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THE INFLUENCE OF FORESTS FROM LUNCA MUREŞULUI NATURAL PARK ON GREENHOUSE GASES LEVELS

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Abstract

The paper aims to analyze the influence of the stand characteristics in two areas of the Lunca Mureşului Natural Park, on the main greenhouse gases in the atmosphere (O_3, NH_3, NO_2). In the first part, an extensive bibliographic study was carried out, regarding similar research referring to greenhouse gases in generally and O_3, NH_3 and NO_2 in specially, and the relation of these greenhouse gases to forest vegetation. The working method regarding data collection in the period 2014-2019, the types of gases analyzed, the types of collection pads used, the exposure times of the collection pads were presented, together with the working method for data processing. The results were obtained by analyzing relation of certain characteristics of the stand (age, volume, stand density) with concentration of studied greenhouse gases on vegetation season from the period 2014-2019. The obtained results were discussed in the context of other current research in the field and the most important aspects were presented as conclusions at the end of the paper.

Key words: *atmosphere, stand composition, forest age, height of trees.*

INTRODUCTION

Atmospheric emissions of greenhouse gases have increased dramatically in recent decades, compared to the last century, due to technological development (George et al., 2021). This leads to climate change and global warming, which affects people's living standard (Jeffry et al., 2021). The greenhouse effect has two aspects: the main effect that has existed for thousands of years and gives the planet Earth its hospitable temperature, and the secondary effect that has existed for only 250-300 years and is caused by the increase in the concentration of greenhouse gases (Tucket et al., 2019).
Ozone is the air pollutant of major concern for forests and is also recognized as a significant greenhouse gas. Current O_3 levels in the Northern Hemisphere have increased approximately 2-4.5 times since pre-industrial times (Paoletti, 2008). Currently, tropospheric ozone (O_3) is the third most important greenhouse gas after carbon dioxide (CO_2). (Ehhalt, 2001). Ozone (O_3) together with infrared active gases (IR) - mainly water vapor, naturally present in the atmosphere, they absorb the radiation, the atmosphere being heated by this mechanism. (Ledlez et al., 1999).
At the global scale, NH_3 (ammonia) and their deposition on vegetation is considered the most important, among all N (nitrogen) gases in the atmosphere (Krupa, 2003). Among others, agriculture is a significant contributor to emissions of NH_3 in the atmosphere (Duxbury 1994). NH_3 can contribute to the formation of atmospheric aerosols, particles that decrease the amount of light available for plant photosynthesis (Templer et al., 2012).
Nitrogen dioxide (NO_2) is a concern pollutant in the urban areas, related to fossil fuel burning, including transportation, generation of electricity and residential and industrial activities (Restrepo, 2021). Although NO_2 is not actually a greenhouse gas, it is in fact a precursor for formation of a greenhouse gas - tropospheric ozone (Paraschiv et al., 2020).
Forests and woodlands represent a substantial stock of carbon that is contained in soil, trees

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and other vegetation (Morison et al., 2012). Management of forests for mitigation of greenhouse gas emissions assumed conservation management options as slowing deforestation, protection and conservation of forests (Brown, 2012).

Relevant changes of the balance of greenhouse gases in the forest sector are related to forest management. To have a sink of carbon, increment of wood need to exceed harvested timber volume (Baritz and Strich, 2000), but it needs to be considered that mechanized operations on forest harvesting activities are sources of greenhouse gas emissions (Berg and Karjalainen, 2003).

The paper aims to analyse the relation between some stand characteristics in two areas of the Lunca Mureşului Natural Park, and the content of some greenhouse gases in the atmosphere (O_3, NH_3, NO_2).

MATERIALS AND METHODS

This paper analyzes the relation of stand characteristics of forest and greenhouse gases from Lunca Mureşului National Park on two points in the vicinity of forest administrated by Iuliu Moldovan Forest department (Figure 1):

- Point A - Bezdin: located in U.P. (production unit) I, near management units 54A, 54B, 54C, 54D, 54E, 54F, 54G, 54H, 55A, 55B, 55C, 55D, 55E, 55F - close to Munar village, Secusigiu community;
- Point B - Ceala: located in U.P. V, near management units 18A, 18B, 18C, 18D, 18E, 18F, 18G, 18H, 18I, 18 J, 18K, 21A, 21B, 21C, 21D, 21E - close to Arad municipality.

