FOR-IMPACTS ON FOREST AND VEGETATION

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IMPACT OF TEMPERATURE DISTRIBUTIONS ON FOREST AND VEGETATION IN JEJU ISLAND WITH REMOTE SENSING DATA

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ABSTRACT

In this study, the temperature distribution of Jeju Island with coastal ocean and its impact for forest and vegetation in Jeju Island, Korea were carried out based on the thermal band of Landsat 7/ETM+ remote sensing data. For the computation of the temperature of the island on the thermal band, we used NASA method which is the 8 bit Digital Number (DN) converted into spectral radiance. The computed results showed that the land temperature variations were from 0 to 12 Celsius degrees, and a good agreement with the observation ones based on the method. However, the ocean surface temperature was not much changed around 15 degree since the water was well mixed between the coastal and the offshore ocean. The interest results were that the temperature distributions of the southern part (Seogwipo City) of Jeju Island were higher than those of the north one (Jeju City) by more than 2 Celsius degree at the same height although the distance between the Jeju and the Seogwipo is only about 35 km in winter season.

Based on the different temperature of the island, we checked the tree and vegetation distributions in island. From the check, we found that at the same height, the coniferous forest are mostly distributed in north part although the deciduous are in south part. As the deciduous are relatively living in warm area comparing to the coniferous, the impact of temperature was important role of distributions of forest and vegetation in the island.

However, we cannot definitively explain to detect a temperature effect related to forest growth which is usually related with soil nutrition and precipitation.

Key Words: Landsat 7/ETM+, Digital Number, NASA Method, Jeju Island, Seogwipo

1. INTRODUCTION

Remote sensing refers to a technique of image collection system to collect environmental data about the earth's surface. Each image from remote sensing is comprised of a series of square pixels or building blocks arranged in a regular pattern of rows and columns (Lillesand and Kiefer, 2000). The intensity at which pixel is displayed is governed by the digital value. The intensity in turn is a representation of the reflected light from that portion of the target which the pixel represents. For example, in grey colour scale, the low digital number is low light intensity that is dark colour, the high number is high intensity that is related to bright one (Jensen, 1996). From the digital value, we can estimate image characteristics of land using image classification technique.

In the remote sensing data, the Landsat satellites have been widely used for the land classification and the image interpretation, respectively. The LANDSAT program was initiated by the U.S. Department of Interior and NASA under Earth Resources Technology Satellites (ERTS) that was changing the program designation to LANDSAT (USGS, 2000). LANDSAT ones have varied as technologies have been improved and certain types of data proved more useful than others. Particularly, Landsat TM (Thematic Mapper) images have been widely used for land classification with supervised and unsupervised techniques, respectively. The Landsat 7/ETM+ developed after the Landsat TM is a multispectral satellite measuring electromagnetic energy in eight spectral bands ranging from the visible to the Pan images. Landsat 7 are also useful for image interpretation for a wide range of applications like Landsat TM since the data provide 8 satellite images, blue band (band 1), green (band 2), red (band 3), near infrared band (bands 4, 5, 7), thermal band (band 6) and Pan image (band 8). Particularly, the thermal band is widely used in vegetation stress analysis, soil moisture discrimination and thermal mapping (Jo et al., 2001, 2002).

Sugal et al. (2000) provided a verification study on the surface temperature derived from the thermal infrared image data of Landsat 7 for the estimation of thermal condition around Hiroshima city and bay area based on NASA method. Barsi et al. (2003) estimated the on board thermal calibration of Landsat 7 through the ground measurements and showed validation of the temperature values of the Landsat 7. From these studies, we found that the thermal band proposed the reasonable temperature distribution of land and water.

Gillies and Carlson(1995) outlines a method for the estimation of regional patterns of surface moisture availability and fractional vegetation in the presence of spatially variable vegetation cover with NOAA (Advanced Very High Resolution Radiomete). In the study they pointed the surface radiant temperature to a vegetation index (computed from satellite visible and near-infrared data). However, NOAA data usually can not estimate the impact between temperature and vegetation distribution. Whitlock and Barthen(1997) studied the relationship between vegetation and climate change in north west America. In the stduy, they showed the climate can effect the vegetation distribution in the area.

In this paper, the thermal band of Landsat 7 was applied to Jeju Island to estimate the temperature distribution impact for the vegetation and forest types of the area. The calculated results of Landsat data will be also compared to the observation data supported by KMA (2003).

2. DATA AND RESEARCH SITE

In this study, Landsat 7/ETM+ data (2898 x 1897 Landsat pixels) from the cloud-free day of January 6, 2003 was selected. The study area, Jeju Island is a volcanic island located off the southern coast of Korea, the shape of the island is flat and oval-shaped (approximately 126 05′10″N to 126 58′37″N and 33 06′31″E to 33 35′55″E) with high mountain Halla (Figure 1). In the figure, the green lines represent contour line of elevation, the line interval is 100 m. Black lines are roads. Blue lines are county of Jeju Island. Hill side areas of 200-300m above the sea level are gently sloped but most of them are idle land or meadows. The coastal area (less than 200m above sea level) is 1,013.5 □. It occupies 54.9% of the whole area and is mainly used for farm land or residential areas. A high mountain, called Mt. Halla (height 1950 m) is located at the center of the island. Given this difference in elevation, the fluctuations of temperature and climate on the island are strong. Consequently, the environment of the island has a diversity of ecosystems.

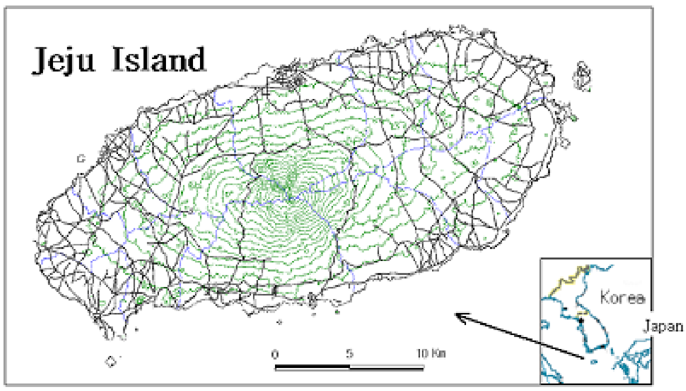

Figure 1. The study area of Jeju Island. Green line is contour line of the Jeju Island with Mountain Halla.

To analyze the ocean surface and the land temperature distributions in the study area based on Landsat 7 data, Image Analyst software was used, that was developed by Inergraph company. Using the software, we extracted the surface temperature from the value of the radiance of DN (Digital Number) in band 6 which is called thermal band. At the same time, we implemented image rectification using the 1:25,000 digital map.

3. METHODOLOGY

Usually, the satellite image needs to be the image rectification process since the orignal image was distorted by the satellite and its sense inclinations at the image capturing stage. To solve the distortion of the image, we used Affine transformation technique with 1/25,000 digital map, which is most widely used in satellite image rectification process. The calculated result shows that the error of the image rectification is less than 0.5 pixel size. Therefore, the results can be accepted to estimate the temperature distribution in Jeju Island.

For calculating the temperature distributions of Jeju Island using thermal band of

Landsat 7/ETM+ thermal band, the following equations were used (Jo et. al, 2002)

$$T = \frac{K2}{\ln\left(\frac{K1}{L_\lambda} + 1\right)} \quad \text{---------------------------(1)}$$

where

$$L_\lambda = gain * DN + offset, \quad gain = \frac{L_{max} - L_{min}}{Q_{max} - Q_{min}}, \quad offset = L_{min}$$

The equations are also known as NASA method. The gain and the offset values are provided by Barsi, et al. (2003), that were calculated by continually monitoring the ground surface temperature observation. The estimated parameters are shown in Table 1 which can be also derived from Landsat 7 project database system (USGS, 2000).

Table 1. ETM+ spectral radiance range and thermal constants

L_{max}	L_{min}	Q_{max}	Q_{min}	K1	K2
17.04	0.0	255	0.0	666.09	1282.71

4. THE TEMPERATURE DISTRIBUTIONS OF JEJU ISLAND

As the calculations of the temperature of Jeju Island using Eq. (1), we can estimate the generally temperature distributions of the island with the coastal ocean. Figs. 4.1 and 4.2 show the computational and the observational results of the temperature distributions of Jeju Island. The four observation areas were selected for temperature estimation in Jeju Island. The comparison between the observations and the computations was shown in Table 4.1 and Figure 4.1, respectively.

From the Figure 4.2, we know that the calculation results are a good agreement with the observation ones although the observation and the computations are a little bit difference in Sungsan area. The quantitatively estimated accuracies are shown in Table 4.1.

Figure 4.2 shows the results of spatial temperature patterns of the island based on Landsat 7/ETM+ in January 2003. In the figure, we know that the temperature variations are from 0 to 15 Celsius degree. Around top of the Halla mountain is less than 0 degree, and the coastal ocean is about 15 degrees that is almost the same temperature distribution in the ocean since the horizontal and the vertical mixing process in the coastal ocean.

Table 4.1. The temperature difference between the observations and the computations (Unit: □) in January 6, 2003

Obs. Period	Jeju	Sungsan	Gosan	Seogwi
Jan. 6, 2003	0.2	0.9	0.4	0.3

The ocean surface temperature is almost 3 degrees higher than the highest temperature in Jeju Island. Because of the high temperature effect of the ocean, we can expect that Jeju Island air temperature can be relatively warm in winter season. The interesting thing of the figure is that the temperature of the north part of the island is relatively lower than that of the south at the same height. Based on the height contour of the Figure 4.3, at the height of less than 400 m, the temperature difference between the north and the south is about 3 degrees. However, at the area of the higher than 800 m, the temperature is almost same between the north and the south as 5 degrees.

Figure 4.4 shows the viewshade of sunshine and shade areas in the island. In the figure, we can easily find out that the area of south viewshade(sunshine) is larger than the north (shade). Comparing temperature distributions of Figure 4.2 to the sunshine of Figure 4.4, we can easily find out that the temperature distribution is strongly related with viewshade area.

From the results, we can assume that the non-symmetric temperature distribution is related with the geographic characteristics and viewshade during winter seasons.

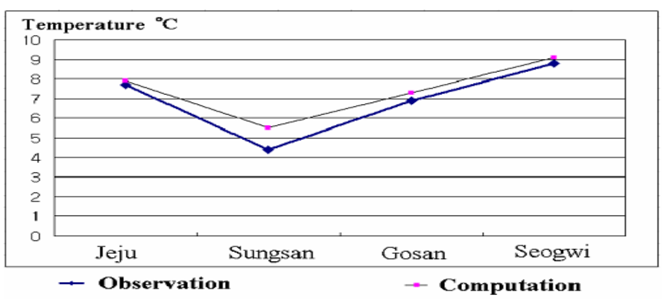

Figure 4.1. The comparison of the calculation and the observation data at four areas such as Jeju city, Sungsan, Gosan and Seogwipo city.

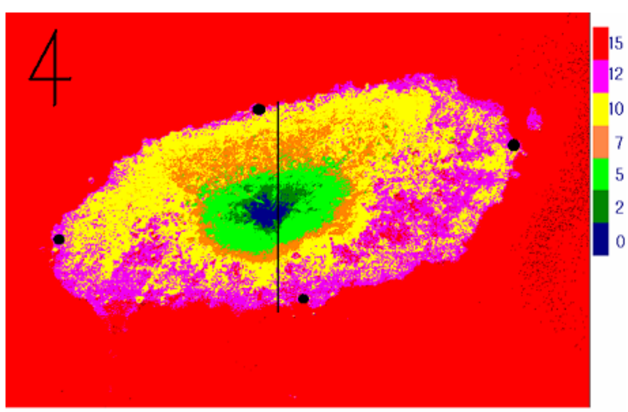

Figure 4.2 The temperature distributions of Jeju Island and around ocean using Landsat 7 image. The black spots showed the observation ones.

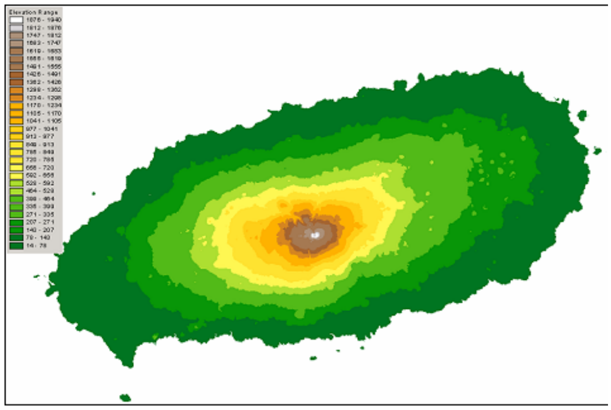

Figure 4.3 The elevation contour of the Jeju Island using 1/25,000 digital map.

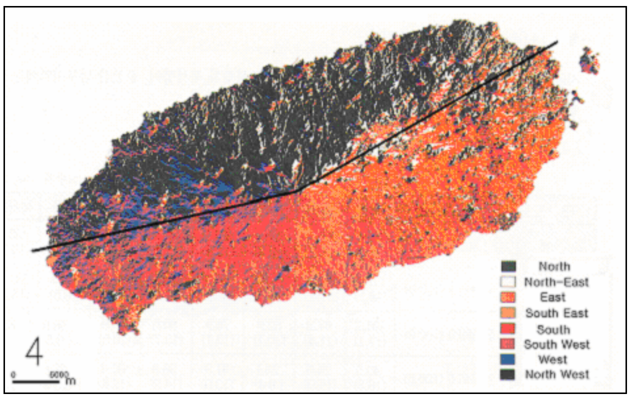

Figure 4.4. The estimated areas of the sunshine and the shade of Jeju Island. The straight black line pointed the boundary between North and South viewshade.

To check the detail temperature difference between the north and the south, we estimated the temperature changes not only from south coast to the top of the mountain but from north to the mountain according to black center line based on Figure 4.2, respectively. The results were shown in Figure 4.5. In the figure, the horizontal line is the temperature and the vertical one the height of Jeju Island, respectively. In the figure, the temperature difference between the north and the south from the bottom to the top of the mountain is about 2□3 degrees.

This results can be explained that the temperature of south part of Jeju Island during winter season is higher than those of the north part by the geographic effect. To find out the reason of the difference, we check solar radiation energy between the north and the south. Figure 4.6 shows the monthly solar irradiation variation between the north part (Jeju city) and the south (Seogwipo city) supported by KMA during 2003. Horizontal line is time variation (months) and the vertical line is solar irradiation values. The figure identified the solar energy variation pattern at the north and the south parts, respectively.

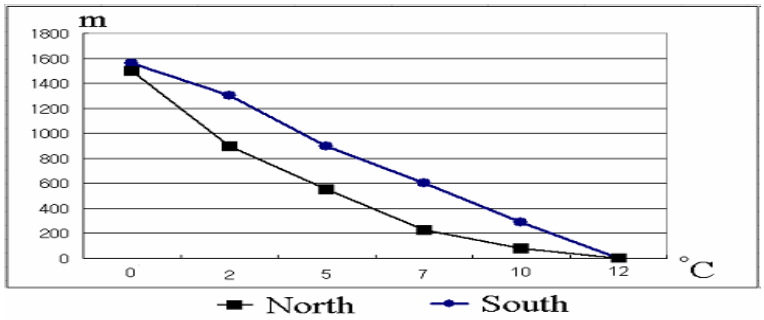

Figure 4.5 The temperature variation between the north and the south along the black straight line of the Jeju Island in Figure 4.2.

