THE ASSESSMENT OF THE EFFECTS OF THE ATMOSPHERIC PRESSURE ON THE INTENSITY OF CO_2 EMISSION FROM POLISSYA SOILS IN THE COLD TIME PERIOD

Assoc. Prof. Candidate of Agricultural Sciences Trofimenko P. I.[1], Assoc. Prof. Candidate of Economic Sciences Trofimenko N.V.[1]
Assoc. Prof. Candidate of Engineering Sciences Borisov F.I. [2], PhD applicant Zubova O.V.[1]
Agronomy Faculty – Zhytomyr National Agroecological University, Ukraine [1] ,
Faculty of Engineering and Power Engineering – Zhytomyr National Agroecological University, Ukraine [2]
E-Mail: Trofimenkopetr@ukr.net

Abstract: *The paper presents the results of the investigations into the effects of the atmospheric pressure on the intensity of CO_2 emission during the cold time period from podzolic soils of Ukraine's Central Polissya. It is shown that due to global warming, the winter period getting milder, against the background of less intensive soil freezing, the part played by the atmospheric pressure in intensifying the carbon dioxide emission from the soils, along with their temperature , is becoming quite significant. It has been established that the values of CO_2 emission from podzolic soils of Ukraine's Polissya after the "the post – freezing" period (III) are significantly higher as compared to the corresponding values of " the pre-freezing" period (I) of the cold period of 2015-2016.*

KEYWORDS: COLD PERIOD, "THE PRE-FREEZING" PERIOD, "THE POST – FREEZING" PERIOD, FREEZING, DEFROSTING, EMISSION OF CO_2, PODZOLIC SOILS, CARBON DIOXIDE EMISSION.

1. Introduction

As of late, the problem of increasing the rate of greenhouse gases concentration in the atmosphere proves most urgent. In the context of enhancing the greenhouse effects the soil cover of the agrosphere and forest formations is more and more often considered by researchers as an effective lever of regulating the volumes of greenhouse gases (in the first place), carbon dioxide and methane. With respect to the climate growing milder and taking into account the increase in the general global air temperature, the problem of reinforcing mineralization of the organic matter in soils is outlined more and more apparently. With respect to the above mentioned, the problem of determining the real part of separate abiotic stipulating factors which intensify the emission of CO_2 by soils proves quite topical.

2. Problem discussion

Since the peculiarities of the effects of the atmospheric pressure on the velocity of dissipation of greenhouse gases from the soil in winter were investigated by a limited number of researchers, the problem was studied insignificantly. Of late, traditionally warm winters in the countries of Eastern Europe in general, and in Ukraine with its considerable Polissya zone in particular, stipulate the reinforcement of the processes of mineralization of the organic matter in the soils in the cold period of time. The above results in the changes in the correlation between CO_2 emission volumes of warm and cold periods of time, the volumes of the latter prevailing. Along with it, the time intervals and the intensity of complete freezing of Polissya soils are becoming less and less essential, and the part played by the atmospheric pressure along with soil temperature and soil moisture – more and more significant.

Taking into account both the insignificant study of the regularities related to the effects of the atmospheric pressure on the velocity and volumes of CO_2 emission from separate types of Polissya soils to the atmosphere, and the urgent topicality of the above problem, the following tasks aimed at the successful solution of the problem are:

- tracing the dynamics of the intensity of producing carbon dioxide by the soils characteristic of the transition zone of Ukraine's Central Polissya under the conditions of in situ in all monitoring points laid;
- revealing the degree of dependence of the intensity of carbon dioxide dissipation from soils due to the atmospheric pressure.

3. Methods, objects and results of the research.

The research was conducted in 2015-2016 on the territory of the experimental field of Zhytomyr National Agroecological University. In every monitoring point referred to the geodesic and high-altitude networks, metal limiters made of stainless material (0.13 m in diameter and 0.10 m in height) were cut in the soil. During geodetic tie GPS Trimble R3 was used. Under the regime of the dynamic survey the above device contributed to the differential accuracy of reference in the plan WAAS/ EGNOS < 1 m. As a result, the coordinates in the geographic system of coordinates WGS 84 (UTM cartographic projection – Mercator universal projection) as well as their altitudes over the sea level have been obtained.

