# Monitoring the Effects of 18 Mart Çan Thermal Power Plant on Kazdağı Fir Ecosystems (an 8-Year Old Study)

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**Abstract**
Monitoring of forest ecosystems and their health conditions has gained more importance in the last decades. In 1970's, after occurrences of forest dieback due to air pollution and acid rains in Europe, monitoring activities have started for determining the effects of air pollution on forest ecosystems. Afterwards, the studies have been extended to complete monitoring of forest ecosystems.

The Kaz Mountains are one of the most important forest areas in Turkey and they are placed at the crossroad of Aegean and Marmara Regions, with different climate types. Before the establishment of the "18 Mart Çan Thermal Power Plant", the need for monitoring has been noticed because the air drift and wind direction might affect primarily the Kaz Mountains. Kazdağı Fir (*Abies nordmanniana* subsp. *equi-trojani*) is an endemic taxon in the Kaz Mountains and it might be affected, too. Therefore monitoring activities have started with the support of the Electricity Company (EÜAŞ). Through 2002–2008 years, soil and needle samples have been collected twice a year from three Kazdağı Fir populations and analyzed in laboratory for sulfur content by turbid metric method.

There are significant differences between localities and years for both soil and needle analyses.
**Key Words:** Pollution, Kazdağı Fir ecosystem, Thermal Power Plant

## Introduction

Although clean energy policies and public awareness have decreased its impact, air pollution is still a big problem for the world's ecosystems. In the 1970's, air pollution caused a significant tree dieback in Europe (Çakır, 1988). As a result, monitoring of forests began in the 1980's. In the last decade these studies were transformed into a complete monitoring of forests' condition and health (www.icpforests.org).

Thermal power plants are among the world's most important electrical energy suppliers and also a major pollution source due to their use of lignite coals (Avcı, 2005). But new technologies such as fluidized bed technology have helped to alleviate the effects of pollution caused by these power plants. The 18 Mart Çan Thermal Power Plant was built in 2004 using fluidized bed technology on the northeast slopes of the Kaz Mountains (TUBITAK, MAM 1999). During the planning stage of the power plant, it was also decided to monitor the Kaz Mountains for potential pollution effects in the future. It was determined that because of wind directions in the region the Kaz Mountains might be negatively affected by the plant's emissions.

The Kaz Mountains form the border between the Aegean and Marmara regions of Turkey. They have been identified as an important natural area due to the geographical location (Eken et al., 2006). Additionally, they have rich flora and fauna diversities and are the highest mountains of the northern Aegean Region. One of the studies performed in the Kaz Mountains is "In-Situ Conservation of Plant Genetic Diversity Project", and is supported by a World Bank Global Environmental Funds (GEF) grant. With this study, economically important target species were identified. At the end of the project, gene diversity of these species was determined, as well as locations of significant biodiversity. Subsequently, these locations were designated as "Gene Management Zones" (GMZ). Besides being the border between the Aegean and Marmara regions, the Kaz Mountains are very important because of the Kazdağı fir, an endemic and very important taxon in Turkey (Özel, 1999).

The establishment of a power plant was an obvious potential threat to the Kaz Mountains ecosystems and the Kazdağı Fir. To avoid potential damages, a monitoring program was also planned from the very beginning. The study was initiated by the Aegean Forestry Research Institute under orders issued by the Turkish Ministry of Environment and Forest, and supported by the Turkey Electricity Generation Co. Inc. Between 2002-2009 plant species on 3 selected monitoring plots were observed and recorded. At the end of the study similarities and differences of the plots were determined.


Figure 1. General View of Kaz Mountains and Monitoring Plots

**Materials and Methods**

**Materials**

The study subject is Kazdağı Fir populations in Kaz Mountains. For the monitoring of sulfur content we identified 3 plot locations in places which may be affected by the Çan Thermal Power Plant (Table 1).

