EMEP ASSESSMENT REPORT - BELARUS

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1.Monitoring Network

Measurements by EMEP Programme on the territory of Belarus started 1979 at EMEP Vysokoje monitoring site. At this site according to EMEP monitoring programme precipitates, gases and aerosols were collected with sampling time 24 hours. Analytical programme included analysis of main ions in precipitates, SO_2 and NO_2 in the air, SO_4, NO_3 and NH_4 in aerosols. Since1992 in continuation of ten years due to problems with samples analysis this station have been in operation occasionally. In 2001 it resumed its work (daily bulk precipitates collection and main components analysis only). For this report data for 1979-1991,1995-1996 and from 2001 is available.

Due to the lack of EMEP monitoring data results of national monitoring network was used for this assessment also (State of the Environment.., 1992-2002; National Report.., 1995, 1998, 2002).

In Belarus monitoring of precipitates started 1962 at Berezino station (monthly samples). Till 1980 sampling was conducted at one site; in 1981 measurements started at the Berezinsky Reserve site (Complex Backround Monitoring Station). In 1990-1991 precipitates collection began at 12 new sites (located mainly in cities). Main components of chemical composition (SO_4^{2-}, NO_3^-, Cl^-, HCO_3^-, NH_4^+, Ca^{2+}, Na^+, K^+, Mg^{2+}, H^+) and conductivity are monitored in monthly samples. At Berezinsky Reserve station also air sampling is conducted, in which SO_2, NO_2 in the air, SO_4 and total particulate (TSP) are monitored (daily samples); sporadically other components in the precipitates, air and aerosols are analysed (heavy metals, beno(a)pyrene etc).

From this network two sites – Berezino and Berezinski Reserve (*Figure 1*) are of main interest: they are the oldest with longest rows, and located in background (Berezinski Reserve) or semi-background (Berezino) areas. So the analysis of precipitates chemistry and its connections to transboundary fluxes is based mainly on the data from these sites.

2. Data Quality Assurance

<u>EMEP data set</u>

Data check of Vysokoje EMEP site by full programme is problematic due to the fact that late 90th samples from this site were analysed in laboratories abroad which reported results directly to CCC so there are no initial measurements data in Belarus for this period.

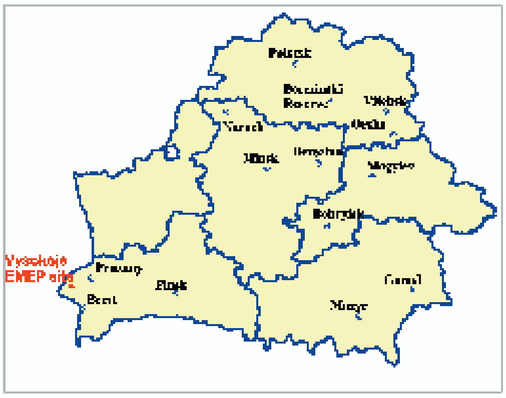

Figure 1. Map of monitoring sites in Belarus

Other sites data set

Precipitation chemistry data from 14 sites was checked using EMEP recommended control procedures. The following routines were used: visual inspection of raws, ion balance test, conductivity test. WMO and EMEP quality criteria for ion balance and conductivity were used.

On the whole most of samples have acceptable quality. More than 98% of samples comply with conductivity (average accuracy 8-10%), and 90% - with ion balance tests (average accuracy 5-8%).

3. Trend Analysis Methodology

For statistical trend analysis following procedures were used: test for existence of trends at each site and running average.

Non-parametric Seasonal Kendall Test (SKT) was applied for trend detection and measurement (Gilbert, 1987).

4. Main Trends

4.1. Precipitation

Sulphur

At Vysokoje site in spite of sporadic character of measurements feebly marked upwards trend of sulphur content in precipitates can be detected (*Figure 2*).