Table 1 *Names of soils and location of monitoring points*

Number of monit. point	Name of soil, crop	Coordinates		H, m
		B	L	
P 6	sod middle podzolic gleyic sandy soil on waterborne and glacier sediments, Eutric Podzoluvisols (Pde) (FAO), winter rye (Secale cereale L.)	50º26'09,15"	28º41'37,67"	254,97
P 8	Light grey podzolized gleyic sandy soil on forest sediments with waterborne and glacier sediments strewn under on the depth of 1.0-1.5 m Eutric Podzoluvisols (Pde) (FAO), winter spelt (Triticum spelta L.)	50º26'21,00"	28º41'47,37"	252,46
P 15	grey podzolized gleyic sandy soil on forest sediments with waterborne and glacier sediments strewn under, Haplic Greyzems(Grh) (FAO), winter spelta (Triticum spelta L.)	50º26'27,98"	28º41'47,37"	247,97

Decade-oriented measurements of CO_2 emission with the simultaneous measurements of values of the atmospheric pressure, air and soil temperature in monitoring points were made (0-3 cm).

The measurement and calculation of carbon dioxide volumes on the basis of chamber static method were made by means of metal cylinder chamber with the parameters of d=0.13 m, h=0.35 m(V= 0,0455 m^3) and gas analyzer Testo- 535.

Taking into account a short exposure (5 min) and assuming that $P_1 = P_2$, the calculation of SRI (soil respiration intensity) (E_{co2}) was made according to the formula (SI system) [1, 2] :

$$E_{CO_2} = \mu_{CO_2} \frac{h - h_Z}{Rt} \left(\frac{P_2}{T_2} C_{2\,ppm} - \frac{P_1}{T_1} C_{1\,ppm} \right) \quad (1)$$

where μ_{co2} – CO_2 molar mass; h – chamber height, m; h_z – the depth of the chamber submergence in the soil, m; R – molar gas constant; t – exposure time, sec.; P_1, P_2 - atmospheric pressure in the chamber at the beginning and at the end of the exposure, Pa; T_1, T_2 – temperature in the chamber at the beginning and at the end of the exposure, K; C_{1ppm} C_{2ppm} – initial and final concentration of CO_2 in the chamber.

According to the standard techniques the basic soil and agrochemical characters were determined in the soil samples selected (28.10.15, 04.11.15): granulometric soil composition according to Kachynsky (GSTU (government standard of Ukraine) 4730: 2007), the content of humus according to Tiurin (GSTU 26213-91), the content of organic matter carbon (GSTU 4289), ammonium nitrogen (GSTU 4729), aqueous pH (GSTU 26423-85), saline pH (GSTU 26483-85), the content of movable phosphorus P_2O_5 and exchange potassium K_2O according to Chyrikov (GSTU 4115-2002) (see Table 2).

Table 2: *Characteristics of soils*

Number of monitoring point	Indices of soils, content							
	physical clay, %	humus, %	C, %	NH_4^+, mg/kg	P_2O_5, mg/kg	K_2O, mg/kg	pHkcl	pH_{H_2O}
P6	14,20	1,07	0,62	16,59	111,06	129,54	4,39	5,45
P8	19,03	1,76	1,02	18,42	91,03	69,29	5,01	5,82
P15	24,63	2,09	1,21	32,09	114,14	144,60	4,95	6,46

In the process of investigating the problem cited above the cold period ranging from 01.11.15 till 02.05.16 was divided conventionally into 3 periods: "pre-freezing" period (I) (from 01.11.15 till 24.12.15), "freezing " period (II) (from 24.12.15 till 02.02.16) and "post – freezing" period (III) (from 02.02.16 till 02.05.16).

The investigation results prove that during the 1st and 3rd parts of the cold period the character of the effects of the atmospheric pressure on the velocity of carbon dioxide production from soils proved unequal. In general, the intensity of the course of CO_2 emission in the soils investigated during the cold period of 2015-2016 was subordinated to the temperature and water regimes of soils which are characteristic of the given territory in the last few years and has a strongly pronounced horseshoe outline:

