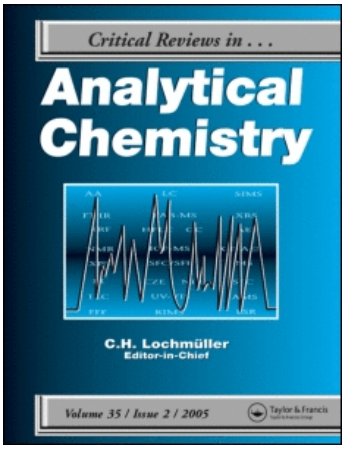

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Assessment and Mitigation of Environmental Impacts of Industrial Processes in Macedonia

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1. INTRODUCTION

The environmental situation in Macedonia is comparable to that of other Central and Eastern European countries, where development was shown mainly in terms of increasing industrial and energy production that led to environmental degradation and over-exploitation of natural resources [1].

In 1997, the National Environmental Action Plan (NEAP) was developed with input from governmental and non-governmental representatives, establishing the following main national environmental policy goals: air and water quality improvement, biodiversity conservation, forest renewal and preservation, as well as strengthening the environmental management capacity of institutions responsible for monitoring and enforcement.

In this paper, the contribution of industrial processes to environmental pollution in Macedonia is considered. For illustration, more detailed results concerning greenhouse gases (GHG) emissions are presented. In conclusion, some key areas and strategies for improvements are recommended.

2. INDUSTRIAL POLLUTION

Because half of the country's urban population is affected by poor air quality (particularly in the cities of Skopje, Veles, Bitola, and Tetovo), the NEAP rated air pollution the most important environmental problem in the country. Pollution is caused mainly by industries (e.g., metallurgical plants and thermal power plants) and traffic. In addition to sulfur dioxide, hydrocarbons, carbon oxides, and nitrogen oxides, significant concentrations of heavy metals, such as lead, zinc, and cadmium are being emitted by some of these sources. Various studies, particularly those conducted in Skopje and Veles, have shown that a large number of children in cities are suffering from respiratory diseases associated with air pollution. Reduction of emissions in Veles is one of the top priorities of the NEAP.

Concerning the wastewater, the amount receiving treatment in Macedonia is extremely low, since there is only one official wastewater treatment plant in the whole country that treats only a very small portion of the country's total discharges. Consequently, large parts of the country are affected by surface-water and groundwater pollution. The Vardar River supplies 75% of the country's total water resources and is heavily polluted by untreated urban and industrial pollution. The largest contributors of industrial pollution are the metallurgical, chemical, and mining industries.

Serious and widespread problems are arising from industrial and hazardous wastes. There is no nationally organized system for the collection, storage, treatment, or disposal of industrial waste and no adequate legislation governing waste export to other countries. The existing regulations controlling the management of solid waste in Macedonia are inadequate. The current

practices are rudimentary and associated environmental problems are clearly evident. Furthermore, Macedonia has introduced limited policies and legislative controls on the use, transport, storage, and safe disposal of chemicals, including ozone-depleting substances, pesticides, and biocides.

Macedonia is trying to make progress in the field of environmental protection. Recently, steps have been taken to begin research projects that deal with environmental problems, the creation of appropriate institutional structures, the establishment of an environmental legislative.

3. GHG EMISSIONS FROM INDUSTRIAL PROCESSES

Amounting 1141 kt/year CO_2-equivalent emissions out of a total of 14 612 kt/year CO_2-equivalent emissions, the Industrial Processes sector significantly contributes to the total GHG emissions in Macedonia. However, the main GHG pollution comes from the Energy sector. For the sake of comparison, some relevant results of two recent studies on GHG in Macedonia are graphically presented in Figures 3.1 and 3.2 [2, 3]. As shown, a sectorial approach has been applied, distinguishing the five most important sectors-contributors to total GHG emissions: energy, industrial processes, agriculture, land use change, and forestry and waste.

GHG emissions from Industrial Processes mainly include carbon dioxide. In addition, this sector is accountable for the low emissions of nitrous oxide and methane, which are related to the production of some chemicals. The inventory of GHG emissions for Industrial Processes covers the following three areas: mineral products, chemical industry, and metal production. CH_4 emissions related to industrial wastewater from the sector waste, amounting about 2 kt/year CH_4 (i.e., 42 kt/year CO_2-equivalent), can also be considered as GHG emissions coming from industry.

Due to the intensive transition processes in the national economy and politics during the analyzed period (1990–1998), a drop in the industrial production growth rate occurred. Consequently, the closing of some large industrial companies led to an intensive decrease of total production. As a result, a decline of CO_2 emissions of more then 36% occurred from 1990 to 1998. The stabilization process of the activities in the industry is still ongoing, partially with the privatization of some capacities and with restarting the process in some sectors of the industry.

