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Impacts of long-term intensive organic inputs on carbon index correlations in meadow ecosystems

Saulius Marcinkonis[1]*,

Sigitas Lazauskas[2],

Virmantas Povilaitis[2],

Colin A. Booth[3]

[1] *Lithuanian Institute of Agriculture Vokė Branch, Žalioji a. 2, Trakų Vokė, LT-02232 Vilnius, Lithuania*

[2] *Lithuanian Institute of Agriculture, Instituto al. 1, Dotnuva-Akademija, LT-58344 Kėdainiai distr., Lithuania*

[3] *School of Engineering and Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, West Midlands WV1 1SB, UK*

Carbon (C) accumulation and distribution in an organic fertilized meadow ecosystem are presented, with the aim of assessing the impact of farm waste applications on spatial C dynamics and CO_2 emissions. C distribution in intensively manured soils (long-term slurry application) from the Lake Lapoja basin and in vegetation were determined *in-situ* and by laboratory analyses which revealed large variations of C in both soil organics (0.7–6.8%) and vegetation (17–41%). CO_2 concentrations in soil surface (74%) with the vegetation removed, in a mowed vegetation surface (62%) and above the vegetation canopy (43%) have been determined relative to the soil arable layer. This is perceived to be a consequence of natural variability and anthropogenic impact. Therefore, for land use simulation, geostatistical approaches were developed to assess the impacts on CO_2 concentrations *in situ*. However, they have also revealed a variety of spatial C index patterns and as such were deemed unsuitable for CO_2 emission modelling.

Key words: meadow ecosystem, gas exchange indexes, contour maps, landuse

INTRODUCTION

Livestock production systems exert various effects on the environment. Slurry management is the central topic in the agronomic and environmental analysis of intensive livestock production systems (Lopez-Ridaura et. al., 2009). Manure management systems are conducive to nutrient and carbon losses. Their influences greatly depend on the livestock production system itself, the management and the environmental conditions (Oenema et. al., 2007).

Slurry, particularly from pig breeding farms, is an acknowledged source of groundwater pollution. In the EU-27 housing systems, 20–30% of livestock excreta is collected in the form of slurry and / or liquid (Menzi, 2002). Generally, pig slurry from intensive livestock systems is inefficiently recycled and can, potentially, lead to atmosphere pollution, both during storage and after field spreading (Sherlock et al., 2002). At sites with high rates of slurry application, soil biota is suppressed, and natural soil fertility, despite an increase in nutrient contents, decreases. Considering different forms of emissions throughout the livestock commodity chains, greenhouse gas (GHG) estimates for the livestock sector are substantial, with animal wastes contributing mainly through ammonia and methane (Gerber, Steinfeld, 2008). Releases from manure have two sources: hydrolysis of urea, leading to NH_3 and CO_2 and anaerobic degradation, and organic components (Pholippe et al., 2008). Carbon is released from manure in gaseous forms (mainly as CO_2 and CH_4), in dissolved forms as inorganic and organic C (ΣHCO_3, DOC), and as particulate matter (via run-off) (Oenema et al., 2007). However, the balance between CO_2 and removals in agricultural land is uncertain (Smith et al., 2007). Recent recommendations for a unified multidisciplinary approach to future research in the response of terrestrial ecosystems to global climate change and responses of terrestrial ecosystems and their components to elevated

* Corresponding author. E-mail: saulius.marcinkonis@voke.lzi.lt

atmospheric CO_2 include evaluation of potential thresholds or ecosystem 'tipping points' (Rustad, 2008).

Land cover and management changes around water areas have caused a serious environmental degradation. Nutrient load and pollution studies are often geographically defined basins. Therefore, the primary aim of this investigation was to assess the utilization of farm waste C dynamics and CO_2 emissions from the Lake Lapoja basin soils by determining how slurry applications affect site (small basin) carbon and gas exchange indexes.

