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LOCAL BASED SOLUTIONS EDAPHIC-BLOOM DANUBE - CONSIDERATIONS ON THE ROLE OF ORGANIC CARBON IN REDUCING GREENHOUSE GASES IN AGRICULTURE

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Abstract

Following Parliament's call in January 2020 to set binding targets for saving biodiversity, in May 2020 the European Commission presented the new 2030 Biodiversity Strategy. At its June 2021 plenary session, Parliament adopted a position on the EU's 2030 Biodiversity Strategy: Bringing Nature back into our lives to ensure that the world's ecosystems are protected, restored, and resilient by 2050. Parliament wants the EU to become a leader, guaranteeing that 30% of its territory will be in natural areas by 2030 and taking biodiversity into account in all its policies. Climate change is one of the most important threats to humanity and it will increasingly matter how we manage our existence and development. Climate stabilization, as provided for in the Paris Agreement, requires mitigation and adaptation measures to reduce the impact of climate change and increase the resilience of essential ecosystem services. In the wetland environment, the degradation and loss of wet habitats, especially carbon-capturing ecosystems, results in an unprecedented loss of biodiversity and ecosystem services. Blue carbon is the carbon stored in wetlands, coastal and marine ecosystems, which represent significant carbon sinks. Indeed, they sequester carbon in its organic form and store it for thousands of years. Moreover, "blue carbon" ecosystems provide a wide range of ecosystem services that underpin livelihoods and support adaptation to climate change. However, despite the importance of the ecosystem services provided, these habitats are disappearing at an alarming rate.

Key words: *sustainable-biodynamic-regenerative agriculture, permaculture, paludiculture.*

INTRODUCTION

"Edaphic-Bloom Danube - Ecological resizing through urban and rural actions & dialogues for GHG mitigation in the Lower Danube Floodplains & Danube Delta" is an ambitious project in the frame of EUKI Programme, that aims to develop actions and dialogues both on the conservation of organic soils that have the ability to fix and store Carbon, one of the most harmful greenhouse gases, but also the energy efficiency of buildings in urban areas, thus contributing to reducing the carbon footprint and its impact.

The project addresses the reduction of the ecological footprint and the importance of organic soils in GHG mitigation, through 4 steps: a DPSIR analysis, an Artificial Neural Networks type process, an Agent-Based Modeling control function, and planning solutions for Ecosystem-Based Management.

Moreover, the most important challenge is to get out of the Citadel of Science and Innovation in the Living Lab, just implementing the knowledge of collaborators from KIT, Karlsruhe University, Steinbeiss, Institute of Pedology, URBAN INCERC, ASE, City Halls, and County Councils from Danube Floodplain and Delta geographical area, an area that has undergone major changes in the last hundred years and which through adaptive and ecosystem management will contribute to the reduction of greenhouse gases and the reduction of the ecological footprint.

In the first stage, the analysis of carbon reserves and flows from the Danube area soils will be performed, their mapping and scenarios of conservation, soil restoration, modification of the type of activities through Land-Based Management (e.g. modernization of agriculture through methodologies of agri-environment) or changing the utility of land with organic soils to improve carbon sequestration and storage.

In the second stage, a Master Plan for GHG reduction in the Floodplain and the Danube Delta and guides for good practices in land management with organic soils will be elaborated. These steps will be followed by the creation of a WEB Platform and the organization of exchanges of experience between administrators who manage regions rich in organic soils, knowledge transfer, demonstration farms, publications of scientific articles, and promotion of sustainable land use, etc.

In the third stage, the involvement of the Ministry of Environment and the Department of Sustainable Development is opportune and desired, which will consist of actions for the application of these scenarios, for example, the creation of regulations (legislation, application norms) regarding the audit and monitoring of greenhouse gas emissions. greenhouse gases (GHGs), incentives for activities (e.g. environmentally friendly agriculture) that preserve its organic soils.

It is also desirable to create a Networking with all stakeholders: the Ministry of Environment, County and local councils, NGOs, and private companies that manage the lands in the Meadow and Danube Delta for the implementation of the Master Plan to reduce GHGs in this area.

In the last stage, the good practices resulting from this Networking will be promoted at the national and European levels, correlated with the results of other complementary projects, contributing to the EU's goal of reducing the effects of climate change by reducing global warming by 1.5 - 2 degrees Celsius and become climate neutral by 2050.

We try to highlight the importance of carbon sequestration by protecting organic soils in the Danube Floodplain/Delta, GHG policy guidelines for achieving the goals of reducing the carbon footprint with benefits for farmers, the economy, society, and the environment.

Organic soils have formed under conditions of permanent humidity, which prevents the complete decomposition of dead biomass, which leads to the rich accumulation of carbon in organic matter. When the soil is no longer saturated with water, this organic matter decomposes quickly, causing huge GHG emissions. By draining organic soils for agriculture, pastures or forestry on about 70%, being responsible for a huge amount of anthropogenic GHGs that influence global warming in the Romanian Plain and Dobrogea.

This requires the protection of existing organic soils if we are to achieve the goal of the Paris Agreement - zero GHG emissions by 2050.

Unfortunately, there will be some impacts of climate change that we will not be able to avoid and that we will have to adapt to, but it is important to limit the magnitude of future impacts. The good news is that we can do a lot. Not only politicians can take action. We can all contribute by making smart choices - such as storing C.

