AIR POLLUTION DUE TO NO_x EMISSIONS IN AN IRON-STEEL INDUSTRY REGION IN SOUTH-EASTERN TURKEY AND EMISSION REDUCTION STRATEGIES

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ABSTRACT

Emission measurements exposed Isdemir, the 2nd largest integrated iron and steel plant of Turkey, as the largest source of NO_x emissions with 6490 tons/yr followed by all other steel industries in the area with 804 tons/yr of NO_x. Contribution of industrial, domestic heating and traffic sources in the annual NO_x emissions was found to be 67.7%, 1.3% and 31%, respectively. In this study the ground level concentrations of NO_x were estimated by using the US EPA's ISCST3 Model. This study has been carried out for the first time and is important for the region.

The results of dispersion modeling showed that the maximum ground level NO_X concentrations due to Isdemir, is surprisingly low due to tall stacks of Isdemir and the wind condition. The NO_X concentrations due to domestic heating were very low, well below the National and EC limits. However, the NO_X emissions from traffic are found to pose an air pollution problem in the urban areas.

INTRODUCTION

The most industrialized region on the Eastern Mediterranean Coast of Turkey is the Gulf of Iskenderun. This region contains Isdemir, the 2nd largest integrated iron and steel plant of Turkey, and a number of foundries and steel re-rolling mills. Most of these industries does not have emission control systems, or if there is they are not working properly. As a result of uncontrolled emissions from steel industries in this region the air pollution level is high. The population of this area is under risk of poor air quality.

Emission measurements exposed Isdemir as the largest source of NO_x emissions with 6490 tons/yr followed by all other steel industries emitting 804 tons/yr of NO_x. Contribution of industrial, domestic heating and traffic sources in the annual NO_x emissions was found to be 67.7%, 1.3% and 31%, respectively. In this study the ground level concentrations of NO_x were estimated by using the US EPA's ISCST3 Model. This study has been carried out for the first time and is important for the region.

Objectives of the Study

The main objectives of this study are:

- To use the emission inventory results as an input for the air quality modeling studies
- To estimate the ground level concentrations of NO_x by dispersion modeling and to prepare ground level concentration maps
- To designate the areas where NO_x concentration is high as the possible areas prone for high ozone concentration
- To list suggestions based on modeling results for the development of a "clean air plan" for the Iskendern Region, which is necessary according to Turkish Regulation.

Location and Physical Characteristics of the Region

The Iskenderun Region is located between the Mediterranean Sea and Amanos mountain range where peaks reach up to 1700m high from sea level. This gulf region forms a narrow coastal area between the sea and mountains. There are 415,000 inhabitants residing in the study area (SIS, 2002). Major population centers are İskenderun, Dörtyol and Payas with populations of 160,000, 54,000 and 32,000, respectively. The rest of 169,000 people live in several sub-urban areas and villages scattered in the study area. Iskenderun Gulf region is the most industrialized region of the Southeast Turkey. This region is also regarded as the citrus depot of Turkey. During winter most of the dwellings use coal for domestic heating. There are two major inter-city highways passing through the study area, the Iskenderun-Adana Motorway and the E-5 Highway.

Industrial complexes are located at about 17 km north of Iskenderun city. Among these industries, the largest one is ISDEMIR which is an integrated plant with a production capacity of 2,200,000 tons/year and it is the 2nd largest integrated iron and steel works of Turkey. In Turkey, 37% of the total integrated iron and steel production capacity is installed at ISDEMİR.

There are three industrial zones in the area along with ISDEMIR, two in the north and the other in the south of ISDEMIR. Re-rolling steel mills are concentrated in these Organized Industrial Estates. These industries use fossil fuels, iron ores (hematite, magnetite, pyrite) and steel scrap for their production and were suspected to emit large amounts of pollutants including SO_2, NO_x, CO, CO_2, VOC and particulate matter. ISDEMIR produces 45% of the steel production in the region.

MATERIALS AND METHODS

Emission Inventory

The area of interest in this study is the Iskenderun Region covering an area with a width of 25 km and length of 50 km. An emission inventory of the study area has been prepared in this work by taking into account all the possible emission sources. These sources include all the industrial and residential sources (rural and urban), ISDEMIR and all other industries in the Organized Industrial Estates of Iskenderun, Dörtyol and Payas. Moreover, emissions from traffic sources on the Iskenderun-Adana motorway, Iskenderun-Adana highway and urban roads in the cities were also included. Five major pollutants, namely, PM, SO_2, NO_X, CO and VOC were included in this study. Emissions from industries were measured at sources, while emissions from domestic heating and traffic were estimated by using the CORINAIR emission factors (Corinair, 1999). This paper will focus on the NO_x pollution.

