PlasTEP

plasma for environment protection

List of the emission processes in the Baltic Sea region

Working group:

Institute of Nuclear Chemistry and Technology, Warsaw, Poland:
Andrzej Pawelec
Sylwia Witman

Vilnius Gediminas Technical University, Vilnius, Lithuania:
Saulius Vasarevičius

Part-financed by the European Union (European Regional Development Fund)

PlasTEP

plasma for environment protection

Content

Part-financed by the European Union (European Regional Development Fund)

List of Tables

Part-financed by the European Union (European Regional Development Fund)

1 Introduction

Non-thermal plasma-based technologies are widely used in such industries as surface treatment, metallurgy, medicine, electronics and others. They are also used for environmental protection purposes with regard to pollutants emission control, water treatment, sterilization and hygienization of wastes. Plasma technologies are very promising due to a wide spectrum of possible applications, however as relatively new ones they are not well known. The PlasTEP project was established to inform the decision makers from politics and economy about the practical possibilities of the low-temperature plasma technology for environmental purposes and to establish a market driven knowledge transfer process to increase number of practical applications.

One of the work packages of this project is “Plasma-based cleaning of exhaust gases of combustion”. This work package is focused on spreading information about plasma technologies reducing nitrogen oxide (NO_x) and sulphur dioxide (SO_2). The removal by use of the various plasma technologies in different stages of development refers to commercialisation-ready electron beam flue gas treatment (EBFGT) over ozonisation up to direct plasma treatment with or without catalytic reactions in laboratory scale.
Mapping the specificity of NO_x and SO_2 emission in the Baltic Sea region is the base for further discussions on possible implementation of plasma pollution control technologies in this part of Europe. Therefore, this document presenting main sources of emission in certain countries has been elaborated. As a next step of this work, an elaboration list of potential processes suitable for plasma technologies application is foreseen.
A more detailed report is prepared by Dr Saulius Vasarevičius from Vilnius Gediminas Technical University in the frame of workpackage 3 of the PlasTEP project. As most data were collected in cooperation with Dr Vasarevičius and his team, the authors want to thank him for his help.

Baltic Sea Region Programme 2007-2013
Part-financed by the European Union (European Regional Development Fund)

2 Total Emissions in the Baltic Sea region countries

According to PlasTEP's project assumptions, emissions in the following countries was concerned: Finland, Estonia, Latvia, Lithuania, Poland, north Germany, Denmark and Sweden.
The emissions of SO_2 and NO_x reported in these countries are presented in Table 1.

Table 1. Annual SO_2 and NO_x emissions in Baltic Sea region countries.

Country	Emission t/year	
	SO_2	NO_x
Finland	70119	165877
Estonia	69333	34393
Latvia	2831	38122
Lithuania	31531	67739
Poland	998561	831225
North Germany	842	6190
Denmark	19605	151686
Sweden	30521	154403

The highest emission was reported in Poland, however it is the biggest of all concerned countries (38.1 mln citizens). The lowest emissions were reported in north Germany with 1.7 mln citizens. Therefore, total emission per capita is a better indicator in order to compare emissions in BSR countries. The emission of main inorganic pollutants per capita is presented in Table 2.

Table 2. Annual SO_2 and NO_x emissions per capita in Baltic Sea region countries.

Country	Emission kg/year	
	SO_2	NO_x
Finland	13	31
Estonia	52	26
Latvia	1	17
Lithuania	9	20
Poland	26	22
North Germany	0.5	3.6
Denmark	4	28
Sweden	3	16
Average	15.4	22.8

Total emission per capita in eight Baltic Sea region countries is similar in the case of NO_x. In case of SO_2 two countries are considerably above average. North Germany reports very low emissions in both cases, however it has to be noted that only the low industrialised part of the country is regarded. These differences shall be explained by an emission and industry structure in the discussed countries.

Part-financed by the European Union (European Regional Development Fund)

3 SO_2 and NO_x emissions in selected Baltic Sea Region Countries

3.1 Sweden

Sulphur dioxide emissions in Sweden come from the energy production, transport and industry sectors decreases in the 1990s.
The highest SO_2 emitters are located in Västerbotten County. The main emitter is "Rönnskärsverken" facility: a leading European metals producing company (mining and smelting).
Nitrogen oxides are formed in all combustion processes in the energy production and transport sectors, and the largest emission sources are road traffic, machinery, navigation and generation of electricity and heat.
The highest NO_x emissions are released in Norrboten County. Here, the main emitters are one of the world's largest ore iron mining facilities "Malmbergsgruvan" and "Kirunagruvan".