Table 1. Properties of the Plots

| Plot No. | Plot Name | Coordinate | Altitude (m) | Aspect | Slope (%) | Dominant Species |
|---|---|---|---|---|---|---|
| 1 | Eybek dağı (GMZ) | 39° 42′ 34″ K 27° 07′ 21″ D | 1,000 | N | 100 | Fir-Black Pine |
| 2 | Gürgendağ (GMZ) | 39° 45′ 21″ K 26° 55′ 42″ D | 1,350 | N | 5 | Fir-Black Pine |
| 3 | Ağıdağı-Ciğer gölü | 39° 53′ 05″ K 26° 56′ 21″ D | 960 | NE | 50 | Fir-Black Pine |

**Properties of Study Area**

The Kaz Mountains are located between 39°30′-39°50′N and 26°15′-26°35′E and extend around the southwestern part of the Biga Peninsula, in an east to west direction. It is an isolated area with the highest point of surrounding area. The highest point is Babadağı Peak with an altitude of 1,796 m. Other important peaks are Kartalpınarı Peak (1,774 m), Sarıkız Peak (1,730 m), Kocatepe Peak (1,340 m), Eybek Dağı Peak (1,298 m), Karaçam Peak (1,210 m), İnkayası Peak (1,180 m), Hacıöldüren Peak (1,060 m), Kocakatrancı Peak (1,030 m) and Küçükkatrancı Peak (1,015 m) respectively.

The bedrock in the Kaz Mountains generally consists of granite, gneiss and tuff (Bürküt, 1996), with permeable soils of coarse and medium texture.

**Climate**

Data to determine climatic conditions of the Kaz Mountains was obtained from eight nearby stations including Ayvacık, Balya, Bayramiç, Çan, Edremit, Etili, Ezine, and Yenice. All stations in the study area are at lower altitudes than those of the Kazdağı Fir populations and therefore do not represent the study area's climate accurately, but at least they may provide a reasonable description of the area's data range.

According to Emberger (1952), the summer drought index (S), PE/M values (PE = total rainfall in summer months, M = mean temperature in the hottest month) were below 5 at all stations. The total rainfall in summer months was less than 200 mm. This confirms that all stations are under the Mediterranean climatic effect.

Annual temperature indices were identified according to the Thornwaite (Akman 1990) method. The Ayvacık, Balya, Çan, and Edremit stations are humid, while Bayramiç, Etili, Ezine, and Yenice stations are semi humid. All stations are meso-thermal, having a water deficit in the summer season.

**Methods**

**Selection of Plots**

Kazdağı Fir populations are located in Eybek Dağı, Ağı Dağı and Gürgen Dağı locations. Plots were selected within those three population areas. The plots were 100 $m^2$ and square in shape.

Needle samples were taken in two periods: one in the dormancy period (autumn) and the other during the vegetation period (summer). Three representative trees were selected and marked in each plot. Samples were collected from the same side of the trees each year. Collected needles were put in bags after classification by age, as being 1 or 2 years old. During transportation from field to laboratory the samples were refrigerated.

Soil samples were also collected from the same place each year. Samples were taken from the topsoil (0-10 cm) and subsoil below 10 cm. Collected samples were bagged, tagged and brought to the laboratory.

**Analysis Methods**

Soil samples were dried first for pretreatment. After drying, the samples were ground and sieved through a 2 mm sieve and prepared for analysis.

Needle samples brought to the laboratory were first dried at 65 ºC and then ground. Then the samples were prepared for analysis using a mixture of nitric and perchloric acid. Sulfur analysis of needle samples was made using the turbid metric method (Kacar 1972).

Sulfur analysis of soil samples was also made by turbid metric method (Combs et al., 1998). Total nitrogen content was determined using "Kjeldahl Method" (Bremner, 1965). Soil reaction of the samples was measured by pH meter as per (Jackson, 1958).

