Emission of Acidifyng Air Pollutants in The Republic of Macedonia

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Abstract

The paper will be made a comparative analysis of the emissions are continuously measured as SO2 and NOx in the atmosphere in the Republic of Macedonia. The trend of the total emission of pollutants will be displayed by sectors of activities under the SNAP Nomenclature for the period 2001-2010. Will be processed and the trend of the total amount of emitted SO2 and NOx by several sources and shown for many years and cartographic items. Emissions of acidifying substances cause damage to human health, ecosystems, buildings and materials. This paper aims to show the situation in the Republic of Macedonia regarding this issue and what progress has been made in reducing acidifying substance emissions in the air.
Keywords: acidification, emission, pollutants

Introduction

Acidifying pollutants originate primarily from the anthropogenic emissions of sulfur dioxide (SO2), nitrogen oxides (NOx) and ammonia (NH3), (EMEP, 2012). The SO2 is mostly emitted into the atmosphere by the burning of coal, especially in the installations for production of electrical energy. This pollutant substance is also discharged by industrial processes that take place in smelters, oil refineries, the paper and cellulose manufacturing industries, metal industry and transport (Djukovic, Bojanic, 2000). The NOx emissions in the atmosphere come from the processes of high temperature burning (like those that happen in automobiles), the burning of coal, oil, home fireboxes and the incineration of waste (MEPP, 2012). The NH3 emissions are related to agricultural activities such as storage of manure, soil fertilizing, animal husbandry etc. (EMEP, 2012). They can be transported over the national borders and cause adverse effects far away from the actual emission sources. Acidifying pollutants are removed from the atmosphere by wet ("acid rain") or dry (direct uptake by vegetation and surface) deposition (Markovic et all., 1996). The deposition of the acidifying pollutants causes many adverse effects on all the elements of the environment. They raise the acidity of the surface and groundwater threatening the survival of the living organisms usually found in them. They have harmful effects on the soil they fall on, destroying forests and other vegetation. The acid rains also destroy the material goods (steel constructions, building objects, cultural and historical monuments, automobiles etc.). Indirectly, the acid rains have adverse effects on the health of the humans (Dimitrovska, 2004).

Study Area

The Republic of Macedonia is located in Southeastern Europe, in the center of the Balkan Peninsula. According to the geographical position it is the central Balkan country. The geographical position of the country is very favorable and many important roads that connect many countries of the Balkans and this part of Europe intersect here. An important traffic route is the corridor 8 and corridor 10, and the international highway E-75, the road M5 and the international railway route. The Republic of Macedonia covers a surface of 25.713 km2. The relief is mostly mountainous and is characterized by large and high mountain massifs, allowing for extensive valleys and plains in between the; the average altitude is 829 m. The sub –

Mediterranean climate is prevalent in the Republic of Macedonia with typical hot and dry summers and cold and damp winters.

Map of the Republic of Macedonia
Sourse: http://www.nationsonline.org

The average annual temperatures fall from the north to the south of the country. The average annual rainfall in the mountains is around 1000-1500 mm, and about 600-700 mm in the valleys. The longest river is Vardar that mostly runs through the central part of the country. Its basin covers most of the surface of the country and is a part of the Aegean catchment basin. Three big natural lakes: Ohrid, Prespa and Dojran lay on the southern border. According to the 2002 census, the total population is 2.022.547 inhabitants with an average population density of 78.6 citizens per km2, with 60% of them live in urban areas. From the industrial branches most distinguished are the food and the tobacco industry, and also the production of iron and steel.

Data and Methods

The paper is mainly based on the analysis of data and information collected mostly from governmental institutions and their publications. The main sources of data for the quantity of emission of substances that cause acidity are gathered from the State Statistical Office and the Ministry for Environment and Physical Planning of the Republic of Macedonia. Furthermore, the necessary data for the sectors energy industry and transport are gathered from the State Statistical Office of the Republic of Macedonia. Because this paper is focused on presenting the condition and the trend of emissions of the substances that cause acidity, few statistical methods are used for processing the data: method of analysis, method of synthesis and comparative method.