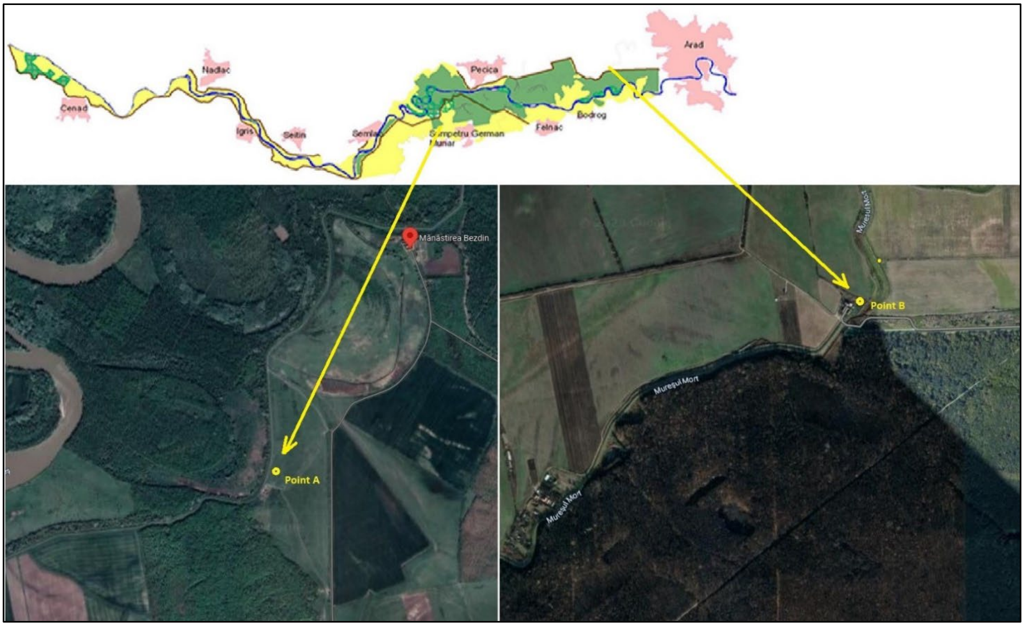

Figure 1. Location of Point A and B where greenhouse gases concentration was measured (Google Maps)

In the above-mentioned points, O_3, NH_3 and NO_2 concentration was measured using passive samplers (Ogawa & CO): O_3 (PS-114), NH_3 (PS-154), NO_2 (PS-134) monthly exposed in the field, in the vegetative season, in the period July 2014 - September 2019. Each month measurement was duplicated in the field, results of the monthly analyses being obtained by the average of the results for the two duplicates samples. For each year, result of O_3, NH_3 and NO_2 analyses was obtained using the average for the entire sample period on the year.

The concentrations of the greenhouse gases mentioned above and captured in the passive samplers during the specified period, were determined in the chemistry laboratory of INCDS "Marin Dracea" - Câmpulung Moldovenesc Research Station. Results of

analyses for the ozone, ammonia and nitrogen dioxide concentrations were expressed in parts per billion (ppb).
Management units considered in this study, from vicinity of A and B points (Figure 1) are the closest forest area delimited by parcel lines, being part of Bezdin and respectively Ceala forest. Based on a bibliographic data, stand characteristics were analysed using data from management plan of production units 1 and 5 from Iuliu Moldovan Forest department, namely data corresponding for management units from vicinity of point A and B - greenhouse gases passive sampler location. For each stand, elements from each management unit, and the following stand characteristics were considered for analyses: age, species, diameter, height, stand density, volume.
The relationship between the above mentioned characteristics and the concentration of O_3, NH_3 and NO_2 was studied in the period 2014-2019.

RESULTS AND DISCUSSIONS

The determinations expressed in ppb regarding the concentrations of O_3, NH_3 and NO_2 in the Bezdin and Ceala locations were made by analyzing the passive samplers exposed monthly in these locations (Figure 1). The results of the analysis, summarized by each analyzed period, and standard deviation for the analyzed samples, are shown for Point A - Bezdin in Table 1.