In the figure, from January to March and September to December, solar irradiation of the south area is higher than that of the north.

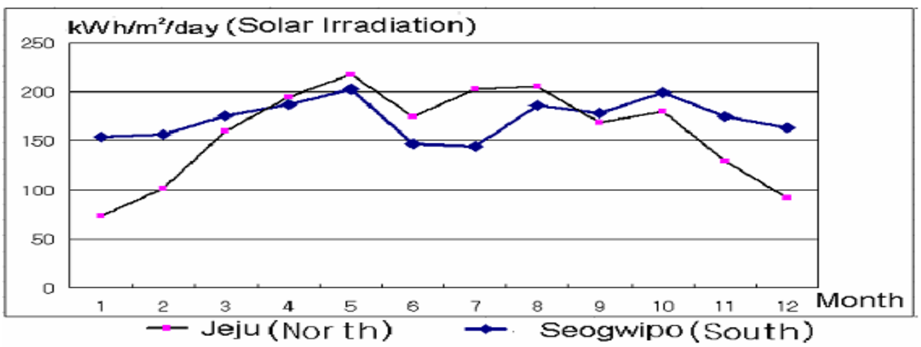

Figure 4.6 Solar irradiation between Jeju city (North) and Seogwipo (South) city.

However, from April to August, the north is higher than the south. Since the effect of solar irradiation, the temperature distribution of south area of the Halla mountain is higher than that of the north one at the same height of the mountain. This result can be explained that the solar irradiation was an important role of the temperature distributions in Jeju Island between the north and the south areas.

5. VEGETATION AND FOREST DISTRIBUTION

In previous section, our analysis showed the strong correlation between solar irradiation and surface temperature and viewshade with the height of the island. From the results, we check the relationship between the temperature and the vegetation and trees types. To do this, we propose a hypothesis that is, the different temperature distributions of the island will affect the vegetation intensity and diversity. Based on the hypothesis, we check the distribution and species of the forest based on the temperature distribution in the island.

Figure 5.1 shows vegetation distribution of Jeju Island. Along boundary line of sunshine direction in the figure, the south forest area is larger than the south in the island. Figure 5.2 shows the three forest types as the coniferous, the deciduous and the mixed types. In the figure, we can easily find out that the most part of forest are charged by the deciduous not coniferous. However, the top of the island is mostly covered by coniferous as low temperature. The other part is most affected by deciduous forest. From the results, remote sensing data showed a strong correlation with solar radiation and forest characteristics. Given the vegetation distribution between the coniferous and the deciduous it is not surprising the effect of solar radiation to vegetation will strongly related with vegetation diversity and distribution in the Jeju Island. Finally, we can conclude that the different distribution between the coniferous and deciduous forest is that the coniferous of the north part is relatively abundant than that of the south.

To check also the growth of the trees related with temperature distributions, we used the tree diameter data supported by KRISH(1997). Figure 5.3 shows the tree diameter characteristics of the island. In the figure, 30 cm larger sizes of the trees are mostly grown in the south part of the mountain. However, the small size of the tree also grows in south part. The reason is not found. We just expected that since the area is mostly composed of rocks and stones, the growth of the plant was restricted by nutrition and precipitation.

Up to now, we tried to set up our hypothesis of the effect of temperature to the forest distribution based on solar radiation, the tree species and the tree size. From the data, we detected that the temperature distribution is related with the Jeju Island forest types such as coniferous and deciduous. However, we can not definitively explain to detect a temperature effect related to forest growth which is related with soil nutrition and precipitation.

In the past, most researcher argued that the vegetation distribution in Jeju Island is only affected by the height of the mountain since they assumed the temperature only changed by the height of the island. However, from this study, we can propose the new idea for the vegetation distribution that can be affected by viewshade and solar radiation of the island.

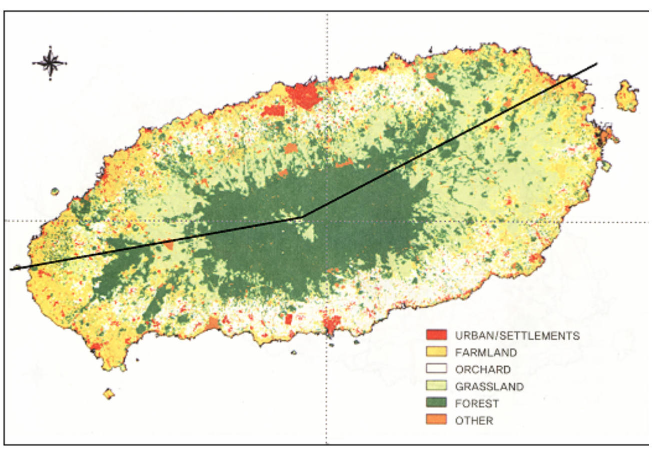

Figure 5.1 Vegetation distribution of Jeju Island.

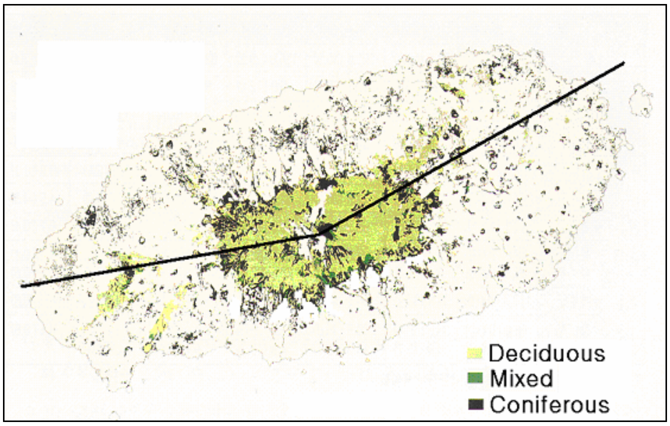

Figure 5.2 Forest distribution of Jeju Island.

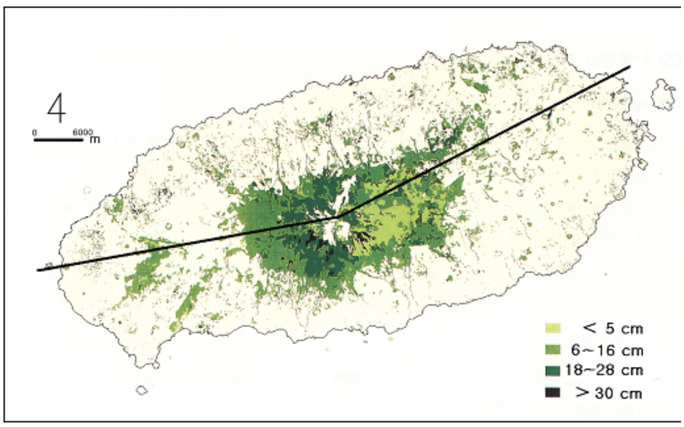

Figure 5.3 The tree diameter characteristics of Halla mountain in Jeju Island.

6. SUMMARY AND CONCLUSIONS

In this study, the estimation of the relationship between the surface temperature and the vegetation distribution of Jeju Island with coastal ocean was studied. Tod do this, we used the thermal band of Landsat 7/ETM+ and the vegetation field observation data supported by KRIHS(Koreas Research Institute for Human Settlements). For the computation of the temperature of the island and the coastal ocean based on the thermal band, we used NASA method which is the 8 bit DN converted into spectral radiance. The computed results showed that the land temperature variations are from 0 to 12 Celsius degree and were a good agreement with the observation ones based on the method. The ocean temperature is almost 3 degrees higher than the highest temperature in Jeju Island. Because the high l effect of the ocean, we can expect that Jeju Island air temperature can be relatively warm in winter season.

The interesting thing of the temperature distribution is that the temperature of the north part of the island is relatively lower than that of the south at the same height. The temperature difference between the north and the south from the bottom to the top of the mountain, respectively is about 2□3 degrees. It means that the temperature of south part of Jeju Island during winter season is about 2□3 degrees higher than those of the north part at lower area although the distance between two cities is only about 35 km. However, at the area of the higher than 800 m, the temperature is almost same between the north and the south as 5 degrees. To find out the reason of the difference. we checked solar radiation energy between the north and the south during 2003 between the northern part (the Jeju City) and the southern (the Seogwipo City). The result shows that the north solar irradiation is higher than the south one during the winter season only.

We also found that since the different effect of seasonal variations of the solar irradiation between the north and the south parts, the temperature distribution of south area of the Jeju Island at lower area (less than 800 m) is higher than that of the north one at the same height. It means that the solar irradiation and the island geographic characteristics were an important role of the temperature distributions between the north and the south areas.

Based on the temperature data, we tried to set up our hypothesis that is the temperature will influence the forest distribution, forest types and the tree size. To do this, we compared the temperature and viewshade to forest types(deciduous and coniferous) and its diameter.

From the comparison, we can propose the new idea for the vegetation distribution in Jeju Island. The vegetation and forest types can be affected by not only the height of the island but the viewshade and solar radiation. Up to now, most researchers argued that the vegetation distribution in the island is only affected by the height of the mountain since they assumed temperature only changed by the height of the island. Finally, we can draw a conclusion that the temperature distribution is related with the tree species such as the coniferous and the deciduous forests in the Jeju Island.

However, we can not definitively explain that the temperature distribution is related to the forest growth which is strongly affected by soil nutrition and precipitation.

7. ACKNOWLEDGEMENTS

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EVALUATION OF THE MITIGATION EFFECTS OF VEGETATION ON AIR QUALITY IN THE FLORENCE METROPOLITAN AREA

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ABSTRACT

The work presented at this conference is aimed to evaluate the mitigation effects of a green area on the air quality in the Florence (Italy) metropolitan area. For the calculation of the dry deposition velocity for each involved specie a model based on the plant cover and on the vegetation structure (the so-called canopy) has been created. The dispersion process has been simulated using SAFE AIR. Simulations have been carried out for three scenarios. This work showed that an adequate localisation of a green area, with plant species effective in removing atmospheric pollutants, can play a determinant role for the improvement of the air quality in the considered area.

Key Words: Dispersion modelling, dry deposition, vegetation, mitigation, pollutant removal

1. INTRODUCTION

Vegetation in urban areas can affect air quality both locally and at regional level. Green areas can affect air quality in four main ways:

- temperature reduction and other microclimatic effects;
- direct atmospheric pollutants removal;
- volatile organic compounds (VOC) emission;
- and, energy consumption reduction.

Trees and their transpiration influence air temperature, radiation absorption, heat storage, wind velocity, relative humidity, atmospheric turbulence, surface albedo and mixing height. These micrometeorological modifications can sensibly affect pollutant concentration in urban areas. The main effect on the temperature is a reduction due the increased shadow and the transpiration. This enhances air quality because the emission of many pollutants, as well as ozone formation, is temperature-dependent. VOCs emission by vegetation can contribute to ozone and carbon monoxide formations. However, since VOCs production is temperature-dependent and temperature is decreased by the presence of the trees, also the VOC emission as well as ozone production are lower (Cardelino and Chameides, 1990). Trees also contribute to the buildings energy consumption reduction. This is due to the summer temperature reduction as well as to protecting buildings from the winds in winter (Heisler, 1986).

Vegetation contribute also directly to atmospheric pollutants removal by means of the leaves (see, e.g., Smith, 1990). Trees have direct effects also on the atmospheric particulate: a part of this is absorbed by the plant, but most of it is stored only temporary on the plant surface. The larger the canopy surface, the larger the increase of air quality.

In this paper only the latter effect has been taken into account. The work presented at this conference is aimed to evaluate the mitigation effects of a green area on the air quality in the Florence metropolitan area (Italy). The research has been performed in the framework of the VIS project (Health Impact Assessment applied to the Waste Management Plan of the Province of Florence), funded by the Province of Florence and the EU (LIFE 02 ENV/IT000018 “VISP project”).

Pollutant removal models and dispersion models have been jointly applied to investigate on the effects of some mitigation scenarios.

2. POLLUTANT REMOVAL SIMULATION MODEL

For the calculation of the dry deposition velocity for each involved specie a model based on the plant cover and on the vegetation structure (the so-called canopy) has been created. In each model the canopy has been treated as single or multiple layer based on the complexity of the model.

The model has been implemented in visual basic. It starts from the definition of the deposition velocity V_d (Baldocchi et al.,1987, Nowak, 1994, Scott et al., 1998) as:

$$V_d^i = (R_a + R_b^i + R_c^i)^{-1} \tag{1}$$

where $R_a = u(z)/u_*^2$, u(z) is the wind speed at height z, and u_* is the friction velocity; the resistance of the boundary layer is described by the following function (Pederson et a.l, 1995):

$$R_b = 2(Sc)^{\frac{2}{3}}(\mathrm{Pr})^{-\frac{2}{3}}(ku_*)^{-1} \tag{2}$$

where *Sc* is the Schmidt number and *Pr* is the Prandtl number. $R_{c,}$ is the canopy resistance and it is the main descriptor of the deposition model based on vegetation. R_c is calculated as (Baldocchi 1988; Nowak, 1994):

$$1/R_c = 1/(r_s + r_m) + 1/r_t \tag{3}$$

r_m is the component of the resistance depending from the mesophyill, r_t is the value of the cuticular resistance. Both parameters depends from the pollutant studied. $1/r_s$

is the stomatal conductance and can be calculated following the so-called big-leaf models, starting from:

$$g_s = g(PAR)g(T)g(T)g(\psi)D_v / D_i \tag{4}$$

D_v e D_i are the molecular diffusivity of the water vapour and of the pollutant, respectively. The response of the stomatal conductance to the *PAR* (Photosynthetic Active Radiation) is assessed as:

$$g_s(PAR) = 1 / r_s(PAR) \tag{5}$$

where $r_s\ (PAR) = r_5$ (min) + $b_{r5}r_5$ (min) / *PAR*; r_s(min) is the minimum value of conductance in optimal conditions and b_{rs} is a constant. There are a number of published papers reporting the value of r_s(min) for many vegetal species (eg. Korner et al., 1979). The stomatal conductance of the canopy G_s is calculated as a PAR function:

$$G_s = (PAR) = \int_0^f df_{sun}(f)g[PAR_{sun}(f)] + df_{shade}(f)g[PAR_{shade}(f)]df \tag{6}$$

where f is the leaf area, df_{sun} e df_{shade} are the differences in leaf area in light (f_{sun}) and in shade (f_{shade}) between f and $f+df$. The PAR_{sun} and the PAR_{shade} are the densities of the fluxes for the lighted and shaded leaves, respectively. To calculate f_{sun}, df_{shade}, PAR_{sun} e PAR_{shade} a radiaction transfer model can be used:

$$f_{sun}(f) = [1 - \exp(-0.5f / \sin(\beta))]2\sin(\beta) \tag{7}$$

where β is the sun elevation angle. The shaded leaf area is $f_{shade}(f)= f\text{-}f_{sun}$. The PAR_{sun} depends from the average angle between the leaf and the sun. The PAR flux inside the canopy is calculated from the radiation transfer model of Norman (1982):

$$PAR_{sun}(f) = PAR_{dir}\cos(\alpha) / sen(\beta) + PAR_{shade}(f) \tag{8}$$

where PAR_{dir} is the density of the flux of *PAR* over the canopy and α is the angle between the leaf and the sun. PAR_{shade} is calculate empirically from the following equation (Norman, 1982):

$$PAR_{shade}(f) = PAR_{dir}\exp(-0.5f^{0.7}) + 0.07PAR_{dir}(1.1 - 0.1f)\exp(-\sin(\beta)) \tag{9}$$

The temperature dependence of the stomatal conductance (g) is calculated as $g(T) = [(T-T_{min})/(T_0-T_{min})][(T_{max}-T)/(T_{max}-T_0)]^{bt}$, where T_{min} e T_{max} are the maximum and minimum temperatures which are able to close the stomata. T_o is the best temperature for the stomatal functioning and b_t is defined as $b_t=(T_{max}-T_0)/(T_{max}-T_{min})$. The dependence of the stomatal conductance from the vapour pressure deficit (D) is linear: $g(D)=1-b_vD$, where b_v is a constant.

