Impact of Certain Sectors of the Economy on the Chemical Pollution of Atmosphere in Romania

Empirical study

NICU MARCU[1]*, MIRELA CRISTEA[2], GEORGETA MADALINA MEGHISAN[2], DOINA DASCALU[3], LAURA NICOLETA NASTA[4]

[1] University of Bucharest, 90-92 Panduri Road, 050657, Bucharest, Romania

[2] University of Craiova, Faculty of Economics and Business Administration, 13 A.I. Cuza Str., 200585, Craiova, Romania

[3] Romanian Court of Accounts, 22-24 Lev Tolstoi Str., 011948, Bucharest, Romania

[4] The Bucharest University of Economic Studies, 6 Piata Romana, 010374 Bucharest, Romania

The present research has as main aim the analysis of the impact of certain sectors of the economy on the emissions of chemical pollutants in the atmosphere. In order to achieve this goal, we used statistical correlation between the emissions of acidifying substances and ozone precursors – SO_2, NOx, NH_3 and NMVOC, on the one hand, and the production of the main branches that will potentially release greater emissions of chemical pollutants in the atmosphere, on the other hand, for a period of 12 years. We focus on the production of the extractive industry, manufacturing, electric power industry, chemical industry, waste processing and decontamination, transport and agriculture.

Keywords: emissions of chemical pollutants, macroeconomic variables, statistical correlations

Together with the emergence of the industrialization at the beginning of the 20th century, it *was the time that toxic exposure first started to become apparent* [1]. Industrialization determines the release of polluting emissions in the environment, such as acidifying substances (sulphur dioxide - SO_2, nitrogen oxides - NO_2 or NO_x, ammonia - NH_3), ozone precursors, heavy metals (lead, mercury, copper, zinc, etc.), persistent organic pollutants (pesticides, dioxins, furans). If these emissions are not controlled and do not meet current quality standards, pollutants may chemically react with different atmospheric constituents resulting new substances characterized by a higher or a lower degree of toxicity with adverse effects on human health and environment.

According to the current legislation [2], the emissions of chemical pollutants in the atmosphere are monitored and evaluated based on the emission ceilings stipulated by Gothenburg Protocol, implemented at EU level by Directive no. 2001/81/EC.

The monitoring of air quality at a national level can be achieved both by manual sampling, followed by laboratory analysis, as well as within the framework of the continuous air quality monitoring system. According to legal stipulations regarding the limitation of the emissions of certain pollutants into the air [3], the determination of the emissions of sulphur dioxide, nitrogen oxides and particulate matter are made with a frequency of at least once at every 6 months.

In order to achieve the stipulations of Directive no. 2001/81/EC in Romania, certain compliance measures were also imposed, such as: investments in the modernization of machinery, equipment; use of liquid fuels with low sulphur content, but a higher price; implementation of the best available techniques (called BREF-BAT) according to the fuels used (black coal, lignite, fuel oil, natural gas, etc.) in order to desulfurize and reduce emissions of nitrogen oxides, reduce dust emissions from the flue gases; achievement of representative determinations for relevant pollutants in accordance with the European standards of quality [4].

Anthropogenic sources of chemical pollutants are particularly extractive companies, chemical industry, electric power industry, due to the burning of fossil fuels, transport, waste processing and decontamination, domestic heating.

In the present paper, we test four sets of correlations between the emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and non-methane volatile organic compounds (NMVOC), each considered as a dependent variable, and seven independent variables represented by the main production sectors with high potential in increased emissions of chemical pollutants into the atmosphere. It is about the extractive industry (mining and quarrying), manufacturing industry, transport and agriculture. Regarding the manufacturing, there were considered for the analysis the following elements: the production of electric power industry, manufacture of chemicals and chemical products, waste processing and decontamination. For the present research, statistical tools for the selected variables over a period of 12 years were applied.

The paper is organized as follows: a section presenting the experimental part, where the used data and methodology is described - statistical data provided by the National Institute of Statistics of Romania, followed by results and discussions, and the research conclusions.

