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2015 International Year of Soils

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ÉDITORIAL

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2015 is the international year of soils. This event will be an opportunity to share and discuss all the current projects and efforts made to assess their contribution to forestry, agricultural and energy productions and to the management of land policy. The research led by ADEME has evolved from characterising different types of pollution to providing a better understanding of complex mechanisms, such as the relationship between soils and climate change. The results of this research have focused on evaluating carbon stocks, their vulnerability to climate change and the impact of land-use change. This letter, the second of a "triptych" of research letters put together as part of the lead up to COP21, will be followed by a technical day dedicated to defining the roles of the various actors of soil management (local authorities, government, businesses, natural parks...). The various parties will meet up on 17 November 2015 in Paris to discuss ways to better understand and manage soil resources.

NEWS

SOILS: FROM CHARACTERISING DIFFERENT TYPES OF POLLUTION **TO TACKLING CLIMATE CHANGE**

The research supported by ADEME that was carried out on soils has successively focused on the evaluation of diffuse pollution, monitoring support and the relationship between soils and climate change.

CHARACTERISATION OF SOILS

In the 1990s, some of the main priorities for research work were

the prevention of soil pollution and the assessment of the impact of spreading wastes on soils. This coincided with the introduction of national and European regulations for waste recycling and composting in agriculture.
Thus, ADEME provided support for research centred on the physical-chemical and ecotoxicological methods for characterising waste disposed of by landspreading, and on the effects of such spreading on the quality of soils and environments (e.g.: contaminants entering waterways, the food chain, ecosystems and so on). On top of numerous scientific journals and reports covering a wide range of disciplines and fields, this research has also resulted in the publication of reference guides, popular science works[1] and the creation of standards that have helped reinforce existing regulations and support discussions over the assessment of health risks and risks to eco-systems.

SUPPORT FOR MONITORING OF SOIL QUALITY

In the early 2000s, in order to support research on the protection of soils, ADEME, in collaboration with the Ministries for Agriculture and Ecology, the INRA (National Institute for Agricultural Research), the IRD (Institute for Research and Development) and the IGN (National Geographic Institute), took part in the creation of GIS Sol[2] (French Soils Scientific Interest Group). Its aim is to collect, organise and provide a national database for soil data. Given the nature of its work, ADEME was particularly supportive of the creation of a Soil Quality Monitoring Network (Réseau de Mesure de la Qualité des Sols or RMQS-see boxed text), whose aim it is to assess the physical-chemical state of soils and pre-emptively detect possible degradation. When they realised there was a lack of methods in place and data to properly assess and quantify the biological quality of soils, the ADEME teams, in collaboration with the ANR (National Agency for Research) and the MEDDE (Ministry of Ecology, Sustainable Development and Energy) (part of the GESSOL[3] programme) launched a call for project proposals in 2004 titled "Bioindicateurs de la Qualité des Sols[4]" (Bioindicators of soil quality). For the next 10 years, over 90 researchers and academics contributed to the development of new methods of soil analysis, by suggesting protocols and references based on microbiology and soil flora and fauna.
Out of all the methods developed, the ones based on DNA extraction from soils proved to be the most promising because they enabled us, with the help of international databases, to quickly and efficiently characterise the biological diversity of soil micro-organisms (bacteria and fungi) and eventually soil fauna. The protocols resulted in the creation of international standards[5].