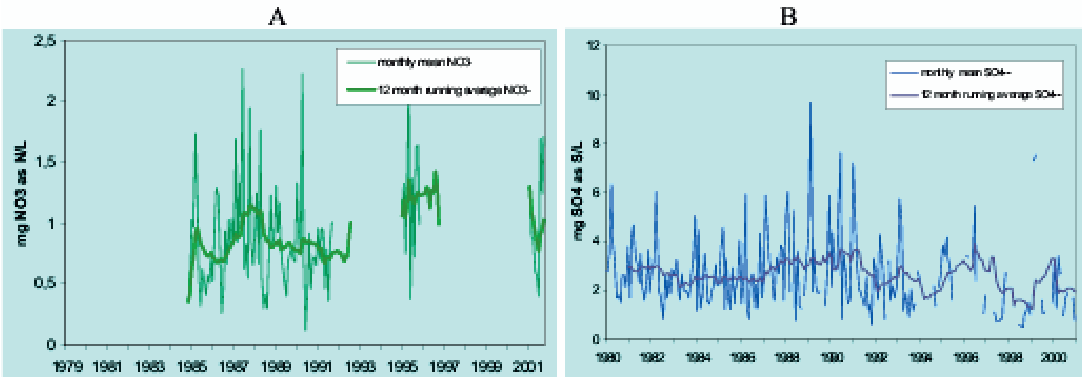

Figure 2. Monthly means of sulphates in precipitation at Vysokoje (A) and Berezino (B) site

Tendencies of long period fluxes can be considered on an example of Berezino site. During the 60s level of sulphur content increased. Within the period from 1970 to 1977 the intensity of fluxes varied, then their reduction started, which lasted up to the middle of 80s. In the subsequent period essential changes of an average level of sulphur depositions at this site have not taken place. Contrary to this at Berezynski Reserve site sulphur content have steadily reduced since early 80s to late 90s. Analysis of dynamics of sulphur fluxes at other sites (for the period since 1990) showed the distinct downwards trend of sulphur content in precipitation in 90s; most sharp reduction is typical for the first part of 90s.

Oxidized nitrogen

At Vysokoje site, with regards for the sporadic character of measurements, signs of general upward trend of nitrates content in precipitation can be detected (*Figure 3*).

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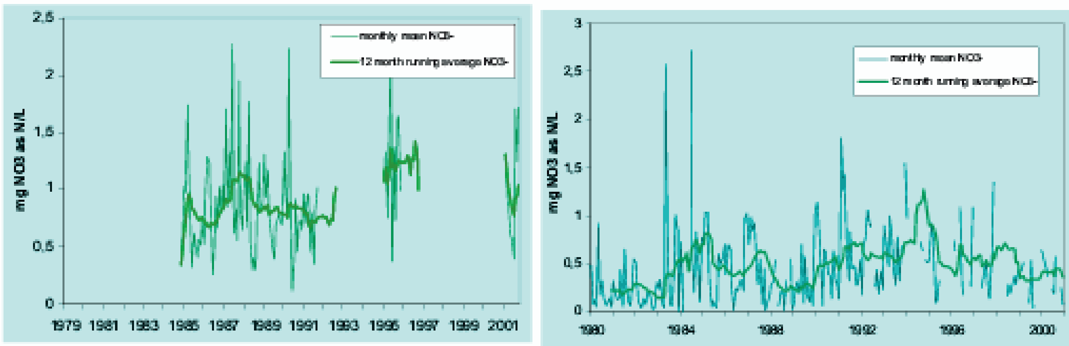

Figure 3. Monthly means of nitrates in precipitation at Vysokoje (A) and Berezino (B) sites

At Berezino site average intensity of nitrates content in precipitates remained rather stable until the beginning of 80s, when the increase began (lasted till middle of 80s). Later at this site mainly fluctuations with feebly marked increase occured.
Rather distinct character of oxidized nitrogen fluxes is typical for Berezinski Reserve site: since 1981 to 1990 nitrates content in precipitates have increased. Lately mainly fluctuations with illegible decrease have taken place.
For 90s statistically significant downward trend for 11 precipitates measurement sites was detected by SKT. But this trend was not linear. Sharp reduction of nitrates content in precipitates was detected for the period from 1994 to 1996. Its reasons are obscure.

Reduced nitrogen

No distinct trend was detected for Vysokoje EMEP site (*Figure 4*).

