Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Soils Newsletter

http://www-naweb.iaea.org/nafa/index.html
http://www.fao.org/ag/portal/index_en.html

ISSN 1011-2650

Vol. 38, No. 2, Jan 2016

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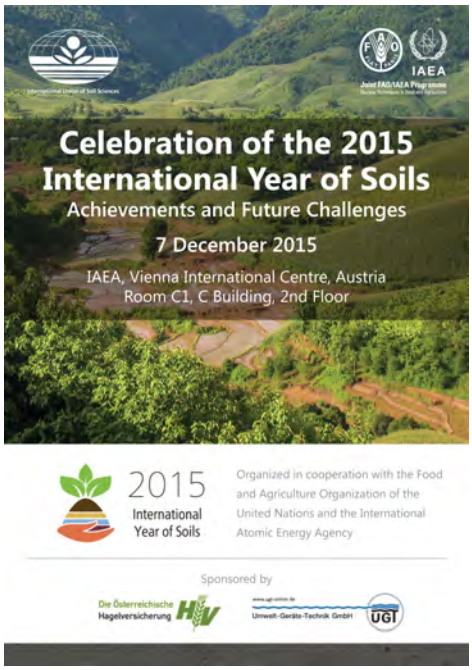
To Our Readers

In 2015 the Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme held several events to celebrate the "International Year of Soils" (IYS), to raise awareness and improve the understanding on the importance of soil for food security and essential ecosystem functions. The side event on 'Managing Soils for Climate-Smart Agriculture' on 16 September 2015 during the 59th IAEA General Conference was well-attended with more than 80 participants including many country delegations attending the IAEA General Conference. The four speakers from Member States showcased the successes and impacts in the field as well as their experience on the importance of soils in global food security, the impacts of climate change on soil and the crucial roles of nuclear applications for climate-smart agriculture. Similarly, the one-day conference on 7 December 2015 on "Celebration of the 2015 International Year of Soils: Achievements and Future Challenges", with the International Union of Soil Science (IUSS), to coincide with World Soil Day on 5 December and to mark the closing of IYS. Speakers from all Regional Soil Science Societies reported on their achievements with regards to managing soils for sustainable crop production and intensification. Working groups discussed future challenges and opportunities for soil research and development, and international partnership and collaboration. The roles of isotopic and nuclear techniques for managing soils to combat land degradation, improve soil fertility and resource use efficiency, while reducing the environmental impacts of agriculture, and improving the nutritional quality of crops were highlighted during the conference. At the event, participants proclaimed the 'Vienna Soil Declaration: Soil matters for humans and ecosystems', which sets the framework for future research in soil science and links achievements to the United Nations' Sustainable Development Goals and global endeavours to combat climate change. It sends a strong message for the future that we want.



The SWMCN Subprogramme is pleased to announce that our work on fallout radionuclides (FRNs) and compound-specific stable isotopes (CSSI) to quantify the magnitude of soil erosion at the landscape level and to determine the exact sources of land degradation, has been showcased in the December 2015 issue of National Geographic. The article highlights how these nuclear techniques can help to curtail the threat of soil erosion to ensure sustainable agricultural management.

As climate change affects many aspects of our work in food and agriculture and subsequently food security, the

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture is participating in the Paris Climate Change Conference or COP21, where Gerd Dercon, the Head of the SWMCN Laboratory, represented the Division at an UN side event on "Food Security under a Changing Climate" on 7 December, 2015.

The SWMCN Subprogramme would like to congratulate Mr. Lionel Mabit for receiving an IAEA Merit Award in recognition of his outstanding performance, contributions and support to our work. We also like to welcome several new staff members, including Mr. Roman Gruber as our new laboratory technician, who will be working on the measurements of stable isotopes using isotope ratio mass spectrometry and isotopic laser analysers. We welcome Ms. Malgorzata Rydeng who is replacing Ms. Kyoko Makovicky, as the team assistant at the SWMCN Section. Kyoko is currently working at the IAEA Safeguard Office in Tokyo, Japan. Finally, we welcome Mr. Joseph Adu-Gyamfi, our ex-staff member, who has just joined the Section to provide support in the Headquarters. We also have an increasing number of interns, fellows and visiting scientists coming to the SWMCN Laboratory for work experience on the use of isotope and nuclear techniques. You can read more on each of them under Staff News.