Results

Trend of emissions of pollutants

In order to get the trend of movement of the total emission of pollutant substances that cause acidity, the emissions of SO2 and NOx have been analyzed in the period from 2001 to 2010, whilst we are not able to analyze the emissions of NH3 due to incomplete data. The trends have been made based on the quantities of emissions that have been processed in accordance with the SNAP (Selected Nomenclature of Air Pollution) nomenclature methodology, which comes from the EMEP/CORINAIR program (Core Inventory for air Pollution). In the frames of the

CORINAIR program, in 2005 in the Republic of Macedonia an Inventory of emissions of substances in the air by giving sectors i.e. activities was established, and in 2008 and 2010 an addition to all the SNAP sectors was made (MEPP, 2012a). The sectors in accordance to the CORINAIR methodology and the SNAP selective nomenclature are given in the following table:

Table 1. SNAP sectors

SNAP sector	Name
01	Combustion in energy and transformation industries (stationary sources)
02	Non-industrial combustion plants (stationary sources)
03	Combustion in manufacturing industry (stationary sources)
04	Production processes (stationary sources)
05	Extraction and distribution of fossil fuels and geothermal energy
06	Solvent and other product use
07	Road transport
08	Other mobile sources and machinery
09	Waste treatment and disposal
10	Agriculture
11	Nature

Source: (MEPP, 2012a)

In the Republic of Macedonia in the period 2001-2010, a variation of the trend of total emissions of acidifying pollutants (Table 2) can be noticed, where from 2008 up until the end of the analyzed period there is a noticeable mild trend of reduction of the emissions.

Table 2. Total emission of acidifying substances according to SNAP sectors (ktonnes/year)

SNAP Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SNAP 01	107,10	107,10	107,10	104,96	103,08	103,08	96,80	111,49	110,53	83,85
SNAP 02	7,44	7,44	14,34	2,56	2,59	2,59	2,46	2,60	2,60	2,14
SNAP 03	0,50	0,60	6,72	9,19	11,26	11,26	17,34	18,03	18,03	14,87
SNAP 04	3,60	38,35	38,97	5,29	5,32	5,32	2,89	4,93	0,50	0,69
SNAP 06	35,10	35,10	7,70	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SNAP 07	11,80	11,80	23,00	9,97	10,47	10,47	12,60	10,49	10,49	8,84
SNAP 08	0,00	0,00	0,00	2,32	2,47	2,47	3,00	2,65	2,65	1,61
TOTAL	165,54	200,39	197,83	134,29	135,19	135,19	135,09	150,19	144,80	112,00

Data source: (MEPP, 2012b)

The energy sector (SNAP 01-03), although it notes variability, still has the greater share of 57.5% in 2002 up to 90.5% in 2009 in the total emissions that cause acidification of the air. In the industrial processes (SNAP 04 and 06) also shows a variation of the trend of emissions where their participation in the overall emissions ranges from 0.3% in 2009 to 36.6% in 2002. The transport sector (SNAP 07 and 08) has a smaller share in the overall emissions and ranges from 5.8% in 2002 up to 11.6% in 2003.

From the analysis of the data (Table 3) there is a noticeable trend of reducing the amounts of SO2 after 2002 with a mild increase in 2008-2009 and a fall in 2010. The emissions of NOx in the analyzed period are variable, that is slight oscillations are seen after 2003.

The largest portion of the quantity of emission of SO2 in the Republic of Macedonia (Table 4), around 65% from the overall emissions in the period 2001-2003 and 85-91% of the overall emissions in the period from 2004-2010 is a result from the burning of fossil fuels for the production of electrical energy in the thermal power plants that use coal (REK Bitola and REK Oslomej) and lack installations for desulphurization and production of heat.

Table 3. Total emission of acidifying substances, SO2 and NOx (ktonnes/year)

Substance	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SO2	136,53	165,88	150,33	100,79	100,63	100,63	100,08	113,57	112,33	83,00
NOx	29,01	34,51	47,5	33,54	34,56	34,56	35,01	36,62	32,47	29,00
TOTAL	165,54	200,39	197,83	134,29	135,19	135,19	135,09	150,19	144,80	112,00

Data source: (MEPP, 2012b)

Table 4. Quantities of emissions of SO2 in the period 2001 to 2010 according to SNAP sectors (ktonnes)

SNAP Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SNAP 01	92,40	92,40	92,40	91,86	90,19	90,19	84,58	97,53	96,57	71,38
SNAP 02	5,03	5,03	15,51	1,06	1,08	1,08	1,01	1,10	1,10	0,83
SNAP 03	0,40	0,10	3,66	6,45	7,93	7,93	12,95	13,57	13,57	9,88
SNAP 04	3,10	32,75	33,06	0,36	0,36	0,36	0,21	0,30	0,02	0,17
SNAP 06	35,10	35,1	7,70	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SNAP 07	0,50	0,50	1,00	0,77	0,80	0,80	1,00	0,78	0,78	0,58
SNAP 08	0,00	0,00	0,00	0,25	0,27	0,27	0,33	0,29	0,29	0,16
TOTAL	136,53	165,88	150,33	100,79	100,63	100,63	100,08	113,57	112,33	83,00