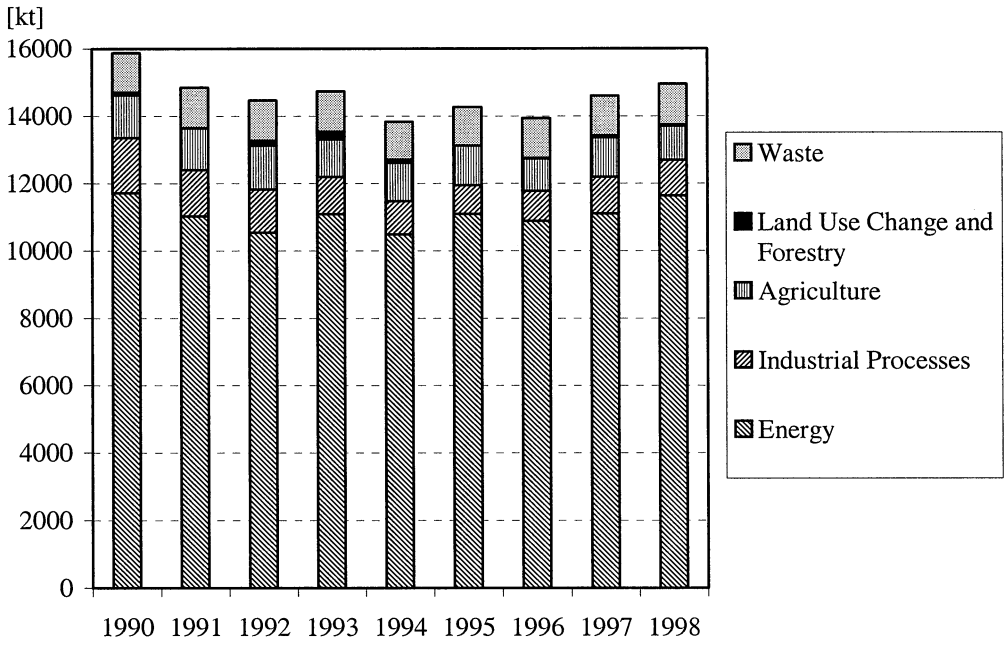

FIGURE 3.1. Sectorial CO_2-equivalent emissions.