The SWMCN Subprogramme will be launching a new Coordinated Research Project (CRP) on 'Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems'' in early 2016, with the aim to develop combinations of nuclear techniques to assess changes in soil erosion, and distinguish and apportion impacts of climate variability and agricultural management on soil erosion in upland agro-ecosystems.

The SWMCN Subprogramme has published several guidelines on the use of nuclear and isotopic techniques in soil, water and nutrient management in the past. However, scientists, technicians and students from Member States have been requesting new guidelines, ones which provide more step-by-step details, with clear illustrations, on the standard operating procedures (SOPs) for using isotopic techniques in climate-smart agricultural practices and response to nuclear emergency in food and agriculture. The SWMCN Laboratory has taken up this request by developing the first of what will be a series of SOPs, on the sampling and processing of soil, water and plant materials to assist our Member States in isotope and nuclear analysis.

The SWMCN Laboratory also purchased two laser isotope analysers in 2015 to measure the Carbon-13 (^{13}C) and the Nitrogen-15 (^{15}N) signatures of CO_2 and N_2O to quantify the sources of these two greenhouse gases (GHG) in soil, as part of our work to develop technologies for reducing GHG emission in agriculture. The two new laser analysers are being tested and calibrated under field and laboratory conditions; with the aim of providing training and analytical services to our Member States in the future. You can read more in the "Laboratory News".

The year 2015 has passed quickly. I would like to thank all our readers for your continual support and also to thank my colleagues in the SWMCN Section and Laboratory for the dedication and commitment that all of you have contributed to the SWMCN Subprogramme. I also wish all of you a very happy New Year and a successful 2016, with good health and happiness.

Looking ahead to 2016, there will be many challenges and opportunities. The new Sustainable Development Goals offer tremendous opportunities for us to work together to address the root causes of poverty and to truly conserve the land and soils – resources which constitute the foundation for sustainable agricultural development and are key to sustaining life on Earth.

Lee Heng
Head
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			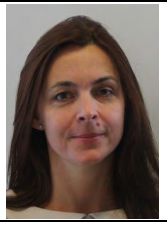
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J. Adu-Gyamfi	**J. Grabenhofer**		

Staff News

Tiezhu Yan joined the SWMCN Laboratory as an intern in October 2015 to learn about the use of stable isotopes nitrogen-15 and oxygen-18 for identification of nitrate sources and quantification of their contribution to nitrate pollution in surface and ground waters. During his stay at SWMCN Laboratory in Seibersdorf, he will also receive training on the use of FAO's AquaCrop model for improving agricultural water management. Yan will be with us until April 2016. In his PhD research at the Beijing Normal University (China), Tiezhu Yan studied the effect of climate change on water quality at watershed level.

Romina Torres Astorga joined the SWMCN laboratory on 21 September as a fellow under the ICTP/IAEA Sandwich Training Educational Programme. The program includes three visits to the SWMCN Laboratory over three consecutive years, with the first visit this year for 3 months. During her stay at the SWMCN Laboratory, she has been working on the validation of using isotope techniques for identifying sources of land degradation, under the supervision of Lionel Mabit and Gerd Dercon. This work is part of her PhD study at the National University of San Luis (UNSL), Argentina, where she is a teaching assistant.

Lionel Mabit received a Merit Award on 29 June 2015 from Deputy Director General of the Department of Nuclear Sciences and Applications (Mr. Aldo Malavasi) and the Director of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (Mr. Qu Liang) in recognition of his contribution and support on the activities of the SWMCN Subprogramme.

Roman Gruber joined the SWMCN Laboratory in October 2015 as a Technician. He will be working on the measurements of stable isotopes using Isotope Ratio Mass Spectrometry and Isotopic Laser Analysers. Roman worked in Octapharma for 10 years in research and development. He graduated from the Technical High School for Chemistry with majors in biochemistry, biotechnology and genetics. He also received a Bachelor Degree (Hons) in Natural Sciences from the Open University (UK) with training on isotope analysis at the University of Bristol.