Data source: (MEPP, 2012b)

The trend of overall emissions shows that the quantities of SO2 from 2001 to 2002 are increased, and from 2002 to 2007 are reduced or range in approximately constant values. In 2008 we find a slight increase of the emissions where the following year they are reduced and in 2010 they reach the lowest value in the analyzed period. Biggest share in the emissions of SO2 has the sector for the production of electrical energy and heat (SNAP 01 and 02), followed by the sector for burning processes in the industrial production (SNAP 03), and in 2002 and 2003 a higher share has the sector of production processes (SNAP 04) and with smaller shares are the sectors for road traffic (SNAP 07) and other mobile sources and mechanization (SNAP 08).

Chart 1 shows the trend of quantities of emissions of SO2 for the analyzed period, where the limit is shown that refers to this polluting substance for 2010 (130 kt) in accordance to the Regulative for quantities of the upper bounds-limits of emissions of polluting substances (MEPP, 2012a). It can be noticed that in the analyzed period only in the period from 2001 to 2003 the upper bound-limit is surpassed, while from 2004 to 2010 the values are below the given upper limit.

The biggest part of the quantity of emission of NOx in the Republic of Macedonia (Table 5) is a result of the burning process during the production of electrical energy from the burning of coal, and also from the road traffic together with the other mobile sources. The trend of overall emissions shows that the quantities of NOx from 2001 to 2003 are increased, and from 2004 to 2007 they move constantly or have slight variations of decrease or increase. In 2008 we see a mild increase of the emissions where the following year they decrease and in 2010 reach the lowest value in the analyzed period.

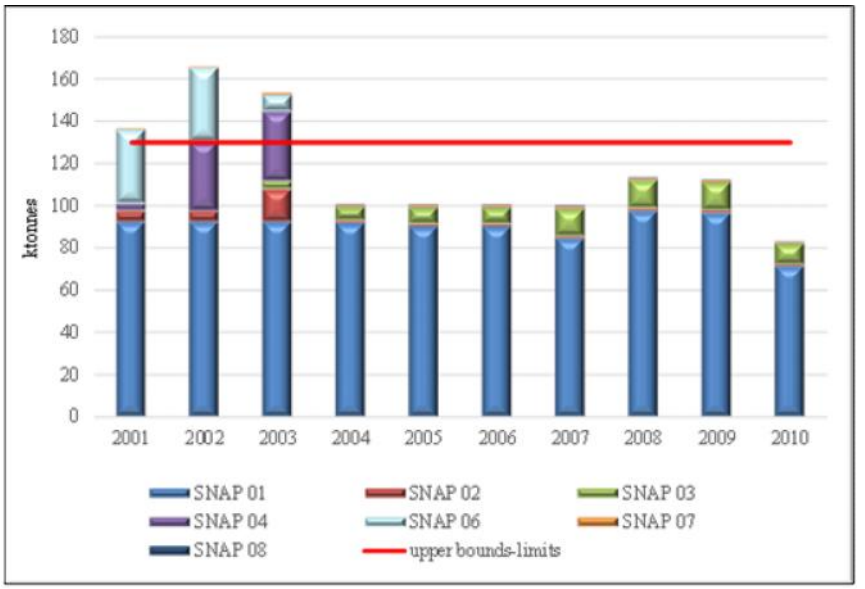

Chart 1. Trend of emissions of SO_2 in the period 2001 to 2010

Table 5. Quantities of emissions of NOx for the period 2001 to 2010 according to SNAP sectors (ktonnes)

SNAP Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SNAP 01	14,70	14,70	14,70	13,10	12,89	12,89	12,22	13,96	13,96	12,47
SNAP 02	2,41	2,41	1,83	1,50	1,51	1,51	1,45	1,50	1,50	1,31
SNAP 03	0,10	0,50	3,06	2,74	3,33	3,33	4,39	4,46	4,46	4,99
SNAP 04	0,50	5,60	5,91	4,93	4,96	4,96	2,68	4,63	0,48	0,52
SNAP 07	11,30	11,30	22,00	9,20	9,67	9,67	11,60	9,71	9,71	8,26
SNAP 08	0,00	0,00	0,00	2,07	2,20	2,20	2,67	2,36	2,36	1,45
TOTAL	29,01	34,51	47,50	33,54	34,56	34,56	35,01	36,62	32,47	29,00

Data source: (MEPP, 2012b)

The biggest emissions on average are almost equally distributed between the sectors for production of electrical energy (SNAP 01) represented with 35-43% and the sectors for road traffic and other mobile sources and mechanization (SNAP 07 and 08) represented with 32-40%. The other emissions belong to the industrial production, in the sector in the burning process (SNAP 03) and the sector for non-burning processes (SNAP 04).