Many believe that the soil is just dust, but it plays a key role in regulating the planet's climate. The soil stores carbon mainly in the form of organic matter and is the second-largest carbon deposit in the Earth, after the oceans. The capacity of the soil to hold huge amounts of stored carbon has declined in recent decades, largely due to unsustainable land management practices and changes in land use. Sustainable agriculture, good forestry practices, and good land management can help maintain or even increase the amount of carbon stored in the soil. The importance of carbon sequestration by protecting organic soils in the Danube Floodplain and Delta, and GHG policy guidelines for achieving carbon footprint reduction benefits for farmers, the economy, society, and the environment, and by promoting environmentally friendly methods such as biodynamic agriculture regenerative, paludiculture and permaculture is the main focus of Edaphic-Bloom Danube.

It is well known that carbon dioxide accounts for 80% of GHG greenhouse gases and 5% of methane, according to the United Nations Framework Convention on Climate Change UNFCCC Data Interface, 2019. Agriculture accounts for 9.27% of total GHGs, according to the same report - Figure 1. Moreover, the price of fertilizers has increased by about 3 times.

What can we do about climate change?

Carbon sequestration on agricultural land is possible through several soil management strategies and could be substantial with widespread implementation. Sequencing historical carbon from emissions is now essential, as it is unlikely that mitigation alone will stabilize our atmosphere. There are many management strategies for extracting carbon from the atmosphere and retaining it in the soil. These strategies vary in efficiency depending on different climates, soil types, and geographical areas.

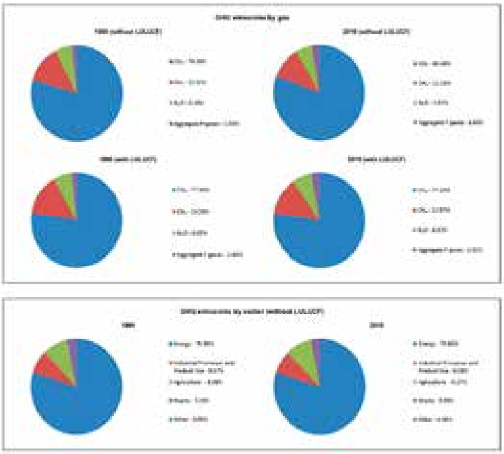

Figure 1. UNFCCC Data Interface, 2019 compared to 1990 as a Base Year
(Summary of GHG Emissions for Annex I. Base Year (Convention) = 1990, UNFCCC. Retrieved from https://di.unfccc.int/ghg_profiles/annexOne/ANI/ANI_ghg_profile.pdf)

MATERIALS AND METHODS

Land characterization is done according to ART - the average residence time of C.

There is an increase in the net carbon balance that enters the soil each year in relation to what is lost. Also, assessing soil respiration as an indicator for carbon emissions from organic soils.

To assess soil respiration, it is mandatory to determine the total porosity of the soils (**n**).

The porosity of the soil (**n**) represents its pores volume (**V_p**) reported to its total volume (**V**), in percents:

$$n = \frac{V_p}{V} \qquad [\%] \qquad (1)$$

In practice, the total porosity (**n**) is calculated with more practical formulas derived from equation 1 such as:

$$n = 1 - \frac{\gamma}{\gamma_s(1+w)} \qquad [\%] \qquad (2)$$

where:

- **γ** is the probe's specific weight in its natural state;
- **γ_s** is the probe's specific weight of its mineral part;
- **w** is the moisture content.

Each of these three parameters can be determined in a testing laboratory.

The evaluation of the γ parameter in the laboratory

It is the easiest parameter to evaluate. By following the specifications from STAS 1913/3-76, the **γ** parameter can be assessed. The soil samples must be taken using a matrix of known volume. It is recommended to weigh these samples in the field, immediately after the sampling. In this mode, the total mass of the sample (in its natural state) is determined. For a known volume, the density of the sample it's easy to be estimated by applying this simple formula:

$$\rho = \frac{m_1 - m_0}{V} \qquad [\mathrm{g/m^3}] \qquad (3)$$

where:

- **ρ** is the density of the probe in its natural state;
- **m_1** is the total weight of the probe;
- **m_0** is the weight of the matrix (in which the probe was contained);
- **V** is the volume of the matrix.

By knowing **ρ**, **γ** can be written as follows:

$$\gamma = \rho g \qquad [\mathrm{KN/m^3}] \qquad (4)$$

where **g** is a constant (gravitational acceleration, **g** = 9.81 m/s^2)

The evaluation of the γ_s parameter in the laboratory

As with **γ**, to calculate **γ_s** - probe's specific weight of its mineral part, the probe's density of its mineral part (**ρ_s**) must be determined. This parameter represents the volume unit mass from the solid phase. **ρ_s** can be computed by applying the specifications mentioned in STAS 1913/2-76.

In the laboratory, to determine the density of the mineral part, the pycnometer method is used. This is a glass flask of precisely determined volume (50, 100, 150 cm^3), provided with an overflow valve and a thermometer.

Methodology: For each pycnometer (of known tare weight **m_0**), one must proceed as follows:

Insert the soil sample into the flask and weigh it (**m_1**). Add the immersion liquid (distilled water or benzene for soils with organic compounds) so that the sample is completely covered. Gradually bring to the boil (15 minutes at most). This is done to eliminate the cohesion between the particles and thus release air from the pores. Then return to a temperature of 15-30°C and add liquid until the known volume is reached, then weigh it (**m_3**). Read the exact temperature of the water/sample mixture. Finally, weigh the pycnometer filled with water to the mark (**m_2**).