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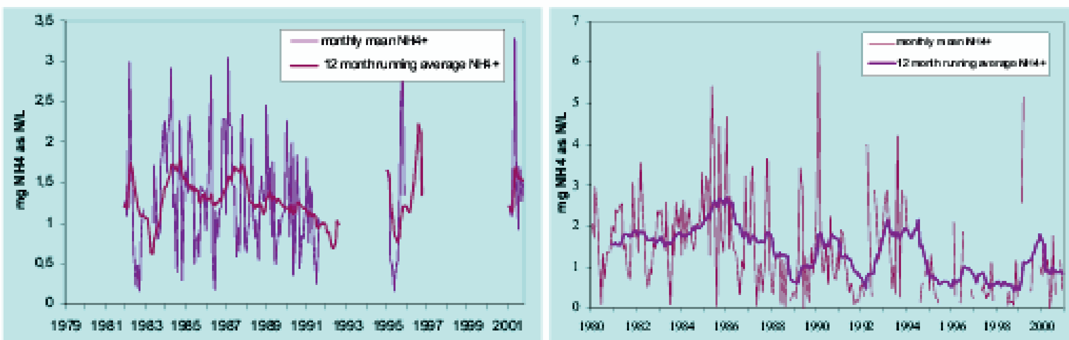

Figure 4. Monthly means of ammonium in precipitation at Vysokoje (A) and Berezino (B) sites

Within the period since 60s highest values of ammonium concentrations at Berezino site were typical for the middle 80s. At Berezinski Reserve site ammonium fluxes grew steadily since 1981 and have the highest values in the late 80s.
Generally for reduced nitrogen content great fluctuations are typical which can hardly been explained now; general trend in 90th was downwards.

<u>Acidity</u>

For the majority of stations reaction of precipitates is close or higher the equilibrium value. This is stipulated mainly by the location of the most of stations in cities. In background conditions precipitates are acid (at Berezinski Reserve mean pH for 1990-1999 – 5.1).
At Vysokoje site steady reduction of pH value till early 90s was detected (*Figure 5*). Later distinct upward trend can be seen.

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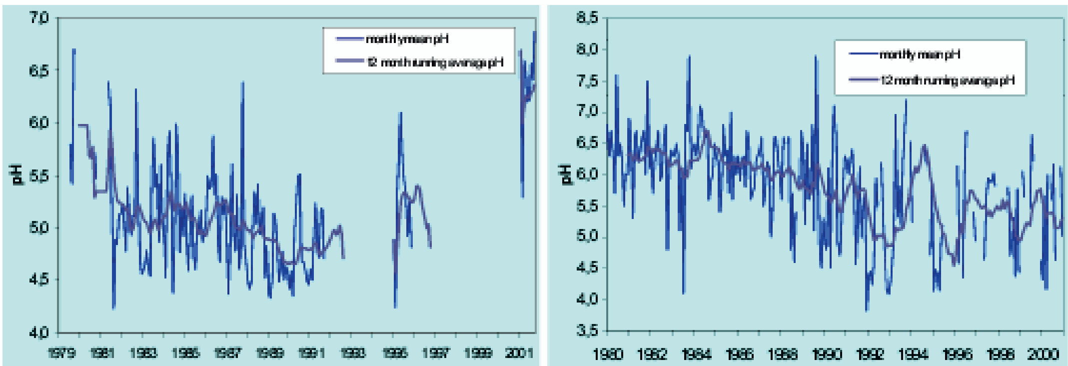

Figure 5. Monthly means of pH of precipitation at Vysokoje (A) and Berezino (B) sites

At Berezino site grows of pH value is typical from early 60s to the end of 70s. Later general tendency – decreasing of pH (*Figure 9*). At Berezinsky Reserve site no general trend in precipitates acidity was detected for 80s; in 90s slight decrease of acidity by SKT test was revealed.
Trend of acidity in 90s is significant for the most of precipitates measurement sites (8 from 14). But sites are heterogeneous in acidity trend: for 5 of them it is positive, and for 3 – negative

4.2. Gases and Aerosols in the Air

Air monitoring data at Vysokoje station is even more limited then precipitation: only for the period 1985-1991. Air measurements have been done also at Berezinski Reserve site (since 1980).