MATERIALS AND METHODS

Field site. The study site is located in the Middle Lithuanian lowland, the river Neris basin, around the small Lake Lapoja, and is situated between the latitudes 54°49′07″and 54°49′31″N and the longitudes 24°46′33″ and 24°45′46″ E. The climatic conditions of the area are characterized by the +6.2 °C mean annual air temperature and 661 mm mean annual atmospheric precipitation. The Lake Lapoja basin collects water from a slurry-irrigated natural meadow which was selected as the experimental area. The average annual application of slurry is ~30 mm per m^2. Annually, slurry is sprayed on the land during several short cycles from April to August (but with negligible quantities in June). The prevailing soil types are *Luvisols*, *Podzols* and *Gleysols* with small spots of *Histosols*.

Thirty-three unique sampling points were chosen based on the summarized morphological site characteristics to sample soils and plant cover. The location of each plot was identical to the location of the plant cover and soil samples (Fig. 1). The GPS unit Garmin Ique3600 was used to identify the location of sampling points (WGS84). Soil (using auger at a depth of 0–20 cm) and plant samples collected from an area of 50–100 m^2 and at the same time CO_2 concentrations were measured.

Analyses of the soil and plant cover samples were performed by the following methods: for total N – Kjeldahl's and for organic C – dry combustion. For *in-situ* measurements, the ADC BioScientific Limited LCi Leaf Chamber / Soil Respiration analysis system (SRS2000) was used to measure CO_2 flow. A highly accurate miniaturised CO_2 infrared gas analyser, designed for a wide variety of environmental research applications, was housed directly adjacent to the soil chamber to ensure the fastest possible response to gas exchanges in the soil and Knoepp and Vose (2002) suggest that data collected using the other soil CO_2 flux measurement methods could be standardized to OC flux rates.

In order to estimate the contribution of aboveground litter to total soil respiration, several kinds of measurements were taken at each sampling point. Gas exchange measurements were performed after cutting plant vegetation (at a height of 3–5 cm) (RV-1), then directly on the underlying mineral horizons on scraped soil (SS-2), and the third measurement was done after digging to imitate ploughing (PI-3) and turning over a 0.2 m topsoil layer from an area of 0.09 m^2 (0.3 × 0.3 m).

Data analysis. The experimental results were subjected to statistical analysis (descriptive statistics, correlation and regression analysis, geostatistical interpolation – Kriging's