SOILS AND CLIMATE CHANGE

In 2010, ADEME shifted its focus to existing links between soils and climate change in the hope of better understanding and characterising the flux of the three main greenhouse gases (nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2)). This work will eventually allow to define agricultural and forestry strategies to help tackle climate change. N_2O emissions are mostly caused by the transformation of nitrogen by bacteria; the sources of CH_4 emissions are mainly humid areas, marshes and rice fields. As for CO_2 emissions, these are caused by the decomposition of the soils' organic matter (which essentially derives from plant biomass).
Although soils are a source of greenhouse gases, they are also the biggest carbon reservoir in the biosphere: the first metre of soil stores over 2000 gigatons of organic carbon, which is the equivalent of both biomass stocks and atmosphere.
In France, the work of GIS Sol based on RMQS data has allowed us to determine that the first 30 centimetres of soil in Metropolitan France currently contain over 3 billion tons of carbon. These stocks vary greatly depending on the type of soil, climate, soil occupation and management: they are for example very high in grass found in high altitude zones, humid areas and pastures and meadows and are quite low in viticulture areas, Mediterranean regions and areas of intensive culture.
The issues around the role that soils play in climate change were integrated into the REACCTIF (Research on the Mitigation of Climate Change by Agriculture and Forestry) call for project proposals. The idea was to highlight opportunities for carbon sequestration and find ways of limiting the risks of emissions. Since 2012, they have supported over 15 projects whose aim was to better understand GHG flux from agricultural and forestry soil systems, which are linked to how they are managed.

1. http://www.ademe.fr/mediatheque/recherche?query=BOUE
2. www.gissol.fr
3. www.gessol.fr
4. https://ecobiosoil.univ-rennes1.fr/ADEME-Bioindicateur/english/index.php
5. NF EN ISO 11063, 2013, Soil quality-Method for directly extracting soil DNA samples

Focus on...

DIAGNOSING AND MONITORING THE STATE OF SOILS IN FRANCE

The Soil Quality Monitoring Network (RMQS) relies on the monitoring of 2,200 sites spread across the French territory (Metropolitan France and overseas territories) according to a square grid (16 km x 16 km). These sites include all types of soil and cover all occupations. Researchers take soil samples and measurements and make observations every ten to fifteen years, which allow them to assess the state of soils in France: fertility, contamination, biodiversity, pathogenic bacteria (see the Report on the State of Soils, published in 2011). The second campaign scheduled to be carried out between 2015 and 2026 will assess how French soils contribute to the fight against climate change, whether through the reduction of carbon emissions or the adaptation of crop production.

GHG FLUX FROM SOIL SYSTEMS **AND CLIMATE CHANGE**

The research was focused on assessing the various levels of GHG flux from soil systems to tackle climate change and improve environmental balance sheets.

The mechanisms that produce GHG flux from soils are complex and rely on a number of factors, including the nature of the soil, the climate and human activity. The presence of clay for example protects organic matter from decomposition; temperature and humidity have an influence on biological activity; and the different types of crops (perennial or annual), types of rotations, soil management and fertilisation also have an impact.

FROM SMALL-SCALE PLOTS...

The aim of a number of projects that benefited from REACCTIF support was to increase our understanding of carbon and nitrogen dynamics in agricultural and forestry soils (speed of storage, GHG emission conditions, distribution of stocks and emissions).

One example is the AGRIPSOL (Agroforestry for the Protection of Soils) project, coordinated by Agroof and used as «course material» for a thesis funded by ADEME and the Fondation de France. This project has enabled us to define for the first time, in national conditions, the distribution and nature of carbon stocks in agroforestry systems, according to which trees are grown around or among crops[6]. And what these soil samples taken from an experimental site clearly highlight is that carbon stocks are significantly more important along the tree line (which hasn't been ploughed but covered with grass). The analyses of organic matter along that line nevertheless reveal its vulnerability to climate change: the carbon decomposes easily, which in case of changing temperature and humidity levels, leads to increased biological activity and consequently to a salting-out effect.

This research work has allowed us not only to define protocols for taking samples from other agroforestry sites, but also to consolidate storage values for a more accurate environmental assessment of cropping systems at field scale.

As for nitrous oxide, we can mention for example the SOLGES (Ability of soils to reduce N_2O) project, coordinated by the INRA UR Sols in partnership with Arvalis-Institut du Végétal and Terre Inovia, which highlighted the link between the soil's pH levels and N_2O emissions. The more acid the soil is (pH < 6.5), the less it is able to transform N_2O into N2 and thus reduce emissions.

