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Environmental *monitoring*

Resource management, impact reduction and risk management

The ***Laboratory for Industrial Environment Engineering and Industrial and Natural Risks*** **(UPR LGEI)** is one of three internal laboratories of the *École des Mines d'Alès* [EMA, having the status of a national public administration (EPA) reporting to the Ministry of Industry]. LGEI focuses its research on resource management, impact reduction, and risk management to meet industrial and societal demand. These research foci are congruent with the field of environmental technologies as technologies, processes, products and services aimed at reducing the impact of human activity on the environment.

The main team

UPR LGEI
Engineering Laboratory for Industrial Environmental Engineering and Industrial and Natural Risks
(EMA)
29 scientists

Other teams working in this area

UMR ITAP
Information/Technologies/Environmental Analysis/Agricultural Processes
(Montpellier SupAgro/IRSTEA)
27 scientists

UPR Recycling and Risk
(CIRAD)
13 scientifiques

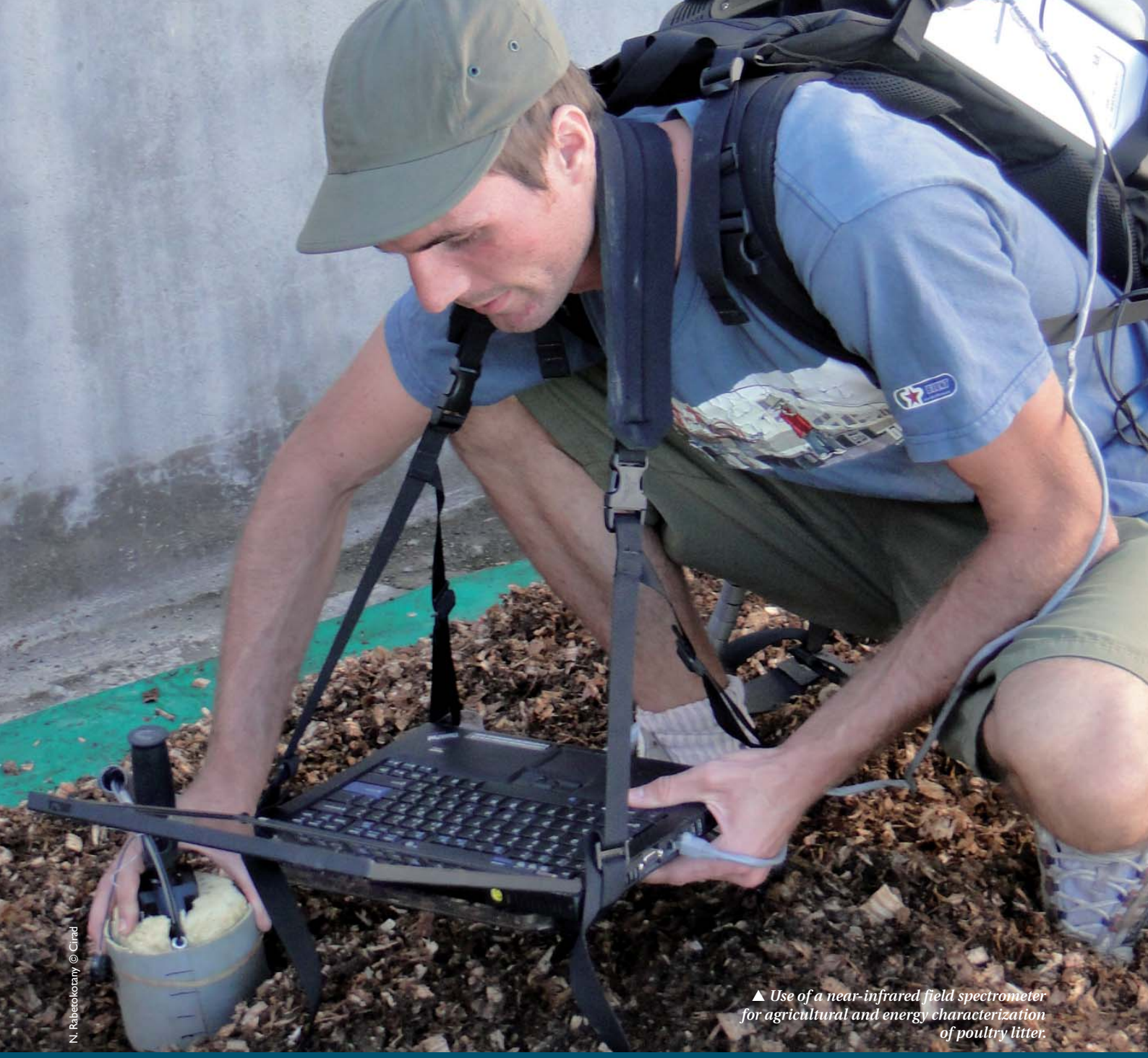
To meet these objectives, LGEI is developing multidisciplinary research covering a wide scope of applications based on complementary disciplines such as: process engineering, analytical chemistry and metrology, microbiology, molecular biology, hydrology, hydrogeology, geomatics, geostatistical methods, information technology and computer modelling, simulation and decision support tools.