The water deficit can be quantified as leaf water potential (ψ). The stomatal conductance is relatively independent from (ψ) until a threshold value (ψ_0) after which g_s decrease rapidly. The function $g(\psi)$ is calculate following a linear model (Fischer et al., 1981): $g(\psi)=1$, if $\psi > \psi_0$, and $g(\psi)=a\psi+b_w$ if $\psi < \psi_0$, where a and b are constants. Thus, the stomatal resistance can be calculated be combining the previous equations: $R_5=1/[G_5(PAR)g(T)g(D)g(\psi)D_i/D_v]$.

3. DISPERSION MODEL

The dispersion process has been simulated using a three-dimensional new generation atmospheric dispersion model. The SAFE_AIR model (Simulation of Air pollution From Emissions _ Above Inhomogeneous Regions) has been implemented at the Department of Physics of the University of Genova (Italy), it simulates the transport and diffusion of airborne pollutants above complex terrain at local and regional scale (Canepa et al. 2003). SAFE_AIR II (the newest version of the model) is included in the Model Database of the European Topic Centre on Air Quality of the European Environment Agency (URL1 2005), while a previous version of the model has been selected by the Italian Agency for Environmental Protection and for Technical Support (APAT; URL2 2005) to be inserted in their list of air pollution models to be used in air quality evaluation. The main improvements of SAFE_AIR II concern its meteorological part and the algorithms to simulate diffusion of pollutants. However, during this world the old version has been applied.

SAFE_AIR consists mainly of two parts: a meteorological pre-processor (WINDS, Wind-field Interpolation by Non Divergent Schemes, Release 4.2) and a model which simulates the airborne pollutant transport and diffusion (P6, Program Plotting Paths of Pollutant Puffs and Plumes, Release 2.1). In the newest version II there is also another meteorological pre-processor (ABLE, Acquisition of Boundary Layer parameters, Release 1.2) capable of calculating the horizontal distribution of relevant boundary layer parameters like mixing height h , Monin -Obukhov length L , friction velocity $u*$, convective velocity scale $w*$ starting from routinely measured meteorological variables.

WINDS (Georgieva et al. 2003) is a diagnostic mass-consistent model which reconstructs the 3D wind field in complex terrain at mesoscale using available wind data. Release 4.2 of the model incorporates advances in numerical formulation. In fact, besides the SOR (Successive Over-Relaxation) iterative method, the ADI (Alternating Direction Implicit) iterative method has been implemented in order to achieve a non-divergent flow field. The ADI method is much more effective than the SOR method as far as converge of the code is concerned. It reduces up to 30 times computational time, especially for stable cases.

P6 (Canepa and Ratto 2003) is a Lagrangian multi-source model that make use of both Gaussian plume segments and puffs to simulate airborne pollutant dispersion, in such a way it allows to deal with numerical simulation of both non-stationary and inhomogeneous conditions. The dispersion parameterisation in P6 has been recently improved with the implementation of new advanced sets of dispersion σ-functions.

4. CASE STUDY

The studied area is 8 km x 8 km and is located in the Florence metropolitan area, approximately 8.5 km north-west from the city centre. The dispersion model has been applied using the climatologic method, that is applying a simplified average meteorology by means of the Joint Frequency Functions (JFF) calculated using a large amount of meteorological data (measures from a meteorological station for a period of 4 years). Simulations have been carried out for an hypothetical waste-to-energy plant to be constructed in the area, as well as for other pollution sources (line sources, the two highways in the area, A1 and A11; and point sources, the main industrial stacks in the area). For the green area, two different scenarios have been studied. The first one is referred to as “mitigation”, while the second one involves a larger area and has been called “improvement” (see map in figure 1). Two different location for the waste-to-energy plant have been studied (referred to in the map as CP and OSM).

Tree and shrubs species used for the study, both evergreen and deciduous, were selected among the most popular species growing in the study area provided they were well-adapted to the environment, fast growing, if possible, and with a big LAI (Leaf Area Index). Following these criteria species such as *Quercus robur*, *Populus alba*, *Populus nigra*, *Fraxinus ornus*, *Fraxinus oxycarpa*, *Ulmus minor*, *Carpinus betulus Salix alba Euonymus europaeus*, *Ligustrum vulgare*, *Viburnum opulus* , etc., were selected.

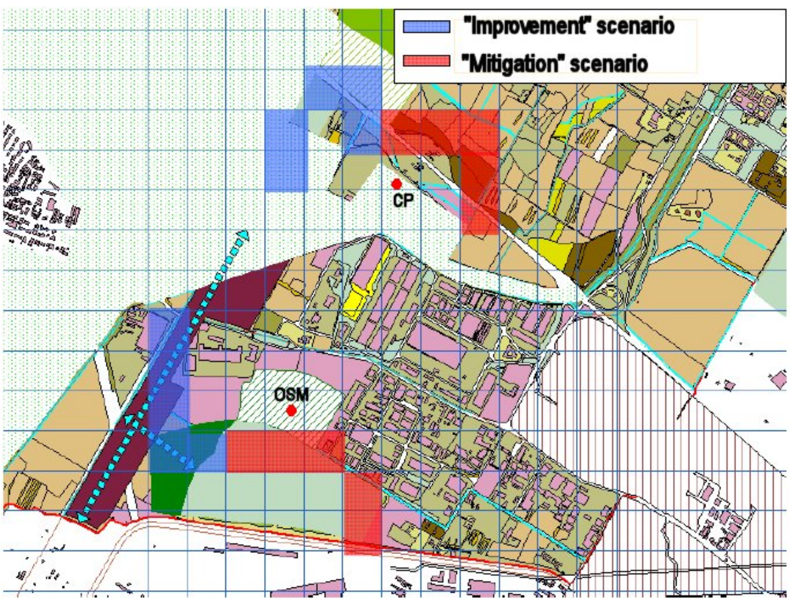

Figure 1. Map of the studied area showing the mitigation scenarios and the two locations for the waste-to-energy plant.

Simulations have been carried out for the three scenarios (scenario 0, businnes as usual, BAU; scenario 1, mitigation; scenario 2, improvement), using the dry deposition velocities previously calculated. Results take into account for the effects on the three sources systems (waste-to-energy plant, main line sources and main point sources) for the five pollutants studied (NO_2, SO_2, PM_{10}, Cd and Pb).

5. RESULTS

Some of the results are showed in figures 2-8, just as examples.

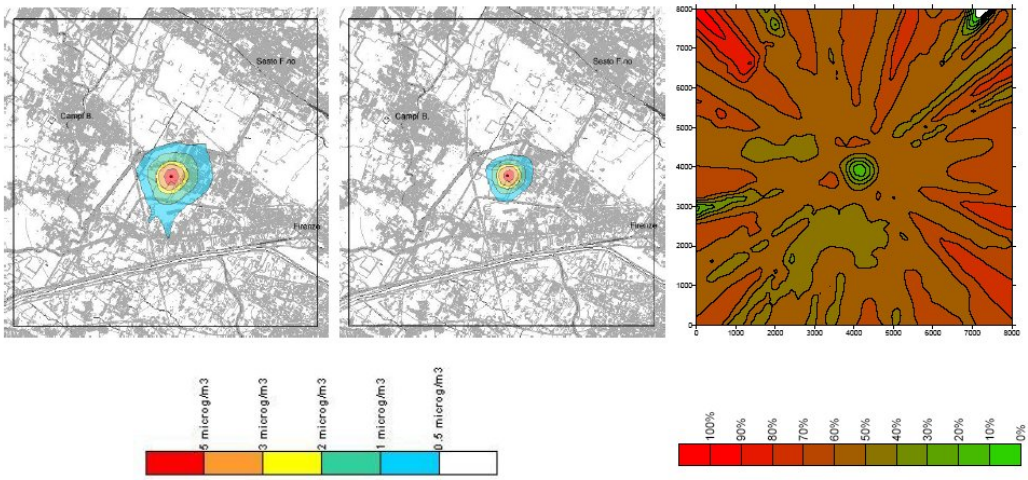

Figure 2. Annual mean concentration map of NO_2 for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the waste-to-energy plant at OSM.

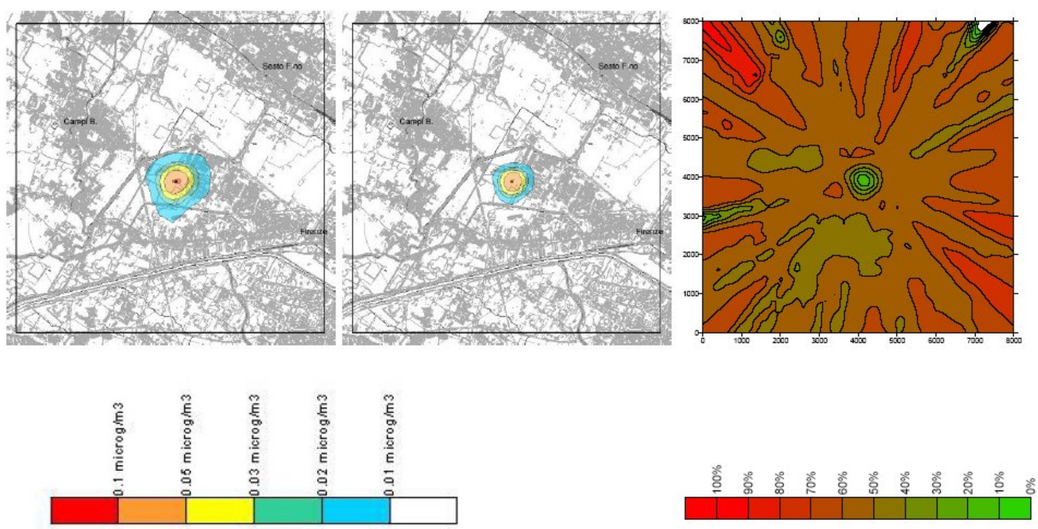

Figure 3. Annual mean concentration map of PM_{10} for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the waste-to-energy plant at OSM.

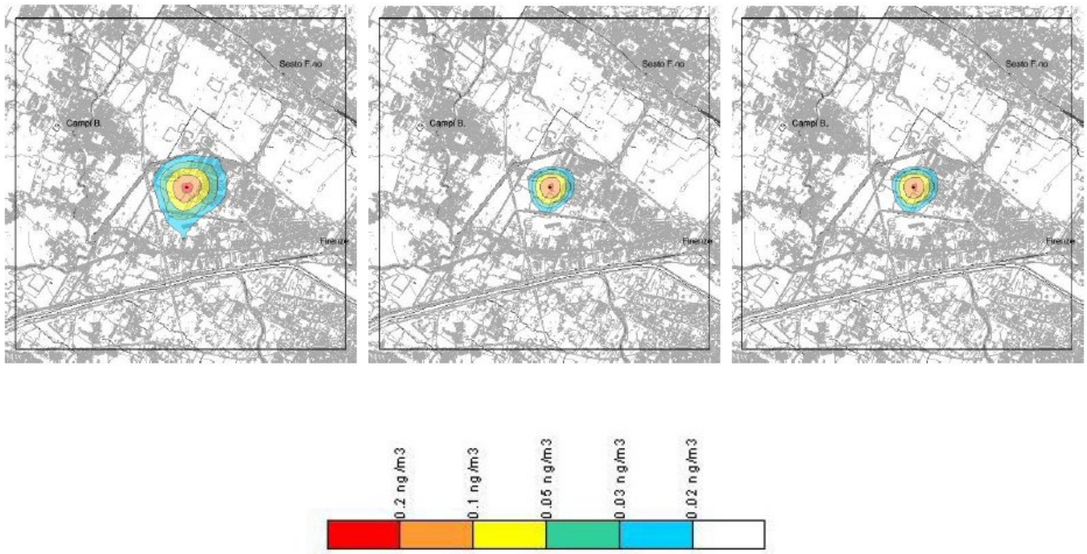

Figure 4. Annual mean concentration map of Cd for the scenario 0 (left), the scenario 1 (centre) and the scenario 2 (right). Emission from the waste-to-energy plant at OSM.

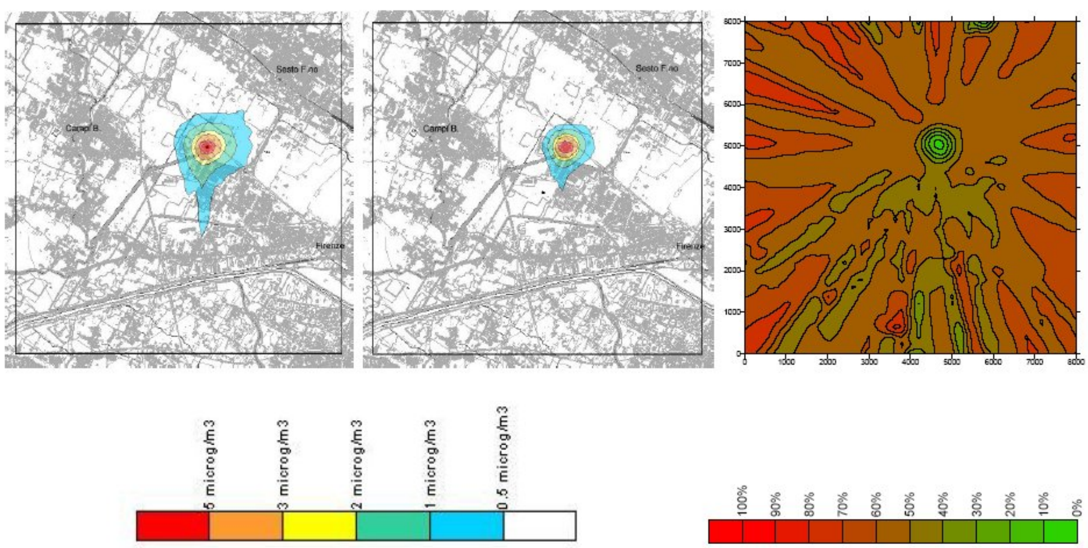

Figure 5. Annual mean concentration map of NO_2 for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the waste-to-energy plant at CP.

For the simulations relative to the waste-to-energy plant, the results show an average reduction of the pollutants concentration between 50% and 90% for the scenario 1. The scenario 2 does not seem to add further advantage to the situation, with a marginal impact on the concentration reduction. This is probably due to the location of the added green area, rather far from the considered stack.