Experimental part

Database and Methodology

According to the data supplied by the National Institute of Statistics of Romania, the emissions of chemical pollutants are included in the National Strategy for Sustainable Development, Objective 3, Sustainable Transport, and Objective 4, Sustainable consumption and production. These objectives include indicators on the emissions of ozone precursors (emissions of nitrogen oxides - NO_x and non-methane volatile organic compounds - NMVOC) and particulate matter in transport industry, respectively emissions of acidifying substances and ozone precursors (sulphur dioxide - SO_2, nitrogen oxides - NO_x, ammonia - NH_3, carbon monoxide

* email: marcu.nicu@yahoo.com

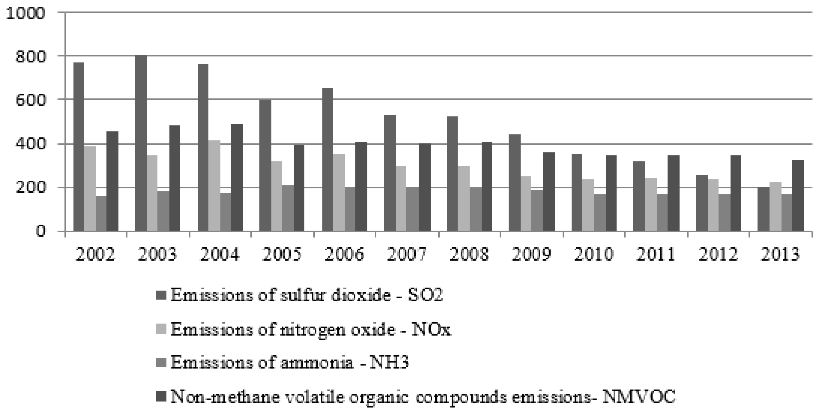

Fig. 1. The evolution of the emissions of acidifying substances and ozone precursors in Romania, period 2002-2013, statistical data retrieved by authors [5]

- CO, non-methane volatile organic compounds - NMVOC), at a national level [5].

Romania's assumed emission ceilings are 918,000 tonnes/year of SO_2, 437,000 tonnes/year of NO_x, 210,000 tonnes/year of ammonia and 523 000 t/year for non-methane volatile organic compounds. Of these, the contribution of large combustion plants (LCPs) is forecasted to 36.6% (i.e. 336,000 tonnes) for SO_2 and 26.08% (114,000 tonnes/year) for nitrogen oxide (NO_x) [6].

In figure1, the evolution of the emissions of acidifying substances and ozone precursors is rendered, based on the data supplied by the National Institute of Statistics of Romania.

Thus, *SO_2 emissions* generally registered a continuous decrease during 2002-2013, with a slight increase in 2002-2003, from 771,800 t/year to 803,500 t/year, and in 2005-2006 from 601,400 tonnes to 654,800 t, in particular, due to the growth and recovery of the industrial sector. During the period 2006-2013, the emission of SO_2 decreased continuously from 654,800 tnto 202,600 t. It is observed that sulphur dioxide emissions are below the cap of 918,000 t/year, established under the Gothenburg Protocol for Romania. Sulphur dioxide, in addition to being harmful to human health, damages the environment and contributes to the occurrence of acid rains.

During the period 2002-2013, *NO_x emissions* were characterized by fluctuations, with an upward trend during 2003-2004, from 347.34 to 414.86 thousand tonnes, then from 317.21 to 353.38 thousand tonnes in 2005-2006 and from 231.8 to 239.54 thousand tonnes in 2010-2011. In the last three years (2011-2013), the amount of NO_x emissions decreased to 218.82 thousand tonnes, mainly driven by industrial equipment modernization and renewal of the national car park.

NO_x emission ceiling set for Romania under the Gothenburg Protocol is 437 thousand tonnes/year, ceiling that was not exceeded during the period under review. The closest value to the emission ceiling was registered in 2004, reaching 414,860 tonnes/year.

The emissions of ammonia (NH_3) present a slight increase in the first two years, i.e. 2002-2003, from 156.3 to 182.27 thousand tonnes/year, then in 2004-2005, from 174.91 to 204.6 thousand tonnes/year. The highest value of ammonia emissions was registered in 2005, during the analysed period, reaching 204.6 thousand tonnes/year; after that, until 2013, there was a downward trend, the amount reaching 165,150 t/year.