**Results**

**Sulfur Values in Needles**

Sulfur values in needles were examined and categorized by plots (Figure 2) and by years (Figure 3). According to the data, all three plots' sulfur values were similar to each other; however plot 2 recorded higher values than the others. Sulfur values were below the damage threshold (Sayman, 2012). Minimum, maximum and average sulfur values are shown in Table 2:

Table 2. Minimum, maximum and average sulfur values

| Age of needles | Minimum | Maximum | Average |
|---|---|---|---|
| 1 | 172.9 | 1764.6 | 781.7 |
| 2 | 323.2 | 1765.0 | 766.4 |

There are some differences in sulfur values by years as well as differences between samples collected in summer and autumn. In the summer period, the highest value was recorded in 2003 and in the autumn period in 2002. There was a significant decrease in values between 2005 and 2006, in both summer and autumn periods. After that a small increase was recorded in summer samples, however not as high as at the beginning of the study. The autumn samples remained unchanged through to the end of the study.

Average sulfur values of plots are given below:

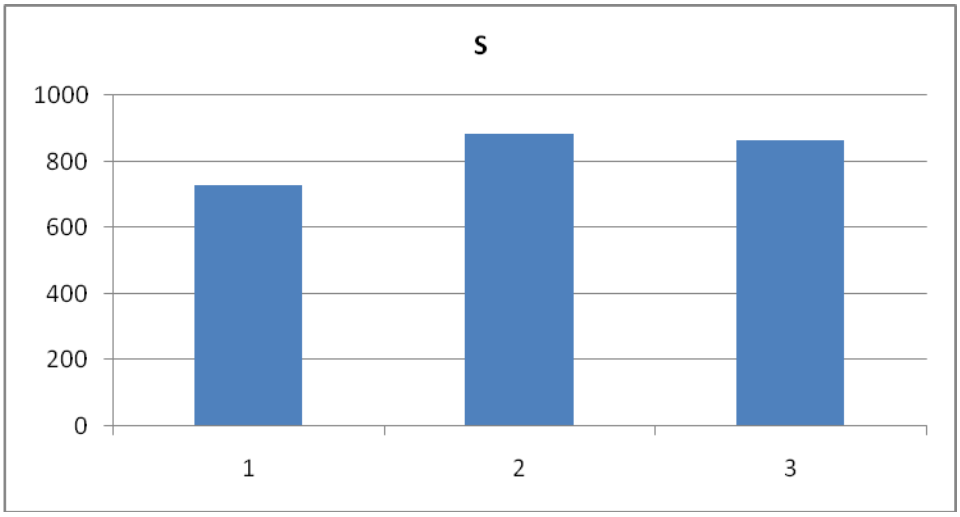

Figure 2. Average Sulfur Values in Needles by Plots

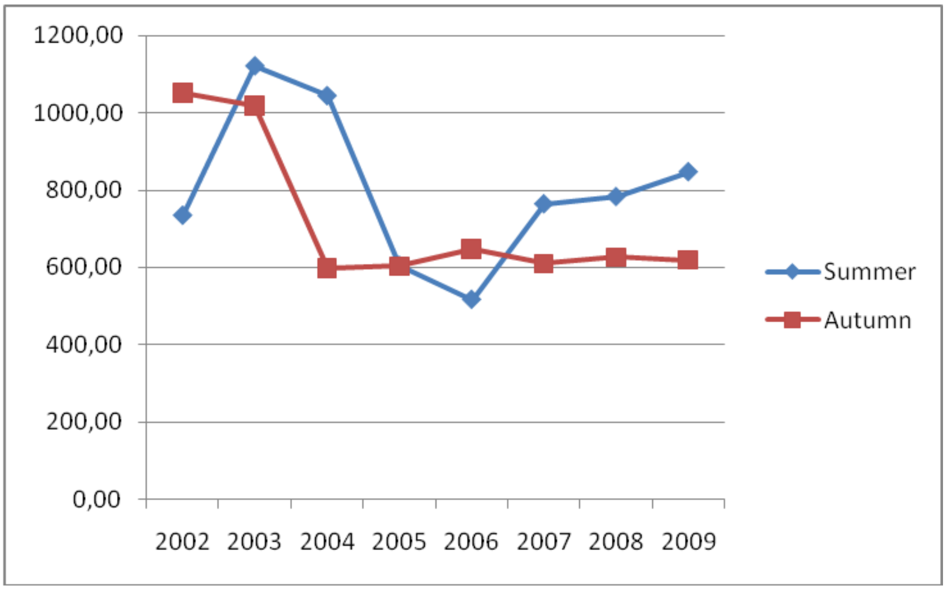

Figure 3. Average Sulfur Values of Needles by Years

**Sulfur Values in Soil**

Sulfur values in soil collected from topsoil (0-10 cm) and subsoil (> 10 cm) have been categorized by collection times and plots. Topsoil sulfur values varied between 5.71 and 88.24 ppm. The highest value was recorded in plot 3 in the 2008 summer period and the lowest value also in plot 3 in 2005 summer period.