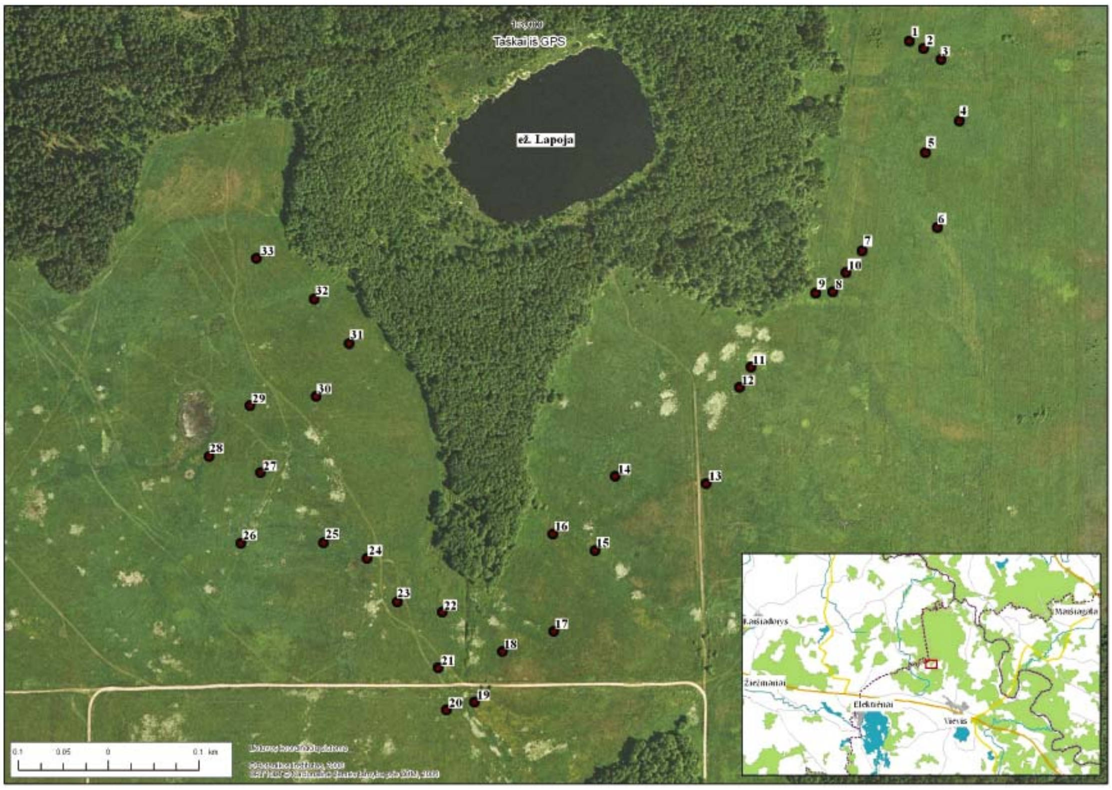

Fig. 1. Experimental site and sampling points

method with a linear variogram) to show the variation in C dynamics and to relate them to the biotic and abiotic factors as well as to produce contour maps for soil CO_2, soil and biomass C. For geostatistical calculations and modelling of the data, 'Surfer 8' software was used.

RESULTS

The mean value of soil organic carbon (SOC) was 2.2%, with more than three times higher values in humus-rich soil spots (*Gleysols* and *Histosols*) (Table 1). The mean value of total soil nitrogen (TSN) was 0.2%, with a variation similar to that of SOC at 3× higher peak values. The mean integrated mineralization parameter – C / N ratio – was 9.1, i. e. close but somewhat lower than could be assumed from the minimal and peak values of SOC and TSN (~11). This indicates a slightly different accumulation of SOC and TSN, and even a very strong correlation was found ($r = 0.97$) (Table 2). Soil cover in the sites highly heterogeneous in terms of OM decomposition conditions, the lowest ratio (4.5) indicating zones where the decomposition is accelerated and even the peak values (12.4) representing arable lands rather than meadow systems.

C accumulation in plants (C% BDM) showed a relatively large variability ranging between 17.3 and 40.8%. N ranging demonstrated a similar level of variation (~2.4×), but these two parameters, surprisingly, showed no correlation ($r = 0.06$, $p > 0.05$). Prediction of carbon C and N mineralisation patterns of plant residues is extensively documented in the literature as directly related to the C : N ratio in plants (C / N BDM) and especially to the lignin content particularly difficult to biodegrade. Biomass is often recognized as easily decomposed, depending on C / N BDM where the lowest values mean the fastest decomposition. The mean C / N BDM was 13.9 and the peak values were even close to 20, i. e. below the most rapidly biodegradable organic matter rate (25–30).

Variability in soil and plant cover creates a unique and highly unpredictable site-specific system for CO_2 emissions. It was clearly demonstrated by *in-situ* measurements of direct CO_2 concentrations above the canopy: this parameter had no correlation with C and N concentrations in soil or plant biomass ($r = -0.14$ to 0.19, $p > 0.05$). The high values of CO_2 concentrations were connected to lower altitudes where the sedimentation of organic waste was most intensive and the soil background was rich in organic matter. These findings are in agreement with those from lysimeter experiments in Sweden where CO_2 emissions from plots with a higher static water table (0.4 m) were greater than with a lower one (0.8 m) (Berglung et al., 2008). The mean value and the standard error for CO_2 concentrations were increasing with increasing soil depth (528 ± 19, 637 ± 34.5 and 857 ± 76 vpm, respectively, for RV-1, SS-2 and PI-3 measurements). These values are much higher than CO_2 concentrations above canopy (368 ± 1.6). However, a direct use of these mean values can lead to controversial conclusions because of a high probability ($p > 0.95$) of non-normal distribution. The maximum measured values >2000 are of special relevance from the sustainable land and environment management point of view. A close correlation was found between CO_2 concentrations SS-2 and PI-3 measurements ($r = 0.81$, $p < 0.01$), but with 1.3 times higher PI-3 mean values (extremes 2.5 times higher). A significant correlation ($r = 0.54$, $p < 0.01$) between CO_2 concentrations in RV-1 and SS-2 was less strong than between SS-2 and P-3, although with a