The ceiling for ammonia emissions set for Romania under the Gothenburg Protocol is 210 thousand tonnes/year and the registered values were below the ceiling in the period under review. The nearest value to the emission ceiling was registered in 2005, representing 204 600 tonnes/year.

NMVOC emissions increased during the period 2002-2004, from 456.31 to 489.16 thousand tonnes/year, then from 394.99 to 405.14 tonnes/year in the period 2005-2006 and from 401.92 to 403.91 thousand tonnes/year, in 2007-2008. Starting with 2008, NMVOC emissions decreased, reaching 322.95 thousand tonnes/year in 2013. Romania NMVOC emission ceiling set by the Gothenburg Protocol is 523 thousand tonnes/year, value that was not exceeded during the analysed period.

In order to test which is the causal relationship between the emissions of acidifying substances and ozone precursors and their main influencing factors, we analysed the statistical correlation of each of the emissions listed above, as dependent variables (four dependent variables), and the following seven independent variables: agriculture, hunting and forestry production, which we noted PA; production of the extractive industries (mining and quarrying), noted PMQ; manufacturing, noted PMF; production of the electric power, gas, steam and air conditioning supply, which we note by PEL; production from chemicals manufacturing and chemical products, noted PCH; water supply, sewerage, waste management and decontamination activities, which we note PW; transport, storage and communication, noted PT.

We chose these variables based on the theoretical dependence at the level of the analysed variables on the influence of the mining and quarrying and manufacturing industry, transport and agriculture, on the emissions of chemical pollutants. In manufacturing industry, the highest emissions of chemical pollutants in the atmosphere are generally made by electric power industry, chemicals manufacturing and chemical products, waste processing and decontamination.

The independent variables used, were taken from the Romanian Statistical Yearbook for the period 2002 – 2011; databases and statistical metadata Tempo online, provided by the National Institute of Statistics of Romania, were also used [6].

Thus, agriculture production (PA) increased from 33,321.9 mil. lei current prices in 2002 to 73,168.1 mil lei current prices in 2013. The production of the mining and quarrying industry (PMQ) increased from 6,820.5 mil lei current prices to 22,131.2 mil. lei between 2002 and 2011; after that, it followed a downward trend, decreasing to 14,396.2 mil. lei current prices in 2013. Manufacturing production (PMF) registered a continuous upward trend, mainly in the last two years, reaching 456,659.7 mil. lei current prices in 2013, compared to 94,984.7 mil. lei as it was in 2002. The production of electric power (PEL) registered an important increase, between 2002 and 2009, from 21,724.5 mil. lei to 62,219 mil. lei; afterwards, it was relatively constant, reaching more than 65,000 mil. Lei in 2013. The production in the branch of the manufacture of chemicals and chemical products (PCH) registered an increasing trend until 2013, from 6,035.9 million lei current

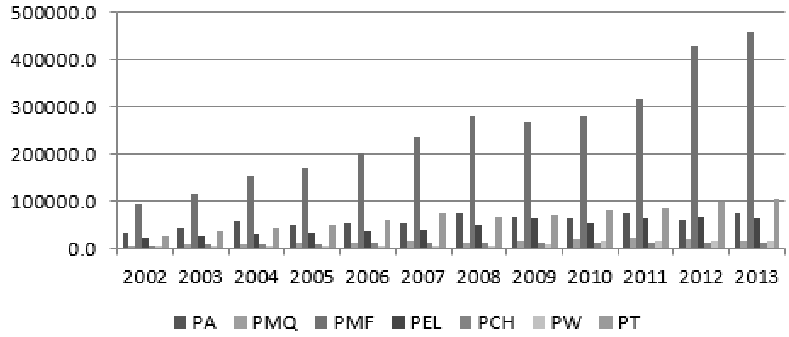

Fig. 2. The evolution of the production for the main branches of the economy in Romania, with impact on the emissions of acidifying substances and ozone precursors, period 2002-2013, statistical data retrieved by authors [7] Section 11. National Accounts

prices in 2002 to 13,293.2 lei in 2008, the highest level of the analysed period. After 2008, the production of the chemical industry registered a decreasing trend and, thus, in 2013, it was only 11,544.4 mil. lei current prices. The production obtained from water supply, sewerage, waste management and decontamination activities (PW) increased a lot in the period 2010-2013, compared to the period 2002-2009. Transport, storage and communication production (PT) also had an upward evolution, from 25,708.7 mil. lei in 2002 to 104,379.8 mil.lei in 2013.