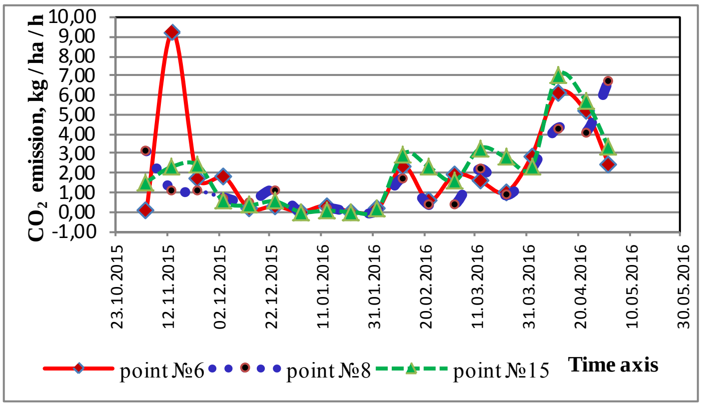
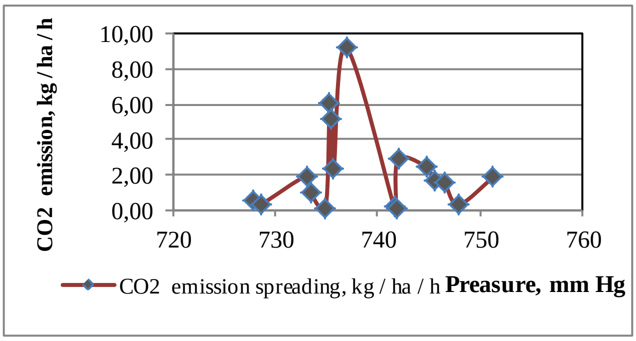
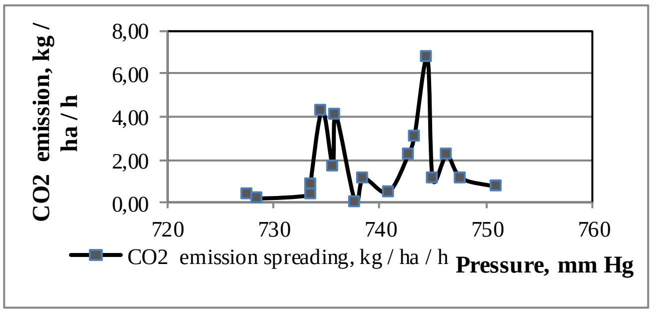


Fig.1 *The dynamics of the intensity of CO_2 emission from the soils of Ukraine's Central Polissya during the cold period, kg / ha / h.*
** names of the soils are given in accordance with the monitoring points and correspond to table 1.*

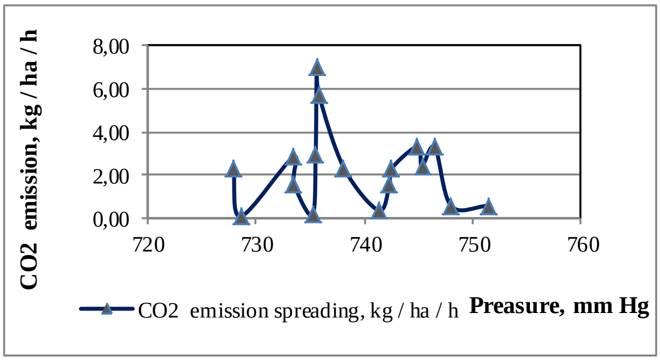
Proceeding from the data of the above figure, on completing soil-freezing period (II), one can observe quite a long-term period of melting and freezing (III) with considerable, unequal in duration, emission splashes of carbon dioxide which take place against the background of heightened moisture resulting from both snow residues melting and precipitations. Along with it, the values of CO_2 emission from soils during "the post – freezing" period (III) prove noticeably higher as compared to the corresponding values of "the pre-freezing" period (I) (see Fig. 1). In the course of the research it has been established that the above cited emission splashes are reinforced by rapid changes in the values of the atmospheric pressure which, in their turn, have both daily and much more long-term fluctuations. The effects of the atmospheric pressure on the velocity of carbon dioxide production was mostly observed in the cases of the rapid decrease in pressure which amounted to not less than 1 mm Hg per 1 hour and totaled > 3 mm Hg. Nevertheless, in separate cases the reinforcement of CO_2 dissipation resulted from the increase in the atmospheric pressure. During "the pre-freezing" period (I) the highest values of CO_2 emission to the atmosphere were accompanied by the atmospheric pressure ranging from 735 to 740. But during "the post – freezing" period the range of pressure with considerable emission of CO_2 was somewhat broader which is connected with several cycles of melting and freezing of soils and gave rise to the reinforcement of CO_2 emission (Fig. 2).