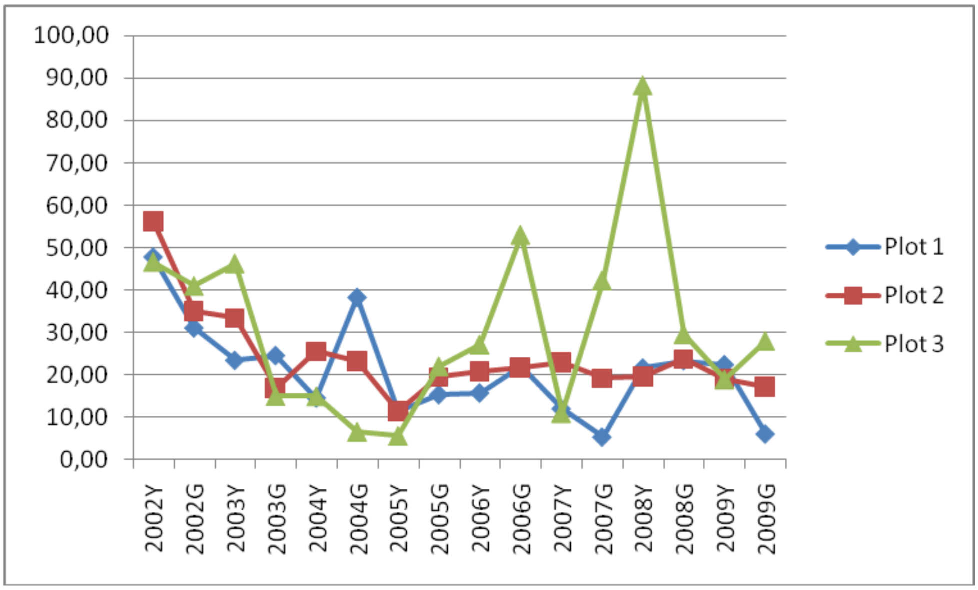


Figure 4. Top Soil Sulfur Values by Years (Y = summer, G = autumn)

Subsoil sulfur values varied between 4.76 and 69.50 ppm in all plots (Figure 5). The highest value was recorded in plot 3 in the 2002 autumn period and the lowest value in the same plot in the 2005 summer period.