Table 1. **Ecosystem C-related properties and their variation in site (0–20 cm depth), Zelvė, 2008**

	Soil			Vegetation cover DM			CO_2 concentrations, vpm			
	SOC%	TSN %	C / N	C%	N%	C/N	AC	RV-1	SS-2	PI-3
$\bar{X}$	2.2	0.2	9.1	33.4	2.5	13.9	368.7	527.7	637.9	857.5
$s_{\bar{X}}$	0.22	0.02	0.33	0.93	0.10	0.64	1.62	18.57	34.50	75.80
Median	1.9	0.2	9.4	34.1	2.4	13.7	368.0	499.0	562.0	708.0
Min	0.7	0.1	4.5	17.3	1.7	7.3	351.3	402.0	449.0	458.0
Max	6.8	0.6	12.4	40.8	4.0	21.9	396.3	894.0	1309.0	2000.0

Table 2. **Correlation matrix of measured soil and biomass parameters, Zelvė, 2008**

	CO_2 concentrations, vpm				In soil			In biomass	
	Above canopy	RV-1	SS-2	PI-3	SOC%	TSN%	C / N soil	C% DM	N% DM
CO_2 RV-1	–0.03								
CO_2 SS-2	0.02	0.54							
CO_2 PI-3	0.01	0.38	0.81						
SOC%	–0.06	0.22	0.46	0.63					
TSN%	–0.06	0.15	0.45	0.62	0.97				
C / N soil	–0.05	0.31	0.37	0.54	0.74	0.57			
C% BDM	–0.06	–0.38	0.05	0.18	0.04	0.07	–0.03		
N% BDM	0.19	0.09	0.24	0.33	0.29	0.27	0.35	0.06	
C / N BDM	–0.14	–0.32	–0.18	–0.20	–0.26	–0.22	–0.40	0.59	–0.74

very good regression slope b = 1.004. However, the correlation between measurements in RV-1 and PI-3 was weaker ($r = 0.384$, $p < 0.05$) and with a rather low regression slope b = 0.09. These results suggest that soil respiration was largely responsible for the elevated CO_2 concentrations in PI-3, but at soil surface this value was reduced by 75%. However, there was no consistent correlation of CO_2 concentrations in the arable soil layer and above canopy. The regression matrix of the measured properties suggests that CO_2 concentrations respond mainly to soil C%, but the strength of the relation gradually decreases with decreasing the depth of measuring – 0.63 (PI-3), 0.46 (SS-2), 0.22 (RV-1) and –0.06 (above canopy), respectively.

Statistical analysis can only explain the sample difference in volume and homogeneity, but not in the spatial C index variability (Fig. 2). Heterogeneous conditions are illustrated by shapes and sectors detected for the estimated parameters. The slightly higher canopy CO_2 concentration zones (X200-300 Y500-700; X800-900 Y500-600) can be ascribed to landscape contours, while C% in vegetation is further associated with soil properties (especially SOC%) and hydrothermal regime, plus their interactions. It has been estimated that abiotic factors (landscape contours, variously textured soils – sands, sandy loams and organic soils, soil hydrothermal regime) cause a huge spatial variability of site C dynamics. The effect of agricultural activities on agricultural topsoil in space and time is evident, although the consequences are determined by natural background effects.

