AIR POLLUTION OF FOREST ECOSYSTEM "RACOVĂŢII DE SUD"

FASOLA REGINA[1]

ABSTRACT. Air pollution of forest ecosystem "Racovăţii de Sud" In this paper was established anthropogenic impact of acid oxides (NO_x and SO_2) and the accumulation of heavy metals in the environmental components of the ecosystem „Racovăţii de Sud". The current state of the ecosystem was estimated based on data information using European Monitoring and Evaluation Programme (EMEP) and dynamic information on emissions for the period 1990 to 2010, for the Republic of Moldova. According to the scale gradations of heavy metals in the soils of the Republic of Moldova Кирилюк (2006), studied soil is characterized as a medium content of heavy metals. Compared with liter, the mosses and lichens show greater storage capacities of heavy metals (Pl, Ni, Cu, Cr), which presupposes an increased penetration of air pollutants from transboundary sources.

Keywords: air pollution, acid oxides, heavy metals, forest ecosystem

1. INTRODUCTION

In our country as well as in Europe, transboundary air pollution determined by the atmospheric emissions of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) leads to acidification and eutrophication of ecosystems. An important contribution to the spread out of pollutants from sources of pollution has wind direction and speed. Republic of Moldova is influenced by Atlantic air masses that are moving through European countries and absorb harmful substances emitted into the atmosphere from various sources of pollution. In this context, as a factor of pollution for the whole territory of our country, serve transboundary sources represented by the industrial centers, with the share of 30% SO_x, 21% NO_x from Ukraine and 14% SO_x, 30% NO_x from Romania (Gauss et al., 2013). According to EMEP Reports (Gauss et al., 2013), by 2010, NO_x emissions in EMEP countries was estimated to be reduced with - 42% compared to 1990. For the same period in the Republic of Moldova emissions were reduced by 65% - NO_x and 95% - SO_x.

2. AREA AND RESEARCH METHODS

The subject of study has served the forest "Racovăţii de Sud", Soroca State Forestry Enterprise. The ecosystem is located in the basin of the river Cereţnovăţ, a tributary of the Dniester river (Fig. 1) in the region of steppe plateaus and forest-steppe plateau (NW of the Republic of Moldova). The characteristics of air

[1] Institute of Ecology and Geography, Chişinău, Moldova
e-mail: reginaf21@mail.ru

pollution sources and the quantity of pollutants emitted by local sources were defined according to the information of State Ecological Inspectorate Yearbook (2011) (Prisacarul, 2012).

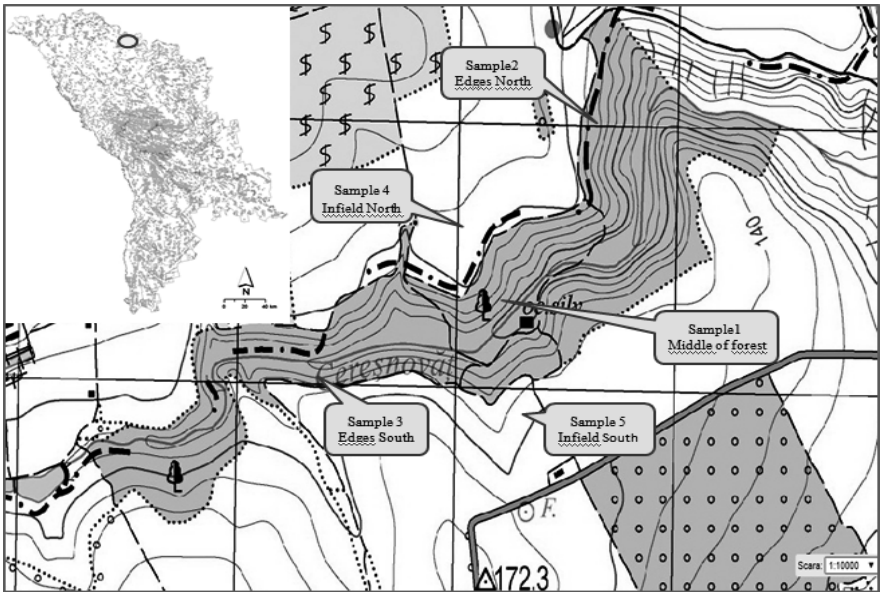

Fig. 1. Ecosystem location and the sampling points

The transboundary atmospheric deposition of pollutants (NO_x, SO_x, NH_3) is according to European Monitoring and Evaluation Programme (EMEP) (Gauss el al., 2013).

In order to evaluate the effects of pollution with heavy metals of the components of the studied forest ecosystem, the studies were performed within the ecosystem as well as within the adjacent agricultural lands.