<u>Sulphur dioxide in the air</u>

No distinct trend for Vysokoje site. But steady and significant decline of sulphur dioxide concentration in the air for Berezinsky Reserve site (mean concentrations - 3.8 μg/m^3 in 1981-1985, and 1.3 μg/m^3 – in 1996-2000) (*Figure 6*).

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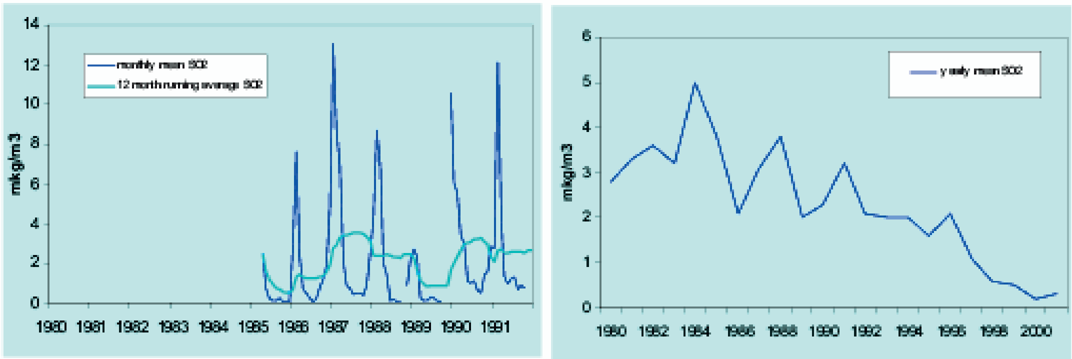

Figure 6. Sulphur dioxide in the air at Vysokoje (monthly means) and Berezinski Reserve (yearly means) sites

<u>Sulphates in aerosols</u>

Sulphates content have fluctuations with general reduction trend for 80th at Vysokoje site (Figure 12); at Berezinsky Reserve site distinct downward trend since late 80th (from 5-6 to 2.5-3 μg/m^3 – *Figure 7*).

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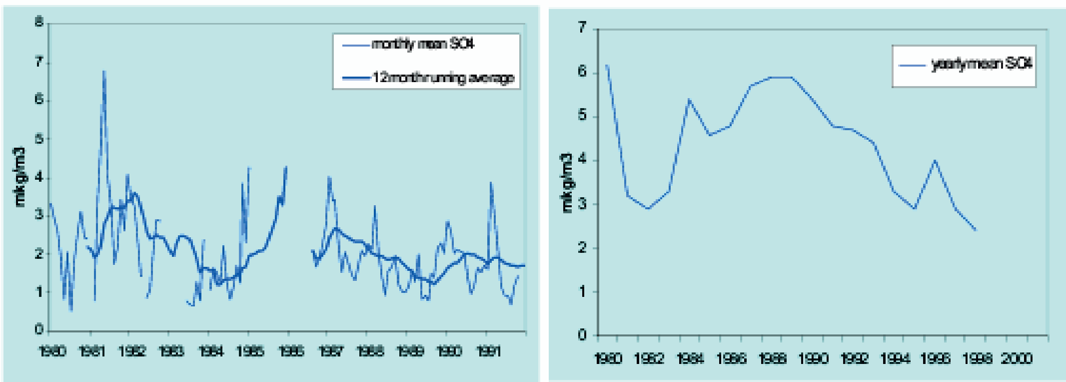

Figure 7. Sulphates in aerosols at Vysokoje (monthly means) and Berezinski Reserve (yearly means) sites

<u>Nitrogen dioxide in the air</u>

Nitrogen dioxide in the air at Vysokoje EMEP site was measured only from 1986 to 1991; during this period general trend was upward. At Berezynski Reserve site (measurements since

1985) in the period since late 80[th] till 1995 sharp reduction of concentrations occured (from 3.4 up to 0.6 µg/m^3). Later concentrations fluctuated mainly within the limits 0.9-1.3 µg/m^3).