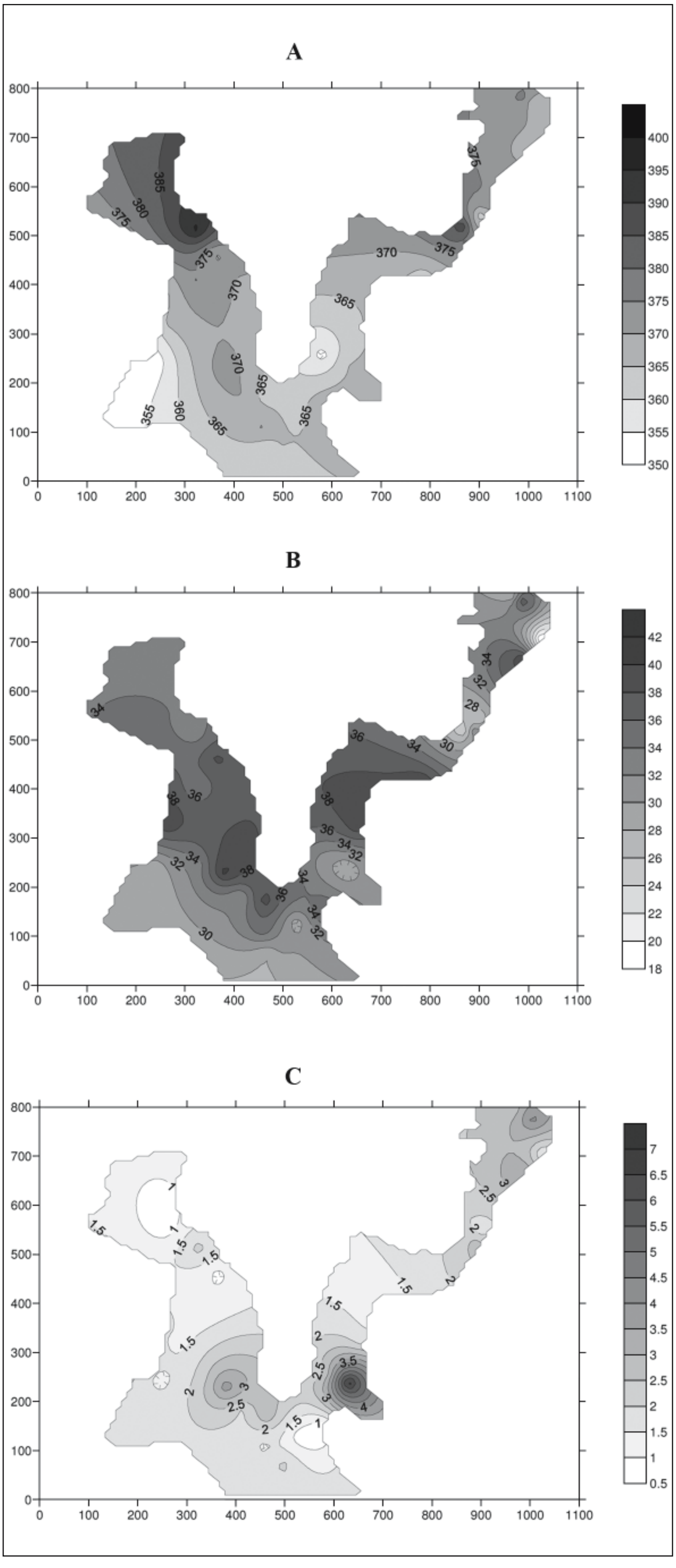

Fig. 2. Modeled contour maps of CO_2 concentrations (vpm) above canopy (A), C% in vegetation (B) and SOC% (C)

DISCUSSION

Nutrient accumulation or depletion in soil depends on soil texture and soil organic matter. Soil CO_2 emissions define the intensity of C, the basic components of SOM and ecosystem cycling. Beside other CO_2 emission controlling factors, soil management and organic amendments (such as animal manure and compost) can affect soil organic C pools, soil nutrients and microbial environments and activities (Ginting et al., 2003).