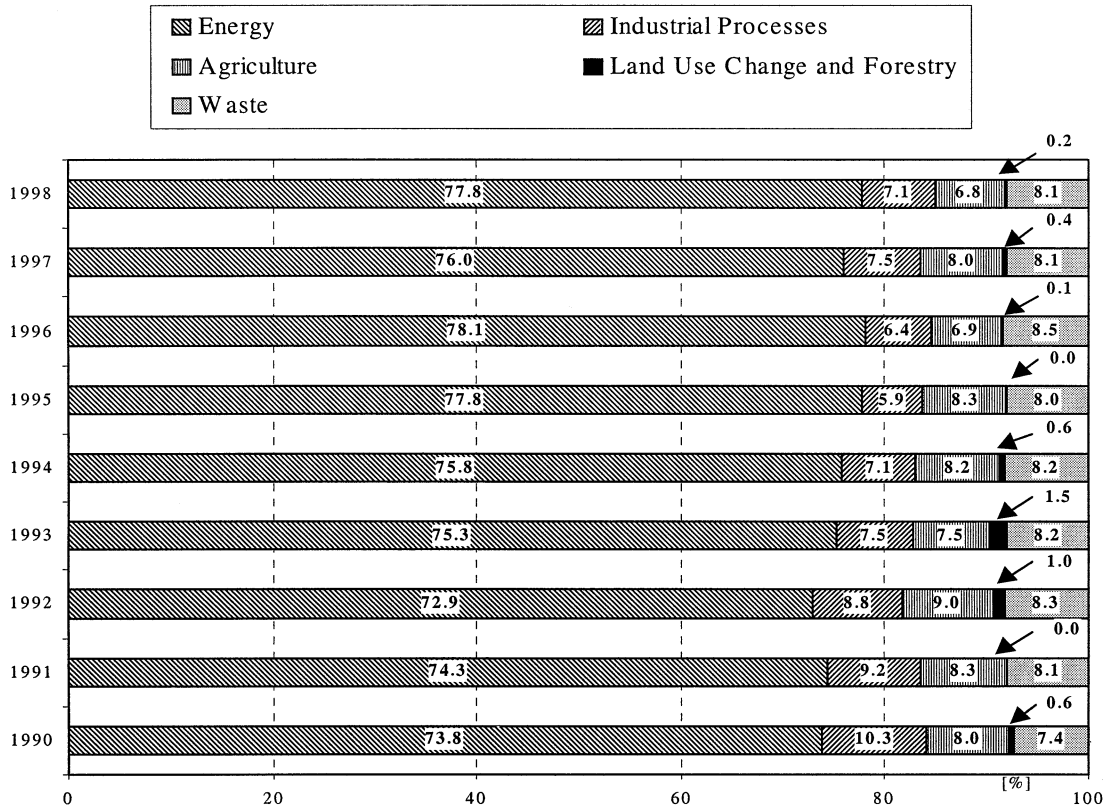

FIGURE 3.2. Sectorial contribution to CO_2-equivalent emissions.

3.1 Mineral Products

The share of Mineral Products in the total emission of CO_2 in the Industrial Processes sector is 41%, and emission is coming from three main processes: cement production, lime production, and limestone and its dolomite use. Emission of CO_2 from soda ash production and its use is a minor share of total emission, being less than 1% and can be neglected. Table 3.1 summarizes the CO_2 emissions from this subsector.

It can be concluded that after a certain drop in CO_2 emission and a small increase from 1993 to the present, the total emission is stabilized on the level of approximately 400 kt/year CO_2. This level is expected to be maintained in the near future with a small annual increase.

3.2 Chemical Industry

The share of Chemical Industry in the total emission of CO_2 in the analyzed period is only 1%. Emission is coming from two main processes: ammonia production and carbide production. The CO_2 emissions from this subsector are presented in Table 3.2.

TABLE 3.1
CO_2 Emissions (kt) from Mineral Products

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Mineral Products	621.86	536.13	439.30	342.03	358.05	416.81	398.32	455.73	376.75
Cement Production	318.55	301.96	257.25	248.80	242.50	260.96	244.69	304.47	229.91
Lime Production	29.59	23.06	26.76	19.67	11.14	9.76	7.67	3.43	0.76
Limestone and Dolomite use	273.72	211.10	155.29	73.56	104.42	146.08	145.96	147.83	146.08

TABLE 3.2
CO_2 Emissions (kt) from Chemical Industry

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Chemical Industry	17.53	15.82	14.54	15.85	12.73	12.38	14.58	11.80	14.09
Ammonia Production	11.93	10.96	10.77	11.61	9.11	7.39	9.90	7.71	10.48
Carbide Production	5.60	4.86	3.77	4.24	3.62	4.99	4.68	4.10	3.60

TABLE 3.3
CO_2 Emissions (kt) from Chemical Industry

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
C Metal Production	919.79	745.13	780.53	690.22	515.65	364.37	427.50	569.44	602.95
Iron and Steel Production	538.05	356.44	319.04	238.58	128.46	87.85	82.35	108.66	108.68
Ferroalloys Production	250.27	244.18	298.40	244.84	213.87	229.57	262.78	268.16	307.29
Other (Zn,Ag,Cd,Pb)	131.47	144.50	163.09	206.80	173.32	46.95	82.37	192.62	186.99

TABLE 3.4
CO_2-Equivalent Emissions [kt] (1 kt $CH_4 \equiv$ 21 kt CO_2 1 kt $N_2O \equiv$ 310 kt CO_2)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total Industrial Processes	1629.6618	1369.2776	1279.33	1102.72	989.131	844.413	893.272	1099.89	1062.1
Mineral Products	621.86	536.13	439.3	342.03	358.05	416.81	398.32	455.73	376.75
Chemical Industry	88.01	88.02	59.50	70.47	115.43	63.23	67.45	74.72	82.40
CO_2	17.53	15.82	14.54	15.85	12.73	12.38	14.58	11.8	14.09
CO_2-equivalent from CH_4	0.17	0.31	0.23	0.13	0.12	0.17	0.05	0.05	0.05
CO_2-equivalent from N_2O	70.31	71.89	44.73	54.50	102.58	50.69	52.82	62.87	68.26
Metal Production	919.79	745.13	780.53	690.22	515.65	364.37	427.5	569.44	602.95