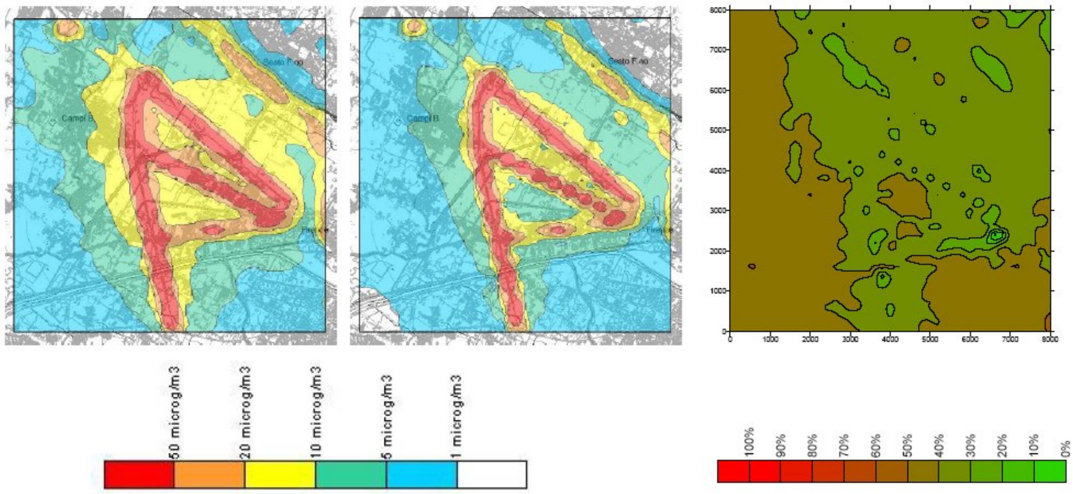

Figure 6. Annual mean concentration map of NO_2 for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the main line sources.

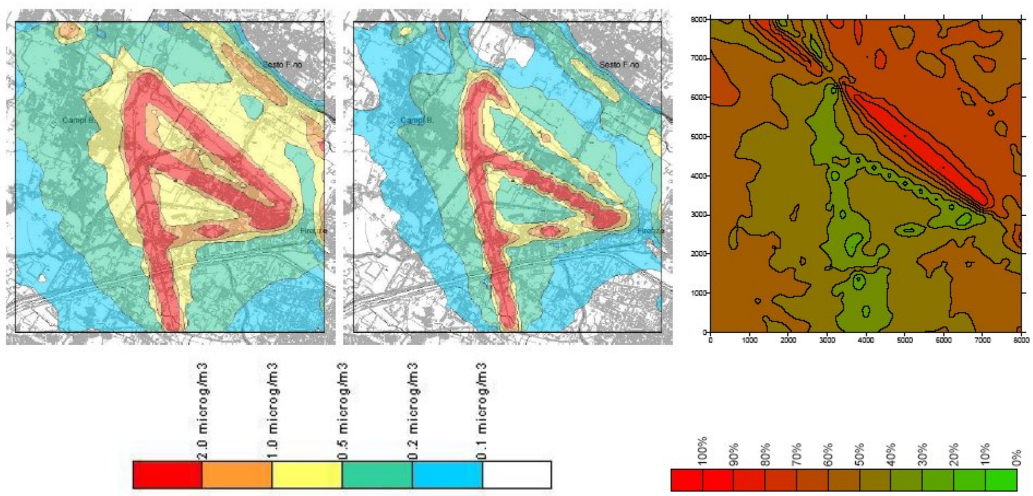

Figure 7. Annual mean concentration map of PM_{10} for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the main line sources.

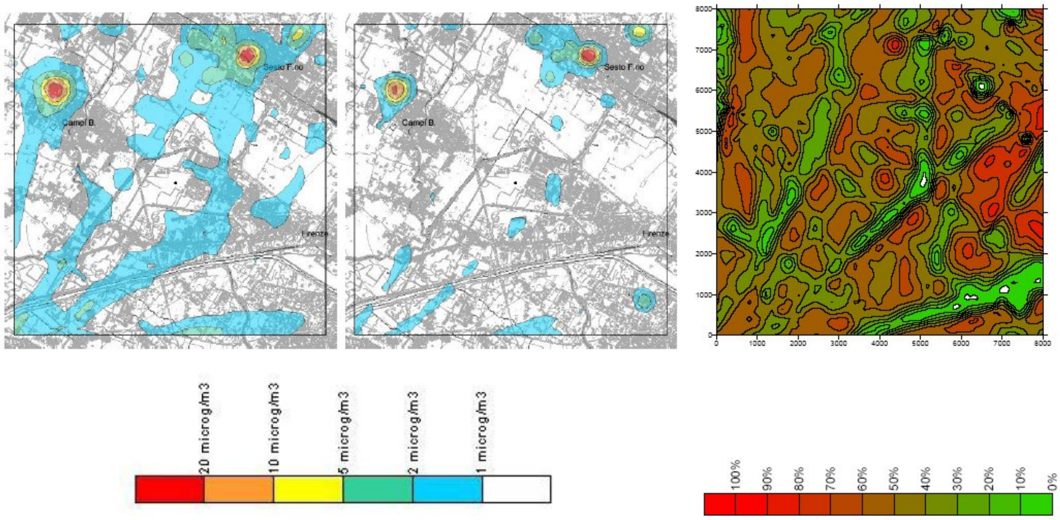

Figure 8. Annual mean concentration map of SO_2 for the scenario 0 (left) and the scenario 1 (centre); Contour map of the relative difference between the two scenarios (right). Emission from the main point sources.

Similarly, for the main line sources and the main point sources, the simulations show a pollutants concentration reduction in the scenario 1 between 30% and 60%, with maxima of 80-90% for some pollutants. Also in this case the scenario 2 does not add further advantages.

6. CONCLUSION

In conclusion it can be stated that an adequate localisation of a green area of 2 km^2 (scenario 1), with plant species effective in removing atmospheric pollutants, can play a determinant role for the improvement of the air quality in the considered area. They are capable of effectively reducing the impact of the waste-to-energy plant, with a considerable effect on the existing pollutant sources as well.

7. ACKNOWLEDGEMENTS

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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

I . 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
P I N U S S Y L V E S T R I S Z O N E	1700	P. .sylvestris	2003			1904	1	P. sylvestris			1390	1
			2002	1	2049	2258	2		1	1650	1780	2
			2001	2	2308	2366	3		2	1810	1950	3
			2000	3	2474				3	1980		
		P. nigra	2003	1			1	P. nigra				1
			2002	1			2		1			2
			2001	2			3		2			3
			2000	3					3			
	1600	P. sylvestris	2003			1666	1	P. sylvestris			1350	1
			2002	1	1710	1760	2		1	1380	1510	2
			2001	2	1904	2021	3		2	1610	1860	3
			2000	3	2049				3	1910		
		P. nigra	2003				1	P. nigra			1410	1
			2002	1			2		1	1520	1610	2
			2001	2			3		2	1620	1880	3
			2000	3					3	1930		
	1500	P. sylvestris	2003			1717	1	P. sylvestris			1700	1
			2002	1	1803	1948	2		1	1790	1810	2
			2001	2	2150	2258	3		2	1850	2030	3
			2000	3	2380				3	2130		
		P. nigra	2003				1	P. nigra			1080	1
			2002	1			2		1	1390	1520	2
			2001	2			3		2	1560	1650	3
			2000	3					3	1760		
	1400	P.sylvestris	2003			1873	1	P. sylvestris			1310	1
			2002	1	1948	2123	2		1	1430	1560	2
			2001	2	2157	2279	3		2	1560	1710	3
			2000	3	2366				3	1830		
		P. nigra	2003					P. nigra			1150	1
			2002	1					1	1560	1610	2
			2001	2					2	1740	1810	3
			2000	3					3	2180		
P I N U S S Y L V E S T R I S - P I N U S N I G R A Z O N E	1300	P. sylvestris	2003			1356	1	P. sylvestris			1700	1
			2002	1	1486	1536	2		1	1940	2090	2
			2001	2	1666	1717	3		2	2130	2230	3
			2000	3	1854				3	2310		
		P. nigra	2003			1529	1	P. nigra			1470	1
			2002	1	1623	1659	2		1	1650	1880	2
			2001	2	1760	1854	3		2	2010	2150	3
			2000	3	2056				3	2230		
	1200	P. sylvestris	2003			1623	1	P. sylvestris				1
			2002	1	1666	1717	2		1			2
			2001	2	1803	1904	3		2			3
			2000	3	2049				3			
		P. nigra	2003			1270	1	P. nigra			1650	1
			2002	1	1443	1573	2		1	1990	2110	2
			2001	2	1623	1728	3		2	2130	2250	3
			2000	3	1775				3	2290		
P I N U S N I G R A Z O N E	1100	P. nigta	2003			1479	1	P. nigra			1510	1
			2002	1	1580	1659	2		1	1570	1740	2
			2001	2	1753	1854	3		2	1790	1940	3
			2000	3	1955				3	2030		
	1000	P. nigra	2003			1392	1	P. nigra			1880	1
			2002	1	1410	1486	2		1	2030	2120	2
			2001	2	1498	1623	3		2	2170	2290	3
			2000	3	1971				3	2380		
	900	P. nigra	2003			1659	1	P. nigra			1740	1
			2002	1	1803	1897	2		1	2080	2140	2
			2001	2	2056	2150	3		2	2190	2290	3
			2000	3	2207				3	2540		
P I N U S B R U T I A Z O N E	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		

SOUTH EXPOSURE

I . CROS SECTION AFTER A. ÇÖMEZ								II. CROS SECTION AFTER E.TUNCER				
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	2003	P. sylvestris			1803	1	P. sylvestris			1610	1
		2002		1	1904	2005	2		1	1650	1760	2
		2001		2	2021	2157	3		2	1790	1910	3
		2000		3	2227				3	2180		
		2003	P. ngra				1	P. nigra			1260	1
		2002		1			2		1	1650	1710	2
		2001		2			3		2	1740	1920	3
		2000		3					3	2030		
PINUS SYLVESTRIS- PINUS NIGRA ZONE	1600	2003	P. sylvestris			1710	1	p. sylvestris			1110	1
		2002		1	1803	1904	2		1	1390	1550	2
		2001		2	1955	2005	3		2	1580	1900	3
		2000		3	2207				3	1980		
		2003	P. nigra			1543	1	p. nigra			1270	1
		2002		1	1573	1635	2		1	1390	1490	2
		2001		2	1710	1872	3		2	1650	1740	3
		2000		3	1904				3	1740		
P I N U S N I G R A Z O N E	1500	2003	p. sylvestris				1	P. sylvestris				1
		2002		1			2		1			2
		2001		2			3		2			3
		2000		3					3			
		2003	P. nigra			1573	1	P. nigra			1610	1
		2002		1	1635	1710	2		1	1640	1690	2
		2001		2	1775	1824	3		2	1890	1890	3
		2000		3	1971				3	1960		
	1400	2003	P. sylvestris				1	P. sylvestris				1
		2002		1			2		1			2
		2001		2			3		2			3
		2000		3					3			
		2003	P. nigra			1710	1	P. nigra			1230	1
		2002		1	1775	1904	2		1	1230	1310	2
		2001		2	1921	2056	3		2	1410	1540	3
		2000		3	2174				3	1570		
	1300	2003	P. sylvestris				1	P. sylvestris				
		2002		1			2					
		2001		2			3					
		2000		3								
		2003	P. nigra			1623	1	P. nigra			1790	1
		2002		1	1760	1854	2		1	1790	1840	2
		2001		2	1904	2005	3		2	1890	1980	3
		2000		3	2099				3	2130		
O A K - J U N I P E R - P I N U S N I G R A Z O N E	1200	2003	P. sylvestris				1	P. sylvestris				
		2002		1			2					
		2001		2			3					
		2000		3								
		2003	P. nigra			1529	1	P. nigra			1300	1
		2002		1	1565	1717	2		1	1330	1420	2
		2001		2	1760	1804	3		2	1510	1520	3
		2000		3	1854				3	1610		
	1100	2003	P. nigra			1277	1	P. nigra			1390	1
		2002		1	1399	1435	2		1	1430	1490	2
		2001		2	1486	1529	3		2	1510	1610	3
		2000		3	1589				3	1620		
	1000	2003	P. nigra			1199	1	P. nigra			1270	1
		2002		1	1325	1410	2		1	1350	1420	2
		2001		2	1454	1540	3		2	1470	1530	3
		2000		3	1573				3	1550		
	900	2003	P. nigra			1119	1	P. nigra			1270	1
		2002		1	1147	1241	2		1	1350	1460	2
		2001		2	1270	1367	3		2	1490	1620	3
		2000		3	1399				3	1650		

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.