Those applications relate to proposed diagnostic and monitoring tools to assess resource quality (detection and measurement of physicochemical and biological parameters), integrated environmental management of resources in a region or on an industrial site (pollutant flow, matter, products), risk management and control (hazard, impact and vulnerability analyses).

As regards environmental technologies, its development foci are:
- development of measurement methods for the quantification of organic and metallic pollutants in different matrices (water, sediment, liquid and gaseous effluents), biosensing and bioassay system development (assessing pollutant effects);
- development and improvement of processes for the treatment of liquid or gaseous effluents. For that purpose, one area for improvement is the functionalization of materials whose origin is biological (biopolymers), mineral or synthetic, with different molecular structures (composites, nanostructures) or different packaging (encapsulation), and the use of biological processes in purification;
- study of processes for resource re-use and recycling, considered in terms of quality and use.

In support of these issues, LGEI has access to laboratory equipment (HPLC/MS/MS, GC/MS/MS, ICP, extractors…) as well as a test centre for experiments on a semi-industrial pilot scale. These facilities are open to academic and industrial teams of the regional technology platforms.

In addition, LGEI has been a stakeholder in the Ecotech LR platform *(cf. p. 43)* since its inception and is actively involved in the ELSA cluster, *cf. p. 32)*. LGEI's particular responsibility, within that cluster, is the "industrial ecology" focus. Finally, LGEI is part of the M.IN.E.S. Carnot Institute, whose accreditation has been renewed, showing LGEI's key role in relations with the economic sector. The Laboratory is active in a number of clusters: Water, Trimatec, Territorial Risk and Vulnerability *(cf. p. 43)*, and Eurobiomed. ■



N. Rabetokotany © Cirad

▲ *Use of a near-infrared field spectrometer for agricultural and energy characterization of poultry litter.*

Choice of waste recovery mode based on waste characterization by near-infrared spectroscopy

On Réunion, the increasing production of organic waste (water treatment plant sludge, fermentable fraction of household waste, green waste, manure and agri-food waste), referred to as exogenous organic matter (MOEx), goes hand in hand with the increase in both population and animal husbandry. The island's insularity and isolation make it impossible to export the MOEx; it must be locally managed. There are two possible ways of recovery: ❶ to maintain and enhance soil fertility, ❷ to produce renewable energy. The choice of the most appropriate recovery mode can be eased if a typology of MOEx is drawn up, to assess value vs. risk (e.g., with respect to greenhouse gas emissions). The development of MOEx characterization tools represents a scientific challenge: to decide how it should be managed in a context of sustainable development.

Near-infrared spectroscopy (NIRS), a qualitative and quantitative technique, is the tool used. Calibration is required to convert an observed spectrum into a valuable parameter (e.g. concentration of a particular component) using statistical tools. The model developed is then used to predict the parameter in question from NIRS spectra of samples of a nature similar to those in the calibration range. NIRS is used to compile baseline data sets in the field or in the laboratory: transformative potential of nitrogen and carbon ("humus" potential), combustion potential, methane potential. This technique, when applied to MOEx in the raw state or during processing (e.g. composting and anaerobic digestion), should allow data to be generated reliably, quickly and at low cost so as to evaluate different scenarios for using these resources.

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▲ *Aerial view of the port of Port Camargue.*

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ECODREDGE project

method and technique for global and local management of harbour dredging products

In France, 50 million cubic metres of sediment is dredged annually, including 17,500,000 m³/year in French Atlantic coast ports, while the volume dredged is lower on the Mediterranean coast. Small ports and marinas produce nearly a quarter of all sludge from marine sediment dredging in France. In this context, the *Grenelle de la Mer* made a number of commitments for the reduction of marine pollution from dredging, including a ban on the dumping of polluted sludge at sea and implementation of sludge treatment processes.