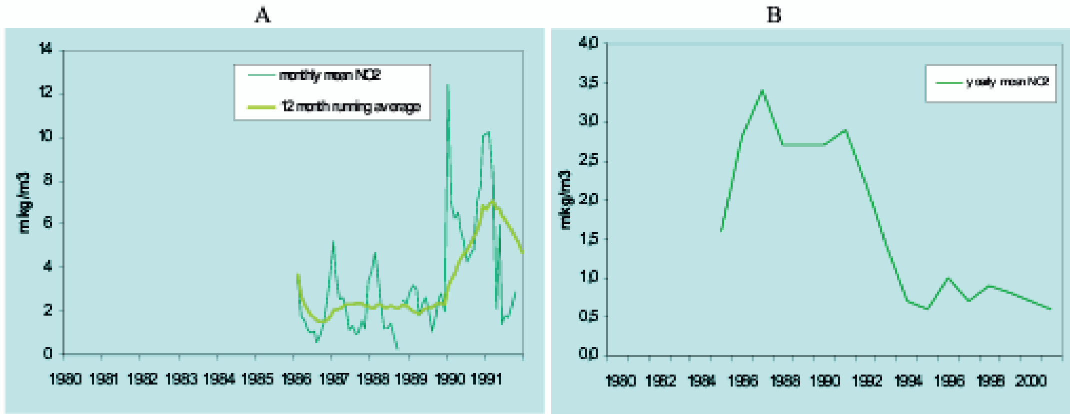

Figure 8. Nitrogen dioxide in the air at Vysokoje (monthly means) and Berezinski Reserve (yearly means) sites

4.3.Depositions

Deposition fluxes were analysed using data on precipitates composition for all sites; for comparison EMEP modelling results (Transboundary Acidifying.., 1998, 1999) were applied.

<u>Sulphur Deposition</u>

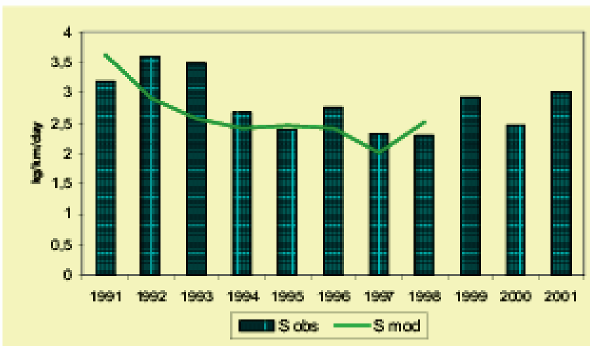

Figure 9. Dynamics of averaged levels of sulphur deposition on the territory of Belarus by precipitation monitoring network (obs) and by EMEP model calculations (mod)

Analysis of dynamics of wet deposition fluxes for the period since 1990 (*Figure 9*) showed the distinct downwards trend of sulphur deposition till late 90s (its average fluxes reduced from 3.4 kg S/km^2 day in 1992-1993 to 2.5 kg S/km^2 day in 1997-1999).

This trend has statistically approved significance for 10 sites. Only one site has positive trend (Mozyr), but statistically not different from zero. Most sharp reduction is typical for the first part of 90s; contrary to this for last years no distinct trend can be detected.

Tendencies of long period fluxes can be considered on an example of Berezino site. During the 60s level of sulphur deposition increased twice (from 3.8-4.4 kg S/km^2/day to 8.4 kg S/km^2/day. Within the period from 1970 to 1977 the intensity of fluxes varied within the limits 6.0-8.2 kg S/km^2/day; then their reduction started, which lasted up to the middle of 80s. In the subsequent period essential changes of an average level of sulphur depositions at this site not take place. Contrary to this at Berezynski Reserve site sulphur depositions steadily have reduced since early 80s to late 90s from 3-3.2 kg S/km^2/day to 1-1.2 kg S/km^2/day.

Oxidized Nitrogen Deposition

For 90s statistically significant downward trend for 11 sites was detected by SKT. But this trend was not linear (*Figure 10*). Sharp reduction of nitrates deposition detected in period from 1994 to 1996. Its reasons are obscure.