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

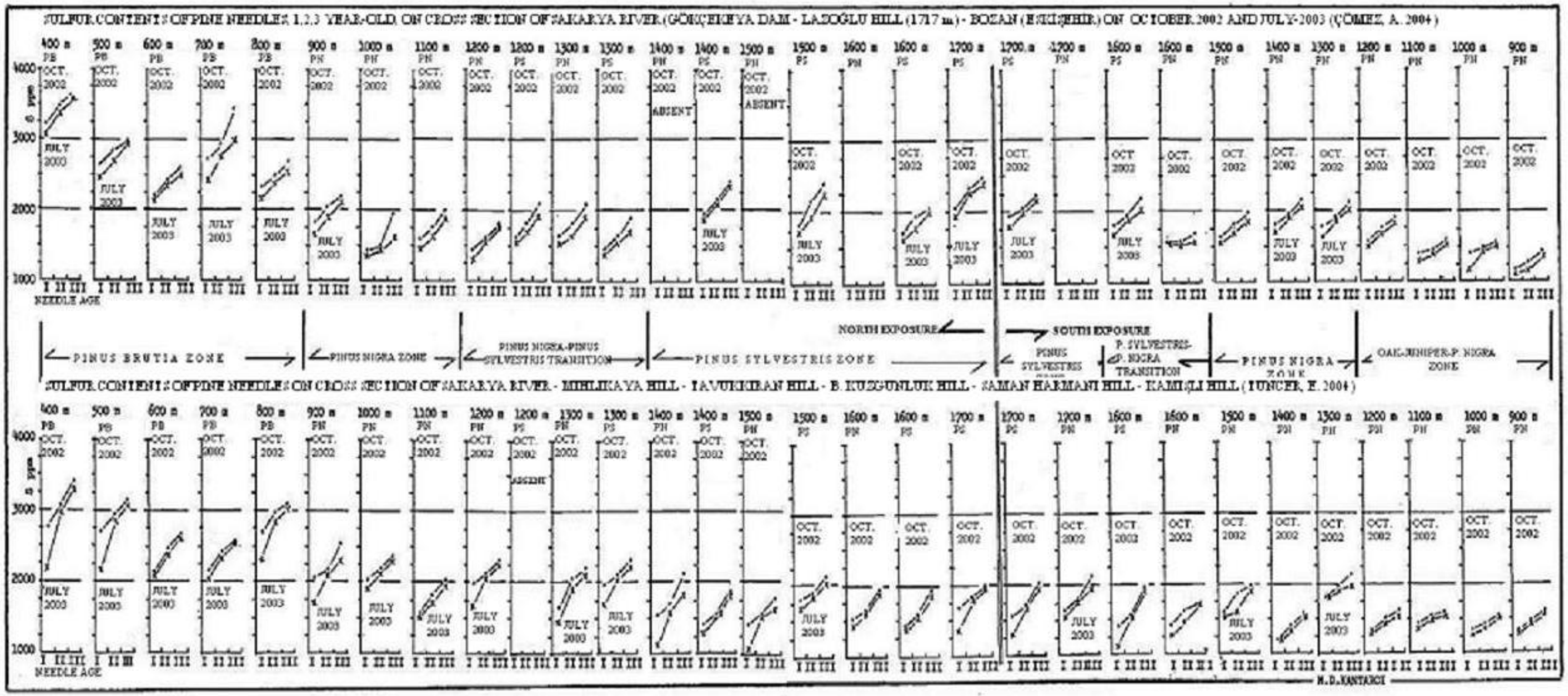
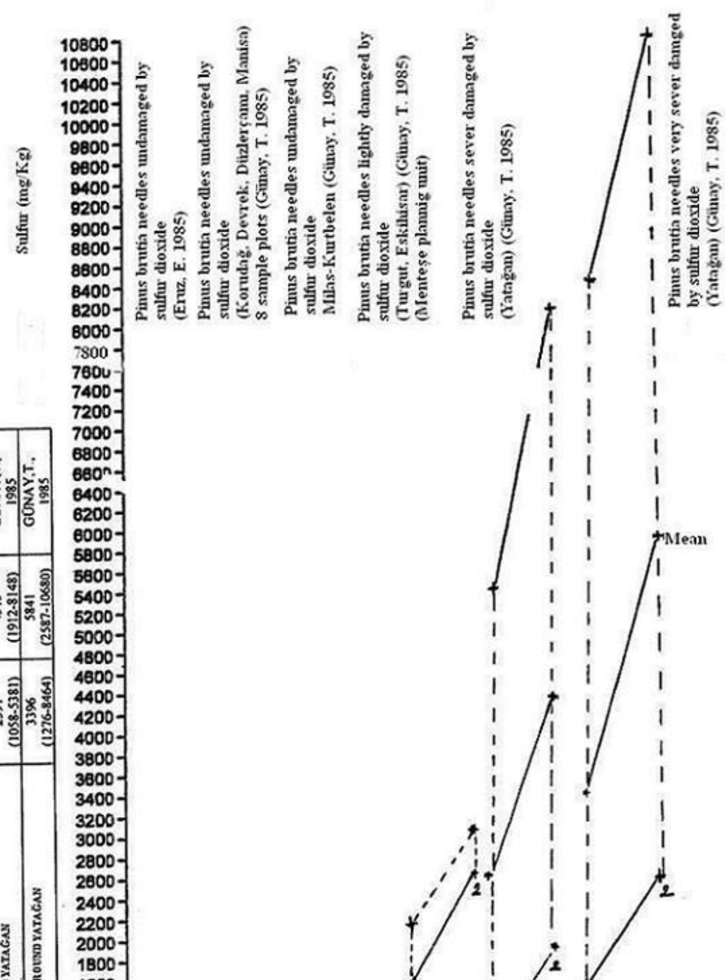


Figure 1. Changes in sulfur contents of Pinus brutia, Pinus nigra, Pinus sylvestris needles, 1, 2, 3 year-old, on north and south exposure of the Sündiken massif according to elevation and seasons (October-2002 and July-2003).

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

LOCATION	NEEDLE AGE 1	NEEDLE AGE 2	REFERENCE
HEALTHY YATAĞAN/MENTEŞE PLANTATION	250	780	ERUZ.E. 1985
KORUDAĞ, DEVREK, DÜZLERÇAMI, MANISA 8 SAMPLE PLOTS TOTALLY	854.67 (536-979)	1026.9 (820-1229)	GÜNAY,T.,1985
MILAS-KURTBELEN	1067	1220	GÜNAY,T.,1985
LIGHTLY DAMAGED AROUND YATAĞAN (3 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

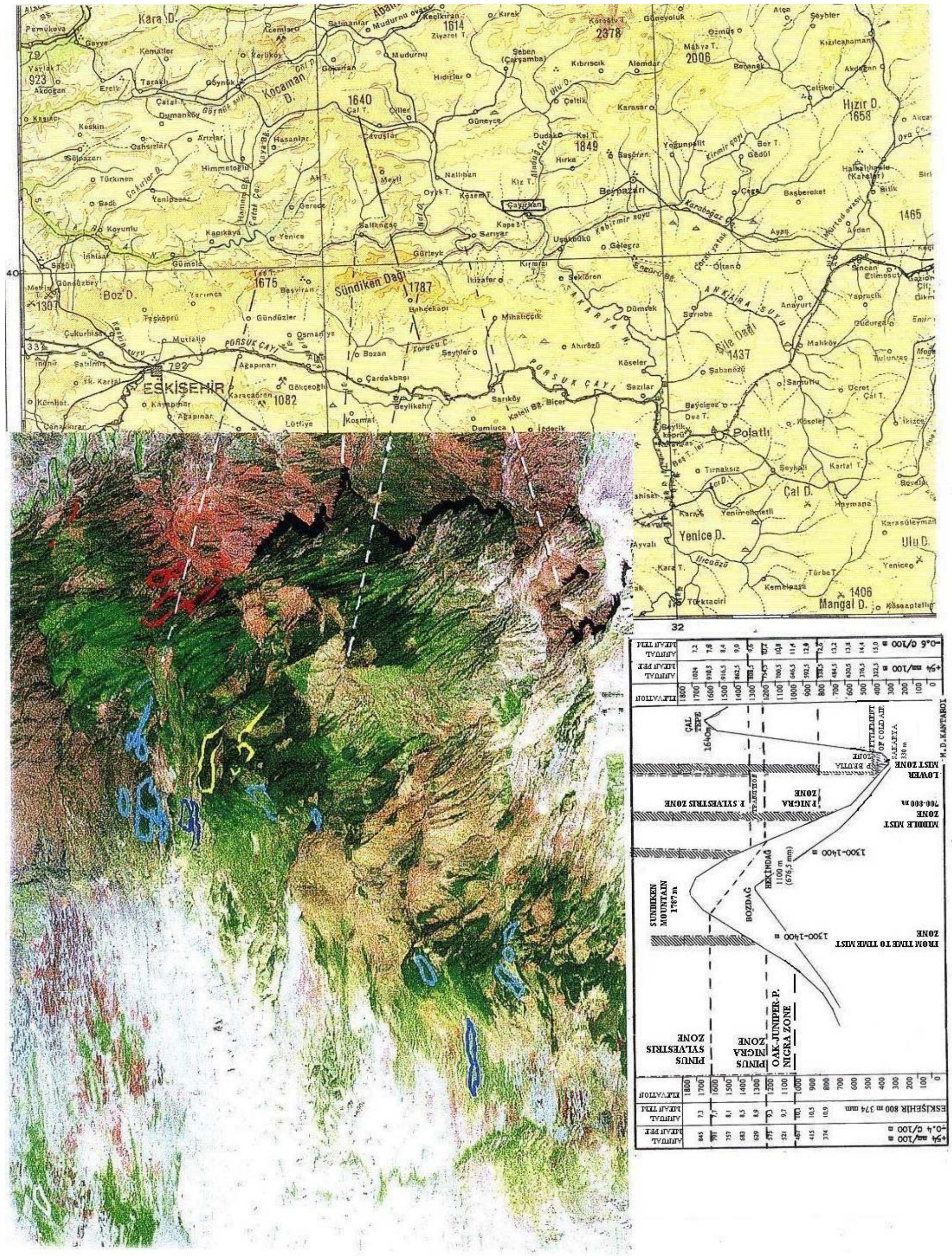


(1) Sulfur amount belong to 1 and 2 yaer-old Pinus brutia needles, in 1985
(Sulfur contents are high in trees even which appear healthy)

(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.

M.DOĞAN KANTARCI

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

LEAD (Pb) CONCENTRATIONS IN URBAN SOIL AND SOME TREE SPECIES OF ISTANBUL

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ABSTRACT

Exhaust gases that comes from the burning of the leaded fuel in these vehicles cause air pollution. And lead (Pb), which is found in the exhaust gases, pollutes soil and affects plants negatively. In this investigation, Pb concentrations of 7 different deciduous tree leaves, which were collected in spring and autumn periods from 9 sampling area (+1 control), were determined. Leaf samples were taken from *Acer negundo, Aesculus hippocastaneum, Ailanthus altissima, Fraxinus angustifolia, Platanus spp, Populus nigra* and *Robinia pseudoacacia* species that are found in the urban parks and close to the roadsides. Pb concentrations in the leaves were detected as 2.0-23.76 mg kg^{-1} in spring and 3.99-34.40 mg kg^{-1} in autumn. Pb concentrations of the urban leaves were higher than the control leaves both in the investigated seasons. We have also studied Pb concentrations of soils from the same sampling areas. Pb concentrations were found as 26.63-445.60 mg kg^{-1} in spring, 23.23-1121.20 mg kg^{-1} in autumn, respectively. Pb content of the urban soils was also quite higher than the control soils. These results have shown that Pb pollution in Istanbul exceeds the limits of toxicity especially in the areas with high traffic density.

Key Words: Lead, tree, air pollution, urban soil,

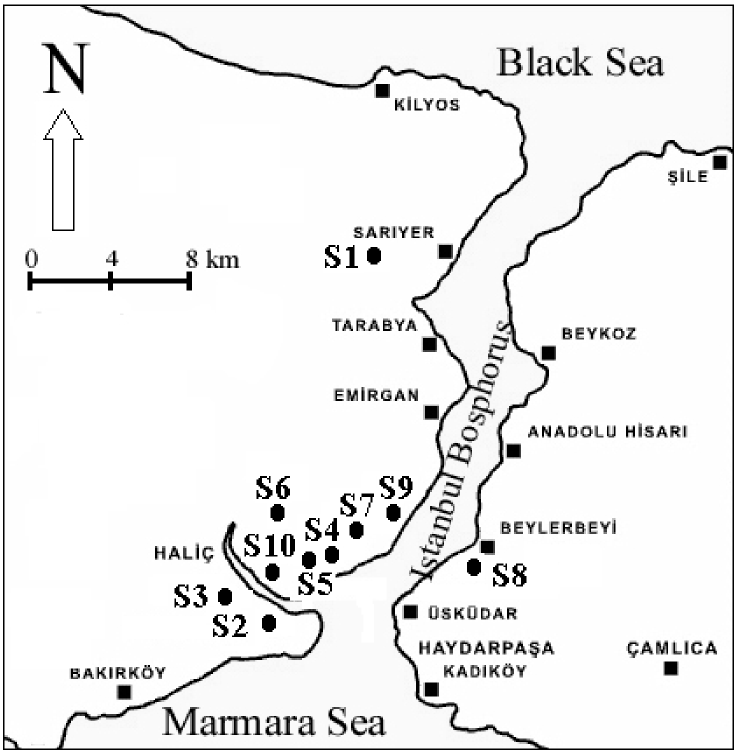
1. INTRODUCTION

Lead (Pb) is not a vital element for the living organisms but it is naturally found in the soil depending on the parent material. The most significant sources causing Pb concentrations in nature to increase may be enumerated as being fossil fuels, traffic, mining, fertilizers used in agriculture and forestry, pesticides, wood protection chemicals, sludges, household and industrial waste, metalwork industries (Alloway, 1999; Davies, 1999). In most large cities air pollution measurement stations have been set up to measure the levels of pollutants such as SO_2, NO_x and dust in the air. During the winter months heating is achieved through the burning of fossil fuels, which when combined with traffic emissions causes intensive air pollution including heavy metals. And it is for this reason that in recent years a lot of attention and research has been directed towards heavy metal content in the urban soils and in urban plants. In this study, the primary objective has been to investigate the total Pb content in various soils and tree leaves the from urban parks and roadsides of Istanbul.

2. MATERIALS AND METHODS

2.1. Soil and Plant Sampling

Istanbul lies between with a population exceeding 10 million, is one of the Turkey's most populous city and important industrial center. Sampling was carried out in May and September 1999 from nine presumably polluted urban sites and one from a relatively clean area (Istanbul University Education and Research Forest, Bahçeköy) (Figure 1).



Sample Site No.	Sample Sites
S1	Istanbul University- Faculty of Forestry/ Research Forest-Bahçeköy (Control)
S2	Saraçhane Urban Park-Saraçhane
S3	Old City Walls Vicinity-Edirnekapı
S4	Taksim Urban Park-Taksim
S5	Democracy Urban Park-Maçka
S6	Çağlayan Urban Park-Çağlayan
S7	Yahya Kemal Urban Park / Barbaros Boulevard-Beşiktaş
S8	Bosphorus Bridge / Asian Side Exit (E-5 Highway)-Beylerbeyi Intersection
S9	Bosphorus Bridge / European Side Exit (E-5 Highway) vicinity
S10	Cezayirli Hasan Paşa Urban Park-Kasımpaşa

Figure 1. Map of Istanbul with location sample sites

Tree leaves (118 samples) and soil samples (104 samples, 0-5cm and 20-25 cm depth) were collected from the roadsides and from the urban-parks exposed to the exhausts of heavy traffic. Analyzed tree species: *Acer negundo* L. (Box-Elder), *Aesculus hippocastaneum* L. (Common Horse Chestnut), *Ailanthus altissima* (Miller) Swingle (Tree of Heaven), *Fraxinus angustifolia* (Vahl.) (Narrow-leaved Ash), *Platanus sp.* [*Platanus orientalis* L. (Oriental Plane) and *Platanus X acerifolia* (Ait.) Willd. (London Plane), *Populus nigra* L. (Black Poplar), *Robinia pseudoacacia* L. (Locust tree).

2.2. Soil and Plant Analysis

Heavy metal determinations: Both plant and soil samples were dried and wet-digested with HNO_3 (Sastre et al. 2002). The obtained suspensions were filtered, diluted and final solutions were analyzed for Pb using flame AAS (Shimadzu AA-680). The results were calculated on dry weight basis (mg kg^{-1} dw).

Soil analysis: Soil samples were sieved, dried and the particle diameter distribution was designated using the Bouyoucous hydrometer method. The pH values, electrical conductivity, $CaCO_3$ organic carbon (Walkley-Black method) and total nitrogen (Kjeldahl method) were also determined (Gülçur, 1974).

3. RESULTS AND DISCUSSION

3.1. Selected Soil Properties

The soil samples taken from the control site (S1) are considered to be natural. On the other hand, those taken from the urban parks and roadsides of the city are such that they have been brought from elsewhere by various methods and they are usually spread soil or material. Thus, one may easily encounter construction waste, etc. and other unnatural substances in these urban soils. Although it may not be stated during the course of the study, various fertilizers in the form of organic substances have possibly been mixed in the parks. The soil textures are mostly loamy clay and sandy-loamy clay. In urban soil, actual acidity ranges between 6.88-8.56 pH in spring and 5.70-8.43 in autumn (Table 1). The least reactions among the sample site were to be observed for the control site at the Faculty of Forestry-Research Forest (S1) and there was no lime content in that soil.

In general, the average electrical conductivity in the soil samples was found to be below 500 µS cm^{-1} (Table 1). As mentioned above, there was no lime in the control site; on the contrary, there was lime in all the other soils obtained from within the city. In general, the level of organic carbon at the top soil is between 0.50-7.73% whereas in the lower soil it is between 0.09-2.86% (Table 1). At all the sample sites the total nitrogen content of the top soil taken in both seasons is higher in comparison to the lower soil, generally varying between 0.084-0.671%. Nitrogen values for the lower soil varies between 0.045-0.227% (Table 1).