ECODREDGE-MED, a collaborative project initiated by the independent management board at Port-Camargue, offers an innovative approach to sustainable management of harbour sediment. with two goals in mind: first, to institute dredging and materials processing technology that does not rely on temporary storage on land and, second, to find local recovery processes to meet the demand for materials. This project has been accredited by the Water cluster under thrust 2 ("concerted management of resources and resource use"), to which it belongs.

Its scientific objectives are:

- to develop ways of better evaluating the recovery potential of the dredged sediment while respecting environmental constraints;
- to define constraints on materials formulation for recycling purposes;
- to monitor the effects of dredging on the mobilization and ecotoxicity of metals and organic compounds;
- to develop tools for tracing pollution sources.

ECODREDGE-MED has the support of qualified firms (BEC, BRL-I SOLS Med) and the research laboratories Armines-LGEI (EMA), UMR HydroSciences Montpellier (CNRS, IRD, UM1, UM2), UMR Coastal Marine Systems Ecology (CNRS, IFREMER, IRD, UM1, UM2). EMCC, a company specializing in dredging and owned by the Vinci Group, rounds out the consortium. This project is financially supported by the Single Interministerial Fund, the European Regional Development Fund, OSEO and the Languedoc-Roussillon region.

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What **technologies** for what kind of **pollution?**

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▲ *Field biosensing kit.*

Technological developments currently underway at LGEI aim to develop new detection systems focused on one target pollutant or one type of induced effect and to improve instrumentation in terms of accuracy, reliability, speed of measurement, automation, miniaturization and cost, emphasizing in situ validation of new sensors (including passive sensors and biosensors) to demonstrate their potential for resource monitoring, diagnosis and management.

These sensors would enable screening to be done for persistent organic pollutants (pesticides, PCBs, PAHs) and resource monitoring to be carried out (water, sediment, for example), to judge how contaminated the resources are and whether or not to re-use or recycle them. These research foci are directly related to the concerns of the Water cluster, including: sensor miniaturization, sensor network improvement, data transmission...

Assess carbon sequestration in soils by near-infrared spectrometry

Soil, being the 2nd largest carbon (C) sink after the oceans and rocks, and much more important than biomass, is a major storage channel for C. In the spirit of the Kyoto Protocol, farmers could be paid for this storage service under two types of contract: remuneration of good practices or generation of carbon credits. The second approach is the most effective but requires a means of measuring sequestered carbon accurately and inexpensively.

An international consortium (UMR ITAP, UMR Eco & Soils [INRA/Montpellier SupAgro/CIRAD/IRD], INRA Orléans, University of Sydney; financial support from ADEME and the Ministry of the Environment)—the INCA project—was set up through an exchange of researchers funded by the Languedoc-Roussillon Region via the EcoTech-LR platform, to develop equipment and a method for measuring the concentration of C in soil by volume. That method, based on NIRS, must be implemented in the field to avoid the costs of sample preparation & extraction and to allow repeated measurements.

Laboratory soil measurement by NIRS: to record spectra the measuring head is applied to triturated screened soil samples. ▲

Several methodological and technological obstacles remain: How can the concentration of carbon by volume be predicted? How can soil/infrared radiation interactions be modelled, to optimize the optical interface and improve measurement reliability? How much do outdoor influence quantities (temperature, humidity…) influence measurements…)? How can measurements be made reliable? How can a database of spectra measured from dried, triturated samples (taken from the soil sample collection of the national soil quality network) be used and applied to samples in the field? How can the accuracy and reliability of calibration be improved, in particular by reducing systematic error in doing the calibration through alternative chemometric approaches?

These issues are being addressed through experimental modelling approaches in the laboratory. Spectral bases will be built by combining existing data and newly acquired spectra and data. This project will have to validate a planned portable sensor for field use.

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There are currently two main development goals:
- **Development of passive sensors** for polar herbicides (study of kinetic retention models, optimization of receiving phases, laboratory and in situ calibration). As part of a thesis prepared in co-direction with BRGM Orléans, these sensors are used to monitor water resources (surface and groundwater). These screening tools are also being used to evaluate potential contamination sources in the aquatic environment during dredging (ECODREDGE-MED project, *cf. p. 38*).
- **Development of biosensors** based on a molecular (antibody) recognition system kept immobile on a newly devised (biopolymer) medium, connected to a signal processing system, to quantify the level of pollution. This system is integral to the development of an instrument for continuous biological multiparametric pollutant measurement (ANR COMBITOX). Finally, this work has helped to develop a field detection kit for environmental toxins.

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▲ *Passive sensors deployed on site.*