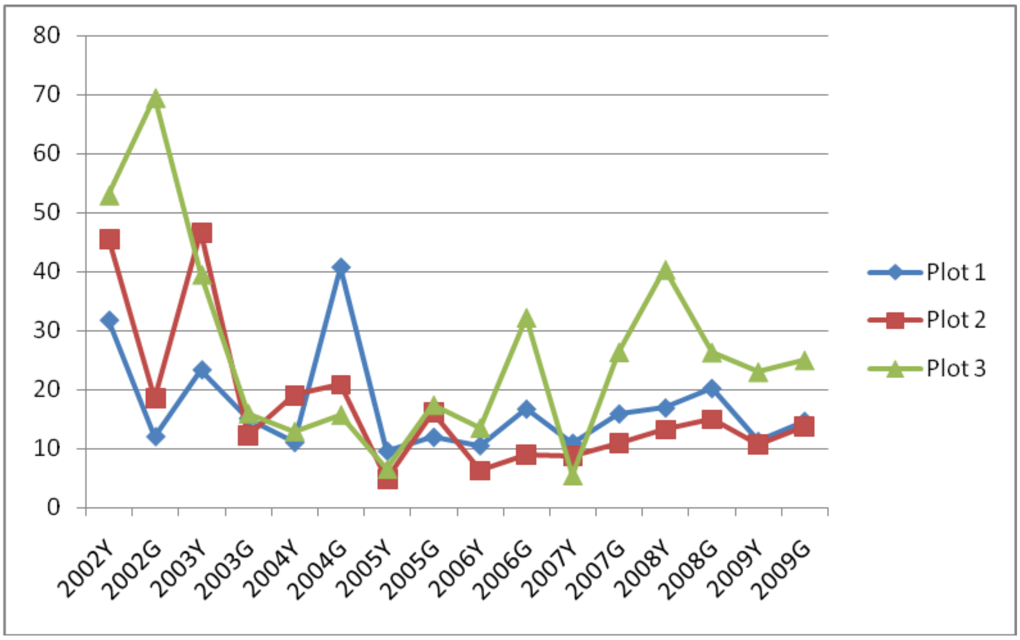


Figure 5 Deep Soil Sulfur Values by Years (Y= Summer, G= Autumn)

**Nitrogen Values**

Nitrogen values in soil were evaluated by plots, topsoil, subsoil and seasons. The highest nitrogen value was recorded in plot 2. The lowest nitrogen value was found in plot 3 (Figure 6).

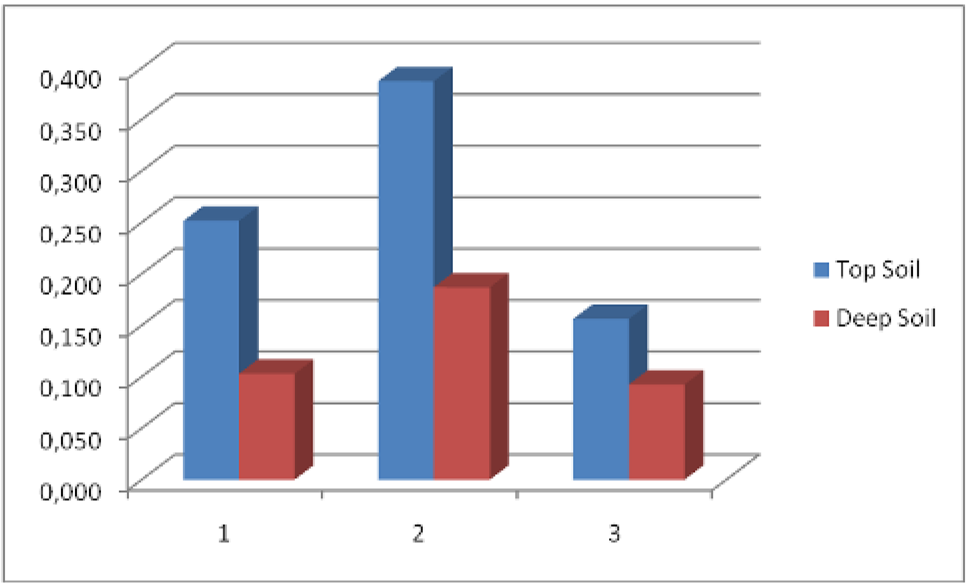


Figure 6. Average Nitrogen Values by Plots

Generally, topsoil nitrogen values are higher than those found in the subsoil. Topsoil nitrogen values fluctuated between 0.062 and 0.543 %. Subsoil nitrogen values were recorded between 0.062 and 0.255 % (Figure 7-8). The graph reflects a tendency toward the increase in nitrogen values in both topsoil and subsoil (more prominent in the subsoil samples).