Results and discussions

In order to better highlight the analysis of the correlation between the values of the national emissions of acidifying substances and ozone precursors (sulphur dioxide - SO_2, nitrogen oxides - NO_x, ammonia - NH_3, non-methane volatile organic compounds - NMVOC) and the identified variables, respectively the value of the production obtained in agriculture, mining and quarrying industry, manufacturing, electric power industry, chemical industry, waste management and transport, we used Pearson correlation coefficient, calculated using SPSS 22 software for Windows. The values of this coefficient, which emphasizes the possible correlations between all variables considered in this analysis and their significance level, are further highlighted.

Thus, we tested four statistical correlations with each of the dependent variables and the seven independent variables, for a total of 12 observations (period 2002-2013), as shown in tables 1-4 of the Annex.

According to the analysis Pearson coefficient values, it can be noticed that *SO_2 emissions (noted ES)* are negatively strongly correlated, with most of the analysed variables. This means that, while the production of the analysed branches increases, SO_2 emissions decrease. Thus, the highest value for the Pearson coefficient was registered in case of the dependence between SO_2 emissions and transport (-0.964), while the lowest, but significant value was registered for the production of the chemical industry (-0.699). High values were also registered for the other variables, as follows: manufacturing production - PMF (-0.951), production of electric power industry - PEL (-0.947), waste processing and decontamination - PW (-0.921), production of the mining

Correlations

		ES	PA	PMQ	PMF	PEL	PCH	PW	PT
Pearson Correlation	ES	1,000	-,745	-,831	-,951	-,947	-,699	-,921	-,964
	PA	-,745	1,000	,737	,753	,833	,786	,688	,775
	PMQ	-,831	,737	1,000	,723	,853	,796	,778	,833
	PMF	-,951	,753	,723	1,000	,923	,742	,860	,966
	PEL	-,947	,833	,853	,923	1,000	,737	,899	,923
	PCH	-,699	,786	,796	,742	,737	1,000	,517	,819
	PW	-,921	,688	,778	,860	,899	,517	1,000	,844
	PT	-,964	,775	,833	,966	,923	,819	,844	1,000
Sig. (1-tailed)	ES	.	,003	,000	,000	,000	,006	,000	,000
	PA	,003	.	,003	,002	,000	,001	,007	,002
	PMQ	,000	,003	.	,004	,000	,001	,001	,000
	PMF	,000	,002	,004	.	,000	,003	,000	,000
	PEL	,000	,000	,000	,000	.	,003	,000	,000
	PCH	,006	,001	,001	,003	,003	.	,043	,001
	PW	,000	,007	,001	,000	,000	,043	.	,000
	PT	,000	,002	,000	,000	,000	,001	,000	.
N	ES	12	12	12	12	12	12	12	12
	PA	12	12	12	12	12	12	12	12
	PMQ	12	12	12	12	12	12	12	12
	PMF	12	12	12	12	12	12	12	12
	PEL	12	12	12	12	12	12	12	12
	PCH	12	12	12	12	12	12	12	12
	PW	12	12	12	12	12	12	12	12
	PT	12	12	12	12	12	12	12	12