Meteorological Data

The air quality modeling of the Iskenderun region in this study is based on the emission inventory data for the year 2001. Therefore, meteorological data of the same year was used in this modeling work. The meteorological data of the Iskenderun station for year 2001 was acquired from the State Department of Meteorology (SDM). This data consisted of sequential hourly records of values for temperature, atmospheric pressure, sunshine hours, cloud cover, mixing height, precipitation, and wind speed and wind direction. The hourly meteorological data is required by the dispersion model (ISCST3) to be used. In addition to these parameters, data for morning and afternoon mixing heights measured at Adana, the nearest synoptic station to Iskenderun, were also taken from the SDM. In order to prepare the meteorological data input files from the raw data the PCRAMMET program was used. The annual wind rose for Iskenderun for the year 2001 is given in Figure 1.

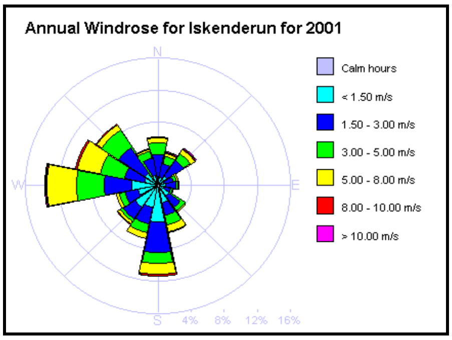

Figure 1. Annual wind rose for Iskenderun for year 2001

Air Quality Modeling

Industrial Source Complex Short Term Version 3 (ISCST3), a model developed by the U.S. EPA (1995) was used to model the NO_x pollution of the study area. The ISCST3 model provides options to model emissions from a wide range of sources that might be present at a typical industrial complex and area surrounding it.

RESULTS AND DISCUSSION

Emission Inventory

The results of emission inventory have shown the total emissions from Industrial activities in the Iskenderun Region. Table 1 gives contributions of several sources to the total NO_x emission and annual emissions from all sources in the study area. Industrial sources include stacks of ISDEMIR and other industries located in the organized industrial estates of Iskenderun, Dortyol and Payas. Area sources contain the dwellings in the city of Iskenderun, town of Dortyol, and other rural residential areas. Emissions from traffic in urban areas and also on the highway and motorway were considered as line sources.

Table 1. Emission load and contributions of several sources to the total NO_x emission

Sources	Total Emission Load, NO_X ton/yr)	Contributions of Sources, %
Industrial	7,295	67.77
Domestic Heating	140	1.30
Traffic	3329	30.93
Total	**10,764**	**100.00**

Air Quality Predictions

Figure 2 shows the annual average ground level concentrations of NO_X. As can be seen from this figure, the annual average ground level concentration reaches up to 158 µg/m^3 in the city center of Iskenderun. Mostly concentration in Iskenderun city lies between 50-150 µg/m^3.

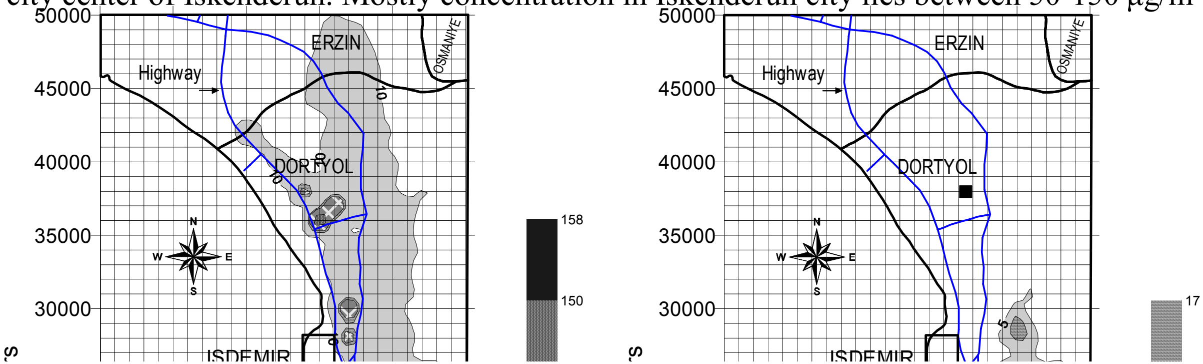

Figure 2. Annual average ground level conc. (µg/m^3) of NO_X due to all sources

Figure 3. Annual average ground level conc. (µg/m^3) of NO_X due to ISDEMIR

In Dortyol and Payas maximum concentrations are 150 and 100 µg/m^3, respectively. The long-term limits for NO_2 and NO are defined as 100 and 200 µg/m^3, respectively, in TAQPR. The major nitrogen oxide in the atmosphere is NO_2. The annual average NO_2 concentrations exceed this limit at the locations mentioned above except Payas. Around these high concentration locations and along the highway and the motorway, there are some pockets where the NO_X concentration is in the range of 100 to 200 µg/m^3. These regions are above the limits set by TAQPR for NO_2. The annual average concentrations of NO_X in the study area except the ones mentioned above are from 10 to 50 µg/m^3. The long-term limits of NO_2 set by EC Regulation and WHO Guidelines are 50 and 40 µg/m^3, respectively.