The content of heavy metals in soil and biota was determined using the spectrometry Roenthgen – fluorescent method at Spectroscan MAX-G in the laboratory of Natural and Anthropized Ecosystems of the Institute of Ecology and Geography.

3. RESULTS AND DISCUSSIONS

Ambient air quality in Republic of Moldova is influenced by emissions from two types of pollution sources local and transboundary, local sources can be divided into fixed and mobile. Transboundary air pollution in the Republic of Moldova, the main source of pollution, as in the rest of Europe, is caused by emissions of SO_x and NO_x from thermoelectric centers, large industrial companies, coal and other fossil fuels burning in the domestic sector and transport related emissions which are manifested by acid rains. Regarding the ratio of import/export

of pollutants (SO_x NO_x) in a transboundary aspect, Republic of Moldova proved to be an importer of sulfur, nitrogen oxides and ammonia (Brega et al., 2006).

According to Gauss et al. (2013) the transboundary import quota in 2011 for the quadrant 87/65 (ecosystem "Racovăţii de Sud") consisted of over 90% for deposition of sulfur oxides (SO_x), 80-90% deposition of nitrogen oxides (NO_x) and a lower amount of 50-60% of ammonia (NH_3) (Table 1). The strongest (mainly) transboundary impact on the studied ecosystem is caused by SO_x and NO_x pollutants, with the largest share in neighborhood countries - Ukraine (30%) SO_x (21%) NO_x and Romania (14%) SO_x, (30%) NO_x.

Table 1. Deposition of pollutants in the EMEP (50x50km) grid 87/65 – region Soroca in 2011, mg/m^2 (www.emep.int)

Atmospheric depositions	1990			2011		
	SO_x	NO_x	NH_3	SO_x	NO_x	NH_3
Dry deposition	523	149	200	107	91	68
Wet deposition	1213	361	397	290	187	136
Total deposition	1736	510	597	397	278	203

Under the regulations of the LRTAP Convention, where Republic of Moldova is a signatory, the air quality in the studied area, as well as across the country, significantly improved compared with 1990. The total deposits in 2011 decreased compared to 1990 by 4.4 times for SO_x, 1.8 – NO_x and 3 – NH_3 (Table 1). Nitrogen oxides, which recorded the lowest discounts, may experience a negative impact on the studied area as a result of the increased number of automobiles. A significant impact has wet depositions that are more dangerous (2 times) than dry deposition (Table 1) and reflect the impact of transboundary ecosystems.

Out of local both stationary and mobile sources, a more pronounced impact on the environment and natural ecosystems of studied area have emissions from urban/industrial centers – Balţi, Soroca, Rezina that are located at 52, 55 and 14 km distance. For 2011 counted emissions of NO_x from respective sources were about 790, 520 and 300 t, and for SO_x counted emissions were – 194, 48, and 73 t respectively, and the dominant sources of emissions are mobile ones. The main stationary sources are S.A."Lafarge Ciment" (1034 t) – Rezina, S.A. „Floarea Soarelui" (128 t), CET „Nord-Balti" (70 t) (Prisăcarul, 2012).

The most of metals have an ambivalent role in the environment, depending on the concentration the metals can be essential micronutrients or toxic components for plants and soil organisms. As a result, emissions and deposits of heavy metals and their cycle in the environment are important issues in research of the environment (Smidt et al., 2012).

In our study the content of heavy metals in the upper layer (0-20 cm) of the soil of ecosystem, determined based on soil gradation scale of the Republic of Moldova (Кирилюк, 2006) (Table 2) recorded a *medium* content for all studied metals in the soils of the ecosystem. For agricultural fields adjacent to forest

ecosystems, heavy metals recorded a *high level*. So wasn't registering any case of pollution caused by analyzed metals, both in the ecosystem, as well as in adjacent lands. In the ecosystem, the values of heavy metals are below the threshold alert value and much less than the intervention threshold level after (Kloke, 1980), which excludes the risk of toxicity in studied forest ecosystems for plants and soil organisms. Alert threshold was exceeded in the north farmland soil, worked extensively, just – for the metal Cr (107 mg/kg), but the value is within the range for soils of Moldova (25-145).

Table 2. The level of heavy metals in soil (0-20 cm) ecosystem Racovăţii de Sud, mg/kg d.w. (dry weight)

No.	Sampling location	Pb	Zn	Cu	Ni	Cr
1	Middle of forest	5.7	76.1	27.1	43.4	86.1
2	Edges North	1.8	60.1	38.7	35.8	80.0
3	Edges South	-	59.3	34.7	33.2	69.8
4	Infield North	-	85.5	73.9	69.9	107.0
5	Infield South	-	70.1	70.0	42.2	82.7
Alert threshold, Kloke (1980)		50	300	100	75	100
Intervention threshold , Kloke (1980)		100	600	200	150	300
Average Klark, Lăcătuşu (2008)		30	66	22	23	30

The trend of increased metal accumulation in adjacent land compared to soil within the ecosystem can be explained by anthropogenic contribution as a result of agricultural work (chemical processing, use of fertilizers).

