MANAGEMENT OF AIR QUALITY IN IRON-STEEL INDUSTRY REGION IN SOUTH-EASTERN TURKEY AND EMISSION INVENTORY OF SEVERAL POLLUTANTS

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ABSTRACT

Iskenderun Gulf Region is the most industrialized region of the Southeast Turkey. The second largest integrated iron and steel works of Turkey is located in this region. There are also several re-rolling steel mills. Air pollution control is not applied in the region and has become an alarming problem. The population in this area is about 415 000 and the region is regarded as citrus depot of Turkey. Also there are fertile lands in the northern part of the region. A good air quality management system is necessary here in order to protect the environment.

In this study, an emission inventory has been done in this region for the first time. The types of sources included in this study were industrial, domestic heating and traffic on inter-city as well as urban roads. Pollutants included were Particulate Matter (PM), SO_2, NO_X, and CO. The emissions from industrial sources were determined by stack gas measurements, and from domestic and traffic sources emissions were calculated by using emission factors.

The results of the emission inventory revealed that the annual emissions of PM, SO_2, NO_X, and CO were 19,951 tons, 40,833 tons, 10,764 tons, 109,938 tons and 5665 tons, respectively. Industrial sector was responsible for more than 95% of the total emissions of PM and SO_2. Traffic sources were responsible for 31% of NO_X and 27% of CO in the total annual emissions from the Iskenderun Region.

INTRODUCTION

Clean air is considered to be a basic requirement for human health and their well- being. Air pollution has become an alarming problem with industrialization, and protection of air quality turned into a topic of great interest since early 1960's. The United Nations Conference on Environment and Development (UNCED) held in 1992 at Rio de Janeiro, Brazil, adopted the Framework Climate Convention (Agenda 21) which underlined the need of air pollution control. Also, the declaration of Habitat II (United Nations Conference on Human Settlements held in June 1996, at Istanbul, Turkey) emphasized the "sustainable development" and "sustainable human settlements" for the protection of environment. In sustainable human settlements clean air was one of the most important considerations put forward among the other environmental issues.

Industry is a major source of pollution when proper controls of the emissions are not made. Consequently, industrial operations can affect the health of workforces, the environment and the health of nearby and some times very far located populations. Iron and steel industry is regarded as one of the basic industries for the development of any country. On the other hand, iron and steel industries are one of the major sources of air pollution, which is included in the list of industries with significant health impacts (WHO, 2000).

Objectives of the Study

The main objectives of this study are:

- To prepare an emission inventory of a region which contains the most polluting iron and steel industry
- To find the contributions of several industries to air pollution in the region,
- To use this inventory as an input for the air quality modeling studies
- To list suggestions for "clean air plan" in the Iskendern Region

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 ISDEMIR. 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

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). The emission inventory of the Iskenderun region in this study is based on the inventory data for the year 2001. The emission inventory is used to describe and compare the contributions of several air pollution sources to the total pollution load, and to evaluate the control measures. This inventory is also used as an input to the dispersion modeling calculations and provides basis for preparation of a "clean air plan".

Pollutants included in this study basically depends upon the raw materials and fuel used in industries, vehicles and domestic heating activities. The largest industrial installation in the study area is İSDEMİR, which is the 2nd largest integrated iron and steel complex of Turkey. It uses iron ores, coal, fuel oil and LPG as raw material and fuels. Other steel industries located in Organized Industrial Estates use fuel oil in their furnaces. On the other hand major fuel used for domestic heating is coal followed by fuel oil in some dwellings in the urban areas. Diesel and gasoline are fuels used in vehicles as usual. Therefore, five major pollutants, namely, PM, SO_2, NO_X, CO, and VOC are included in this study.

RESULTS

Types and properties of several fuels used in the study area are summarized in Table 1. Generally the sulfur content of the fuels is high except coke.