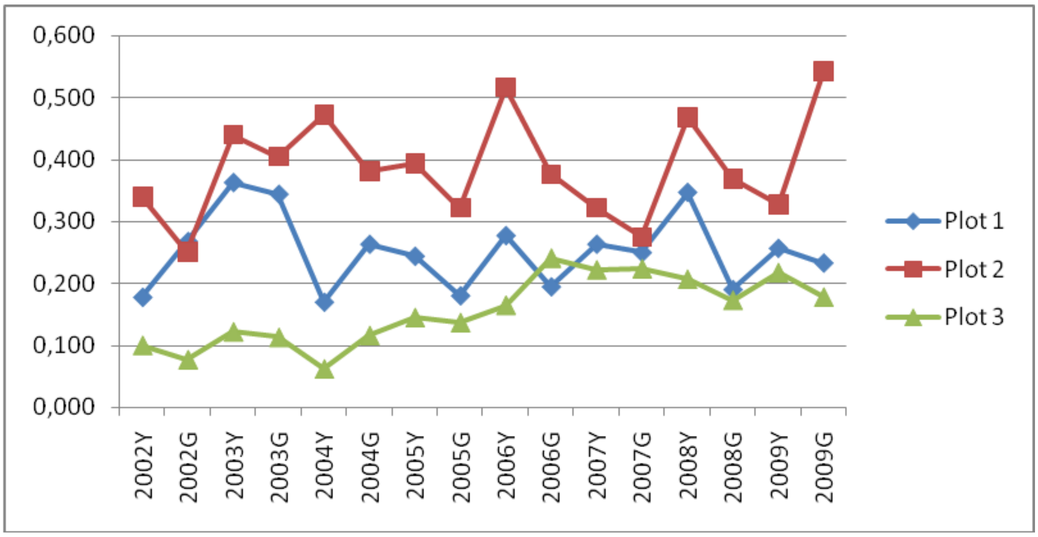


Figure 7. Top Soil Nitrogen Values by Years

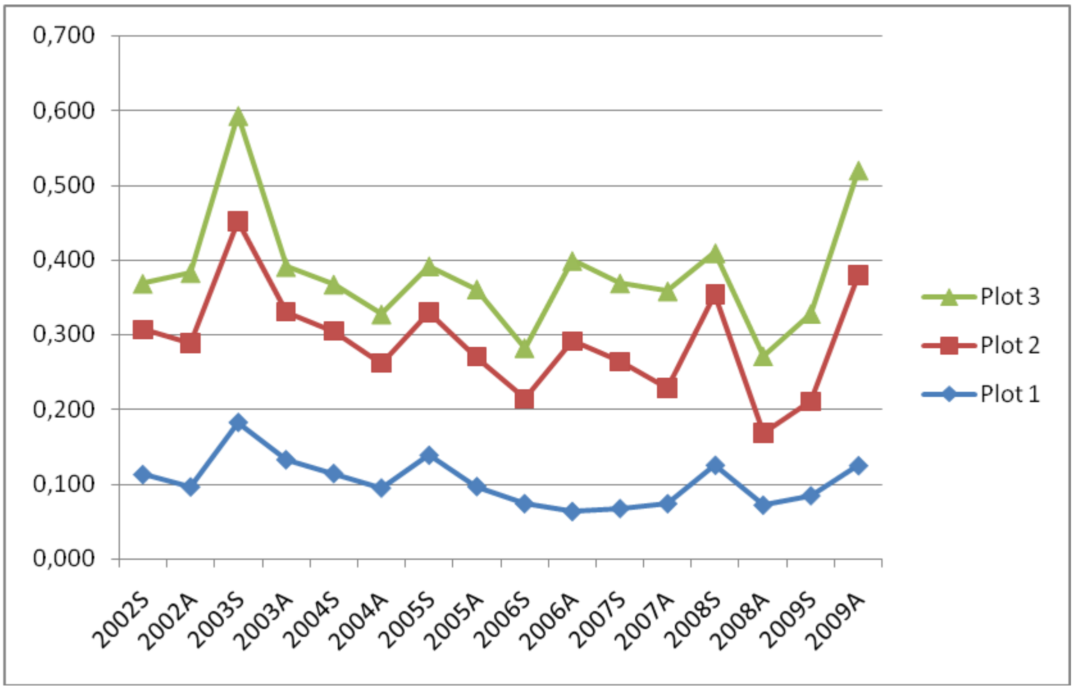

Figure 8 Deep Soil Nitrogen Values by Years

**Soil Reaction Values**

Soil reaction values were examined and categorized by plot, topsoil, subsoil and year. The study area soils are generally below a ph value of 6, or acidic (Figure 9). The lowest soil reaction value (4.56) was found in plot 1 in the summer period of 2005. The highest pH value (6.33) was recorded in plot 3 in the autumn of 2006.