Biota of forest ecosystem "Racovăţii de sud" shows increased capacity for accumulation of Cu and Zn (Fig. 2) as a result of intensive processing of adjacent agricultural land (planted with orchards and vineyards) with chemicals, particularly Cu. In the case of Ni, Cu and Zn, moss proved to be better accumulators than lichens and vice versa for the metals Pb and Cr. For all metals (Pb, Cu, Cr), both moss and lichens accumulated higher levels than litter, which proves penetration of heavy metals by air.

The highest concentration of Pb (10.5 mg/kg) recorded in lichens. Concentration recorded in litter (5.6 mg/kg) exceeds the range of Pb values registered in oak leaves (0.1-3 mg/kg) (Кирилюк 2006), that indicates a transboundary pollution and a local negative impact of emissions from road Chisinau-Soroca located about 5 km W-NW. For the rest of the studied metals were not detected values exceeding the range of specifications for oak leaves for Republic of Moldova, which according to (Кирилюк, 2006) are: Zn – 1-50, Ni – 1-10, Cu – 5-80 and Cr – 1-20 mg/kg.

The content of heavy metals from oak bark is the smallest one of analyzed biotic components for Ni (2.1 mg/kg) and Zn (45 mg/kg), while for Pb, Cu, Cr the content is higher than in litter for Cu higher than in lichens and mosses (Cr) (Fig. 2). Thus, as in the case of lichens and mosses, just with a higher ratio the chemical

composition of bark is influenced by throughfall depositions and canopy drip (Schulz et al., 1999), a factor that could explain the higher or lower concentrations of heavy metals compared with other biotic component, depending on the chemistry of precipitation. Also, heavy metals can be transported by wind from the soil surface to bark. The structure of bark has a considerable influence on the passive accumulation of heavy metals, a rough surface (ex. oak) easily accumulate pollutants than a smooth one.

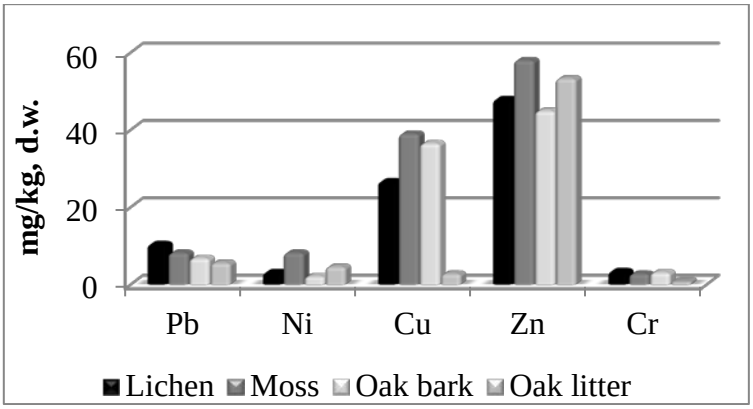

Fig. 2. The level of heavy metals in vegetation of ecosystem Racovăţii de Sud, mg/kg, dry weight (d.w.)

Heavy metal content in mosses analyzed was compared with values recorded in ICP Vegetation program (heavy metals in mosses: spatial patterns in 2010/2011 and long-term temporal trends in Europe) (Harmens et al., 2013). According to this program in our ecosystem were recorded *optimal concentrations* for Pb and Zn (Pb – 8-12 respectively Zn – 40-60 mg/kg), *moderate concentrations for* Cr (2-3 mg/kg) *high concentrations* for Ni (6-9 mg/kg) and the increased pollution levels recorded for Cu, being the *highest concentrations* (> 24 mg/kg).

5. CONCLUSIONS

The main source of air pollution of the forest ecosystem ”Racovăţii de Sud” is transboundary pollution, with the highest ratio of Ukraine as a result of the location of the ecosystem at the country's eastern border.

Trends of increased accumulation of heavy metals in soil samples from adjacent agricultural lands, especially Cu, Zn and Pb, don’t present a risk of pollution for the studied forest ecosystem, but for a long term this risk may persist as a result of very wide use of Cu, less Zn, in chemical processing of crops and forests.

The concentration of pollutants that is below the allowable limit and lack of major sources of local and transboundary pollution for studied ecosystem provides favorable conditions.

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