Table 1. Properties of several types of fuels

Fuel Type	Heating Value (MJ/kg)	Sulfur (% by wt)	Ash (%by wt)	Density (kg/m^3)
Domestic Fuel oil[1]	41	1.5	0.1	950
Fuel oil No.6[1]	41	6	0.2	998
Coal[3]	26.7	0.6-3.6	8.5-11	1600
LPG(Liquefied)[2]	45.4	-	-	550
Natural gas[2]	49.8	-	-	0.68
Coke[3]	27.7	0.7	11	1200
Blast furnace gas[3]	2.4	Unknown	Unknown	1.31
Coke gas[3]	36.7	Unknown	Unknown	0.44

[1] TUPRAŞ, 2002, [2] BOTAŞ, 2002, [3] İSDEMİR, 2001

Emissions from Industry

The emissions from the integrated iron and steel industry is given in Table 2. As can be seen from this table, the largest pollution load is due to CO, and then due to SO_2 and PM. The other integrated iron and steel industries in Turkey are ERDEMIR and KARDEMIR. The amount of emissions from coke and by products and sinter units of ERDEMIR and ISDEMIR are compared in Table 3.

Table 2. Pollution loads from the stacks of ISDEMIR

Unit	PM (kg/h)	SO_2 (kg/h)	NOx (kg/h)	CO (kg/h)	PM (ton/y)	SO_2 (ton/y)	NOx (ton/y)	CO (ton/y)
Coke and By Products	177	341	109	1265	1403	2704	866	10019
Sinter	758	1308	129	4043	6002	10359	1022	32021
Blast Furnace	512	-	46	4192	4054	-	364	33197
Steel Making	64	-	12	549	505	-	95	4349
Re-rolling Mills	102	491	96	-	805	3890	758	-
Energy Production	788	2006	427	-	6239	15884	3384	-
Total	**2400**	**4146**	**820**	**10049**	**19009**	**32836**	**6490**	**79585**

Table 3. Comparison of emissions from ERDEMIR and ISDEMIR

Industry	Unit	Pollutant Emissions (g/kg)			
		PM	SO_2	NO_X	CO
ERDEMIR	**Coke**	0.25	1.45	0.92	2.70
	Sinter	0.50	1.09	1.09	17.81
ISDEMIR	***Coke***	1.08	2.07	0.66	7.69
	Sinter	2.79	4.81	0.47	14.86

As given in Table 3, the PM emissions from coke and sinter units of ISDEMIR were 4 time and about 6 times more than the emissions from same units of ERDEMIR, respectively. High emissions of PM from ISDEMIR are attributed to either improper working or need for maintenance of PM control systems. Moreover, after privatization of ERDEMIR, investments were made for improving the PM control systems.

SO_2 emissions from coke units of ISDEMIR and ERDEMIR are close to each other. But sinter unit of ISDEMIR emits almost five times more SO_2 as compared to the sinter unit of ERDEMIR. Both ERDEMIR and ISDEMIR do not have FGD systems, thus the difference in SO_2 emissions comes from the sulfur contents present in iron ores and coal used at respective steel mills. Sivacoumar et al. (2001) reported NO_X emissions of 667 kg/h from TISCO (Tata Iron and Steel Company, Jamshedpur, India). TISCO is also an integrated iron and steel mill like ISDEMIR. NO_X emissions from ISDEMIR are found to be 820 kg/h, which is close to that of NO_X emissions from TISCO.

Total annual industrial emissions are given in Table 4. As seen from the table ISDEMIR is the largest contributor to the emission load and the % is more than 90 except SO_2.

Table 4. Annual industrial emissions

INDUSTRY	PM (ton/y)	SO2 (ton/y)	NOx (ton/y)	CO (ton/y)	VOC (ton/y)
ISDEMIR	19,009	32,836	6,490	79,585	208
All Other Industries	94	6,802	804	143	10
Total	**19,103**	**39,638**	**7,295**	**79,728**	**218**
ISDEMIR	99.5%	82.8%	89.0%	99.8%	96.0%
All Other Industries	0.5%	17.2%	11.0%	0.2%	4.0%

Emissions from Domestic Sources

The emissions from domestic sources are calculated by using the emission factors given in Table 5. The total population in the area is 413,642. The total number of dwellings is 79,547, out of which 48,231 use coal for heating during winter. About 210 000 of the population live in the urban area and the rest in the rural area. The total annual emissions from domestic sources are given in Table 6. The largest amount of emission is SO_2 and PM.