With these data, the density of the mineral part can be calculated with the formula:

$$\rho_{s_{20^\circ C}} = \frac{m_s}{V_s} = \frac{m_1}{\frac{m_1+m_2-m_3}{\rho_{w_{t^\circ}}}}\Psi \quad [\mathrm{g/m^3}] \tag{5}$$

where:

- **$\rho_{s20^\circ C}$** is the density of the mineral part of the probe;
- **m_s** is the mass of the mineral part of the probe;
- **V_s** is the volume of the mineral part of the probe;
- **m_1** is the mass of the probe in the desiccated state;
- **m_2** is the pycnometer mass filled with fluid to the mark;
- **m_3** is the pycnometer mass that contains the probe (after boiling) and filled with fluid to the mark;
- **$\rho w_{t}o$** is the water density at room temperature t°C, before the boiling;
- **Ψ** is a water density correction factor depending on temperature:

$$\Psi = \frac{\rho_{w_{t^\circ C}}}{\rho_{w_{20^\circ C}}} \quad [\text{dimensionless}] \tag{6}$$

where:

$\rho w_{20^\circ C}$ is the water density at 20°C.

Similarly, to the equation 4, **γ_s** can be written as follows:

$$\gamma_s = \rho_s g \quad [\mathrm{KN/m^3}] \tag{7}$$

The evaluation of the w parameter in the laboratory

The evaluation of the moisture content of a probe (**w**) is done according to the STAS 1913/1-82 specifications.

Moisture content is the water mass lost by a soil sample by drying at 105 ± 2°C per its dry mass. It is expressed as a percentage.

In the laboratory, the moisture content is determined by the oven-drying method. As laboratory equipment, the following can be used: containers with lids, glass ampoules, clamped glass bottles, thin chromed brass capsules, technical balance, shelf dryer with adjustable temperature, desiccator containing dehydrating substances (anhydrous $CaCl_2$ or anhydrous granular microporous silica gel).

Methodology: The containers with lids are dried at 105 ± 2°C, cooled, then dried. Their tara weight, **m_c**, must be checked periodically.

The container with the testing material is closed immediately after harvesting it from the field. The next step is to weigh the container to determine its mass (**m_u**). The sample container is then opened and dried in a shelf dryer at 105°C. This temperature must be kept constant with a maximum deviation of ± 2°C. During drying, the vent of the shelf dryer must be kept open.

After drying, the test sample container must be left open in the desiccator to cool for one hour. After cooling, the dried sample container is weighted - **m_d**.

Finally, the moisture content **w** is calculated based on the values of **m_u**, **m_d**, **m_c**, with the following relation:

$$w = \frac{m_u - m_d}{m_d - m_c}100 \quad [\%] \tag{8}$$

where:

- **m_u** is the wet mass of the sample + tare weight;
- **m_d** is the dry mass of the sample + tare weight;
- **m_c** is the tare weight.

In our tasks, we propose also an assessment of sequestered organic carbon under different agricultural land uses versus wetlands, by using the dry combustion method - after SR ISO 10694:1998 Soil quality - Determination of organic and total carbon after dry combustion (elementary analysis), a precise determination of the organic carbon content will be obtained. The amount of organic carbon (**OC**) from the soil will be estimated by extrapolating the **OC** content per soil mass to the **OC** reserve per soil volume, which was obtained by multiplying the

OC by the apparent soil density (**D_a**) and the depth of the horizon layer (**d**) at which the determination is made. As this approach does not take **D_a** into account on the soil profile (because errors may occur), **D_a** values will be used to take into account the standard soil depth. To determine the amount of **OC** accumulated at different standard depths the following formula will be used:

$$OC = OC\% \cdot D_a \cdot d \cdot CF_{st} \qquad (9)$$

where:
- **OC** is the amount of organic carbon from the soil;
- **OC%** is the amount of organic carbon in percent from the laboratory analyses;
- **D_a** is the apparent density of the soil;
- **d** is the depth or the thickness of the analyzed soil layer;
- **CF_{st}** is the correction factor for the skeletal material.

The obtained database was structured for the identified types of soils per corresponding sampling depths.

RESULTS AND DISCUSSIONS

Soil organic matter represents a key indicator of soil quality, both for agricultural functions (i.e. production and economy) and environmental functions (e.g., C sequestration and air quality). Soil organic matter is the main determinant of biological activity. The amount, diversity, and activity of soil fauna and microorganisms are directly related to organic matter. Organic matter, and the biological activity that it generates, have a major influence on the physical and chemical properties of soils. Aggregation and stability of soil structure increase with organic matter content. These in turn increase the infiltration rate and available water capacity of the soil, as well as resistance against erosion by water and wind. Soil organic matter also improves the dynamics and bioavailability of main plant nutrient elements (Robert, 2001).

Most agricultural soils (both mineral and organic) are depleted in C relative to the native ecosystems from which they were derived, due to reduced net primary production and export of harvested biomass-which reduce C inputs to soil; nutrient depletion, intensive soil disturbance, and soil erosion are other contributing factors to soil C depletion. Most cropland mineral soils have lost 30-50% of the C stocks in topsoil layers (0-30 cm) relative to their native condition (Paustian et al., 2019).

The concentration of SOC in agricultural soils

It has been suggested that a critical level of SOC is 2% (SOM 3.4%), below which soil structural stability will suffer a significant decline (Spink et al., 2010)

However, direct measurements of SOC content taken from the continuous corn treatment in the Morrow Plots, which is the oldest agronomic trial in North America, indicate that despite an over 300% increase in grain yield achieved due to crop improvement and agronomic inputs since 1923, SOC contents have not increased in response (Figure 2). Measured trends in SOC in the fertilized soils suggest soils will not even recover 50% of the SOC contained in the soils in 1880 if current practices are maintained (Wander Nissen, 2004).