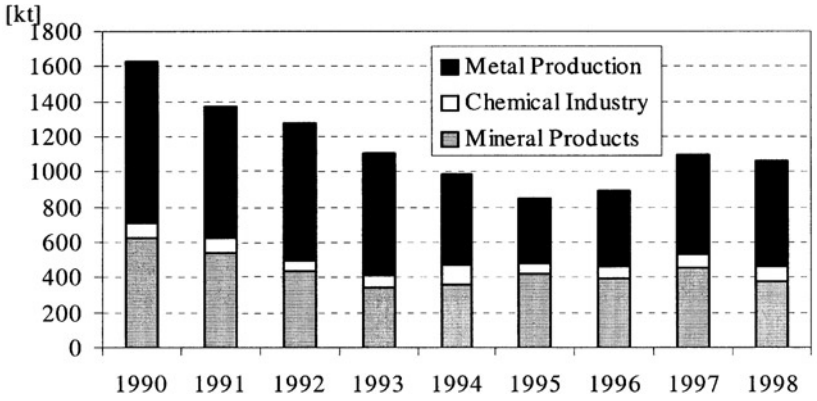

FIGURE 3.4.1. Subsectorial CO_2-equivalent emissions from Industrial Processes.

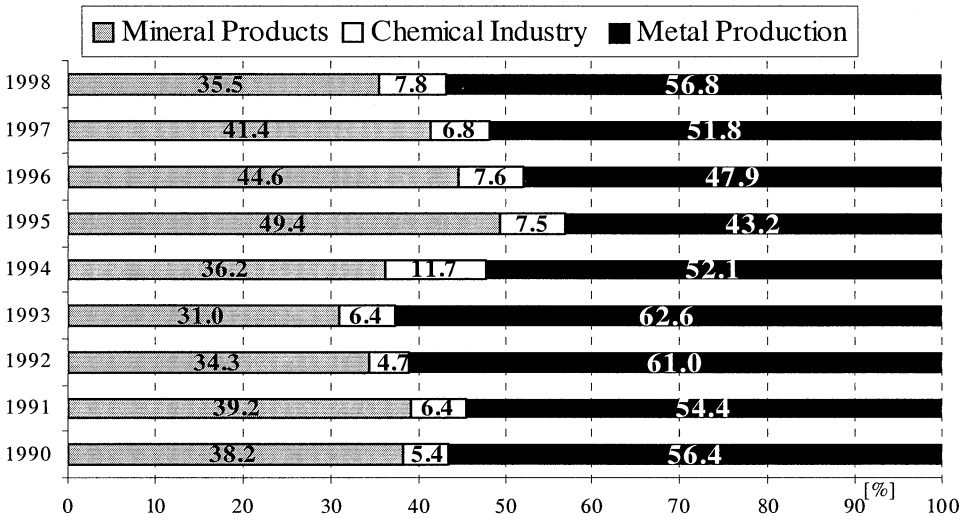

FIGURE 3.4.2. Subsectorial contribution to CO_2-equivalent emissions from Industrial Processes.

Additionally, this subsector accounts for the low emission of CH_4 from the production of other chemicals (ethylene, carbon black, and methanol), amounting less than 0.01 kt/year. The same situation occurs in N_2O emission from adipic acid production, with an average emission of 0.2 kt/year N_2O. These additional emissions increase the contribution of this subsector to total CO_2-equivalent emissions from Industrial Processes to the averaged 7%.

3.3 Metal Production

Emissions coming from this subsector can be divided into three main processes: iron and steel production, ferroalloys production, and production of other metals (Zn, Ag, Cd, and Pb) The production of ferronickel ferroalloy is incorporated into the iron and steel production subsector, as a result of the high percentage of iron in this alloy. The Table 3.3 displays the CO_2 emissions from this subsector.

3.4 Summarized CO_2-Equivalent Emissions from Industrial Processes

The results point out the subsector Metal Production as the most intensive in terms of GHG emissions, with an averaged contribution of 55% to total emissions coming from Industrial Processes in Macedonia. The subsector Mineral Products follows with an averaged share of 38%. Both subsectors include only CO_2 emissions, in contrast to the subsector Chemical Industry, where, besides a small amount of CO_2, the other GHG (N_2O and CH_4) are emitted.

A detailed overview of the emissions from Industrial Processes in the period 1990–1998 is given in Table 3.4, while Figures 3.4.1 and 3.4.2 graphically present the total GHG emissions from Industrial Processes and the contribution of each subsector.

4. CONCLUSION

Regarding environmental pollution, two key areas of improvement emerged: (a) implementation of environmentally acceptable industrial processes, including measures for adequately controlling the use of chemicals, and (b) adequate handling, storage, treatment, and disposal of industrial waste.

These improvements should include a long-term reduction in the amount of energy and material used per unit of product (efficiency or intensity) and could be realized, if sustainable energy technologies are introduced.

In designing and evaluating institutions and incentives to encourage sustainable energy technologies, it will be important to carefully examine system implications for these technologies over their full life cycles. Strategies such as material balance modeling and economic-input-output analysis,

together with the consideration of environmental loadings, should be employed.

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