Johanna Slaets joined the SWMCN Laboratory as an intern in October 2015 to work on carbon and nitrogen cycling and soil organic matter stability in mulch-based cropping systems, and on sediment redistribution in landscapes. She will be with us until April 2016. She graduated from the Katholieke Universiteit Leuven (Belgium) with an MSc in bio-engineering, focusing on soil science, land use and tropical agriculture. In her PhD research at the institute of Plant Production in Tropics at the University of Hohenheim (Germany), she developed methods to quantify reallocation of sediment and sediment-associated carbon and nitrogen in irrigated watersheds, and assessed how this redistribution could affect long-term soil fertility for upland maize and paddy rice production. Furthermore she worked as a teaching assistant and consultant at the Biostatistics Institute in Hohenheim, on experimental design, linear mixed models, spatially and temporally correlated data and uncertainty analysis.

Joseph Adu-Gyamfi, former staff member at the SWMCN Laboratory from 2006 to 2013, joined the Headquarters on 23 November 2015 as a consultant for a 6-month contract. During the previous 2 years, Joseph worked as a Chief Technical Adviser for UNIDO on a soybean value-chain project in Sudan to promote the production, local processing and utilization of soy-based nutritional foods to enhance food security and income generation. In addition, Joseph has been an IAEA expert, conducting hands-on training on the use of nitrogen-15 and carbon-13 methodologies for several TC projects in Benin, Cameroon, China, Malaysia, Mali, Myanmar,

Sudan and Vietnam. Joseph's responsibility during this consultancy is to support Section Head in SWMCN Subprogramme activities, provide technical expertise and inputs in project management for Technical Cooperation projects relating to integrated soil fertility and crop management practices in Africa and Asia-Pacific regions. Joseph will also help in the update of the phosphorus guidelines. We welcome Joseph back to the SWMCN Subprogramme.

Malgorzata Rydeng joined the SWMCN Section on 1 September 2015 as a team assistant. She has been working actively on the implementation of planned events of the Subprogramme of SWMCN by contributing to the Project Management and Organization's objectives and goals. Rydeng had previously worked as a Project Assistant with the IAEA Department of Technical Cooperation Asia-Pacific and Africa Divisions; Department of Nuclear Sciences and Applications Department (Nuclear Data Section) for almost 4 years and as an Office Assistant for several years in various companies, gaining extensive experience in office administration.

Leo Mayr joined the SWMCN Laboratory on 6 July as a consultant for two months to work on the development of protocols using laser isotope analysis to measure the Carbon-13 and Nitrogen-15 signatures of CO_2 and N_2O to quantify the sources of these greenhouse gases (GHG) in soil, with the aim of developing technologies for GHG emission reduction in agriculture. Formerly, Leo Mayr was the senior laboratory technician of the SWMCN Laboratory. We thank Leo on accomplishing his work with great dedication.

Jutta Grabenhofer joined the SWMCN Laboratory on 9 November for a three-month scientific visit on the use of nitrogen stable isotopes to estimate nitrous oxide emissions from agricultural fertilisers, and the influence of biochar on reducing these emissions. This scientific visit is carried out as part of the coordinated research project (CRP) D1.50.16 on "Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems". Jutta Grabenhofer is currently an MSc student at the University of Natural Resources and Life Sciences (BOKU), Vienna. This work is in close collaboration with the Austrian Institute of Technology and Lincoln University New Zealand, as part of her MSc thesis.

Obituary

Seth Kofi Danso, ex-staff member, passed away on 3 April 2015 in Ghana, his home country. Seth received his Ph.D. in soil microbiology from Cornell University, USA. He joined the Soil Fertility, Irrigation and Crop Production Section (currently Soil and Water Management & Crop Nutrition Section) of the Joint FAO/IAEA Division in 1981 and served as technical officer of many coordinated research and technical cooperation projects on Biological Nitrogen Fixation. He was a well-known scientist for his involvement on developing the 15N methodology for measuring nitrogen fixation in legumes, as evidenced by his numerous publications on the topic. His colleagues and friends in Vienna send their condolences to his family in Ghana.

Feature Articles

Combining Old and New Stable Isotope Techniques to Evaluate the Impact of Conservation Tillage on Soil Organic Carbon Dynamics and Stability

T. De Clercq[1], H. Xu[1], M. Heiling[2], G. Dercon[2], C. Resch[2], R. Merck1x[1]

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Soil organic matter (SOM) is a major carbon pool. It is a crucial factor for soil quality including several soil physical properties and a major nutrient source for crops. It also plays a significant role in the global carbon cycle. Soils can act as a carbon sink or source depending on land use and agricultural management practices. Some practices such as conservation tillage or no-tillage could increase SOM stocks, particularly in the topsoil, but in the long term it remains to be seen if and how this SOM is stabilized (De Clercq et al., 2015; Govaerts et al., 2009).