Soil respiration varies with vegetation and also amongst the major plant biomes (Raich, Tufekciogul, 2000). In our study, soil variability was poorly reflected in vegetation cover (Fig. 2, B and C), contour maps of geo-statistically modelled data indicating different spatial variability. Importance of vegetation structures for biogeochemical behaviour has been reported; however, similar vegetation structures in different locations can show very different biogeochemical behaviour (Johnston et. al., 2008). In the present study, vegetation cover varied substantially in different parts of the study site. Grasses, mostly couch-grass (*Agropyron repens* L.) were developed in places used occasionally for hay production, nettle (*Utrica dioica* L.) was prevailing in a few locations where sedimentation of organic waste was most concentrated relating to landscape contours. Similar regularities were found in fields used for wastewater treatment since the 19th century in Gdansk (Kowalik, Suligovski, 2008). Processes of turning extensively used cultural meadows into natural meadows have been reported to last 30 years (Sendžikaitė, Pakalnis, 2005).

Traditional agronomic practice induces application of organic fertilizers as a long-lasting means to improve soil quality and fertility. Long-term fertilization with different rates of cattle slurry significantly improves the microbial, biochemical and chemical properties of the soil as compared with the NPK-treated soil (Martyniuk et al., 2002). In contrast, it is well known that an excessive organic and mineral fertilization causes pollution of the environment with heavy metals, nitrates, phosphates and other chemical substances. Some authors employing STELLA simulation have proven that livestock waste does have a potential of long-term soil carbon gain (Fellman et al., 2008). However, the soil C saturation concept postulates that there is an upper limit to the equilibrium soil C level of mineral soils, even when soil C input is increased (Chung et al., 2008). On the other hand, soil carbon turnover and storage to a great extent are controlled by climate (Jenny, 1980). Our studies indicate that a huge heterogeneity of soil C properties, even at a relatively small scale, is a result of the interaction of soil cover, soil hydrology and intensive organic fertilization. They determine an intra-site SOC variation within 0.7–6.8%. It can be estimated to a range of 21–204 Mg ha^{-1} of topsoil organic carbon stocks (assuming 3000 t ha^{-1} of 20 cm arable layer).

In our observations, we have found that vegetation cover shows a more gradual C distribution than soil in which C concentration varies within 17.3–40.8%. There was no correlation between SOC and C accumulation in vegetation cover ($r = 0.04$). Nevertheless, the correlation of C% in biomass tended to be opposite but stronger ($r = -0.38$) when the CO_2 flux was measured after removing the vegetation cover.

Abiotic and biotic processes affect soil in specific zones, and the effectiveness of management activities is strongly influenced by pedogenic processes. For instance, studies on Lithuanian arenosols have showed that afforested sites are more effective in C and N conservation compared with fallow systems in areas formerly intensively fertilised with mineral and organic fertilisers (Armolaitis et al., 2005, 2007). Apparent C saturation of some of the fractions indicates that SOC pools have a limited capacity to stabilize added C and that such a limit to C stabilization will constrain the ecosystem services provided by these SOC pools (Chung et al., 2008).

The land use and / or tillage technology primarily affects the humus status of superficial soil layers. The current extensive agricultural site management practice and plant cover structure are able to mitigate an increased load of organics and prevent intensive C emission from a site by acting as a strong sink for GHGs. However, in C accumulation zones, the risk remains high, especially in the case of land use change and intensification. With soil and long-term disturbance of native vegetation, the loss of SOC can be rapid and extensive (Franzluebbers, 2005). Because of the greater below-ground allocation in native perennial systems and the removal of a substantial portion of the net primary productivity in agricultural systems, it is unlikely that even the use of no-till practices alone can help to achieve the soil C levels of native ecosystems (Management controls..., 1997).

CONCLUSIONS

1. Great variations of SOC (0.7–6.8%) and C accumulation in vegetation (17–41%) were observed as a consequence of natural variability and anthropogenic impact. Long-term application of pig slurry on a restricted area dominated by *Luvisols*, *Podzols* and *Gleysols* with small patches of *Histosols* caused a heterogeneous background of CO_2 emissions.