Liming practices in fields, which increase pH levels, have shown that the ability to reduce emissions was improved and that consequently there were fewer

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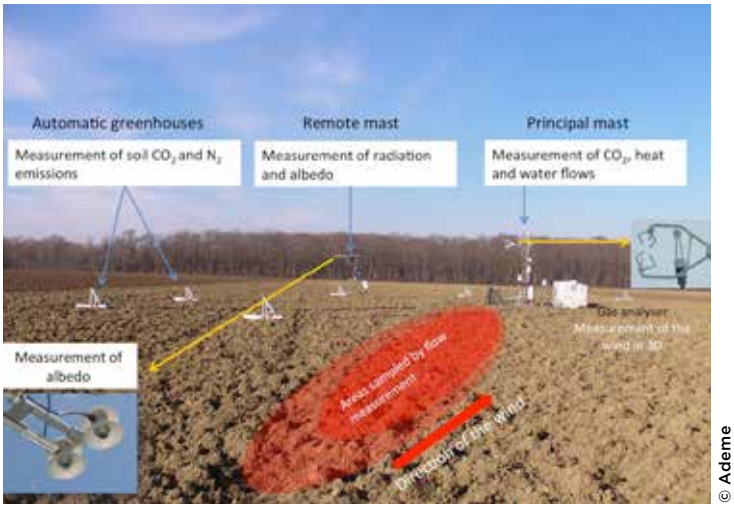
N_2O emissions. Thus the research has helped us highlight a climate change mitigation practice that can be adopted by farmers. It will also allow us to estimate national and territorial emissions with more accuracy, by using specific tools for better soil assessment (GIS Sol).

...TO LOCAL THEN GLOBAL SCALES

On a much larger scale, the various issues that arise in cultivated and forestry areas as a result of human activity (food production, non-food biomass, urbanisation...) require us to take into consideration carbon stocks in soils when making decisions and implementing regulations. In fact, any change in the use of soils (e.g.: converting meadows into arable land, deforestation, urbanisation) will have repercussions on the GHG emissions of the affected land.

For example, the ABCTerre project (Mitigation of agricultural GHG integrating soil carbon on a given territory), coordinated by Agro-Transfert Ressources et Territoires, developed an approach which combined spatial knowledge of soils, of their uses, rotations and agricultural practices within a given model of evolution of organic matter, in order to predict in the medium term the dynamics of carbon storage and de-stocking. This tool will be used to improve the assessment of GHG emissions of a given territory. It will thus help to achieve the aims of the "4 per 1000" programme (see interview) and help us assess the many uses of organic matter (e.g.: limiting soil erosion). In order to tackle issues surrounding land-use change, ADEME is providing funding for research, initially focussing on first generation biofuels, as part of the GIS Changement d'Affectation des Sols (French Scientific Interest Group for Land-Use Change). This was meant to help clarify the environmental balance sheets and identify the various ways in which we can improve land use policies, such as the development of livestock farming and the urbanisation of cultivated land. Although the main purpose of this funded research work was to improve our understanding of soils and land on various scales (plots/local/global), it is now also being used to support a number of public policies (e.g.: supporting the national policy on biofuels). The research was also used to publish guides, establish standards and create tools and factsheets (e.g. agricultural factsheets[7]) and communication material (e.g. the carbon brochure[8]).

6. http://www.sciencedirect.com/science/article/pii/S0016706115300021
7. http://www.ademe.fr/references-agriculture-environnement-pratiques-clefs-preservation-climat-sols-lair-economies-denergie
8. http://www.ademe.fr/carbone-organique-sols-lenergie-lagro-ecologie-solution-climat



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> CESBIO (Purpan Engineering school Lamothe Farm) Lamasquère experimental site in operation since 2005: presentation of the CESBIO measuring tools.