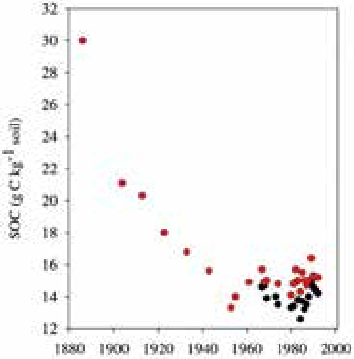

Figure 2. Trends in soil organic carbon contents and corn grain yield in the continuous corn treatment of the Morrow Plots (USA). Red circles - fertilized plots, black circles - non-fertilized plots (Wander, Nissen, 2004)

Clay content correlated to SOC

Most soil structure-related physical properties are correlated to soil organic carbon (SOC) content. Texture, mineralogy, and SOC: clay ratio is also acknowledged to affect physical properties. SOM content is correlated to several soil physical properties, like soil bulk volume, moisture retention curve, fluid transfer properties, and mechanical resistance of the soil to stresses. This can be quantified via numerous parameters, most of which are largely correlated to SOM. This is true for soil aggregate stability, mechanical properties, or penetration resistance. The most documented is probably the relationship between SOM, or soil organic carbon (SOC), and soil bulk density. A continuous increase in soil porosity with SOC was reported in many cases. Studies that included a broad range of SOC values (from 0 to> 50%) usually found a semi-logarithmic relationship, thus decreasing the effect of SOC on porosity or bulk density (BD) at large SOC content. Studies based on a limited range of low SOC contents even found a linear relation, thus proportional increase, between porosity and SOC.

Because in many soils, a significant portion of the SOC is bound to clay minerals, it is considered clay or clay + fine silt content as covariables when analysing the effect of soil constituents on soil physical properties. Together with SOC, the texture is generally assumed to influence the physical properties. By increasing clay content, a larger SOC content is necessary to achieve the same level of aggregate stability.

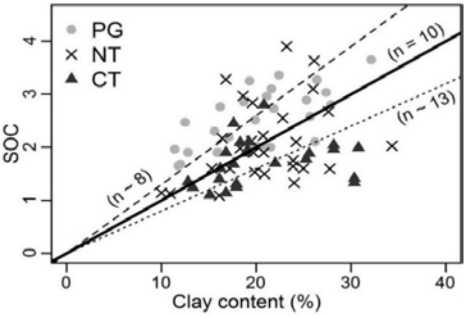

Figure 3. Soil organic carbon content (SOC) as a function of clay content for different soil management practices (PG: permanent grass, NT: no-till, CT: conventional tillage) within soils of good structural state. The dashed line indicates a SOC: clay ratio of 1: 8, the full line a SOC: clay ratio of 1: 10, and the dotted line a SOC: clay ratio of 1: 13 (Johannes et al., 2017)

By analysing the role of the clay: SOC ratio in the relation between bulk density (BD) and SOC using different soil databases that included soils of several taxonomic orders, the concept of "Complexed Organic Carbon" (COC) was introduced as the fraction of the SOC bound to clay. It was determined that the highest coefficient of determination of the linear relation between COC and soil volume (1/BD) for clay: COC = 10, thus interpreted as the saturation of the clay surface by SOC. The same optimum ratio for clay dispersibility was obtained and the fraction of SOC corresponding to a tenth of the clay content was considered to be the maximum COC controlling the structure-related physical properties of soils. In particular, it was concluded that structural porosity was no longer increasing with SOC above 10% of clay content and that the optimum SOC content of soil would thus be 10% of the clay content (Johannes et al., 2017).

For soils showing no evidence of physical stress or structure degradation, the linear relation between SOC and soil pore volume (or 1/BD) means that a SOC increase will result in a proportional increase of soil porosity regardless of how much SOC is complexed to clay. There is no optimum correlation between the physical properties and a COC fraction of the SOC proportional to the clay content. The largest correlations were observed when the SOC content was fully taken into account indicating that total SOC controls physical properties rather than COC.

The SOC: clay ratio, however, appears to be a relevant criterion when considering soil structure quality. Soils with visually evaluated good structure quality have higher SOC: clay ratios than soils of poor structural quality, and the different structure quality scores correspond on average to different SOC: clay ratios. This allows the establishment of criteria for SOC management. A ratio of 1:8 is optimum for good structure quality, and 1:10 is a reasonable goal for farmers, reachable even with tillage. Finally, 1:13 is a ratio below which the structure quality is most likely unacceptable and needs improvement. Nevertheless, the 1: 8 and 1: 10 SOC: clay ratios do not guarantee a good soil structure, since mechanical damage may occur regardless of SOC content (Figure 3). The complexed organic carbon is a relevant concept for soil structural quality, and that clay content has to be taken into account in the definition of objectives for SOC content (Johannes et al., 2017).

Organic Soils (Histosols)

Histosols are the main component of the soil cover of the DDBR. According to RSSC, under this name have been classified all soils with a histic horizon of more than 50 cm thickness with its upper boundary within 25 cm of the soil surface. These soils are formed there as a result of very wet and reducing conditions prevailing in the low-lying areas (<0.5 m above MBSL) of the DDBR which retard the decomposition of the remnants of very rich climax vegetation. This vegetation consists of mostly reed, sedge, and reedmace, with minor participation of some woody species, i.e. *Salix cineraea*. Besides the excess water and reducing environment, one of the main conditions for the occurrence of these soils is the reduced (or at least discontinuous) rate of the mineral sedimentation in the area where they develop.