Table 1. O_3, NH_3 and NO_2 content on collection pads exposed on Point A - Bezdin

Analysed period (month, year)	O_3 content (ppb)	Standard deviation (%)	NH_3 content (ppb)	Standard deviation (%)	NO_2 content (ppb)	Standard deviation (%)
Jul. 2014	33.38	2.20	1.87	4.42	1.46	0.36
Aug. 2014	38.48	5.79	1.82	1.23	1.85	6.45
Sept. 2014	28.15	0.83	1.26	4.85	0.26	5.47
Apr. 2015	29.55	0.00	2.16	5.04	1.39	0.12
May 2015	42.71	0.00	3.09	11.12	1.91	3.13
Jun. 2015	38.94	0.00	3.19	0.90	1.83	3.98
Jul. 2015	31.46	0.12	3.86	0.14	1.25	0.13
Aug. 2015	43.54	0.14	3.05	2.01	1.82	2.31
Sept. 2015	37.74	0.30	5.25	0.14	2.80	0.17
Apr. 2016	39.17	1.87	2.13	6.98	1.57	1.68
May. 2016	40.59	3.53	1.98	1.97	1.24	3.12
Jun. 2016	38.39	0.53	2.89	1.42	1.12	4.86
Jul. 2016	36.69	5.22	2.54	3.55	1.35	2.46
Aug. 2016	31.64	30.11	3.52	0.97	1.77	5.84
Sept. 2016	23.36	5.22	11.20	14.45	1.97	9.07
Apr. 2017	35.18	2.18	3.10	8.49	1.81	15.03
May. 2017	30.73	0.54	4.03	10.08	1.23	0.54
Jun. 2017	44.44	1.28	2.66	0.20	1.64	1.55
Jul. 2017	22.45	2.08	3.87	0.36	1.39	11.16
Aug. 2017	26.51	0.99	2.23	14.76	1.67	0.00
Sept. 2017	26.86	1.90	4.11	5.70	3.62	1.60
Apr. 2018	40.66	1.97	2.43	8.51	1.62	78.61
May 2018	37.34	1.61	2.12	7.23	2.18	77.42
Jun. 2018	33.13	3.32	2.73	0.91	1.86	71.02
Jul. 2018	33.96	0.66	2.10	8.99	1.95	87.81
Aug. 2018	35.19	0.38	2.31	4.17	2.48	40.69
Sept. 2018	28.91	1.03	3.16	5.52	2.53	38.40
Oct. 2018	25.55	1.71	2.23	2.06	3.16	5.67
Apr. 2019*	-	-	5.13	1.85	2.10	0.14
May 2019	23.99	5.41	2.30	13.63	6.66	0.90
Jun.2019	28.90	0.77	4.72	0.65	1.31	12.32
Jul. 2019	23.61	0.76	3.31	4.33	1.22	1.88
Aug. 2019*	-	-	1.30	7.04	1.79	0.95
Sept. 2019	20.65	2.07	0.12	11.69	1.98	0.84

*Data are missing due to filter contamination

For Point B - Ceala, the results of greenhouse gases analyses in vegetation seasons from the period July 2014 - September 2019 are shown on Table 2.

Table 2. O_3, NH_3 and NO_2 content on collection pads exposed on Point B - Ceala