Table 1
THE CORRELATION COEFFICIENTS OF SO_2 EMISSIONS (ES) AND THE INDEPENDENT VARIABLES

Table 2
THE CORRELATION COEFFICIENTS OF NITROGEN OXIDE EMISSIONS (EN) AND THE INDEPENDENT VARIABLES

Correlations

		ES	PA	PMQ	PMF	PEL	PCH	PW	PT
Pearson Correlation	ES	1,000	-,745	-,831	-,951	-,947	-,699	-,921	-,964
	PA	-,745	1,000	,737	,753	,833	,786	,688	,775
	PMQ	-,831	,737	1,000	,723	,853	,796	,778	,833
	PMF	-,951	,753	,723	1,000	,923	,742	,860	,966
	PEL	-,947	,833	,853	,923	1,000	,737	,899	,923
	PCH	-,699	,786	,796	,742	,737	1,000	,517	,819
	PW	-,921	,688	,778	,860	,899	,517	1,000	,844
	PT	-,964	,775	,833	,966	,923	,819	,844	1,000
Sig. (1-tailed)	ES	.	,003	,000	,000	,000	,006	,000	,000
	PA	,003	.	,003	,002	,000	,001	,007	,002
	PMQ	,000	,003	.	,004	,000	,001	,001	,000
	PMF	,000	,002	,004	.	,000	,003	,000	,000
	PEL	,000	,000	,000	,000	.	,003	,000	,000
	PCH	,006	,001	,001	,003	,003	.	,043	,001
	PW	,000	,007	,001	,000	,000	,043	.	,000
	PT	,000	,002	,000	,000	,000	,001	,000	.
N	ES	12	12	12	12	12	12	12	12
	PA	12	12	12	12	12	12	12	12
	PMQ	12	12	12	12	12	12	12	12
	PMF	12	12	12	12	12	12	12	12
	PEL	12	12	12	12	12	12	12	12
	PCH	12	12	12	12	12	12	12	12
	PW	12	12	12	12	12	12	12	12
	PT	12	12	12	12	12	12	12	12

Table 3
THE CORRELATION COEFFICIENTS BETWEEN AMMONIA EMISSIONS (EA) AND THE INDEPENDENT VARIABLES

Correlations

		ES	PA	PMQ	PMF	PEL	PCH	PW	PT
Pearson Correlation	ES	1,000	-,745	-,831	-,951	-,947	-,699	-,921	-,964
	PA	-,745	1,000	,737	,753	,833	,786	,688	,775
	PMQ	-,831	,737	1,000	,723	,853	,796	,778	,833
	PMF	-,951	,753	,723	1,000	,923	,742	,860	,966
	PEL	-,947	,833	,853	,923	1,000	,737	,899	,923
	PCH	-,699	,786	,796	,742	,737	1,000	,517	,819
	PW	-,921	,688	,778	,860	,899	,517	1,000	,844
	PT	-,964	,775	,833	,966	,923	,819	,844	1,000
Sig. (1-tailed)	ES	.	,003	,000	,000	,000	,006	,000	,000
	PA	,003	.	,003	,002	,000	,001	,007	,002
	PMQ	,000	,003	.	,004	,000	,001	,001	,000
	PMF	,000	,002	,004	.	,000	,003	,000	,000
	PEL	,000	,000	,000	,000	.	,003	,000	,000
	PCH	,006	,001	,001	,003	,003	.	,043	,001
	PW	,000	,007	,001	,000	,000	,043	.	,000
	PT	,000	,002	,000	,000	,000	,001	,000	.
N	ES	12	12	12	12	12	12	12	12
	PA	12	12	12	12	12	12	12	12
	PMQ	12	12	12	12	12	12	12	12
	PMF	12	12	12	12	12	12	12	12
	PEL	12	12	12	12	12	12	12	12
	PCH	12	12	12	12	12	12	12	12
	PW	12	12	12	12	12	12	12	12
	PT	12	12	12	12	12	12	12	12