Whenever the NO_2 concentration is high in the atmosphere there may be a possibility of photochemical smog formation along with NMVOC emissions. This poses a danger to human health. Therefore, ozone and NO_2 measurements in the ambient air especially during summer season are advised for the study area.

The sources of NO_X emissions are industry, traffic and partly residential heating. The contributions of each source in the total annual NO_X emissions were 68%, 31% and 1.3%, respectively. According to the emissions measurements and the emission inventory it was found that 60% of the annual NO_X emissions in the study area were due to ISDEMIR. In order to find the contribution of ISDEMIR on the annual average ground level NO_X concentrations, the model has been run to see its effect separately. The results are shown in Figure 3. As it is clearly seen from the figures that the contribution of industry on the annual average NO_X concentrations is very little, up to 20 µg/m^3 in two small areas. Although ISDEMIR is the largest NO_X emitter in the area, its effect on the annual average ground level NO_X concentration is not much. This is most probably due to tall stacks of ISDEMIR and the wind condition, which ensures better dispersion of NO_X. The maximum NO_X concentration due to domestic heating was 5 μg/m^3, because of very low concentrations the map for domestic heating is not given here. These concentrations are well below the limits set by the TAQPR, EC Regulations and WHO Guidelines.

Figure 4 shows the annual average ground level concentration of NO_X due to the traffic on Iskenderun-Adana Highway and Motorway located in the study area. This figure shows that there are a number of pockets along these roads where NO_X concentration changes between 10 and 40 μg/m^3. The maximum NO_X concentration due to highway traffic was found to reach up to 55 μg/m^3 but only at three very small pockets adjacent to these inter-city roads. The contribution of all other sources to the NO_X concentration at the ground level is very small, being between 5 and 10 μg/m^3. Only on very small area the concentration reaches up to 15 and 20 μg/m^3.

Figure 5 shows the annual average NO_X concentrations due to urban traffic at Iskenderun, Dortyol and Payas. The maximum NO_X concentration reached in the central parts of Iskenderun up to 150 μg/m^3. Generally a NO_X concentration of over 10 μg/m^3 prevails over almost in all of the urban areas in the study area, but central and eastern parts of Iskenderun City found to be subjected to a NO_X concentration of 40-100 μg/m^3, which is although below the limits set by the TAQPR, but exceeds the WHO Guidelines and EC limits. Therefore, the NO_X emissions form traffic are found to pose an air pollution problem in the urban areas.

A very characteristic result is seen in Figure 2. As can be seen in the figure there is a belt of NO_X concentration areas along the highway and motorway where the concentration is between 10 and 40 μg/m^3. Although the limits of TAQPR are satisfied in most of the study area except in cities of Iskenderun and Dortyol, the NO_X concentrations are above the limits according to the EC Regulation and the WHO Guidelines. The sources of NO_X emissions are industry, traffic and partly residential places. The contribution of each in total annual NO_X emissions was 68%, 31% and 1%, respectively. According to the emissions measurements and the emission inventory it was found that 60% of the annual NO_X emissions in the study area were due to ISDEMIR. In order to find the contribution of ISDEMIR on the annual average ground level NO_X concentrations the model has been run to see its effect separately also. The results have shown that the contribution of industry on the annual average NO_X concentrations is small, up to 20 μg/m^3 in two small areas. Moreover, it was revealed that almost all of the ground level NO_x concentration in the study area was due to traffic sources on inter-city (26%) and urban roads (65%). 8% was due to residential heating in Iskenderun.

The comparison of the model accuracy found in this study with those in the previous studies shows a good agreement.

CONCLUSIONS

The result of the dispersion modeling showed that the Iskenderun City, the largest residential area in the region was least affected by industrial emissions due to the prevailing wind directions from S and W, and location of industries at least 15 km north of this city.

Although the limits of TAQPR are satisfied in most of the study area except in cities of Iskenderun and Dortyol, the NO_X concentrations are above the limits according to the EC Regulation and the WHO Guidelines. The results have shown that the contribution of industry on the annual average NO_X concentrations is small. Moreover, it was revealed that almost all of the ground level NO_x concentration in the study area was due to traffic sources on inter-city (26%) and urban roads (65%).

The NO_X concentrations due to domestic heating were very low, well below the National and EC limits. However, the NO_X emissions from traffic are found to pose an air pollution problem in the urban areas. Generally, industries are the first sources that are blamed for the pollution. However, in this case it was seen that in an industrial area NO_x pollution due to traffic has overridden the pollution due to industry. The strategy to reduce the ground level NO_x concentration would be to use catalytical convertors for the cars.

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