In order to evaluate the sustainability and efficiency of soil carbon sequestration measures and the impact of different management and environmental factors, information on SOM stability and mean residence time (MRT) is required. However, this information on SOM stability and MRT is expensive to determine via radiocarbon dating, precluding a wide spread use of stability measurements in soil science. But alternative methods based on stable carbon and nitrogen isotopes, can provide this information at a fraction of the cost.

As part of the coordinated research project (CRP) on Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-based Cropping Systems in Sub-Saharan Africa (D1.50.12), research is being carried out using two stable isotope methods; one developed by Balesdent and Balabane (1992) and a new method by Conen et al. (2008), to develop a cheaper and more accessible technique to determine the stability of SOM.

Last year, we used both stable isotope techniques to look at the impact of long-term conservation tillage on SOM distribution, dynamics and stability on four long term conservation tillage experiments in Belgium (Figure 1).

For each treatment and field, six replicates of 1m soil cores were sampled in the summer of 2014. The cores were divided into 8 different depth layers. Samples from depths of 0-5cm, 10-15cm, 40-60cm were divided into SOM and aggregate classes according to the fractionation schemes described by Conen et al. (2008) and Six et al. (2002). The samples from all depth layers, bulk soil and fractions, were analysed with an elemental analyser coupled to an IRMS for C and N content and their stable isotope ratios.

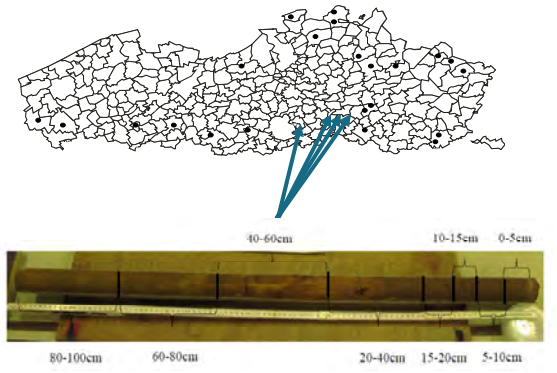

Figure 1. Location of four experimental conservation tillage fields in Belgium sampled for this study.

The soil column sampling showed a significant increase in organic carbon content (%) in the 0-5cm soil layer of the conservation tillage treatment and a slight increase in the total carbon content down to 1m. This increase was mainly concentrated in the particulate organic matter and the protected micro-aggregate fractions.

The relative stability of the SOM was calculated in three soil layers using the ^{15}N fractionation method developed by Conen et al. (2007). A clear increase in SOM relative stability could be seen with increasing depth and no significant difference was found between both treatments, however, a trend indicating decreasing stability with conservation tillage was observed.

When using the method developed by Balesdent and Balabane (1992) on one of the sites that had experienced a C_3 to C_4 crop shift, a decreased half-life of the SOM in the top 5cm of the conservation tillage treatment was found (Figure 2). This decrease corresponds with the trend observed by the Conen et al. (2007) method.

Individually the methods were not powerful enough, but combining all measured parameters in a multivariate principle components analysis allowed discriminating between sampling depth, crop input and land use (till vs

no till) systems and getting an indication of the SOM stability.

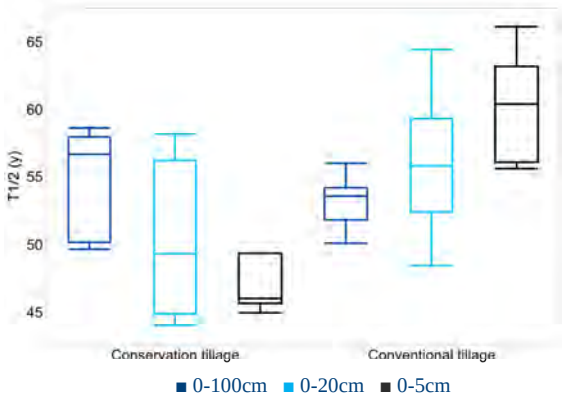

Figure 2. Half-life of SOM (in years) calculated according to Balesdent and Balabane method for one of the four sites.

The next step is to develop a usable model based on the changes in $\delta^{13}C$, $\delta^{15}N$ and C and N concentrations in different soil fractions (essentially combining the two stable isotope approaches used above) to accurately and cost effectively determine SOM stability.