Table 4
THE CORRELATION COEFFICIENTS BETWEEN NMVOC EMISSIONS (ENMVOC) AND THE INDEPENDENT VARIABLES

Correlations

		ES	PA	PMQ	PMF	PEL	PCH	PW	PT
Pearson Correlation	ES	1,000	-,745	-,831	-,951	-,947	-,699	-,921	-,964
	PA	-,745	1,000	,737	,753	,833	,786	,688	,775
	PMQ	-,831	,737	1,000	,723	,853	,796	,778	,833
	PMF	-,951	,753	,723	1,000	,923	,742	,860	,966
	PEL	-,947	,833	,853	,923	1,000	,737	,899	,923
	PCH	-,699	,786	,796	,742	,737	1,000	,517	,819
	PW	-,921	,688	,778	,860	,899	,517	1,000	,844
	PT	-,964	,775	,833	,966	,923	,819	,844	1,000
Sig. (1-tailed)	ES	.	,003	,000	,000	,000	,006	,000	,000
	PA	,003	.	,003	,002	,000	,001	,007	,002
	PMQ	,000	,003	.	,004	,000	,001	,001	,000
	PMF	,000	,002	,004	.	,000	,003	,000	,000
	PEL	,000	,000	,000	,000	.	,003	,000	,000
	PCH	,006	,001	,001	,003	,003	.	,043	,001
	PW	,000	,007	,001	,000	,000	,043	.	,000
	PT	,000	,002	,000	,000	,000	,001	,000	.
N	ES	12	12	12	12	12	12	12	12
	PA	12	12	12	12	12	12	12	12
	PMQ	12	12	12	12	12	12	12	12
	PMF	12	12	12	12	12	12	12	12
	PEL	12	12	12	12	12	12	12	12
	PCH	12	12	12	12	12	12	12	12
	PW	12	12	12	12	12	12	12	12
	PT	12	12	12	12	12	12	12	12

and quarrying industry - PMQ (-0.831) and agriculture production (-0.745). In addition, the value of Sig. significance threshold either equals 0.000, or different from 0, but less than 0.05 for two of the variables (PA and PCH), which means that the reported negative dependencies are strong and significant.

As such, the main source of sulfur dioxide emissions is represented by combustion processes in transportation sector, manufacturing, energy sector, waste treatment and disposal (which registered the highest negative values of the correlations, over 0.9), as well as in the mining and quarrying industry, agriculture and chemical industry.

For *NO_x emissions (EN),* the highest negative value for the Pearson coefficient was registered in the case of the production of the electric power industry (-0.912), followed by transportation sector (-0.889), waste treatment and storage (-0.866), manufacturing (-0.853), mining and quarrying industry (-0.809), agriculture (-0.682) and chemical industry (-0.620). In addition, the value of Sig significance threshold either equals 0.000, or is different from 0, but less than 0.05 for three of the variables (PA, PMF and PCH), which means that the registered negative dependencies are strong and significant.

As for *ammonia emissions (EA)*, the only correlation that occurs is that with waste treatment and disposal (-0.569), for which the value of Sig significance threshold is 0.027, below the permitted limit of 0.05, underlying a moderate negative correlation with the production in this branch. In case of other branches, a correlation between production and ammonia emissions is not confirmed. Surprisingly, a correlation between agriculture production and ammonia emissions is also not confirmed, knowing the potential contribution of this sector to the total ammonia emissions.

For *NMVOC emissions*, the highest negative value for the Pearson coefficient was registered for transportation sector (-0.903), followed by electric power industry (-0.889), manufacturing (-0.858), waste treatment and storage (-0.838), mining and quarrying industry (-0.831), agriculture (-0.683) and chemical industry (-0.647). In addition, the value of Sig significance threshold either equals 0.000, or is different from 0, but less than 0.05 for two of the variables (PA and PCH), which means that the reported negative dependencies are also strong and significant.

Conclusions

As it is underlined in international specialized literature, 'increasing industrialization without emissions controls will increase releases of chemical precursors of ozone, such as nitrogen oxides (NO_x) and volatile organic compounds (VOCs)" [8], and not only.

In Romania, the emissions of acidifying substances and ozone precursors such as SO_2, NO_x, NH_3 and NMVOC are below the level of the emission ceilings assumed by Romania and specified in the Gothenburg Protocol. Moreover, the values of these emissions, as reported by the National Institute of Statistics, decreased from year to year, except for the ammonia emissions, which remained above 165 thousand tonnes/year. The largest decrease of the emissions of chemical pollutants into the atmosphere during 2002-2013 was registered for SO_2, from 771,800 tonnes to 202,600 tonnes/year.