Chart 2 shows the trend of quantities of emissions of NOx in the analyzed period, where the limit is shown that refers to this pollution substance for 2010 (39 kt) in accordance to the Regulative for quantities of the upper bounds-limits of emissions of polluting substances (MEPP,

2012a). It is noticeable that in the analyzed period, the quantities of emissions have not surpassed the upper bound-limit.

Environmental impacts of acid deposition

The deposition of acidifying pollutants causes several adverse effects on all the elements of the environment. The acidification of the soil causes are removed of certain nutrients that in fact reduces the ability for neutralization of the acid, furthermore, lowering the content of calcium, magnesium and potassium in the soil, and lowering of the plant growth. They directly damage the roots of trees or with the water reach the leaves of trees and they damage their tissues. In the acid soils there is releasing of aluminum. The acid deposition has its biggest influences on the freshwater ecosystems, where the lakes are most affected. With the increase of the acidity in the waters comes to lowering of the growth and development of their flora and fauna (Markovic et all., 1996).

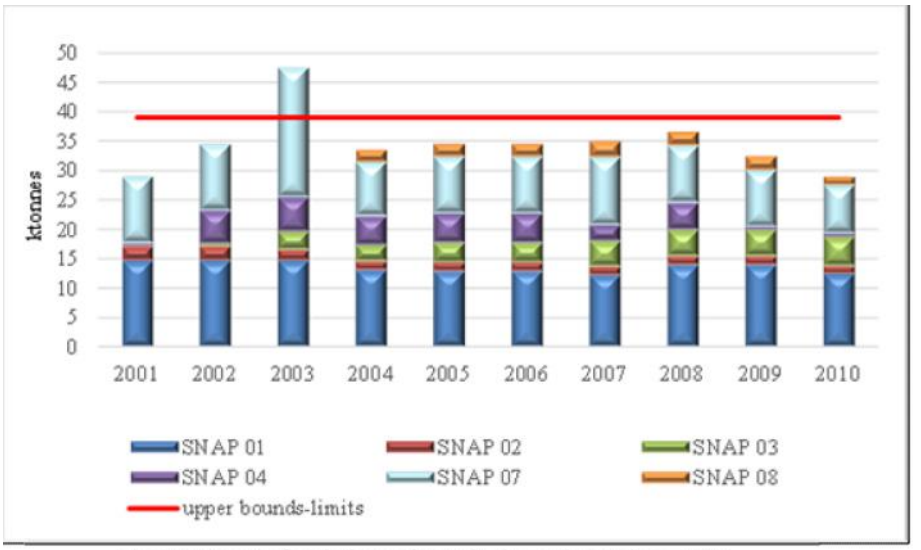

Chart 2. Trend of emissions of NO_x in the period 2001 to 2010

The acid deposition has adverse effects of the forest complexes where the conifer trees are more affected compared to the deciduous trees. Most damage suffers the forests in places with frequent and heavy rains that have relatively low average annual temperatures. This refers to forests located at higher altitudes (Dimitrovska, 2004).

The steel constructions and those made from other metals corrode easily under the influence of acid rains. Also, the acid rains have negative effects on those objects that are made with materials that contain CaCO3. Apart from the building objects many cultural – historical monuments are being damaged in this manner. The increased acidity of the waters leads to dissolving of materials and metals, which later the humans directly introduce in their organisms through the water or through eating aquatic organisms where the metals are mostly accumulated. The danger from asbestos particles that chip away from materials (water pipelines and other) if the water is acidic should be particularly emphasized. The asbestos present in the drinking water can result in an increase in the number of people with cancer (Spirevska, 2002).