➡ *Taking the matter further*

Albedo management of cultivated plots: a new tool in the fight against climate change

Morgan Ferlicoq and Eric Ceschia from the CESBIO (Centre d'Etudes Spatiales de la Biosphère-Centre of Spatial Studies of the Biosphere[9]) have been studying the effects of practices and crops on the albedo (reflective power of a surface or reflection coefficient) of agricultural plots. Increasing the Earth's surface's albedo thus reduces the emission of thermal radiation, and so, by extension, reduces global warming. Their research shows that we can increase the albedo of cultivated plots by implanting cover crops and keeping the straw on the surface after the harvest. This albedo effect should now be assessed on a much larger scale, via remote sensing and modelling, whilst taking into account the consequences on water and heat flows between the plots and the atmosphere and their repercussions on the climate.

9. http://www.cesbio.ups-tlse.fr/

MEETING...

JEAN-FRANÇOIS SOUSSANA
SCIENTIFIC DIRECTOR (ENVIRONMENT) AT THE FRENCH NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INRA)

ISABELLE FEIX
NATIONAL SOILS EXPERT AT ADEME.

SOIL AND CLIMATE

"STORING MORE CARBON IN THE SOIL TO FIGHT GLOBAL WARMING"

The soil is, by its very nature, a considerable carbon reservoir. Increasing its storage capacity could enable us to halt the increase in CO_2 emissions and therefore to reduce global warming.

Are soils being taken into account in current international climatic policies?

Jean-François Soussana: The matter of soils is at the heart of a number of global issues (food safety, climate and water regulations, preservation of biodiversity, etc.), and was, as such, brought up in a number of the UN's international conventions: the convention to combat desertification, the one on biological diversity as well as the framework convention on climate change. So, the state of soils is indeed being taken into account in debates and international climatic policies. However, we don't have specific discussions dedicated to this issue.

How is ADEME tackling this issue?

Isabelle Feix: The Agency has launched and has taken part in a number of research and monitoring programmes dealing more or less specifically with the part soil plays in mitigating climate change. The Agency is in fact a member of the GIS SOL, which coordinates efforts to map, monitor and draw up inventories of soils. ADEME is one of the funding bodies for the Soil Quality Monitoring Network (RMQS), which carries out every ten years an assessment of the state of soils in Metropolitan France and its overseas territories, according to a number of parameters, including carbon concentration. Moreover, the Agency coordinates the REACCTIF (Research on the mitigation of climate change by agriculture and forestry) programme, which looks into the part agricultural and forest soils play in mitigating climate change (around 15 research projects). Finally, the relationship between soils and climate change is the subject of eight theses that ADEME is currently supporting as part of its Thèses programme.

What part do soils play in tackling climate change?

J-F. S.: The soil is a considerable carbon reservoir, which currently stores the equivalent of 2 to 3 times the quantity of CO_2 present in the atmosphere. Today, the main issue we are facing is how to increase this storage capacity in order to reduce global carbon emissions and so limit the global temperature rise to 2 degrees Celsius, as recommended in the latest IPCC report. There are a number of possible scenarios. We have of course the technological response, which consists in biomass burning, in order to retrieve the CO_2 contained in the fumes. We would then liquefy it and bury it deep within the rock. Then we have an agro-ecological response, which consists in relying on the ability of living organisms' capacity for CO_2 sequestration, via photosynthesis, in order to limit its increase in the atmosphere. This is at the heart of the "4 per 1000" programme launched by the Ministry of Agriculture, Agrifood, and Forestry last March, which aims to increase stocks of organic matter by "4 for 1000", every year and world wide (which would in theory make up for the planet's anthropogenic greenhouse gas emissions).

Bio express

The Scientific Director (Environment) at the French National Institute for Agricultural Research (Inra), Jean-François Soussana is also a member of The Intergovernmental Panel on Climate Change (IPCC).

What biological and ecological tools and methods do we currently have to allow us to store more carbon in soils?

J.-F. S.: There are two ways in which we

can do this: we can increase the amount of organic carbon that enters the soil, mainly by increasing the primary productivity of vegetation (by for example not interrupting crop growth and having barren grounds at any time in the year). We can also prevent the loss, principally by mineralisation, of organic soil carbon (by for example improving the way the soil is used). When it comes to forests, we will have to focus mainly on increasing primary productivity by restoring degraded land.