The organic matter content of these soils ranges from 20% in the case of organo-mineral materials and up to 95% in purely organic materials (Munteanu, 1996).

Land-use

In the natural state, Histosols function as basic pedological support for wetland ecosystems. Their ecological value is given by their high-water storage capacity and mechanical filtering capacity.

Apart from their bio function in natural ecosystems, Histosols are very fragile soils. If drained, besides the abovementioned acidification, in the Danube Delta under warm and dry climatic conditions, Histosols lose about 5 cm of the top a year due to mineralization and wind erosion. If the groundwater is mineralized, the salinization process also develops more rapidly. Experience has shown that Histosols in the DDBR are almost completely unsuitable for arable land use. Besides the toxicity which develops following acidification, the relatively coarse Histosols offer unfavourable ploughing and rooting conditions and have low water availability. The bearing capacity is low, the tilth is poor, the production of weeds is very high, and the macronutrient supply is extremely unbalanced especially due to excess amounts of nitrogen. More than 10 000 ha of the Histosols in the DDBR have already been lost by burning to obtain arable land in the Pardina and other agricultural polders of the delta (Munteanu, 1996).

Agricultural Soils

About 45% of global soils are under some form of agricultural use. In most soils, organic matter makes up a small fraction (~1-10%) of the total soil mass which is dominated by mineral matter (i.e., sand, silt, and clay particles); these are so-called "mineral soils". It is worth mentioning that the mass of organic matter contains nearly 50% carbon.

Most agricultural soils (both mineral and organic) are depleted in C relative to the native ecosystems from which they were derived, due to reduced net primary production and export of harvested biomass - which reduces C inputs to soil; nutrient depletion, intensive soil disturbance, and soil erosion are other contributing factors to soil C depletion. Most cropland mineral soils have lost 30-50% of the C stocks in topsoil layers (0-30 cm) relative to their native condition (Paustian et al., 2019).

It is not a consensus regarding agricultural soils in Danube Delta. Agriculture, as mentioned above, can use mineral and organic soils such as gleysol, kastanozem, histosol, and to some extent, alluvial soil, psammosol, and even sandy soil.

Carbon sequestration in soils

Soil Organic Matter stores a huge amount of atmospheric carbon. Carbon, in the form of carbon dioxide, is a greenhouse gas associated with global warming. So, by increasing soil organic matter, more carbon can be stored in soils, reducing the potential for climate change (Magdoff, van Es, 2021).

The Soil Organic Carbon represents the largest reservoir in interaction with the atmosphere and is estimated at 1500 Pg C to 1m depth. Vegetation (650 Pg) and the atmosphere (750 Pg) store considerably less C than soils do (Robert, 2001).

Fluxes between terrestrial or soil organic carbon and the atmosphere are important and can be positive (sequestration) or negative (emission of CO_2) (Robert, 2001).

Organic Matter in Soils

The organic matter content of agricultural topsoil is usually in the range of 1-6%. A study of soils in Michigan demonstrated potential crop-yield increases of about 12% for every 1% increase in organic matter. During an experiment, researchers saw an increase of approximately 80 bushels of corn per acre when organic matter increased from 0.8% to 2%. The enormous influence of organic matter on so many of the soil's properties - biological, chemical, and physical - makes it of critical importance to healthy soils (Figure 4). Part of the explanation for this influence is the small particle size of the well-decomposed portion of organic matter, the humus. Its large surface-area-to-volume ratio means that humus is in contact with a considerable portion of the soil. The intimate contact of humus with the rest of the soil allows many reactions, such as the release of available nutrients into the soil water, to occur rapidly. However, the many roles of living organisms make soil life an essential part of the organic matter story (Magdoff, Van Es, 2021).

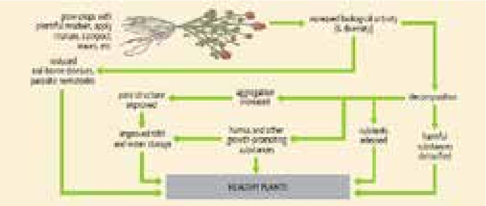

Figure 4. The Organic Matter and its benefits (Magdoff, Van Es, 2021)

The historical conversion of forests and grasslands to farming was responsible for a large transfer of carbon (from accelerated soil organic matter decomposition) into the atmosphere as CO_2. This agricultural conversion is second to the burning of fossil fuels as the largest contributor to increasing atmospheric CO_2 concentrations. As forests are burned and soils are plowed to grow crops (enhancing the use of organic matter by soil organisms), CO_2 is emitted into the atmosphere. But soils managed in ways that build up organic matter can become net sinks for carbon storage and can enhance their health at the same time. Increasing soil organic matter is no silver bullet for combating climate change, but it can help to slow the increase in CO_2 for a while if done on a massive scale all over the world.

If organic matter decreases from 3% (as it is nowadays) to 2%, the amount of carbon dioxide in the atmosphere could double.

Soil organic matter is the key to building and maintaining healthy soils because it has such great positive influences on essentially all soil properties - aggregation, nutrient availability, soil tilth and water availability, biological diversity, and so on - helping to grow healthier plants. Soil organic matter transformations are a key part of plant nutrition and the ability to achieve good crop yields. Soil organic matter is also an integral part of local and global cycles of carbon, nitrogen, and water, impacting many aspects that define the sustainability and future survival of life on earth (Magdoff, van Es, 2021).