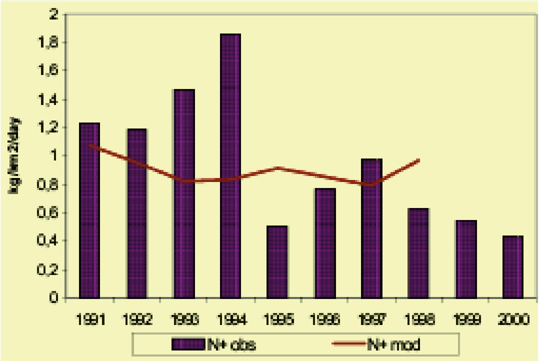

Figure 10. Dynamics of averaged levels of oxidized nitrogen deposition on the territory of Belarus by precipitation monitoring network (obs) and by EMEP model calculations (mod)

Within the long-term period (on an example of Berezino site) average intensity of oxidized nitrogen depositions remained rather stable until the beginning of 80s, when the increase of depositions began (from averaged levels of 0.2-0.4 kg N/km^2/day to 0.6-0.8 kg N/km^2/day at the middle of 80s). Later mainly fluctuations with feebly marked increase occured.

More distict character of oxidized nitrogen deposition is typical for Berezinski Reserve site: since 1981 to 1990 deposition fluxes increased from 0.15-0.2 to 1-1.2 kg N/km^2/day. Lately mainly fluctuations with slight decrease have taken place.

Reduced Nitrogen Deposition

For reduced nitrogen deposition levels great fluctuations are typical (*Figure 11*) which can hardly been explained in simple relations. Such heterogenity of ammonium fluxes is a characteristic feature of this compound across the Europe (A contribution.., 2000).

Within the period since 60s highest values of ammonium deposition (Berezino site) were typical for the middle 80s – 2.5-3.0 kg N/km^2/day.

At Berezinski Reserve site ammonium fluxes growed steadily since 1981 and have the highest values in the late 80s (2.7-2.9 N/km^2/day).

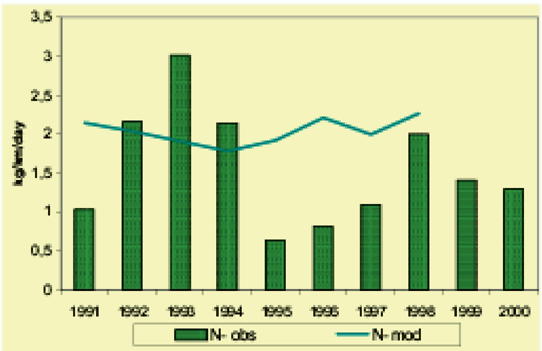

Figure 11. Dynamics of averaged levels of reduced nitrogen deposition on the territory of Belarus by precipitation monitoring network (obs) and by model calculations (mod)

4.4.Emissions

In continuation of the most part of 80s SO_2 emission on the territory of Belarus was stable. Reduction started in 1988, and rapid reduction – in 1992 (*Figure 12*). During the period from 1992 to 2000 SO_2 emission reduced from 652 thous. to 140.2 thous. tonnes or by 78%, in comparison with 1980 – 81%). This was stipulated mainly by changes in fuel balance (replacement of residual oil by natural gas) and decrease in energy production and consumption.

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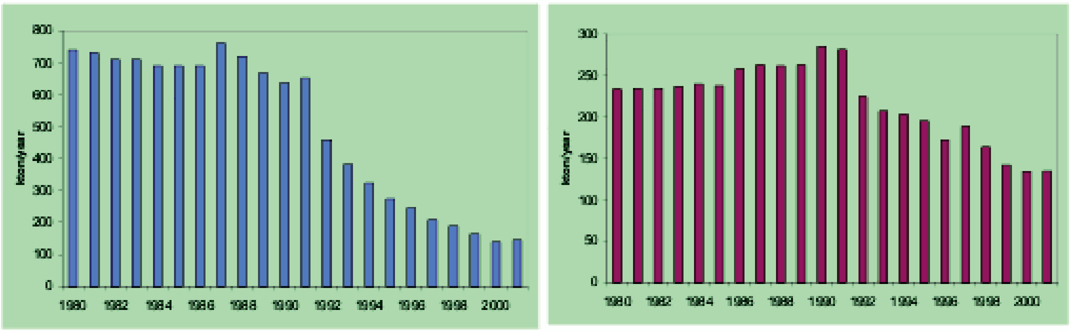

Figure 12. Trends in of SO_2 (A) and NO_x (B) emission on the territory of Belarus

Nitrogen oxides emission increased from 1980 to 1990 (maximum – 285 thous. tonnes); from 1992 stable reduction began and up to 2000 emission reduced up to 135 thous. tonnes 53% reduction in comparison with 1990, and 43% - in comparison with 1980.).