Analysed period (month, year)	O_3 content (ppb)	Standard deviation (%)	NH_3 content (ppb)	Standard deviation (%)	NO_2 content (ppb)	Standard deviation (%)
Jul. 2014	33.16	1.89	3.81	1.27	1.90	2.15
Aug. 2014	36.56	7.04	3.15	0.46	2.61	4.20
Sept. 2014	30.37	1.40	3.01	2.44	3.05	4.73
Apr. 2015	30.72	0.00	3.79	0.12	2.09	2.52
May 2015	43.20	0.00	6.50	1.38	2.96	2.24
Jun. 2015	40.95	0.00	5.12	1.17	2.25	0.29
Jul. 2015	30.75	0.13	4.12	0.15	1.87	6.35
Aug. 2015	47.18	0.13	3.98	0.40	2.81	0.19
Sept. 2015	40.88	0.28	3.19	1.74	3.82	3.24
Apr. 2016	39.34	2.46	3.13	0.04	2.49	0.17
May 2016	40.30	2.11	3.61	2.96	2.27	4.54
Jun. 2016	41.12	2.71	5.54	9.23	2.20	6.18
Jul. 2016	38.17	3.19	5.77	6.20	2.76	0.63
Aug. 2016	51.66	21.39	6.32	0.12	2.75	7.79
Sept. 2016	24.05	7.03	6.26	0.46	2.93	0.57
Apr. 2017	32.19	4.98	4.62	0.36	3.02	0.20
May 2017	31.78	9.00	5.09	2.04	1.99	0.09
Jun. 2017	47.86	3.88	6.37	8.79	2.91	0.06
Jul. 2017	24.13	3.22	6.06	9.80	2.32	0.38
Aug. 2017*	-	-	-	-	2.71	0.30
Sept. 2017*	-	-	-	-	3.85	0.57
Apr. 2018	38.37	5.24	3.88	3.94	3.02	0.45
May 2018	36.07	2.13	5.01	12.30	3.34	1.88
Jun. 2018	28.09	1.02	8.85	0.82	1.98	1.50
Jul. 2018	31.12	0.04	4.12	1.42	2.88	0.47
Aug. 2018	35.03	2.14	3.41	8.11	3.82	0.31
Sept. 2018	27.67	1.13	3.76	5.67	4.71	1.89
Oct. 2018	23.41	3.42	4.20	4.19	4.96	2.17
Apr. 2019*	-	-	5.92	4.17	2.76	1.59
May. 2019	25.04	0.56	6.24	1.77	1.82	1.76
Jun. 2019	24.82	9.34	11.10	0.52	2.36	4.21
Jul. 2019	22.94	0.49	7.90	5.95	2.35	5.54
Aug. 2019	30.75	1.79	9.45	0.32	3.20	0.14
Sept. 2019	19.02	4.28	4.26	2.71	3.07	1.80

*Data are missing due to filter contamination

As it can be seen in Figure 2, O_3 concentration is similar for the entire period between the two analyzed points, showing that between the two points from the vicinity of stands with different characteristics there are not differences on O_3 concentration. This fact leads to the hypothesis that the different characteristics of the stand, such as the age and the volume of woody mass, do not lead to differences in terms of the O_3 concentration in the immediate vicinity.

Regarding NH_3 it can be observed a higher concentration in Point B – Ceala in the majority of analyzed periods (Figure 2). The same situation can be observed also in the case of NO_2 where in almost all the analyzed periods the concentration of this greenhouse gases is higher in the Point B - Ceala compared to Point A - Bezdin (Figure 2).

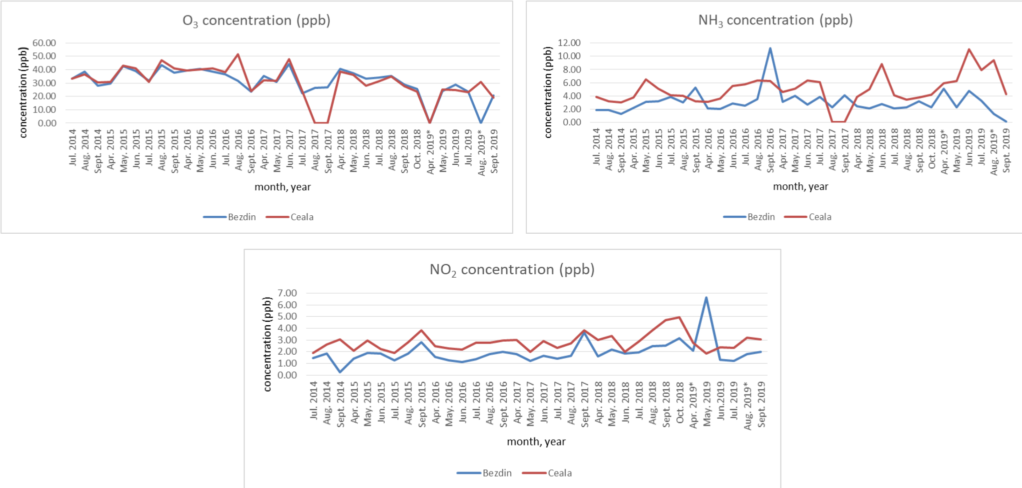

Figure 2. Greenhouse gases (O_3, NH_3, NO_2) concentration in Point A - Bezdin (blue) and Point B - Ceala (red)

The two forests from vicinity of greenhouse gases sample points are similar in terms of specific composition, the main forest species being Pedunculate oak, Turkey oak, European ash, Field maple, Poplar.