Table 1. Range of the selected properties of the control and urban soil samples

Soil Properties		Control (S1)		Urban Soil (S2-S10)	
		0-5 cm	20-25 cm	0-5 cm	20-25 cm
Sand (%)		60-73	40-57	38-87	37-84
Silt (%)		10-20	18-24	7-24	7-25
Clay (%)		17-20	24-37	6-38	9-41
pH (H_2O)	Spring	5.64-6.99	5.49-7.07	6.88-7.87	5.70-8.35
	Autumn	6.31-7.19	6.25-7.23	7.22-8.56	5.98-8.43
EC (µS/cm)	Spring	249-451	52-113	289-688	52-629
	Autumn	311-662	55-148	198-1139	55-438
$CaCO_3$ %	Spring	0	0	0.82-25.82	0-33.19
	Autumn	0	0	0.89-25.51	0-36.06
Corg %	Spring	4.91-7.73	1.62-1.86	0.66-7.73	0.09-2.67
	Autumn	4.83-7.57	0.50-1.30	0.50-7.73	0.10-2.86
N %	Spring	0.327-0.540	0.111-0.181	0.084-0.492	0.057-0.208
	Autumn	0.354-0.549	0.098-0.132	0.091-0.671	0.045-0.227

3.2. Pb Concentrations in Soils

During spring, the Pb concentrations in the urban soils varied between 26.63-445.6 mg kg^{-1} (Table 2). On the other hand, in a significant number of the sites there was an increase in Pb quantity in autumn and was found to range between 23.23-1121.20 mg kg^{-1} (Table 2). The Pb concentrations in the soils obtained from within the city in spring were all higher in comparison to the control site. On the other hand, in autumn the Pb content at the depth of 0-5 cm for sample sites S3 and S5, and at the depth of 20-25 cm for sample site S7 were determined as being lower than that at the control site. The highest concentrations of Pb for both seasons were found at sample site S9 (European side exit of the Bosphorus Bridge), followed by sample site S2 (Saraçhane).

Values between 0.1-20 mg kg^{-1} are accepted as being the most common values in soils (Alloway, 1999). Soils having a Pb content of above 100 mg kg^{-1} are accepted as being polluted, while 200 mg kg^{-1} and higher is considered as very polluted (Smidt, 2000). According to this information the Pb content at the exit from the European side of the Bosphorus Bridge (S9) is categorized as 'very polluted' and is 5-6 times higher than the threshold value for this category of 200 mg kg^{-1}. Similarly, the soil from the Saraçhane Park (S2) may also be categorized as 'very polluted' in terms of Pb content. This must be owing to the intense traffic in that locality, because the most significant reason for increase in Pb content is the exhaust gases of the motor vehicles. If one considers that the number of vehicles in Istanbul is exceeding 1 million and a significant amount of leaded petrol is consumed, it is quite understandable why the levels of Pb in the soils samples from the city are so high in comparison to the control site. High pH, high lime content and organic fertilizers increase the adsorption of Pb to the soil and these properties have direct effects on the Pb adsorption.

Table 2. Total lead concentrations in the soil samples (mg kg^{-1})

Sample Sites	Depth	Pb	
		Spring	Autumn
S1 Control	0-5	24.87±4.20	38.53±12.72
	20-25	26.03±4.15	40.27±21.99
S2 Saraçhane	0-5	247.23±118.43	746.49±72.56
	20-25	290.45±37.55	464.85±176.56
S3 Edirnekapı	0-5	26.63±5.93	32.87±17.17
	20-25	73.85±17.8	82.75±6.86
S4 Taksim	0-5	79.80±28.54	91.80±46.82
	20-25	88.93±33.25	129.68±121.76
S5 Maçka	0-5	29.53±6.36	23.23±2.74
	20-25	53.97±28.12	86.69±27.63
S6 Çağlayan	0-5	114.63±12.00	102.37±28.30
	20-25	62.70±14.90	62.32±57.45
S7 Barbaros	0-5	44.13±20.44	108.39±99.69
	20-25	52.67±33.75	110.23±103.50
S8 Beylerbeyi	0-5	112.40±16.83	86.50±9.76
	20-25	35.00±18.24	27.00±12.02
S9 Bosphorus Bridge	0-5	437.90	1121.20
	20-25	445.60	126.65
S10 Kasımpaşa	0-5	99.80±62.79	77.31±63.92
	20-25	123.40±134.04	63.70±49.71
Average of urban soil (S2-S10)	0-5	107.83	201.73
	20-25	108.60	119.71

When making a comparison with certain other cities, the Pb concentration in spring is higher than that in cities like Stockholm, Hong Kong and Antalya. And as the concentrations increase in autumn the amount of Pb is quite higher than many other cities (Table 2) which indicates that the amount of Pb in Istanbul soils is at high levels. Similarly, in a study conducted by Bayçu et al. (1997) the Pb levels at the control site which is found in close proximity to our control site, were determined as being between 14.95-23.23 mg kg^{-1}. In the same study the following amounts of Pb were found; 182.63 mg kg^{-1} at site S2, 58.43 mg kg^{-1} at site S4, 143.92 mg kg^{-1} at site S5 and 282.25 mg kg^{-1} at sample site S7. In another study (Sezgin et al., 2004) conducted in Istanbul, the Pb content of street dust in the surroundings of the E-5 motorway was found to be between 105.5-555.4 mg kg^{-1} (on average 211.88 mg kg^{-1}). In that study it was stated that the high levels of Pb found at the roadsides was attributed to the motor vehicle traffic and the usage of leaded fuel. Again, in another study, soil samples were taken at varying distances to the E-5 highway at depths of 0-5 cm and the Pb content was found ranging between 73.50-445.00 mg kg^{-1} (on average 186.39 mg kg^{-1}) (Bayçu and Önal, 1993).

Tablo 3. Comparison of the average lead concentrations in some of the urban soils in the world (mg kg^{-1})

City		Depth (cm)	n	Pb	Reference
Coruna (Spain)		0-5	15	309	Cal-Prieto et al. (2001)
Madrid (Spain)		0-20	55	161	De Miguel et al. (1998)
Seville (Spain)		0-10	31	137	Madrid et al. (2002)
		10-20	31	163	
Naples (Italy)		0-2	173	262	Imperato et al. (2003)
Palermo (Italy)*		0-10	70	202	Manta et al. (2002)
Stockholm (Sweden)		0-5	42	101	Linde et al. (2000)
Bangkok (Thailand)		0-5	30	47.8	Wilcke at al. (1998)
Hong Kong		0-10	594	93.4	Li et al. (2001)
Hong Kong		0-5	10	89.9	Chen et al. (1997)
Hong Kong		0-100	100	112.98	Jim (1998)
Hong Kong		0-15	152	94.6	Li et al. (2004)
Nanjing (China)		Horizon	138	107.3	Lu et al. (2003)
Antalya (Turkey)		0-5	73	36.5	Güvenç et al. (2003)
Istanbul (This study)	Spring	0-5	24	107.83	
		20-25	22	108.60	
	Autumn	0-5	24	201.73	
		20-25	22	119.71	
Background values				<20	Alloway (1999)
Tolerable values				20-100	Alloway (1999)
Polluted soil values				>100	Alloway (1999)

* Median

According to the results it has become apparent that the soils of Istanbul are becoming polluted with Pb. Furthermore, there is also a variation in the concentrations of Pb in terms of season. Pb concentrations rose in the season of autumn. The reason for the rise in Pb concentrations is attributed to the slowing in decomposition of organic matter thereby increasing the amount of organic matter and a rise in the pH levels. This is because with the increase in organic matter and pH the buffered Pb increase in amount. In autumn the annual increase in distribution of rainfall also affects the rise in concentrations of Pb.

3.3. Pb Concentrations in Leaves

The lowest Pb concentrations were found in the control tree species both for spring and autumn period. Concentrations of Pb in the spring samples collected from control site were ranged from 0.0 mg kg^{-1} (*Robinia*) to 4.13 mg kg^{-1} (*Fraxinus*) and the range was found from 0.0 mg kg^{-1} (*Platanus*) to 3.59 mg kg^{-1} (*Acer*) in the autumn samples (Table 4). Pb range in the urban site leaves were detected as 2.00 (*Platanus*, S4)-23.76 mg kg^{-1} (*Aesculus*, S10) in spring; and 3.99 (*Ailanthus*, S4)-34.40 (*Robinia,* S4) mg kg^{-1} in autumn (Table 4). We obtained a general increase in the Pb concentrations of the urban site samples compare to control samples and also an increase was observed in the autumn samples of urban sites compare to spring (Table 4). There are considerable data on the retention and bioaccumulation of heavy metals by tree leaves and their phytotoxicity. Generally, toxic concentrations of Pb are defined as 30-300 mg kg^{-1}dw (Kloke et.al., 1984).

Table 4. Pb concentrations in the tree leaf samples from different sampling sites of Istanbul.

Tree Species	Season	S1 Control	S2 Saraçhane	S3 Edirnekapı	S4 Taksim	S5 Maçka	S6 Çağlayan	S7 Barbaros	S8 Beylerbeyi	S9 Bosphorus Bridge	S10 Kasımpaşa
Acer negundo	Spring	1.72	7.83	11.14	3.15	7.09	11.07	9.08			8.32
	Autumn	3.59	12.80	15.80	8.28	8.36	12.35	20.84			8.45
Aesculus hippocastaneum	Spring	1.49	11.99	9.29	3.34		5.05	10.76	16.88		23.76
	Autumn	0.00	15.00	22.83	7.91		12.47	10.22	22.07		28.91
Ailanthus altissima	Spring	3.90	6.11	5.26	5.61	3.59	7.38	2.53	5.36	12.59	
	Autumn	2.61	6.81	13.79	3.99	9.63	14.16	5.16	11.00	19.25	
Fraxinus angustifolia	Spring	4.13	13.79	8.30	11.81	5.43	9.01	5.53	7.79		10.62
	Autumn	1.65	12.51	21.65	10.94	7.52	6.98	6.80	10.52		12.73
Platanus sp.	Spring	0.44	6.21	5.23	2.00	7.31	16.49	8.83	14.18		3.38
	Autumn	0.00	12.08	6.53	8.43	15.51	14.91	15.84	16.81		12.48
Populus nigra	Spring	3.53	6.08	12.57		7.14	5.68	6.75			7.36
	Autumn	2.58	7.39	6.46		7.80	10.26	8.53			9.59
Robinia pseudoacacia	Spring	0.00	9.28	12.51	4.39	5.89	12.09	14.56	2.70		19.35
	Autumn	1.23	7.06	11.51	34.40	5.96	14.99	25.11	9.07		12.47

According to theresults, it can generally be stated that the areas within the vicinity of heavy urban traffic are affected by the exhaust emissions as they contain high loads of heavy metals, especially Pb. In most of the urban sites, there were elevated Pb concentrations probably indicating a pollution coming from the usage of the leaded oil. Meanwhile, the concentration of Pb in the examined trees was under the toxicity range as described by Fergusson (1990) except the autumn samples of *Robinia* at S4. Pb is believed to be the metal with the least bioavailability and the most highly accumulated metal in root tissues (Kabata-Pendias and Pendias, 1986). This can be the reason for the low accumulation of Pb (in mg kg^{-1}) (spring, 12.59- autumn, 19.25) in *Ailanthus* at S9, which has a very high soil Pb content (spring, 437.90- autumn, 1121.20) in 0-5 cm depth soil.

Bereket and Yücel (1990) have investigated the Pb pollution of *Populus nigra* leaves which comes from the traffic emissions in Eskisehir (Turkey) and found 9,06-26,83 mg kg^{-1} Pb. Bayçu ve Önal (1993) have studied the Pb concentrations of *Ailanthus* *altissima* leaves which were collected from the roadsides in İstanbul and determined 16-67 mg kg^{-1} Pb. We have also determined similar Pb concentrations. Furthermore, 5.12-109.17 mg kg^{-1} Pb concentrations were found in the 1-year old needles of the coniferous tree species which were collected from the roadsides of the Istanbul city center (Bayçu et al, 1997). These concentrations were found high compare to the control values (Table 5).

Table 5. Pb concentrations in the 1-year old needle samples from different sampling sites of Istanbul (Bayçu et al 1997)

Tree Species	Atatürk Arboretum (S1)*	Haşim İşcan (S2)*	Taksim (S4)*	Maçka (S5)*	Barbaros (S7)*	Dolmabahçe	Beyazıt
Pinus pinea	1.17	11.23	9.47	5.12			
Pinus pinea	2.62	13.55	7.10	7.10			
Pinus nigra	1.91	8.56			8.52		
Pinus nigra	2.82	9.16			10.80		
Picea abies	1.66				80.54	54.45	
Picea abies	2.63				109.17	60.83	
Cedrus libani	1.95						13.83
Cedrus libani	2.22						15.00
Cedrus deodora	2.10			14.86			
Cedrus deodora	2.65			16.15			

* The same sample sites with our investigation.

4. CONCLUSIONS

The results of our investigation were evaluated as follows:

- According to the traffic emissions, Pb concentrations have increased both in the soil and also in the tree leaves compare to the control.
- Pb concentrations of soils from two sampling sites were found higher than the toxic limits. Similarly, high Pb concentrations which exceed the toxic limits were determined in some of the plant samples.
- Because of the high lime amount, high pH, and organic matter content soil adsorbs more Pb.
- There is a seasonal difference between the Pb concentrations of soil and plant samples.
- We have found higher accumulations of Pb in *Robinia* and *Aesculus* species.

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THE EFFECTS OF CEMENT DUST ON OLIVE TREES IN THE AREA SURROUNDING TARTOUS CEMENT FACTORY

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ABSTRACT

Concentration of total suspended particulate (TSP), particulate less than 10 microns (PM10) and particulate less than 3 microns (PM3), were measured in different sites in the surrounding area of Tartous cement factory.

The effects of cement dust emission on the growth of olive trees have been investigated. The results show that the, TSP, PM10 and PM3 concentrations in the air were higher than world health organization standards (WHO) at the factory site as well as in the surrounding area within a diameter of 3 – 4 km.

The study shows that branch length, branch weight, amount of chlorophyll and leaves number were decreased significantly. The average weight of the annual dust fall on leaves was 34.5, 26.4 and 10.9 g/m^2 at the sites around the cement plant, while in the reference site a value of 1.9 g/m^2 was measured.

Key Words: Cement dust emission, olive trees, TSP, PM10, Syria.

1. INTRODUCTION

Cement industry in most countries is considered one of the most air pollution sources, especially for a lack or insufficient filtration systems. For example an air pollution of cement about 200 ton/day in Halwan factories in Egypt was investigated (El-Awag, 1994). Lerman mentioned that the quantity of dust fall around cement factory in some part of Germany is in a range between 45-114 ton/km^2/month (Lerman and Darley, 1975).

Cement dust contains many elements such as, calcium, silicon, lead, and arsenic etc (Turbas, 1991). In addition cement industry forms an important source of vanadium (Abdel Shafi et al., 1990) and mercury pollution (Fukuzaki et al., 1986).