Monitoring P. 6



Monitoring P. 8



Monitoring P. 15

Fig. 2 *The dependence of E_{CO2} emission (kg / ha / h) on the atmospheric pressure P_1 (mm Hg) *names of soils correspond to Table 1*

During the cold period the correlation dependence between the values of E_{CO2} carbon dioxide emission and P_1 atmospheric pressure was established separately for " the pre-freezing" and " the post – freezing" periods (Table 3). The values of the temperature of soils in "the pre-freezing" period was ranging from 1.0 to 7.1° C, and in "the post – freezing" period – from 0.8 to 22.7° C. Along with it, in the field conditions one could determine the marginal value of temperature for all soil types investigated when hardly noticeable production of CO_2 from the overwhelming majority of soils of the Central Polissya transition zone (t = 0.8° C) was observed. In the cases with t < 0.8°C, emission splashes were not observed.

***Table 3**: The correlation dependence between E_{CO2} and P_1*

Number of monitoring point	Correlation coefficients	
	pre-freezing period, n = 6	post – freezing period, n = 10
T6	-0,56	0,13
T8	-0,11	0,49
T15	-0,48	0,09

* names of soils correspond to Table 1

It has been established that the character of E_{CO2} conditionality by the atmospheric pressure during the cold period differed considerably before and after soil freezing. In "the pre-freezing" period (I) one could observe the inverse dependence, and during the "the post – freezing" period (III) – the direct dependence which testifies to the ambiguity of the part played by the atmospheric pressure under unequal temperature regimes of soils. The inverse dependence of the emission intensity on the atmospheric pressure conforms with Fick's law. The essence of the law in the soil – atmosphere system lies in the fact that under the decrease in the atmospheric pressure one can observe the increase in the difference between the concentrations of CO_2 in the soil and in the atmospheric air which results in the reinforcement of gas emission to the atmosphere. Thus, a short-term disturbance of the dynamic balance stipulated by the change in the atmospheric pressure " urges" the system to renovate itself with respect to the increase in the emission flow of carbon dioxide from the soil to the atmosphere. This process lasts until the system is completely balanced.

Under the recurrent character of the cycles of the soil melting and freezing, the effects of the atmospheric pressure of CO_2 production by Polissya soils were mostly leveled which must be considered quite natural. Besides, the role of the soil temperature together with the atmospheric pressure (as the sources of the effects on the emission) increased and became dominating.

4. Conclusions

The investigation results prove that with respect to the processes of global warming und the increase in the air temperature in the cold period, the part played by the atmospheric pressure as one of the most important factors which stipulate the character of CO_2 emission to the atmosphere is being somewhat transformed. The research results also prove that the values related to the intensity of CO_2 emission from podzolized sandy soils of Ukrainian Polissya depend considerably on the abiotic factors – temperature and atmospheric pressure. During the cold season the latter affected the velocity of carbon dioxide production unequally. The reinforcing effects of pressure on the course of CO_2 emission became the most apparent in "the pre-freezing" period (I). The revealed inverse character of the effects of the atmospheric pressure on the intensity of CO_2 emission from podzolized sandy gleyic soils of Ukrainian Polissya in "the pre-freezing" period (I) was displayed against the background of the insignificant fluctuations of the soil temperature in 0 -3 cm layer. Besides, the role of the atmospheric pressure along with the temperature of the soil proved dominating.

5. References

1. Pat.98998 Ukraine. МПК GO1F 1 / 76 (2006/01). The method for determining the intensity of emission of gases from the soil / Trofimenko P.I., Borisov F. I.; applicant and patentee Zhytomyr National Agroecological University. - № u 2014 13566: appl. 17.12.2014: publ. 12.05.2015, Bul. № 9.

2. Trofimenko P.I., Borisov F. I. The scientific substantiation of the algorithm of applying chamber static method for determining the intensity of emission of greenhouse gases from the soil / Trofimenko P.I., Borisov F. I. // The interdepartmental subject – matter collection of research papers. Agrochemistry and Soil study. - 2015. - № 83. – P. 17 -24.