Ammonia emissions which are mainly originated from agriculture (domestic animals) have also downward trend (*Figure 13*). Reliable estimates are available only from 1990; ammonia emissions decreased since that time approximately by 35%.

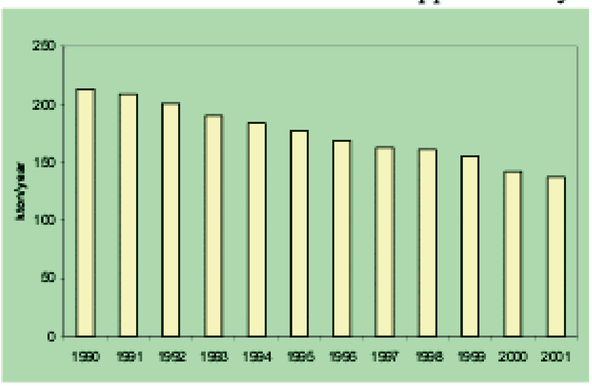

Figure 13. Trends in NH_3 emission on the territory of Belarus

4.5. Precipitation and emissions

Generally decrease in emission of sulphur is not equivalent to the decrease of its deposition.

This can be demonstrated on the examples of cities with precipitates sampling where emission of SO_2 in 90s reduced a few times but sulphates deposition reduction is significantly less.

In the most of cities with precipitates sampling emission of SO_2 in 90s reduced a few times: so in Mogylev from 55.6 thous. tonnes in 1990 to 4.3 thous. tonnes in 1998; in Bobryisk –

from 36.6 to 5.7 thous. tonnes, in Vitebsk – from 17.2 to 6.5 thous. tonnes etc.; nitrogen oxides emission reduction also typical though not so sharp. But adequate changes in SO_4^{2-} and NO_3^- content in precipitates did not occur. These can be explained as the result of growth of tranboundary input into chemical composition of precipitates even in cities.

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Characteristic feature of Belarus – prevalence of transboundary sulphur and oxidized nitrogen in depositions: the share of transboundary sulphur and oxidized nitrogen in depositions on the territory of Belarus significantly exceeds own contribution from own sources. On the data for 1998 (Transboundary Acidifying…, 1999), 83% of sulphur and 89% of oxidized nitrogen total deposition fluxes are originated from abroad, mainly from Poland and Germany. Contrary to sulphur and oxidized nitrogen reduced nitrogen input is mainly due to domestic sources (> 60%).

Conclusions

Decrease of emission of acidifying compounds on the territory of Belarus last 20 years is obvious, especially for sulphur dioxide.

On the whole limited data unequal on quality is available for analysis of pollutants fluxes on the territory of Belarus; this makes difficult to reveal distinct trends.
Reduction of sulphur content in precipitates and sulphur wet depositions have been fixed, in spite of it is not adequate reduction of emission.
Regarding nitrogen fluxes there are no so evident regularities. For 90s statistically significant downward trend for most of sites was detected, but this trend was not linear. Sharp reduction of nitrates deposition detected in period from 1994 to 1996. Its reasons are obscure.

For reduced nitrogen content in the precipitates and deposition levels great fluctuations are typical; general trend for 90^{th} with caution can be marked as downwards.

Available limited information on sulphur and nitrogen content in the air and aerosols shows significant reductions of these compounds content, more evident than in precipitates. This is especially evident for sulphur. This shows more essential decrease of dry depositions in comparison with wet.

Prevalence of transboundary sulphur and oxidized nitrogen in depositions on the territory of Belarus became more sharp. So we can speak that now deposition fluxes of sulphur and oxidized nitrogen on the territory of Belarus has more close relation to these compounds emission levels on the territory of Europe as a whole rather than to emission of domestic sources. This issue shows more evident reduction of dry depositions of sulphur and nitrogen in comparison with wet.
Trend in acidity of precipitates is not evident; generally we can conclude that there was not detected (especially for background conditions) distinct upwards trend of pH value which can be expected from reduction of sulphur fluxes.

Acknowledgements

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