Studies (Yhdego, 1992), (WHO, 1987), (Yong et al., 1996) show that the pollution of cement dust increase lung sicknesses for people living near by the plants, especially bronchitis, emphysema, forced expiratory volume and forced expiratory flow.

Cement dust also cause sister chromated changes in lymphocytes (Fatima et al., 1995). Also all plants are affected on their growth, harvest. The quantity of chlorophyll decrease in leaves and increase the exposures of infestations to insects and fungus diseases because of forming a hard salt crust at the surfaces of leaves, especially with the presence of high percentage of humidity (Mudd and Kozlowski, 1975). This crust is not removable by wind or rain and is a reason for the changing of specific structure of plants societies (Hegazy, 1996; Brandt et al., 1973).

The particulate pollutants are divided into ‘respirable’ particulates with diameters below 10 µm (PM_{10}) and ‘non-respirable’ particles with diameters up to 100µm (TSP) [Ormstand et al., 1997]. The heavier particles deposit faster than the lighter ones. Therefore their effects can be observed mainly near emission sources. Small particles sometimes behave like gases and remain in the air for a long time (Vesilind, 1982).

The goal of this study was the proof of the influence of these pollutants on growth of olive trees existing around the factory. The total suspended particulate, distribution of particulate matters less than 10 microns according to aerodynamic diameter were measured in the investigation area.

2. METHODOLOGY

2.1. Particulate Measurements

Sampling of total suspended particulate TSP, Particulate less than 10 microns PM10 and distribution of PM10 according to particle size were executed in selected sites, inside and near the Tartous cement factory up to a distance of 4 km.

A high volume air Samplers (HVAS), 5 stages Anderssen cascade impactors with an average air flow rate of 50 m^3/h were used. TSP and total PM10 samples were collected with Whatman EPM2000 glass fibber filters. PM10 samples as a function of particle size were collected with filters type SAC230GF.

The impactor stages consist of aluminum plates with outside dimensions of (15x18) cm. The 2, 3, 4 , 5, 6 have 10 parallel slotted impaction jets. Stage 1 has 9 slots. This impactors has the ability to distribute the PM10 according to the aerodynamic diameter in six ranges (10-7.2; 7.2-3; 3-1.5; 1.5-0.95;0.95-0.49; less than 0.45 microns).

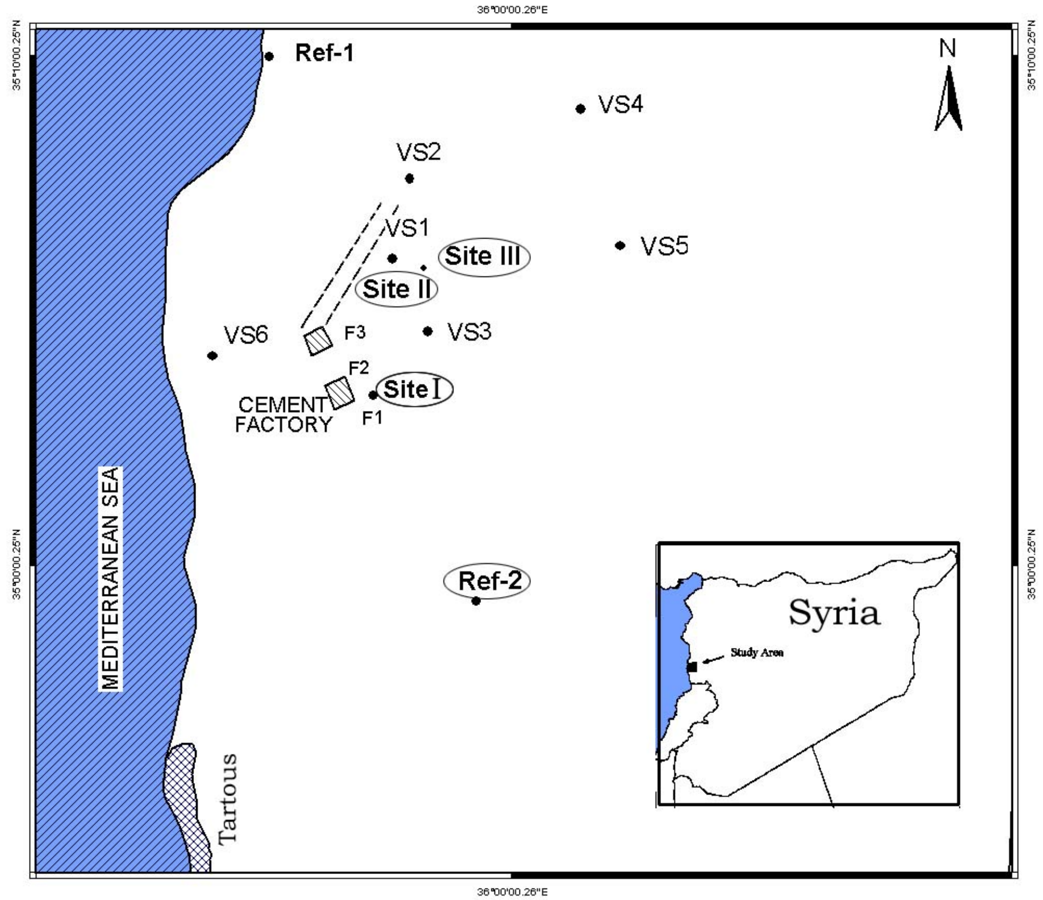

Figure 1: Map of the study sites.

2.2. Plant Measurements

Four sites of olive trees varying in distance from each other and from the cement factory were chosen. These sites are (Fig. 1):

1. Reference area, 7 km away from the factory, which is rarely exposed to the cement dust.
2. Site I, 500 m away from the factory and 30 m above sea level.
3. Site II, Husen Al- Bahr village, which is located 2 km north/east of the factory, altitude 50 m.
4. Site III, which is located 3 km from the factory, altitude 170 m.

Ten trees from each field were randomly chosen and the following parameters were measured:

- The length of annual growth of 10 branches from each tree, the number of leaves on each branch and the dry weight.
- The diameter of the 10 branches of the year before, from each, at the beginning (May 1999) and at the end of the growth season (September 1999).
- The number of growth rings of 10 main branches .
- The size of all leaves of the main branches; the measurements were carried out according to the procedures of (Klein and Klein, 1970).

- The amount of dust accumulated at the surface of leaves, by sampling of 10 samples from each field. Each sample contains 100 leaves. The leaves were washed with water and the residues dried for calculating of the weight of dust.
- The leave content of chlorophyll was measured using an instrument of Minolta, SPAD-502 chlorophyll meter.
- For the statistic purposes an Anova, LSD, Statview4 program was used.
-

3. RESULTS AND DISCUSSION

3.1. Suspended Particulates

Table 1 shows that TSP concentration was too high in the factory and in all other sites compared to the given standards of 120 μg/m^3. The range of concentration differs between 985 and 1844 μg/m^3 and exceeded the national standards (Syrian Ambient Air Quality Standards, 2004) and the world heath organization standard (WHO, 1987;) by 8-15 times.

Differences between the values were extreme, for example in "*Husen Al-Bahr*" values varied from 94 μg/m3 to 703 μg/m^3 and in worker's settlement beside the factory between 110 and 1499 μg/m^3.

In the selected villages near by the factory, TSP was also higher than the reference area value (80μg/m^3), whereas TSP reached to 290 μg/m^3 in "*Husen Al-Bahr*", and to 686μg/m^3 in worker's village. TSP concentrations differs according to the climatic situation (wind, rain etc.).

Table 1. Average concentration of suspended particulate (μg/m^3±SD).

Region	Site's name	TSP	PM10	PM3
Factory area	Main entrance	985±387	-	-
	Administration	1419±849	1067.0	341.0
	laboratory	1844	664.0	256
Reference Area	*Shekh saad*	80±20	14.0-36.0	5.8
	Shalehat	110±28	24.0-38.0	23.4
Villages surrounded the factory	*Husen Al-Bahr*	290±161	70.0-213.0	20.3-77.0
	Matn Al-shahel	164±50	49.0-67.0	49.0
	Dwer Taha	73±31	28.0-39.0	13.5
	Zamreen	91±29	-	-
	Worker's village	684±474	-	-

Data are means ± SD (Standard Deviation).

PM10 concentration was also high in factory area. The values ranged between 664-1067μg/m^3, and also they exceeded WHO standard of 70 μg/m^3 (WHO, 1987) by 9.5-15 times. In quarters surrounding the factory, the PM10 was diverse from one day to another, according to wind speed and direction. In "*Husen Al-Bahr*" it ranged between 70-210 μg/m3.

PM3 was also very high in factory site and reached up to 314 μg/m^3. Ditto these values exceeded the standard suggested by Environmental protection agency in the USA (EPA) of 15 μg/m^3 (Moghhissi, 1997) by 23 times.
In the villages surrounding the factory, PM3 was mainly within the standards, in some sites higher than the standards of the EPA, also depending on the climatic situation.

3.2. Effects Of Cement Dust On Olive Trees

Large amount of cement dust emitted during all manufacturing steps of cement has affected obviously olive trees surface by depositing a salt coat "crust" (Mudd and Kozlowski, 1975) on the leaves.

Table 2. effects of cement dust on growth of olive trees.

	Ref. Site	**Site I**	**Site II**	**Site III**	**LSD 95%**
Average dust weight precipitated g/m2 surface leaves	1.980	34.550	26.400	10.900	3.460
Average leaf area/cm2	5.030	2.700	3.360	3.940	0.440
Average leaf weight /g	0.113	0.072	0.084	0.093	0.020
Average length of branch in the year before /Cm	11.220	3.440	4.300	9.230	1.760
Average number of leaves/branch	19.300	7.750	8.200	13.00	2.070
Average weight of dry branch on the year before/g	1.810	0.510	0.780	1.380	0.250
Average increasing of main branch’s diameter/Cm	0.180	0.027	0.036	0.086	0.046
Average increasing of 2 years old branch diameter/Cm	0.101	0.014	0.013	0.041	0.023
Average increasing of 1 year old branch diameter/Cm	0.086	0.019	0.017	0.030	0.024
Average diameter of growth ring	0.410	0.220	0.250	0.330	0.032

Data are means ten replicates.
LSD 95%: Lowest Significantly Different at 95% level of confidence.

Table 2 shows that the quantity of cement dust deposited on leaves surface is increasing proportionally with approaching to the factory. It was 1.98 g/m^2 from leaves surface in reference area and increased to 34.6, 26.4 and 10.9 g/m^2 from leaves surface in region I, II and III respectively. This means high cement dust deposition on the leaves surface in these regions compared to the reference area by 5.5 and 13 times.

It is worth to show that the cement dust deposition on leaves surface amounts to 0.8%, 13% , 10.6% and 4.6 % from the weight of dry leaves in reference area, region I, II and III respectively.

Deposition of cement dust on plant leaves has effected negatively the growth and proportional with approaching to the factory. Leaf size has decreased in comparison with the reference site by 34.5%, 33% and 21%. Leaf weight has also decreased by 36.5%, 26.3% and 18% in the sizes II, III and I respectively. More over dust fall has affected the growth of new shoots, so its average weight, length and number of leaves grown on these shoots decreased.

The average length of the new grown shoots at the end of growth season was about 11.2 cm in the reference area. In the sites I, II and III the average length decreased to 3.4, 4.3, 9.2 cm respectively. The number of leaves on each shoot decreased from 19 in reference area to 7.8, 8.2 and 13 leaves in the region I, II and III respectively. The dry weigh and amount of chlorophyll decreased in the same way and were less than reference area. In the sites I, II and III were lower by the following factors 25%, 15% and 9%.

Measurements of growth rings thickness in main shoots showed decreasing values with approaching of the factory. The annual average thickness of shoots in the reference area was 0.41 cm. This value decreased to 0.22, 0.25 and 0.33 cm in the sites I, II and III approaching to the factory respectively. Table 3 also shows that the diameter of the main, the 1 year and 2 years old shoots decreased registerable in comparison with the reference site. The average diameter of main shoots was 0.18 cm in the reference sites, and decreased to 0.027, 0.036 and 0.086 cm in the sites I, II and III respectively. The same was noticeable also for 1 and 2 years old shoots.

4. DISCUSSION

The results of this study show the TSP, PM10 and PM3 values were very high in the factory region. Especially those of PM3, which reached in some days 341 $\mu g/m^3$. This value exceeds the suggested values (15 $\mu g/m^3$) of EPA by 23 times (Moghhissi, 1997).

PM3 is considered to be the most dangerous particulate because of its effectiveness on health. PM3 penetrates the defenses of respiratory system and the lungs up to depth, which cause serious problems like asthma (Pope, 1991), emphysema (Shandaala and Zviniatskovski, 1988) and coughs (Ostro, 1991). Furthermore eyes diseases occur (Shandaala and Zviniatskovski, 1988).

High concentrations of PM3 were not limited to factory site, but were also registered in the villages near by, especially when the wind blew in the direction of these villages.

The Neutron Activation Analysis (NAA) of the cement dust showed a percentage of 27.5% of calcium (Meslmani and Al-Oudat, 2004). By presence of humidity calcium silicate occurs, which immediately dries and becomes a hard salt crust. Therefore in the regions near by the factory cement dust formed this kind of salt coat on the surface of the leaves.
This coat causes the decreasing of shoots growth, less number of leaves on it and lower leaves sizes and chlorophyll contents in the studied sites compared to the reference site.

Results of this study show like other studies carried out in the world that cement dust decreases the growth of trees by approximately 50% (Bohne et al., 1963), and cause death of leaves, and decrease chlorophyll content (Mandre et al., 1997).

5. CONCLUSIONS

TSP, PM10 and PM3 concentrations in the air of the factory site and neighborhood were higher than International and Syrian standards (Syrian Ambient Air Quality Standards, 2004). The cement dust in the factory neighborhood has a noticeable negative influence on the growth of trees, depending on the distance from the polluting source.

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PEROXIDASE ACTIVITY IN LEAVES OF PLANE TREE AS A MARKER OF AIR POLLUTION IN RASHT

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ABSTRACT

Peroxidase (POD) induction is a general response of higher plants to the uptake of toxic amounts of heavy metals, low temperature, salt stress, wounding, pathogens, UV radiation and poisonous gases. Screening of plane trees (*Plantanus Orientalis*) located at a highly polluted urban area of Rasht demonstrated considerable peroxidase activity compared to the activity of enzyme in the leaf extracts of the same plant located in clean air area of the same city. Using the leaves of the tree as a source, the peroxidase content was isolated, partly purified and characterized. The specific activity of peroxidase was increased at various stages of purification process. However, in all cases it was found that the leaves of plane tree located at highly polluted urban area exhibited higher peroxidase activity (total and specific). It was suggested that variation in peroxidase activity could, therefore, be used as a marker to show the plant response to various environmental pollutions. The novel peroxidase extracted from polluted plane leaves showed characteristics similar to horseraddish peroxidase, a commercially availabe enzyme used extensively as antioxidant in food and cosmetic industry as well as in analytical techniques. Optimum pH and temperature of the novel peroxidase was measured and its substrate specificity obtained and compared to other peroxidases. It was, therefore, suggested that in addition to being a marker for air pollution, peroxidase extracted from highly polluted plants could also be used as an alternative to the commercially available peroxidase.