3.2 Denmark

SO_2 from stationary combustion plants stands for 88% of the total SO_2 emission in Denmark. Especially large power plants (> 300MW_{th}) are the main emission source responsible for 79% of the SO_2 emission.
NO_x from stationary combustion plants cover 37% of Danish NO_x emission. NO_x emissions from stationary sources are mostly released from energy production facilities which are the largest emission source responsible for 54% of the emission from stationary combustion plants. The emission from public power plants > 300 MW_{th} accounts for 61% of the emission in this subcategory.
Annual SO_2 and NO_x emissions from stationary sources in 2008 in Denmark are presented in Table 3.

Table 3. Annual SO_2 and NO_x emissions from stationary sources in 2008 in Denmark.

Industry sector	**Emission t/year**	
	SO_2	**NO_x**
Agriculture/forestry/fisheries	1572	715
Residential	2466	6702
Commercial/institutional	273	811
Industry	5383	9557
Other energy industries	8	7031
Petroleum refining	316	1490
Public electricity and heat generation	6281	24056

Part-financed by the European Union (European Regional Development Fund)

3.3 Poland

SO_2 emission in Poland is strictly connected with combustion processes. Other sources of emission are lower at least two orders of magnitude.
In the case of NO_x, the emission is connected with combustion processes (different types) and transport and vehicle sectors. The highest numbers are observed in energy production and road transport activities.
Annual SO_2 and NO_x emissions in different sectors in Poland (2008) are presented in Table 4.

Table 4. Annual SO_2 and NO_x emissions in 2008 in Poland.

Industry sector	**Emission t/year**	
	SO_2	**NO_x**
Waste management	70	2161
Other vehicles and equipment	520	94219
Road transport	1150	256231
Production processes	4630	18894
Combustion in manufacturing industry	180840	100240
Combustion in municipal sector and housing	238840	85453
Combustion processes in energy generation	572510	274027

3.4 Lithuania

In Lithuania the biggest part of SO_2 is emitted from heat and energy sectors, the rest from fertilizers production and cement and concrete production sectors. Very high SO_2 emission could originate from the biggest fertilizers production company in the Baltic states called SC ”Achema”.
The highest NO_x emissions in Lithuania are recorded in the Northern part of Lithuania (Šiauliai region) where the biggest industrial plants as SC “Akmenes cementas” (cement and concrete production) and SC “Orlen Lietuva” (oil refinery enterprise) are placed. The highest NO_x emissions are released from cement and concrete production sector, fertilizers production, heat and power production and fuel/oil refinery plants.
Annual SO_2 and NO_x emissions from different industry sectors in Lithuania (data for 2009) are presented in Table 5.

Baltic Sea Region Programme 2007-2013
Part-financed by the European Union (European Regional Development Fund)

Table 5. Annual SO_2 and NO_x emissions from different industry sectors in Lithuania (2009).

Industry sector	Emission t/year	
	SO_2	NO_x
Metal production	0	4
Furniture production	0	18
Painting, car maintenance	0.2	3
Pharmacy	0	1
Paper production, printing	0	29
Plastic production	0	2
Cement and concrete production	1556	4263
Fertilizers and lime production, animal waste treatment	2378	2366
Power and heat generation	2430	2574
Fuel and oil production/storage	776	3937

3.5 North Germany (Mecklenburg-Vorpommern)

North Germany reports very low emission of both SO_2 and NO_x. However the data does not concern the whole country with its industrialised regions. Therefore, it is hard to compare this data with other countries.
Similar to other discussed regions, the highest emission of both SO_2 and NO_x is generated by energy and mining sector. Some amount of SO_2 is also emitted in ceramic and building sector as well as by waste management. NO_x is also emitted by waste management and chemical sector.
Annual SO_2 and NO_x emissions in 2004 in selected sectors of industry in north Germany are presented in Table 6.

Table 6. Annual SO_2 and NO_x emissions in 2004 in north Germany.

