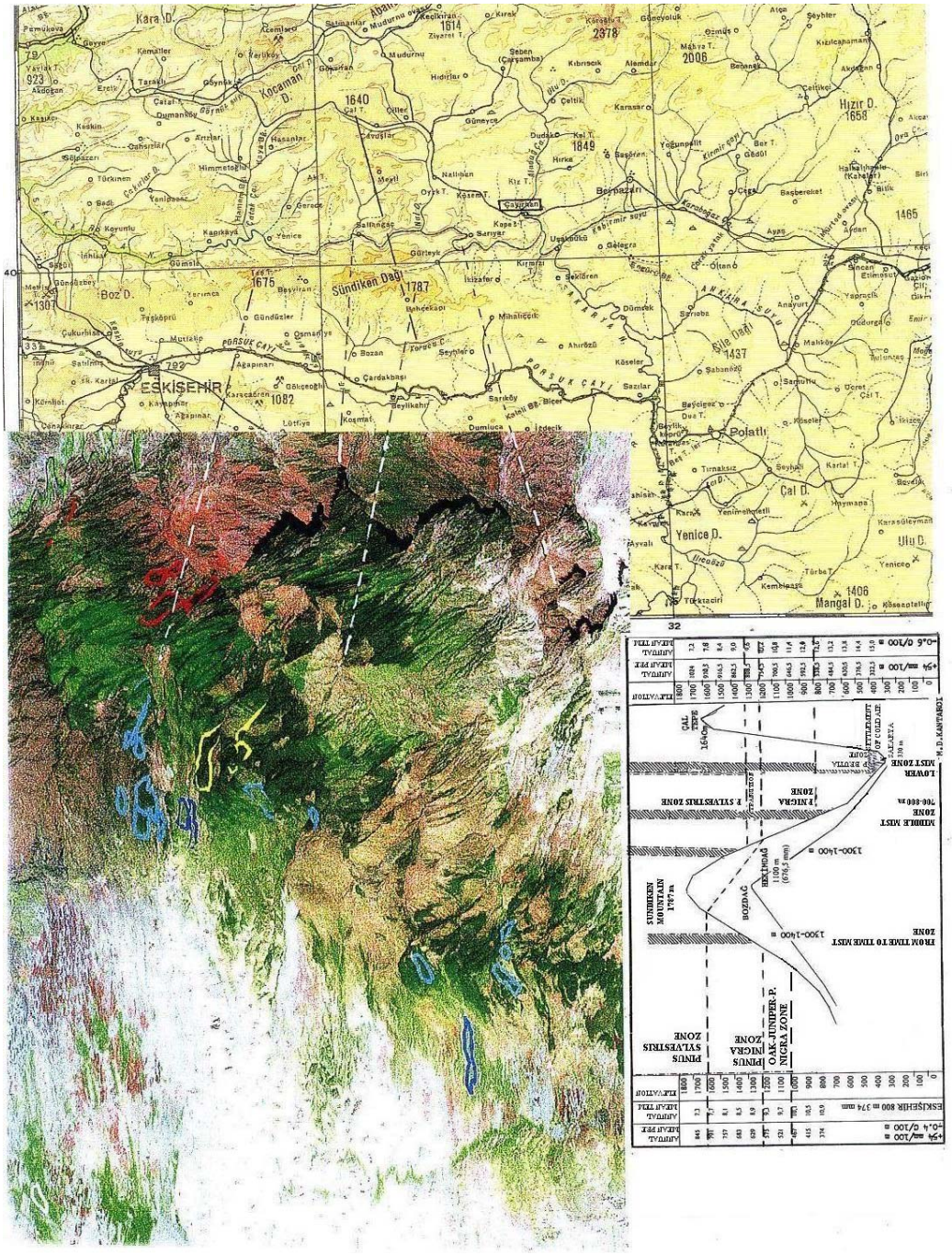
EXPLANATION: PB: Pinus brutia, PN: Pinus nigra, PS: Pinus sylvestris



LOCATION	1 NEEDLE AGE	2	REFERENCE
HEALTHY YATAĞAN/MENTEŞE PLANTATION KORUDAĞ, DEVREK, DÜZLERÇAMI, MANISA 8 SAMPLE PLOTS TOTALLY MILAS KURTBELEN	250	780	ERUZ,E. 1985
	854.67 (536-979)	1026.9 (820-1229)	GÜNAY,T.,1985
	1067	1220	GÜNAY,T.,1985
LIGHTLY DAMAGED AROUND YATAĞAN (8 SAMPLE PLOT)	1596-2128	2544-2993	GÜNAY,T.,1985
SEVERE DAMAGED AROUND YATAĞAN	2591 (1058-5381)	4313 (1912-8148)	GÜNAY,T., 1985
VERY SEVERE DAMAGED AROUND YATAĞAN	3396 (1276-8464)	5841 (2587-10680)	GÜNAY,T., 1985

(1) Sulfur amount belong to 1 and 2 yaer-old Pinus brutia needles, in 1985
(Sulfur contents are high in trees even which appear healthy)
(2) The yellow stains are more seldom in the needles of pinus brutia which was effected lightly. That yellow stains are more evident in ones which was effected severly. The most evident yellow stains are belong to very severly effected trees. It is misleading that sulfur amounts belong to these 3 group are inside each other. The degree of damage has been seen when evaulating sulfur amounts and appearance of needles at the same time.

Figure 2. Sulfur contents of Pinus brutia needles, undamaged, lightly damaged, severe damaged and very severe damaged by flue gases, around Yatağan thermal power plant in Turkey (re-evaluated by Kantarcı, M.D, 2004 after Eruz, 1985; Günay, 1985; Karaöz, 1994)



Map/ Cross 1. Location of Sündiken Massif, position of Çayırhan thermal power plant, a view from aerial photo, elevation-climatic zones, mist zones, annual mean temperature and precipitation values on Çaltepe- Sakarya River- Sündiken-Korucu stream cross section