Key Words : Plane tree (*Plantanus Orientalis*), peroxidase, metal stress, air pollution

1. INTRODUCTION

Many industrial and natural environmental stresses can affect plants in a variety of ways. Emissions of motor vehicles, for example, are a very major source of heavy metals and toxic gases [Lagerwerff JV, Spetch AW.]. It is known that heavy metals originated from industrial and agricultural activities, can also be found in soils under natural conditions [Castellio FJ,]. Peroxidase (POD) induction is a general response of higher plants to the uptake of toxic amounts of heavy metals [Reddy GN, Prasad MNV.and, Shaw BP.], low temperature, salt stress, wounding, pathogens, UV radiation and poisonous gases [Ashraf MY et al. and Scalet M et al.]. Some trees such as: arborvitae, boxelder, douglas-fir, English oak, magnolia, read oak, white dogwood and white spruce are relatively tolerant to common air pollutants, while many trees including American elm, catalpa, jack pine, larch, ponderosa pine, quaking aspen, Virginia pine, white pine and willow are relatively intolerant to common air pollutants.

Peroxidases (PODs, E.C. 1.11.1.7) are haemoproteins that are widely distributed in the plant kingdom [Lin Z et al.]. They can catalyze the oxidation of a wide variety of substances through a reaction with hydrogen peroxide [Sakuraka J et al. and Cilento G, Adam W]. Peroxoidases are considered to protect cell membrane against the active oxidants and enable plants to be resistant to stress factors [Edreva Asalcheva Ggeorgieva D.and , Everse J et al.].

The effect of heavy metals such as cadmium and lead on the peroxidase activity of *pinus pinea* [Baycu G et al.], water hyacinth [Meksongsee L et al.], and Pinto bean leaves [Peters J.L. et al.] and some other plants [Van Assche F and Clijters H.] have been studied. Many studies have shown that peroxidase increases due to increased levels of heavy metals both in soil and environment.

Plane tree is commonly grown on the sides of many roads and streets in order to provide pleasant atmosphere and image to the surrounding environment. There are few literatures available on the effects of environmental pollutants on the peroxidase activity in leaves of this tree.

2. MATERIALS AND METHODS

2.1 Material

Fresh and healthy leaves samples were selected from plane trees located at two environmentally different parts of the city.
Horseradish peroxidase, 1-phenyl-2,3-dimethyl-4-amino pyrazolan (AAP), folin-ciocateus, acrylamide, N,N-methylene-bis-acrylamide, hydrogen peroxide, 2-mercaptoethanol, ammonium persulphate, bromophenol blue, guaiacol, ascorbic acid were purchased from Merck Chemical Company, glycine and pyrogallol from BDH, tyrosine from Sigma and protein molecular weight marker from MBI.

2.2 Selection of leaf samples

The study was preformed during August (~ 26°C) when the leaves were fresh and undamaged by hot or cold weather. Fresh, young and healthy leaves of plane trees were picked and delivered to the laboratory within three to four hours. Rasht is a comparatively large city with congested population and many factories located near the city. The road traffic is extremely high in some parts of the city; however, there are some streets far from heavy traffic jams with nice clean and fresh air.

2.3 Preparation of plane leaf extract

3 g leaves of plane trees approximately 5 m in height were homogenized in liquid nitrogen. A 10 ml solution of 0.10 M phosphate buffer (pH 7.0) containing 0.1mM EDTA (to prevent possible reaction of proteases), 1 mM mercaptoethanol (to inhibit peroxidase oxidation) and 0.1 M NaCl was then added. The resulting solution was centrifuged at 7500 rpm at 5°C for 40 minutes. The total protein content was

measured in the supernatant using Lawry protein assay. The activity of peroxidase was measured in the presence of 1-phenyl-2,3-dimethyl-4-amino pyrazolan and H_2O_2.

2.4 Enzyme assay

Peroxidase activity was determined spectrophotometrically using a method similar to [Sakharov I Yu, Bautista G.]. 50 μl of enzyme solution was added to 475 μl of 0.2 M phosphate buffer containing both substrates (2.5 mM 1-phenyl-2,3-dimethyl-4-amino pyrazolan and 1.7 mM hydrogen peroxide) and the absorbance change at 510 nm was measured at 25°C. One unit of activity (U) is the amount of peroxidase oxidating 1 μmole of substrate per minute. Specific activity is units of activity per mg of protein.

2.5 Enzyme purification

The leaves (350 g) from plane trees were milled and homogenized in 1 liter solution of 0.10 M phosphate buffer (pH 7.0) containing 0.1 mM EDTA and the homogenate was incubated for 1 h at ambient temperature. Tissue derbis was removed by filtration and centrifugation, and the extract fractionated by adding ammonium sulphate, $(NH_4)_2SO_4$ to 85% at 4°C and controlled pH. The sample was mixed for another 30 minutes followed by centrifugation at 5000 rpm at 5°C for 30 minutes. 2 ml of 0.2 M phosphate buffer was then added to the precipitate and mixed well. The mixture was centrifuged again under the same conditions for 10 minutes. 2 ml of 10 mM phosphate buffer was added to the resulting precipitate and the solution was dialyzed 3 times against 500 ml of 10 mM phosphate buffer (pH 7.0) using dialysis bags with pores less than 12000 daltons. The resulting peroxidase solution was applied to a DEAE-Sepharose column (1 × 50 cm) equilibrated with the same buffer. The elution was carried out with 10 mM tris-HCl buffer (pH 8.3) at a flow rate of 25 ml/h. Peroxidase passed through the column, but colored compounds of the leaf extract were absorbed. The fraction containing active peroxidase was stored at 5°C.

2.6 Thermal stability

Thermal stability of a 4×10^5 M of purified peroxidase was measured at temperatures of 10-90 °C. The enzyme was incubated at the desired temperature for 15 minutes and the change in its absorbance was recorded as discussed in section 2.4.

2.7 Optimum pH

2.5 mM 1-phenyl-2,3-dimethyl-4-amino pyrazolan was used as electron donor and 1.7 mM hydrogen peroxide as electron acceptor and using the following buffers different pH ranges were made: glycine/HCl (pH 3.0), sodium acetate (pH 4.0 and 5.0), phosphate (pH 6.0 and 7.0), tris/HCl (pH 8.0) and glycine/NaOH (pH 9.0).

2.8 Analytical methods

The purity and molecular weight of the extracted enzyme was determined by sodium dodecyl sulphate polyacryl amide gel electrophoresis (SDS-PAGE). Electrophoresis was performed under denaturing conditions [Electrophoretic Theory Catalogue] and the gels were stained using Colloidal Brilliant Blue-G (B.B.G). The protein content of each solution was measured by Lawry method using our purified peroxidase as standard.

2.8 Substrate specificity of purified peroxidase

The substrate specificity of plane tree peroxidase was examined using known peroxidase substrates. The change in substrate absorbance due to the peroxidase action was monitored. The wavelength used depends on the type and structure of the substrate, i.e. 290 nm for ascorbic acid, 470 nm for guaiocol and 1-phenyl-2,3-dimethyl-4-amino pyrazolan, 420 nm for pyrogalol and 260 nm for tyrosine.

3.RESULTS AND DISCUSSIONS

Screening of plane trees planted in two environmentally different area of Rasht showed higher peroxidase activity in the leaves of polluted trees. Table 1 shows changes in specific activity of the enzyme extracted from leaves of plane tree collected in a highly polluted area during various stages of purification. Using the step by step purification processes in this study, plane tree peroxidase was specifically isolated with a purification fold of 39. A similar procedure was used for purification of peroxidase from leaves of the same tree located in an exceptionally air clean area. In this case also and the success in purification was the same. Table 2 compares total protein and peroxidase activity in leaves of plane trees grown in two environmentally different roads measured directly after homogenation.
The results also showed that the decrease in peroxidase activity is proportional to the increase in air pollution especially in terms of heavy metal concentration (mostly lead and cadmium) in the leaf extracts (the data not shown here, to be published later). Sakharov et al [Sakharov I Yu et al.] have shown that peroxidase activity in leaf extracts of royal palm tree does not depend on the age and height of the plant or on the time of the year. We, therefore, assumed that peroxidase measured in August did not change considerably during other seasons. A comparison between total and specific activity of peroxidase in leaf extracts of polluted and not polluted plant shows that peroxidase assay may be used as a quick test to show the level of pollution in urban area. The total peroxidase activity is about 1.5 times in plants living in polluted area when compared to the leaves of the same plant living in an environmentally clean area.

Table 2. Purification of peroxidase from plane tree leaves grown in a highly air polluted area.

Procedure	Volume (ml)	Protein (mg)	Specific activity (U/mg protein)	Total activity (U)	Yield (%)	Purification fold
Homogenate	5.32	4.8	73.3	351.6	100	1
$(NH_4)_2SO_4$	1.35	0.312	586.4	183	52	8
DEAE-sepharose	0.081	0.072	2053	156	44	28
Sephacryl S100	0.012	0.192	2871	55.1	15.5	39

Table 2. Peroxidase difference in homogenates of leaf extracts form plane trees located at different environmental conditions.

Tree location	Homogenate volume (ml)	Total protein (mg)	Specific activity (U/mg protein)	Total activity (U)
Light traffic road	5.70	4.36	61.9	270
Highly busy road	5.320	4.80	73.3	351.6

Extraction of peroxidase from leaves of plane tree was carried out using 0.10 M phosphate buffer (pH 7.0) containing 0.1mM EDTA. Exclusion of EDTA from the extracting buffer did not change the yield at the extraction step, suggesting that most of peroxidase in plane tree leaves is not bound to the cell walls but is present in a soluble form. This was also assumed for peroxidase from royal palm tree leaves [Sakharov I Yu et al.].

Addition of $(NH_4)_2SO_4$ in the second step of purification increased the specific activity of the enzyme to about 8-fold and removed some colored substances and wax from the extract, as the solution was almost clear and lighter in color after this stage. The next step in the presence of DEAE-sepharose, followed by elution of the chromatographic column with elution with 10 mM tris-HCl buffer caused peroxidase passage through the column, while colored compounds in the plane leaf extract were absorbed. The resulting solution was, therefore, clear and colorless. The final step of purification was a gel filtration process on Sephacryl S100. The purified plane tree peroxidase showed a specific activity of 2871 U/mg of protein in the case of highly polluted leaves. Lawry protein assay was performed to measure the protein concentration using purified enzyme instead of bovine serum albumin as a standard. A yield of 15.5% after 39 fold purification is a fairly high yield compared to the values obtained for other peroxidases [Sakharov I Yu et al.], suggesting that tree leaf wastes from highly polluted area are good sources for peroxidase extraction and its possible use in industrial applications.

The UV-Visible spectrum of the novel peroxidase extracted from leaves of highly polluted plane trees showed the typical Soret maximum at 403 nm observed for all plant peroxidases [Smulevich G] The purity index (RZ value) was 2.76 calculated from the product of the absorbance at 403 and 280 nm as follows

$$RZ = A_{403}/A_{280} = 2.76$$

The molecular weight of plane tree peroxidase was 55.6 kDa estimated from its single band in SDS-electrophoresis. This molecular weight value is lower than that reported for peroxidase extracted from leaves of African oil palm tree (57 kDa) [Sakharov I Yu et al.], but higher than peroxidase from royal palm tree [Electrophoretic Theory Catalogue] and peroxidases from other sources [Gazaryan I.G.]. The difference in molecular weight of various peroxidases is probably due to different degree of glycosylation of the enzyme.

Since the optimal conditions for catalysis by different peroxidases are not identical the optimum pH and temperature for plane tree peroxidase was obtained prior to measuring the substrate specificity (Figures 3 and 4 respectively). Using some known peroxidase substrates, i.e. ascorbic acid, guaiocol, 1-phenyl-2,3-dimethyl-4-amino pyrazolan (4-AAP) and tyrosine the substrate specificity of our peroxidase was examined under optimum pH and temperature (Table III). It was shown that for all substrates the pH optima occurred between 6.0-6.2. We found that the plane tree peroxidase is relatively unstable to changes in pH. The enzyme stability remained almost unchanged at pH 6.0-7.0 as shown in Figure 1. Measuring thermal stability of plane peroxidase, we showed that a wide range of temperature is optimal of the activity of this peroxidase (20-40°C). Increasing temperature beyond 40°C caused a steady decrease in the % activity (Figure 2) up to 60°C when plane tree peroxidase totally was unreactive. This kind of thermal stability has also been observed for peroxidase from leaves of *lipomoea palmetto* [Srinivas N.D et al.] and soybean peroxidase [R Sariri et al.].

Table 3. The activity of plane tree peroxidase on various substrates compared to horseradish peroxidase.

Substrate	Activity of peroxidase (μmol/min/mg)	
	Plane tree	Horseradish
4-AAP	157	248
Guaiacol	103	184
Ascorbic acid	95	172
Pyrogallol	73	97
Tyrosine	3	49

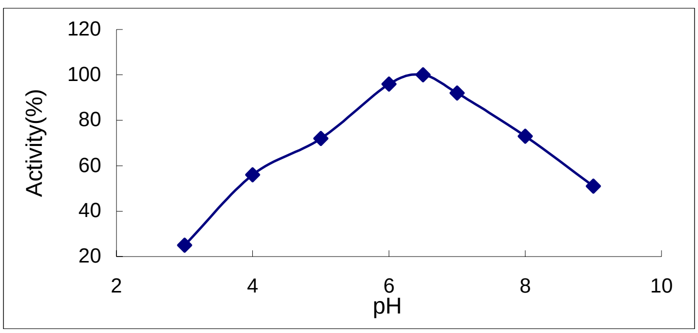

Figure 1. Dependence of plane tree peroxidase activity on pH.

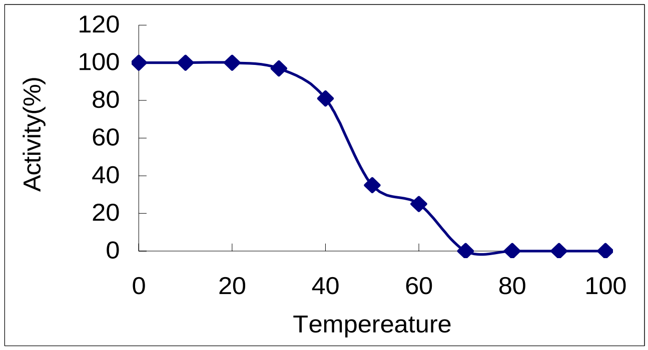

Figure 2. The effect of temperature of the activity of plane tree peroxidase.

4. CONCLUSIONS

1. Peroxidase activity in the leaves of polluted plane trees is higher than the activity of the enzyme extracted from the same tree located in a clean air area.
2. Decrease in peroxidase activity is proportional to the increase in air pollution.
3. The optimum pH of plane tree peroxidase is 60-6.2. Thermal stability of plane peroxidase is constant at 20-40°C and increasing temperature, slowly decreases the activity. The enzyme is totally inactive at 60°C.
4. The yield of purified peroxidase was15.5% after 39 folds purification. The relatively high yield suggests that leaf wastes from plane tree located at highly polluted environment are good sources of the enzyme.
5. The change in peroxidase activity in leaves of plants present in urban area could be used for monitoring the degree of air pollution.
6. The highest activity of plane tree peroxidase is exhibited when 1-phenyl-2,3-dimethyl-4-amino pyrazolan (4-AAP) and guaicol are used as its substrates.

5. ACKNOWLEDGEMENTS

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