Increased SOC through improved management practices is likely to add substantial resilience to croplands and farming systems, particularly during drought years or increased seasonal variability, helping to avoid edaphic (soil-related) droughts that result from land degradation. Given that hundreds of millions of small farmers for their subsistence depend upon croplands around the world, mitigation benefits of enhanced SOC storage must be recognized as only one significant component of an array of multiple benefits to achieve (Zomer et al., 2017).

In the past, the development of agriculture was the main cause of the increasing CO_2 concentration in the atmosphere, but now the combustion of fossil carbon by industry and transport (6.5 Pg yr^{-1}) represents the main contribution. An important point is that, at present, while deforestation in many tropical areas produces C emissions estimated at 1.5 Pg C per year, elsewhere around 1.8 to 2 Pg C per year is accumulating in terrestrial ecosystems. This represents what is called the "missing carbon" in the cycle: a sink that may be mainly situated in the northern part of the northern hemisphere. The main factors acting on organic matter evolution concern the vegetation (residue input, plant composition), then climatic factors (temperature/moisture conditions), and soil properties (texture, clay content, and mineralogy, acidity) (Robert, 2001).

Other factors, relating to soil fertilisation (N, P, or S), or irrigation, have an effect on plant production and hence on organic matter content. The rate of SOM mineralization depends mainly on temperature and oxygen availability (drainage), land use, cropping system, soil, and crop management. In a given soil type exposed to constant practice, a near-equilibrium (steady-state) SOM content is normally reached after 30 to 50 years (Robert, 2001).

Erosion

Soil erosion is one aspect of soil physical behaviour in which SOC content is regarded as a factor. Being a selective process, soil erosion preferentially transfers fine and light materials, which are typically enriched in SOC relative to the bulk soil. This process can lead to carbon loss in the eroding profiles and enrichment of the labile C fraction in the depositional profiles (Li et al., 2019).

Soil erosion by wind and water and subsequent sediment transport and depositional processes may lead to soil organic carbon (SOC) loss, especially from a sloping agricultural land unit. The erosion processes change land unit SOC stock by transporting SOC-rich sediment off an agricultural land unit, oxidizing SOC stocks, and releasing carbon dioxide (CO_2) into the atmosphere, as well as causing loss of SOC through surface runoff. Thus, erosion, transport, and depositional processes redistribute landscape SOC, enhance oxidation, and create a SOC source and a sink. However, redistributed SOC to bottomland soils is not sequestered SOC if it originates outside the borders of the measured land unit (Olson et al., 2016).

In Figure 5, the relationship for soils under cereals is, effectively, non-existent, whilst that for soils under pasture is more definite. From the graph, it would seem that soil loss decreases markedly above a SOC content of about 3% (Loveland, Webb, 2003). It is noted that in the case of cereal crops, even if there is no obvious relationship between SOC and Soil Loss, it is observed that the latter is more pronounced in the case of a lower percentage of OC.

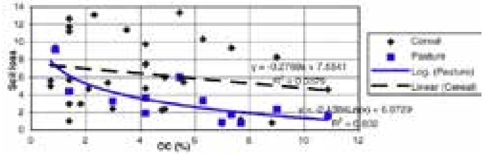

Figure 5. Relationship between SOC content (%) and soil loss (g/m^2 per month) under different land uses (Loveland, Webb, 2003)

In poorly drained soils and soils of the wetlands, decomposition reactions of humic matter occur at a greatly reduced rate. These soils support a different population of microorganisms that produce different types of end products, although CO_2 is included for the continuation of the carbon cycle. An incomplete decomposition under anaerobic conditions generally yields fermentation products, e.g., methane, mercaptans, nitrosamines, and the like, some of which are foul-smelling whereas others are believed to be carcinogenic. The main decomposition processes in such environments are expected to be hydrolysis and reductive cleavage. A schematic representation of the formation of methane through hydrolysis of humic substances by methanogenic bacteria is given below as an example:

$$(C_6H_5) - COOH + 6H_2O \leftrightarrow 3HCOOH + CO_2 + 3CH_4 \tag{10}$$

where:

- (C_6H_5)-COOH is part of the humic molecule;
- HCOOH is Formic Acid.

In summary, it can be stated that humic matter is an active constituent of the organic cycle in the soil ecosystem. Utilizing organic carbon for the formation of humic substances means preserving it for the benefit of the physicochemical condition of the soil ecosystem. It is a form of soil carbon sequestration, a process considered of vital importance for the environment. Although relatively stable, the stored carbon remains a formidable energy source for many microorganisms. The microbial population is often noted to thrive prolifically in soils rich in humus. By way of enzymatic decomposition and mineralization, the humic substances are eventually broken down into H_2O and CO_2, which completes the cycle.

Researches in Danube Delta

DDNI Tulcea within the Edaphic Bloom Project (***European Climate Initiative, 2020), analysed soil samples collected from the Danube Delta. In addition to the soil samples of organic origin specific to the Danube Delta, samples from agricultural soils were also collected. Sampling was realized in two field expeditions, in the summer (July) and autumn (September-October) of 2021 (Table 1). The target parameter was the percentage of organic carbon - OC in soils. The results on the soils of agricultural origin showed that Organic Carbon - OC on the first 10 cm of soil falls in the range of 2.4-6.7%, corresponding to a normal concentration found worldwide (1-6%) (Magdoff, Van Es, 2021). There is also a seasonal variation in the concentration of Organic Carbon, which can be explained by the fact that the summer sampling was carried out on cultivated land and in autumn on the already plowed land.