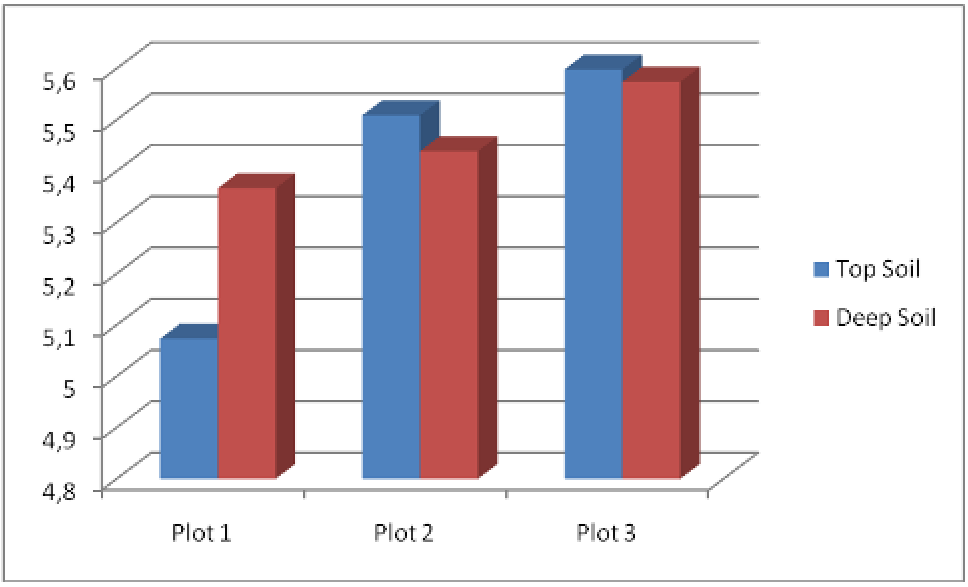

Figure 9 Average pH values by Plots

The graph shows no great difference between topsoil and subsoil pH values but some small fluctuations year by year (Figures 10 and 11).

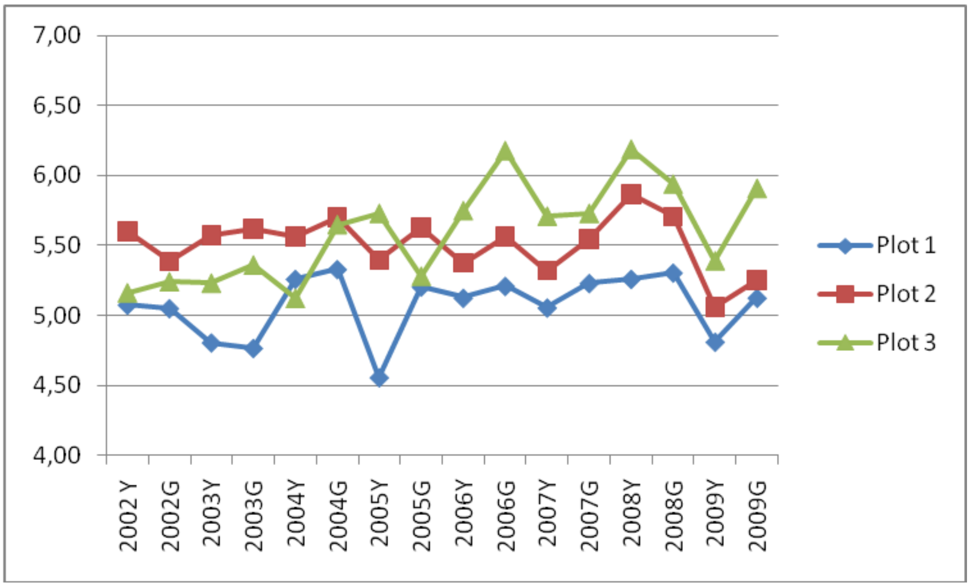


Figure 10 Top Soil pH Values by Years (Y = summer, G = autumn)