Table 5. Emission factors used for domestic heating. (Corinair, 1999)

Fuel	Emission Factors					
	Units	PM	SO_2	NO_X	CO	VOC
Coal	kg/ton	1.5 * A	15 * S	2.9	1	2.5
Fuel oil	kg/m^3	0.3	17.24 * S	2.2	0.6	0.3

A: ash content of coal (% by weight), S: Sulfur content of fuel (% by weight)

Table 6. Annual emissions from domestic heating

Place	PM (ton/y)	SO2 (ton/y)	NOx (ton/y)	CO (ton/y)	VOC (ton/y)
Dortyol Urban	93	172	20	6	15
Dortyol Rural	134	209	25	8	22
Iskenderun Urban	283	524	60	18	47
Iskenderun Rural	185	289	35	11	30
Total	**696**	**1,195**	**140**	**42**	**114**

Emissions due to Traffic

The traffic emissions are increasing every day with the increase in the number of vehicles in the study area. The number of registered vehicles and assumed to be on road per hour is given in Table 7. Again the emissions are calculated by using Corinair emission factors.

Table 7. Number of registered vehicles (2001) and assumed to be on road per hour

City	No. of Registered Vehicles	No. of vehicles exclusive of tractors, trucks and 75% of buses	% of vehicles on road/h	No. of vehicles on road/h
Iskenderun	45,436	41,712	45	18,770
Dortyol	9,923	8,296	20	1,660
Payas	5,923	4,952	20	990

Table 8. Total emissions from traffic sources

Source	PM (ton/y)	NO_X (ton/y)	CO (ton/y)	VOC (ton/y)
ISKENDERUN City	54	2,419	24,975	4,462
DORTYOL Town	7	314	3,237	578
PAYAS Town	3	116	1,203	215
Iskenderun-Adana Highway	62	307	420	45
Iskenderun-Adana Motorway	27	173	333	32
Total	**153**	**3,329**	**30,168**	**5,332**

Total Emissions: The results of total emission inventory are given in Table 9. Table 10 gives the contributions of several sources to the total annual emission from all sources. As can be seen from tables the largest emission load is for CO and SO_2, then PM and NO_x. It is interesting to note that about 30 % of CO and NO_x emissions are due to traffic. The contribution of traffic on VOC emissions is about 94%.

Table 9. Total annual emission loads from all sources

Sources	Total Emission Loads (ton/y)				
	PM (ton/y)	SO_2 (ton/y)	NO_X (ton/y)	CO (ton/y)	VOC (ton/y)
Industrial	19,103	39,638	7,295	79,728	218
Domestic Heating	696	1,195	140	42	114
Traffic	153	-	3329	30,168	5332
Total	**19,952**	**40,833**	**10,764**	**109,938**	**5664**

Table 10. Contributions of several sources in the annual pollution load

Sources	Contributions of Sources to Total Annual Emissions				
	PM (%)	SO_2 (%)	NO_X (%)	CO (%)	VOC (%)
Industrial	95.75	97.07	67.77	72.52	3.85
Domestic Heating	3.49	2.93	1.30	0.04	2.01
Traffic	0.76		30.93	27.44	94.14

CONCLUSIONS

The result of the emission inventory have shown that industrial sector is the largest contributor in the pollution load in the study area, and this sector is responsible for 97% of the total SO_2 emission, 96% of the total PM emission, 73% of the total CO emission and 68% of the total NO_X emission. As far as VOC emissions are concerned the share of traffic sources is 94% followed by 4% and 2% from industrial and domestic heating sources, respectively.

For the air quality management the very important issue in this area is to control the emissions. Therefore, if some clean air plans were to be made in this area, the major target to reduce pollution is the industrial sources. The emissions of PM from ISDEMIR are 160 times higher than the limit defined in TAQPR. A scenario was studied assuming that PM emissions from ISDEMIR are below the limit. The results of this scenario show about 59% reduction in the ground level concentrations of PM due to ISDEMIR. It is, therefore, suggested that in the clean air plan due attention should be given to control PM emissions from ISDEMIR. Efforts should be directed towards shifting the industries and houses to cleaner fuels such as natural gas instead of fuel oil or coal. Natural gas will be available for use in the Iskenderun region in 2004 (BOTAŞ, 2002).

Major sources of emissions in Iskenderun Region have been identified in this study. Based on outcomes of this study a comprehensive clean air plan should be developed by local authorities for Iskenderun region.

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