Aside from sequestering carbon, what other benefits does soil provide in terms of climate?

I.F.: In cities, climate change will increase the frequency and intensity of floods and heat waves in the summer. Soils help cities adapt to climate change in at least two ways: by acting as a sort of «sponge» in urban areas as well stemming the floods before they reach these areas. Moreover, soils and vegetation provide a cooling effect in urban areas via evapotranspiration, thereby helping reduce GHG emissions that are caused by air conditioning. Finally, thanks to their ability to store water and distribute it to plants, soils play an active role in helping forests and agricultural areas adapt to periods of drought, which are likely to increase with climate change.

"The state of soils is indeed being taken into account in debates and international climatic policies. However, we don't have specific discussions dedicated to this issue."

Nowadays, we tend to include the impact that soils have in environmental balance sheets; why is that?

I.F.: The aim of an environmental assessment is to analyse the life cycle of a product or process, covering their environmental impacts, including GHG emissions. Leaving out the matter of soils from such assessments can lead to erroneous decisions being made. Let's take the example of biofuels: the recent inclusion of GHG emissions caused by land-use change has negatively affected their carbon assessment because the emissions are as important as the GHG emissions that were avoided thanks to the substitution of fossil fuel. ADEME has consequently sought to improve the assessment of the scope and evolution of direct and indirect land-use changes in order to analyse their impact, namely in terms of GHG emissions. As a result, the Agency partnered up with the INRA, the ministries in charge of ecology and agriculture and France AgriMer to create the Scientific Interest Group for Land-Use Change (GIS CAS). Progressively, the GIS CAS widened the scope of its work and today also covers land-use change caused by urbanisation, food policies and the extensification of agriculture. In the longer term, the GHG assessment linked to soils will be integrated into the life cycle assessment of products and processes and in the environmental assessment of land management policies, which will help decision-makers and consumers make certain choices, for example, through appropriate environmental labelling.

Earlier you spoke about storing more carbon in soils by using ecological means to restore them. Is this feasible on the scale you have in mind?

J.-F. S.: The experiments previously carried out seem to show that this solution is indeed achievable. Even better, this process is actually part of a virtuous cycle, as storing carbon in soils encourages an increase in organic matter, which in turn makes the soils more fertile. Carbon storage therefore appears to be a promising alternative that can contribute to reducing global food shortages.

CALL FOR PROJECT PROPOSALS

INVESTMENTS FOR THE FUTURE

4 NEW CALLS FOR PROJECT PROPOSALS FOR TRANSPORT

On 24 July 2015, the government launched 4 calls for project proposals (Appels à projets or AAP) in partnership with ADEME and the Commissariat Général à l'Investissement (General Investment Committee) as part of Investments for the Future programme and its Véhicules et transports du futur (Vehicles and Transports for the Future) scheme. The aim of these AAPs is to improve and speed up the development of innovative technological solutions for better, more efficient urban transport and mobility, that also use less fossil fuel.

PUBLICATION

AGRICULTURE AND AIR POLLUTION

Impacts, contributions, perspectives: current state of knowledge

ADEME and the MEDDE have issued a state of knowledge and some targeted approaches to reduce the intertwined effects of air pollution and agriculture. This publication, produced in collaboration with the INRA and based on the seminar organised on 2 July 2014, as part of their research programme PRIMEQUAL, will be followed by another call for project proposals in the 2nd semester of 2015.

www.ademe.fr/113909

EVENT

20 NOV. 2015

CORTEA RESULTS DAY

PARIS

The first day of the restitution of research results will be held on 20 November 2015. The research was carried out as part of the CORTEA programme to improve our understanding, reduce and treat air pollutants emissions.

www.ademe.fr/actualites/manifestations/1ere-journee-restitution-cortea-emissions-polluants-lair

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