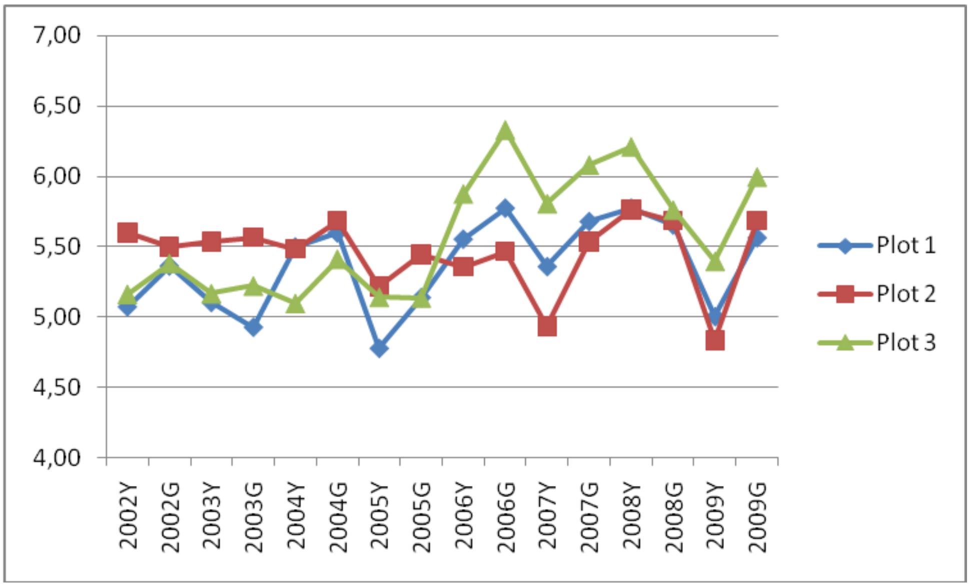


Figure 11 Deep Soil pH Values (Y = summer, G = autumn)

**Discussion**

Kazdağı Fir is an endemic taxon specific to the Kaz Mountain Region. There is no previous study in the existing literature on the effects of air pollution on Kazdağı Fir. However, there are some studies on other species of the Kaz Mountains and in surrounding areas.

Before the power plant was established, Karaöz (1996) examined in his study individual tree dieback in the Kaz Mountains and determined sulfur values up to 9,824 ppm in Turkish red pine needles and up to 10,277 ppm in black pine needles. He reasoned the dieback might be caused by polluted air and acid rain coming from Europe, the Black Sea and Marmara regions due to air currents and prevailing winds.

Sarıgül (1995), referring to Steiguer (1990), indicated that if the sulfur content of needles was higher than 2,000 ppm it might cause different types of damage. Tolunay (2001) also reported that in areas of Turkey where there are no air pollution symptoms, sulfur values are generally below 2,000 ppm. According to Günay (1986), in 1-year old needles of Turkish red pine individuals not showing signs of damage, sulfur values have been found as high as 1,100–2,100 ppm, whereas in needles of Turkish red pine individuals with damage, sulfur values reached 2,600-3,400 ppm. Sulfur values found in this study's area are lower than the above mentioned values (Tuna et al., 2005). Thus, plants in the area showed no sign of damage.

In this study, sulfur values in needles and soil are below the values mentioned above. Also, in the later years sulfur values are lower than the initial year's sulfur values. This downward trend may be due to the success of clean energy policies in Turkey and in Europe.

For nitrogen and pH values no study has been found. UN/ECE (2010) says that there is a trend in Europe for increased nitrogen deposits and this threatens vegetation and forest ecosystem stability. This is in harmony with our nitrogen values.

## Conclusion

Needle and soil samples were collected from three plots biannually from 2002 to 2009. Sulfur values in both needles and soil are below critical levels, and recent sulfur values are in fact lower than the sulfur values recorded in the study's first year.

Slight increases in nitrogen values and some variations in pH values were recorded. However all are below critical thresholds for vegetation as well as the initial year's values. Therefore it can be stated that the 18 Mart Çan Thermal Power Plant has not had a significant effect on Kazdağı Fir ecosystems to date; however monitoring studies should be carried on in the future.

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