Industry sector	Emission t/year	
	SO_2	NO_x
Waste management	97	661
Food, agriculture	9	56
Wood, pulp	0	395
Surface treatment	0	5
Chemicals pharmaceuticals	0	662
Metallurgy	0	41
Stone, glass, ceramics, building	134	185
Energy and heat generation, mining	601	4141

Part-financed by the European Union (European Regional Development Fund)

3.6 Latvia

The highest SO_2 emission in Latvia origins from the minerals production sector, however metallurgy and energy generation are also an important source of the emission. In 2009, the main SO_2 emitters were JSC "Ventspils siltums" and manufacture of concrete products “Būvmateriāli AN“. These companies emitted 493,9 and 444,7 t of SO_2 per year, respectively.

Metallurgy is the highest NO_x emitting industry sector in Latvia. Unexpected low emission is reported in the case of energy generation. The biggest emitter of NO_x in 2009 was the company JSC "Liepājas Metalurgs" which emitted 2.819,19 t of NO_x per year.

Annual SO_2 and NO_x emissions from main sectors in 2009 in Latvia are presented in Table 7.

Table 7. Annual SO_2 and NO_x emissions from main sectors in Latvia (2009).

Industry sector	Emission t/year	
	SO_2	NO_x
Wood processing, forestry, agriculture	0.03	411
Waste management	4	74
Chemical industry	22	441
Minerals production	952	1689
Metallurgy	479	3009
Energy	507	191
Other	55	328

3.7 Estonia

SO_2 primarily originates from oil-shale-fired power plants. A small quantity of SO_2 emissions was given off from non-industrial fuel combustion and transport (use of sulphur containing motor fuels) and chemical industry.

The main source of NO_x emission is the process of fuels combustion in the energy and heat generation sector. Some amount is released in cement and other industries. The main polluters in the case of both sulphur dioxides and nitrogen oxides are power plants in Ida-Viru County.

Annual SO_2 and NO_x emissions from main sectors in Estonia in 2009 are presented in Table 8.

Part-financed by the European Union (European Regional Development Fund)

Table 8. Annual SO_2 and NO_x emissions from main sectors in Estonia in 2009.

Industry sector	Emission t/year	
	SO_2	NO_x
Cement	153	448
Cellulose and paper	40	73
Glass	130	41
Energy	45975	8856
Oil industry	531	217
Chemical industry	3689	46
Heat generation	1805	939

3.8 Finland

In Finland, the highest SO_2 emission origins from energy generation and industry sectors. In the case of NO_x, the most important source of emission is energy generation and transport.
Annual SO_2 and NO_x emissions from main sectors in Finland in 2008 are presented in Table 9.

Table 9. Annual SO_2 and NO_x emissions from main sectors in Finland (2008).

Sector	Emission t/year	
	SO_2	NO_x
Energy	49000	99000
Transport	1300	59000
Industry	20000	7600
Waste management	70	320

Part-financed by the European Union (European Regional Development Fund)

4 Conclusions

Emission of SO_2 and NO_x in Baltic Sea region with regard to countries and industry sectors has been presented. Poland emits the largest total amount of both considered pollutants, however it may be explained by the largest number of citizens and the largest territory. Moreover, it shall be noticed, that most of Polish heavy industry, that is responsible for the emission, is placed in the south part of the country, far away from Baltic Sea. Analysis of total emission per capita shows, that NO_x emission level is similar in all considered countries. In the case of SO_2, the highest emission per capita is reported in Estonia which is connected with shale oil use in energy sector. North Germany reports very low emission of both pollutants, however the data do not cover the whole country and therefore comparing it with other data for whole countries may lead to errors.

Different countries reported emission in different way according to industry sectors and regarding stationery/mobile sources. However, in spite of this, general conclusions may be easily withdrawn.
The largest emission of both considered pollutants is released from energy and heat generation sector. As the second source, metallurgical industry shall be mentioned. The emission from other industrial processes is also mostly connected with combustion processes.

It shall be noticed that relatively high emissions from mobile sources (transport) exist- especially in the case of nitrogen oxides. Small, dispersed sources as vehicles are problematic for emission control and shall be especially carefully analysed.

The results of this elaboration may be a good base for further work on plasma emission control technologies' development.

Baltic Sea Region Programme 2007-2013
Part-financed by the European Union (European Regional Development Fund)