2. CO_2 concentrations from the soil surface (74%) with the vegetation removed, from the mowed vegetation surface (62%) and from above the vegetation canopy (43%) have been determined relative to the soil arable layer. This is perceived to be a consequence of natural variability and anthropogenic impact.

3. Variability in soil and plant cover illustrates a unique and highly complicated system that requires alternative tools to predict CO_2 emissions. Therefore, geostatistical approaches to land use simulation were developed to assess the impacts on CO_2 concentrations. However, these also reveal a variety of spatial C index patterns and therefore are deemed unsuitable for CO_2 emission modelling.

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References

1. Armolaitis K., Aleinikovienė J., Baniūnienė A., Žėkaitė V. 2005. Smėlžemių cheminės ir biologinės savybės dirvonuojančiose ir mišku apželdintose žemės ūkio naudmenose. *Žemdirbystė*. Mokslo darbai. T. 92. Nr. 4. P. 3–9.
2. Armolaitis K., Aleinikovienė J., Baniūnienė A., Lubytė J., Žėkaitė V. 2007. Anglies sekvestracija ir azotas smėlžemiuose apmiškintose ir dirvonuojančiose žemės ūkio naudmenose. *Baltic Forestry*. Vol. 13. N 2. P. 169–178.
3. Berglund Ö., Berglund K., Klemedtsson L. 2008. A lysimeter study on the effect of temperature on CO_2 emission from cultivated peat soils. *Geoderma*. doi: 10.1016/j.geoderma.2008.09.007
4. Chung H., Grove J. H., Six J. 2008. Indications for soil carbon saturation in a temperate agroecosystem. *Soil Science Society of America Journal*. Vol. 72. P. 1132–1139.
5. Fellman J. B., Franz E. H., Crenshaw C. L., Elston D. 2008. Global estimates of soil carbon sequestration via livestock waste: a STELLA simulation. *Journal of Environment, Development and Sustainability*. doi: 10.1007/s10668-008-9157-0
6. Franzluebbers A. J. 2005. Soil organic carbon sequestration and agricultural greenhouse gas emissions in the southeastern USA. *Soil and Tillage Research*. Vol. 83. N 1. P. 120–147.
7. Gerber P. J., Steinfeld H. 2008. Worldwide growth of animal production and environmental consequences. *Proceedings of the 13th RAMIRAN International Conference.* Albena, Bulgaria. P. 17–26.
8. Ginting D., Kessavalou A., Eghball B., Doran J. W. 2003. Greenhouse gas emissions and soil indicators four years after manure and compost applications. *Journal of Environmental Quality*. Vol. 32. P. 23–32.
9. Jenny H. 1980. *The Soil Resource: Origin and Behaviour*. New York: Springer-Verlag.
10. Johnston C. A, Shmagin B. A., Frost P. C., Cherrier C., Larson J. H., Lamberti G. A., Bridgham S. D. 2008. Wetland types and wetland maps differ in ability to predict dissolved organic carbon concentrations in streams. *Science of the Total Environment*. Vol. 404. N 2–3. P. 326–334.
11. Knoepp J. D., Vose J. M. 2002. Quantitative Comparison of *in situ* Soil CO_2 Flux Measurement Methods. Asheville, NC: U. S. Department of Agriculture. 11 p.
12. Lopez-Ridaura S., van der Werf H., Paillat J. M., Le Bris B. 2009. Environmental evaluation of transfer and treatment of excess pig slurry by life cycle assessment. *Journal of Environmental Management*. Vol. 90. N 2. P. 1296–1304.
13. Management Controls on Soil Carbon. 1997. In: Paul E. A., Paustian K. A., Elliot E. T., Cole C. V. (eds.). *Soil Organic Matter in Temperate Agroecosystems: Long-term Experiments in North America.* CRC Press. 414 p.
14. Martyniuk S., Stachyra A., Gajda A. 2002. Long-lasting beneficial effects of slurry application on some microbial and biochemical characteristics of soil. *Polish Journal of Environmental Studies*. Vol. 11. N 6. P. 727–730.
15. Menzi H. 2002. Manure management in Europe: results of a recent survey. In: Venglovsky J., Greserova G. (eds.). *RAMIRAN 2002. 10th International Conference on Hygiene Safety.* Strbske Pleso, High Tatras, Slovak Republic, May 14–18. P. 93–102.
16. Oenema O., Oudendag D., Velthof L. G. 2007. Nutrient losses from manure management in the European Union. *Livestock Science*. Vol. 112. N 3. P. 261–272.
17. Raich J. W., Tufekciogul A. 2000. Vegetation and soil respiration: Correlations and controls. *Biogeochemistry*. Vol. 48. N 1. P. 71–90.
18. Rustad L. E. 2008. The response of terrestrial ecosystems to global climate change: towards an integrated approach. *Science of the Total Environment*. Vol. 404. N 2–3. P. 222–235.
19. Sendžikaitė J., Pakalnis R. 2005. Naturalization of sown meadow communities and biological diversity restoration in Lithuania. In: *The World Conference "Ecological Restoration: a Global Challenge"*. Abstracts. Zaragoza, Spain. P. 138.
20. Sherlock R. R., Sommer S. G., Khan R. Z., Wood C. W., Guertal E. A., Freney J. R., Dawson C. O., Cameron K. C. 2002. Ammonia, methane, and nitrous oxide emission from pig slurry applied to a pasture in New Zealand. *Journal of Environmental Quality*. Vol. 31. P. 1491–1501.
21. Smith P., Martino D., Cai Z., Gwary D., Janzen H., Kumar H., McCarl B., Ogle S., O'Mara F., Rice C., Scholes B., Sirotenko O., Howden M., McAllister T., Pan G., Romanenkov V., Shneider U., Towprayoon S. 2007. Policy and technological constraits to implementation of greenhouse gas mitigation options in agriculture. *Agriculture, Ecosystems & Environment*. Vol. 118. P. 6–28.