Table 1. Agricultural soils - The Organic Carbon content. From summer and autumn 2021 field expeditions data results (***European Climate Initiative, 2020)

Area	Depth	Organic Carbon [%]		Difference	Crop	Soil
	[cm]	july. 2021	sept. 2021			
Nufăru-Rusca	0-10	6.7	2.4	-4.3	wheat	Grey-black loose clayey silty gleyed alluvial soil
Pardina	0-10	4.7	2.7	-2	two rowed barley	Brown-olive silty clayey alluvial soil
Tatanir	0-10	4.7	3.4	-1.3	sunflower	Dark-brown micaceous silty clayey alluvial soil

DDNI Tulcea made a series of measurements aimed at recording CO_2 emissions from the Danube Delta soils in September 2021. Three locations, two natural areas, and an agricultural area were chosen as testing sites.

The CO_2 emissions were recorded continuously for two weeks, and the results are shown in Table 2. It was found that natural soils emit less CO_2 than agricultural soils because the percentage of Organic Carbon accumulated in agricultural soils is lower. In terms of numbers, CO_2 emissions exceed the global value of 412.5 ppm (2020) (***Global Methane Initiative, 2020) and 418 ppm (2022) (*CO_2 Earth. Numbers for living on Earth. Retrieved from https://www.co2.earth/*) for the first two locations. At Matița-Roșca, CO_2 emissions are below global value.

Table 2. CO_2 emissions recorded in the Danube Delta - September 2021 (***Beia Consult International, 2021)

Location	**Medium value [ppm]**	**Minimum value [ppm]**	**Maximum value [ppm]**	**Remarks**
Nufăru-Rusca	428	353	728	Agricultural area
Candura Channel	423	386	627	Natural area
Matița-Roșca	336	203	579	Natural area

Farm managers can strongly influence this dynamic in four ways:

1) Decreasing the level of soil disturbance (i.e. soil agriculture process) to increase the physical protection of soil carbon.
2) Increasing the mass and quality of plant and animal inputs to the soil.
3) Improving soil diversity and microbial abundance.
4) Maintaining the cover of continuous living plants on the ground throughout the year.

Managing these processes can quickly lead to increases in soil carbon sequestration, which can be extremely helpful in lowering atmospheric CO_2 content. Regenerative and therefore biodynamic agriculture goes beyond organic or sustainable agriculture, which only supports the way food is produced but does not reverse the damage ratio.

What is unique about Sustainable-Biodynamic-Regenerative Agriculture?

The concept of Biodynamic Agriculture includes the term Regenerative Agriculture and aspires to be transformative, aiming to maximize the health and vitality of the soil, ecosystem, and crops.

Practices include:

- Replacing chemical herbicides with farm-based herbal products to improve and revitalize crops;
- Replacing chemical pesticides with agricultural practices that promote a healthy balance between predators and prey with appropriate planting techniques;
- Replacement of chemical fertilizers with natural compost produced by the farm for soil fertilization.

Planting cover crops out of season, draws carbon back from the atmosphere and improves soil vitality and nutrient content.

- Disposal of chemicals

Industrialized agriculture is largely based on chemicals that kill important insects and pollute the water and the environment. Replacing toxic chemicals with natural alternatives so that no chemicals with negative effects on human health end up in food!

- Regular crop rotation increases soil vitality and helps retain water.

Unlike organic farming, which focuses mainly on crops, the biodynamic certification certifies the entire farm and all aspects of the farm.

- Sustainable-Biodynamic-Regenerative Agriculture sets higher standards for environmental sustainability and ecology, as it requires that agricultural practices not only refrain from plant damage but also improve it in the process;
- Zero tolerance for GMOs;

Sustainable-Biodynamic-Regenerative Agriculture can contribute to reducing the impact of climate change - by acting on the weaknesses of current practices:

- Current agricultural practices are based only on economic and not ecological grounds. People have manipulated the way we grow and harvest food in an effort to produce in bulk at a cheaper price. These agricultural practices have led to:
    - development of GMO crops;
    - the destruction of healthy soil;
    - animal cruelty;
    - water pollution.
- Excessive use of toxic chemicals such as glyphosate, a cancer-causing chemical found in popular baby foods such as cereals;
- These destructive agricultural practices also play an important role in the loss of biodiversity, pollinators and play an important role in climate change.

Fortunately for us (and for the little ones), there is a better way to cultivate, which could even reverse global warming: Sustainable-Biodynamic-Regenerative Agriculture that seeks to heal the Earth by working with nature to improve and "repair" the earth and farms, rather than harming them. Scientists say that this type of agriculture can even help fight climate change. Globally, in the world, this type of agriculture is more developed in the United States of America, and in Romania, there is no such farm (Figure 6).

Because our study area, the Danube Floodplain, and the Delta, includes peatlands where agriculture is practiced, paludiculture is good to apply. In conventional agriculture, many peatlands are drained to allow intensive farming. Unfortunately, drainage causes a multitude of problems, such as landslides and an increased risk of flooding. By increasing groundwater, these problems can be avoided. After re-humidification, the cultivation of flood-tolerant plant species can prevent eutrophication and provide an alternative product for farmers. Thus, *the main purpose of paludiculture cultivation is the conservation and restoration of peatlands, simultaneously using the biomass produced.* Paludiculture cultivation combines the reduction of greenhouse gas emissions from peatlands drained by re-wetting with continuous land use and wet biomass production.