With regard to the contributions of the main economic branches in Romania to the emissions of chemical pollutants into the atmosphere, there were obtained the following results: for the emissions of SO_2, NO_x and NMVOC the strongest negative correlations are registered in case of electric power industry, manufacturing and transport. The production of the chemical industry presented the lowest, but significant correlation (more than -0.62), for each of the three chemical pollutants emissions. Instead, ammonia emissions are dependent only on waste treatment and disposal. Surprisingly, it was not confirmed a correlation between agriculture production and ammonia emissions.

The obtained negative correlations, in spite of higher productions of the economic branches, can be explained by the implementation of the quality standards for the reduction of the emissions of the chemical pollutants and the EU directives in Romania.

This can be also explained by the closure of many petrochemical and metallurgical plants, which were the main chemical polluters, particularly with SO_2. Thus, of the 21 large petrochemical and chemical plants that operated in Romania in the late '90s, 15 have gone bankrupt or have been closed in the last 15 years. Among the largest Romanian refineries such as Petromidia, Rafo, Petrobrazi, Petrotel, Arpechim, which had also petrochemical plants, only Petromidia is still functioning, while the petrochemical plant from Arpechim was taken over by Oltchim, but, presently, it is closed. With regard to the producers of chemical fertilizers, only Azomureº still works and is currently the largest producer of the Romanian chemical industry [9].

References

1.NIU, J., YU, G., Economics, social, legal and health implications, Point Sources of pollution: local effects and it's control, vol. II, Encyclopedia of Life Support Systems, EOLSS, Available at: http://www.eolss.net/sample-chapters/c09/E4-11-04-05.pdf

2.*** ROMANIAN OFFICIAL GAZETTE (MONITORUL OFICIAL AL ROMÂNIEI), no. 470/July 2003, Law 271/2003 for ratification of the Convention's protocols upon the cross border atmospheric pollution on long distances, signed in Geneva at 13th of November 1979, adopted at Aarhus at 24th of June 1998 and Gothenburg at 1st of December 1999;

3.*** ROMANIAN OFFICIAL GAZETTE (MONITORUL OFICIAL AL ROMANIEI), no. 365/May 2003, Decision no 541/17 May 2003 regarding the establishment of some measures for the emissions limitation of some pollutants from big combustion installations modified and updated by HG no 322/2005 and HG no 1502/2006;

4.***NATIONAL INSTITUTE OF STATISTICS, Indicators of Sustainable Development, National Strategy for Sustainable Development, Emissions of acidifying substances and ozone precursors, Available at: http://www.insse.ro/cms/files/Web_IDD_BD_ro/index.htm

5.MORARU, Al., Instalaþiile mari de ardere din România ºi protecþia mediului, National Environmental Protection Agency (Agenia Naional㠁pentru Protecia Mediului), Available at: http://www.petroleumclub.ro/energy2006/5_Moraru.pdf

6.*** MINISTRY OF ENVIRONMENT, WATER AND FORESTS (MMAP), Ghid pentru monitorizarea 'i automatizarea emisiilor de dioxid de sulf, oxizi de azot 'i pulberi, provenite de la instalaiile mari de ardere, 2015, Available at:http://www.mmediu.ro/app/webroot/uploads/files/2015_06_17_Ghid_monitorizare_lcp.pdf

7.*** ROMANIAN STATISTICAL YEARBOOKS, period 2006-2013, http://www.insse.ro/cms/ro/content/arhiva-publicatiilor-statistice-2007-2015, Section 11. National Accounts, and TEMPO online data bases

8. SELIN, N. E., WU, S., NAM, K. M., REILLY, J. M., PALTSEV, S., PRINN, R. G., and WEBSTER, M. D., Global health and economic impacts of future ozone pollution, Environmental Research Letters, Vol. 4, No. 4, 2009, IOP Publishing, Available at: http://iopscience.iop.org/article/10.1088/1748-9326/4/4/044014/meta;jsessionid=545EB2C5712F2BA5E6D96406DC9B8C73.c1

9.***Ziarul Financiar, Available at: http://www.zf.ro/analiza/oltchimul-a-fost-doar-varful-iceberg-ului-ce-a-insemnat-romania-in-petrochimie-si-ce-dezastru-s-a-ales-in-urma-privatizarilor-esuate-10125675, 27.09.2012, [Accessed on August 2015]

Manuscript received: 12.02.2016