Saulius Marcinkonis, Sigitas Lazauskas, Virmantas Povilaitis, Colin A. Booth

INTENSYVAUS ILGALAIKIO TRĘŠIMO ĮTAKA ANGLIES RODIKLIAMS

Santrauka

Pateikti anglies sankaupų ir jų pasiskirstymo tyrimų, atliktų intensyviai tręšiamoje pievų ekosistemoje, rezultatai. Tyrimų tikslas buvo nustatyti organinių gyvulininkystės komplekso atliekų utilizavimo poveikį C rodikliams ir sumodeliuoti potencialią CO_2 emisiją. Atlikus išsamius lauko matavimus ir laboratorines analizes įvertintas anglies koncentracijų pasiskirstymas intensyviai ir ilgą laiką srutomis tręšiamame Lapojos ežero baseine. Nustatyta, kad gyvulininkystės komplekso taršos teritorija dėl abiotinių ir biotinių veiksnių sąveikos pasižymi didele dirvožemio organinės C koncentracijų (0,7–6,8 % C) ir C sankaupų augaluose (17–41 % C) įvairove, tačiau CO_2 koncentracijos virš augalijos nepriklausė nuo šių rodiklių variacijos. Dirvožemio paviršiuje CO_2 koncentracijos sudarė vidutiniškai 74 %, žolės šienaujamajame aukštyje (4–5 cm) – apie 62 %, o virš augalų vegetacinio paviršiaus – tik apie 43 % dirvožemio armenyje nustatytų koncentracijų. Todėl pagal CO_2 koncentraciją virš augalų vegetacinio paviršiaus sunku vertinti emisijas dirvožemyje, virš dirvožemio paviršiaus ar net ir žolės šienaujamajame aukštyje. Šis rodiklis visiškai nesusijęs nei su dirvožemio, nei su augalijos C ir N koncentracijomis.

Raktažodžiai: pievų ekosistemos, anglies sekvestracija, geostatistinis modeliavimas, kontūriniai žemėlapiai