Figure 6. Regenerative Farms în the world (Regenerative Farm Map. Retrieved from https://regenerationinternational.org/regenerative-farm-map)

With paludicuture cultivation, peatlands are kept productive in permanently humid conditions, preserving peat and potential for peat formation. Thus, it is a model for storing carbon in peatlands, while producing food, feed, and energy. The corresponding benefits of paludiculture cultivation could contribute to the objectives of the *EU Green Deal policy* (*European Commision. European Green Deal. Retrieved from https://ec.europa.eu/clima/eu-action/european-green-deal_en*) by maintaining and restoring more ecosystem services, such as maintaining water, retaining nutrients, cooling the local climate, and providing habitat for rare species, while allowing agricultural production. Paludiculture includes a variety of agricultural production systems that aim to produce plant-based or animal-based commodities - from harvesting vegetation on semi-natural sites to establishing specific permanent crops.

Paludiculture uses above-ground biomass, while underground biomass, i.e. a major part of the net primary production, remains for peat formation. After the establishment of high groundwater near the surface of the soil throughout the year, wet meadows can be developed by a succession of vegetation or permanent crops with specific peat species that can be cultivated. The harvested biomass can be used as food, feed, and fibber for industrial biochemistry, for the production of building materials, high-quality liquid or gaseous biofuels, for the production of heat by direct combustion, or other purposes such as extraction and synthesis of pharmaceuticals and cosmetics. These diverse options for paludiculture biomass show its great potential for future applications of the circular bioeconomy.

Paludicultural plants and utilization options include:

- Isolation material;
- Filling material (fibbers);
- Building Materials;
- Packaging and disposable tableware;
- Horticultural crops that replace peat;
- Pollen for feeding predatory mites (pest control in greenhouses);
- Straw;
- Combustion;
- BIOGAS;
- Protein extraction;
- Paper;
- Liquid fue;l
- Silicone from reed leaves;
- High-performance energy storage devices.

These proposed practices must be supplemented with permaculture. In their book *Permaculture One* (1978), Bill Mollison and David Holmgren outlined the three ethical directions of permaculture:

- *Caring for the Earth: making sure that living systems can continue to survive and proliferate;*
- *Caring for humanity: making sure that people have access to all the resources they need to live;*
- *Ethical distribution and limiting the consumption of resources: by setting limits for our needs, we can obtain resources to support the two previous directions. We will share the surplus with others.*

Permaculture deals with the design of the environment so that it is self-sustaining, on ecological and biological principles, often using patterns that occur in nature. The aim is to optimize the effect and minimize the work. The purpose of permaculture is to create stable, productive systems that meet human needs and harmoniously integrate the environment with its inhabitants. To achieve its goal, permaculture takes into account the ecological processes of plants and animals, their feeding cycles, climatic factors, and weather cycles.

In the last instance, agricultural exploitation is defined by the economic parameters, within which, after the realization of the input-output balance, either a surplus or a steady-state or losses is realized, but also by ecological indicators.

The optimum is defined in a field of action of concrete factors, in which the total cost of production (TCP) per unit of output is the lowest, but with ecological effects beneficial to the environment.

CONCLUSIONS

- Greenhouse gases are a phenomenon with long-term global implications. The alarming rise in GHG concentrations in the atmosphere determined scientists to search for effective methods to reduce emissions of these gases. The main gases that are considered dangerous in this context are carbon dioxide and methane. Even though methane is found in very low concentrations in the atmosphere, it is much more potent than carbon dioxide and can be a real danger in the event of a substantial increase.
- Carbon sequestration in the soil is seen as the main mean of reducing GHG emissions. As agriculture is highly dependent on soil quality, a supply of organic matter is needed to improve soil quality and is, therefore, an effective method of reducing GHG and secondly, it can

visibly improve the quality and quantity of agricultural production.

- Danube Floodplain and Delta Soils, although the monitored properties present non-significant improvements because their evaluation remains in the ranks characterized by the agriculture of subsistence. It is important to note that the decrease of organic content in the soil, understood as organic carbon, favoured the chemicals nutrients input, and degraded physical and biological properties evaluated in the demonstration area.
- Carbon sequestration on agricultural land is possible through several soil management strategies and could be substantial with wide-spread implementation. Sequencing historical carbon from emissions is now essential, as it is unlikely that mitigation alone will stabilize our atmosphere. Farm managers can strongly influence this dynamic in four ways:

1) Decreasing the level of soil disturbance (i.e. soil agriculture process) to increase the physical protection of soil carbon;
2) Increasing the mass and quality of plant and animal inputs to the soil;
3) Improving soil diversity and microbial abundance;
4) Maintaining the cover of continuous living plants on the ground throughout the year.

- Soil quality is constantly deteriorating, either due to natural phenomena (eg soil erosion) or anthropogenic intervention due to the use of destructive practices (eg use of harmful substances to eliminate pests or increase agricultural production). For the soils to be of agricultural and ecological quality, an optimal percentage of Carbon Organic (> 2% SOC) must be maintained. By increasing SOM (SOC) in soils, one can obtain important benefits like detoxification of harmful substances, increasing the growth of the plants, improving pore structure, tilth, and water storage, and releasing vital nutrients for plant health.
- There are many management strategies for extracting carbon from the atmosphere and retaining it in the soil. These strategies vary in efficiency depending on different climates, soil types, and geographical areas.
- The proposals for the Danube Floodplain and Delta Agriculture there are:
    - Sustainable-Biodynamic-Regenerative Agriculture;
    - Paludiculture;
    - Permaculture.

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