Discussions

The energy sector in the Republic of Macedonia has the biggest contribution to the emission of acidifying substances, because nearly 90% of the primary energy is obtained from fossil fuels,

mostly lignite and crude oil. In this sector belongs the production of electrical energy and heat. From 85 to 91% of the emissions of SO2 and 35-43% of the emissions of NOx in the Republic of Macedonia are results of emissions from the burning of fossil fuels during the production of electrical energy in the thermal power plants that use coal (REK Bitola and REK Oslomej) and the lack of installations for desulphurization for reduction of these emissions. For the reduction of the emissions of these pollution substances from the energy sector in the Republic of Macedonia, by 2020 (MEPP, 2012b) there are several proposed measures that generally cover: monitoring of the emissions and the quality of air from the large burning installations, usage of equipment for desulphurization, replacement and lowering of the usage of crude oil and diesel fuel with bio-diesel fuels, larger exploitation of the biomass and biogas as energy sources, usage and greater implementation of natural gas in all the sectors, especially in the households, industry and in the production of heat, increase of the use of renewable sources of energy, improving the energetic efficiency etc.

The industry has a significant place in the development of the overall Macedonian economy and securing its stability has a direct influence on the increase of the employment, increase of the export and also the social life of the population. The most represented industrial branches in the Republic of Macedonia are: metallurgy, chemical-pharmaceutical industry, construction industry, production of food and drinks and other food products, electro-industry and the processing of wood and paper. There are significant differences between the big industrial facilities that have an earlier date and their equipment is outdated and work with technologies that are energetically inefficient and in the small and medium industrial capacities that are equipped with newer technologies and have incorporated technological solutions for better and more efficient fuel burning, re-usage of the heat in the processes and the cleansing of the exhaust gasses before releasing them into the atmosphere. There is a noticeable increase of the emissions of the pollutant substances that arise from the sector industry up to 2002, and from 2003 to the end of the analyzed period there is a continuous decrease of the values, as a result of closing (stopping the work) of a large number of industrial capacities in the Republic of Macedonia. For lowering of the emissions of the pollutant substances from the industry in the Republic of Macedonia by 2020 (MEPP, 2012b) there are several proposed measures where the industrial capacities are forced to implement measures for reduction of the emissions through conduction of monitoring of the quality and the emissions in the air by the industrial sector, introducing the best available techniques, efficient usage of the resources, usage of more quality fuels and renewable sources of energy, introduction of filters and installment of systems for reduction of the pollutant substances etc.

The transport also presents an important and significant source of pollution of the air, and as main emitters are the internal combustion engines incorporated in the different transport vehicles. The transport vehicles have the biggest share in the emissions of nitrogen oxides (ranging from 32-40% in the period 2001-2010), and are mostly expressed in the urban areas. The main measurements that could bring forth reducing of the emissions from the mobile sources in the Republic of Macedonia by 2020 (MEPP, 2012b) are: renewing of the vehicles, improving the quality of the liquid fuels in terms of presence of pollutant substances, promoting the usage of gaseous fuels like natural gas and propane-butane, bio-fuels from homemade resources in transport, promoting of organized transport in the city areas and in the bigger companies and intensifying of the public transportation and railroad transport of goods and passengers.

Conclusions

In the period from 2001 to 2010 a different trend of emissions of acidifying substances is noticed. There is a noticeable trend of reducing the emissions of SO2 (about 39% in relation to 2001) that is mainly a result of the lowered number and the closed production processes in the

metallurgy that were the main sources of pollution with this pollutant. This shows that in the lack of concrete measures and programs for decreasing of the emissions, there is no possibility for reaching a trend for further lowering of the quantities of emissions. In relation of the emission of NOx, there are no significant variations in their quantities and they remain on almost the same level between 2001 and 2010. The production of electrical energy is still the main source of pollution with SO2, mainly as a result of the poor quality (low calorific value) of the fuels with high sulfur content. These processes, together with transport are the main sources of NOx. Unfortunately, the data for emissions of NH3 are not analyzed because being limited and incomplete and data cannot be obtained on the proportion of ammonia and its influence in the process of acidification. For achieving the objectives for reducing the emissions of acidifying substances, as well as degradation of the environment, materials, and the adverse effect on the human health it is necessary the passing of all the planned documents in accordance with the National Convergence Program of the laws in the European Union. Up until now on a national level, two key documents have been passed, those are the National Plan for ambient air protection in the Republic of Macedonia in the period 2013 - 2018 and the National Program for the gradual reduction of the emissions of certain pollutant substances at a level of the Republic of Macedonia with projections of decreasing from 2010 to 2020. The implementation of these two documents should play a significant role in the lowering of the emissions of acidifying substances.

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