In terms of age, the forest from vicinity of Point B - Ceala is older than the forest from vicinity of Point A - Bezdin. Also, the younger forest (Bezdin) has a greater stand density in comparison to the older (Table 3).

Table 3. Stand characteristics in the vicinity of Point A - Bezdin and Point B - Ceala, where analyzed greenhouse gases has been gathered

Monitoring point	UP, management unit	Age (years)	Stand density (%)	Volume per ha (m^3)	Monitoring point	UP, management unit	Age (years)	Stand density (%)	Volume per ha (m3)
A - Bezdin	I, 54A	35	90	229	B - Ceala	V, 18A	80	70	244
	I, 54B	5	50	1		V, 18B	80	70	266
	I, 54C	25	90	151		V, 18C	25	60	107
	I, 54D	30	90	189		V, 18D	60	70	195
	I, 54E	35	90	210		V, 18E	80	70	244
	I, 54F	20	80	51		V, 18F	20	90	68
	I, 54G	25	80	81		V, 18G	80	70	250
	I, 54H	15	80	45		V, 18H	10	60	2
	I, 55A	35	80	217		V, 18I	80	80	280
	I, 55B	70	80	463		V, 18J	5	70	1
	I, 55C	10	90	46		V, 18K	5	60	1
	I, 55D	20	80	64		V, 21A	70	80	269
	I, 55E	10	90	33		V, 21B	20	100	105
	I, 54F	20	80	64		V, 21C	60	70	181
Total/ Average		**25**	**80**	**132**		V, 21D	5	60	1
						V, 21E	80	70	307
					Total/ Average		**48**	**72**	**158**

As it can be seen, in term of stand age, forest from the vicinity of point A – Bezdin have an average of 25 years old, being younger than the others which have an average age of 48 years (Table 3, Figure 3).

In terms of stand density and volume per ha, relations between the two areas are shown a higher stand density for the youngest forest and a higher volume for the older one.

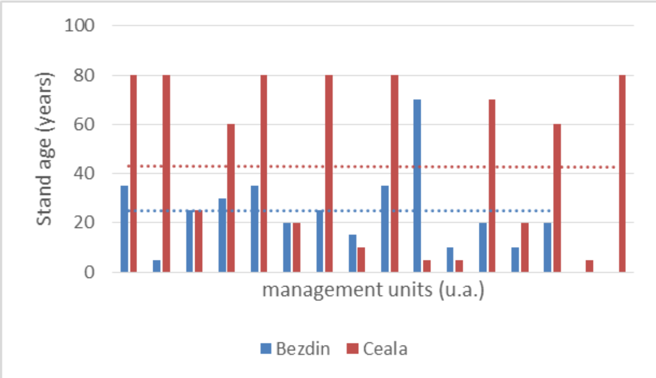

Figure 3. Stand age on the management units from the vicinity of points where analyzed greenhouse gases has been gathered

Based on Figure 2, Table 3 and Figure 3, we can observe similarities between NH_3 and NO_2 greenhouse gases concentration and forest age. Concentration of these greenhouse gases is higher on areas where forest age is higher. This fact shows that the low age of the stands and the increased growth capacity could lead to the reduction of these greenhouse gases.

Regarding stand density, it can be observed that high density of the youngest forest area (Bezdin) can lead to a reduction of NH_3 and NO_2 greenhouse gases concentration. High NH_3 losses from soil are possible in condition of high temperature, forest floor and soil with pH between 5 and 6 and air steadily moving on the soil surface (Watkins et al., 1972). High stand density can contribute to temperature reduction and reduction of air circulation and by these mechanisms, NH_3 from the atmosphere are reduced.

The contribution of high stand density to NO_2 reduction is also confirmed by other studies that show that Absorption of NO_2 into plant leaves contribute to improving urban air quality (Yli-Pelkonen et al., 2020).

CONCLUSIONS

There are not differences on O_3 concentration regardless the differences between age, stand density and volume per ha between the two areas from the vicinity of greenhouse gases gathering points.

Similarities between NH_3 and NO_2 greenhouse gases concentration and forest age, have been observed, concentration of these greenhouse gases being higher on areas where forest age is higher.

Low age of the stands and an increased growth capacity of stand could lead to the reduction of NH_3 and NO_2 on the atmosphere.

High stand density can lead also to a reduction of NH_3 and NO_2 greenhouse gases concentration.

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