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Mobility and Bioavailability of Radionuclides in Soils

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It is crucial to understand the behavior of radionuclides in the environment, their potential mobility and bioavailability related to long-term persistence, radiological hazards, and impact on human health. Such key information is used to develop strategies that support policy decisions. The environmental behavior of radionuclides depends on ecosystem characteristics. A given soil's capacity to immobilize radionuclides has been proved to be the main factor responsible for their resulting activity concentrations in plants. The mobility and bioavailability of radionuclides in soils is complex, depending on clay-sized soil fraction, clay mineralogy, organic matter, cation exchange capacity, pH and quantities of competing cations. Moreover, plant species have different behaviors regarding radionuclide absorption depending on soil and plan characteristics.

The authors have recently reviewed information related to the mobility and bioavailability of key artificial and natural radionuclides (e.g. ^{137}Cs, ^{90}Sr, $^{239,240}Pu$, ^{241}Am, ^{238}U, ^{226}Ra, ^{232}Th) in different soil types under various environmental conditions and identified key knowledge gaps (Iurian *et al.*, 2015). The review was published as a book chapter in "*Radionuclides in the Environment: Influence of chemical speciation and plant uptake on radionuclide migration*" by Springer. The manuscript highlights that by changing soil and environmental conditions, radionuclides can be converted from a potentially mobile to an immobile form or vice versa, having a direct effect on their uptake by plants. For example, the soil redox potential, the pH, the organic matter content and composition, and the sorption to mineral soil constituents represent the main factors controlling the chemical form of radionuclides in soil.

This knowledge is particularly useful for developing long-term remediation and management strategies for terrestrial ecosystems potentially being contaminated by artificial radionuclides or radionuclides originating from uranium mining legacy sites, with the goal of limiting the radionuclides' transfer to the food chain.

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Iurian, A.R, Olufemi Phaneuf, M., Mabit, L.(2015). Mobility and Bioavailability of Radionuclides in Soils. In: Radionuclides in the Environment: Influence of chemical speciation and plant uptake on radionuclide migration. Eds: C. Walther and D.K. Gupta. Springer. pp 37–59.

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Carbon Storage in Soils: Climate vs. Geology

Sebastian Doetterl1[9], Antoine Stevens[2], Johan Six[3], Roel Merckx[4], Kristof Van Oost[2], Manuel Casanova Pinto[5], Angélica Casanova-Katny[6], Cristina Muñoz[7], Mathieu Boudin[8], Erick Zagal Venegas[7], Pascal Boeckx[1]

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In a recently published Nature Geoscience article, scientists took a closer look at the much-discussed topic of carbon storage in soils under Climate Change. In a large-scale study across Chile and the Antarctic Peninsula, they showed that the role of precipitation and temperature in controlling carbon dynamics in soils is less than currently considered in Global Ecosystem Models.

Soils are important for carbon (C) storage and thus for atmospheric CO_2 concentrations. Whether soils act as a sink or source for atmospheric C generally depend on climatic factors, as they control plant growth (driving the incorporation of C into the soil), the activity of soil microorganism (driving the release of C from the soil to the atmosphere), as well as several other chemical processes in soils. However, we still do not fully understand the response of soil C to Climate Change. An international team of researchers led by Pascal Boeckx and Sebastian Doetterl from Ghent University, Belgium and Erick Zagal from University of Concepcion in Chile, have been investigating the interaction between climate, different types of soil minerals, and soil as sink or source for C. They studied this interaction by sampling soils from numerous locations representing different vegetation types in Chile and the Antarctic Peninsula.

“Models for predicting the impacts of Climate Change on nature have generally not sufficiently considered the role of soils in buffering or enhancing the potential impacts of Climate Change” Doetterl says. With their work, the scientists showed the importance of understanding various biogeochemical processes in soils that have developed under different geologic and climatic conditions and how these two aspects are connected. Chile, by its unique geographical position, which crosses many climate zones, and with a very variable geology, offered an ideal natural laboratory to study interactions between climate and geochemistry and their control on carbon storage in soils. For the first time, the close connection of geochemical and climatic controls on soil C dynamics could be shown on a large scale.

“Soils in regions with warmer and wetter climate are generally more reactive than soils in dry or very cold regions” Erick Zagal explains, “These more reactive soils can stabilize more C, for example, adsorbing carbon on their mineral surfaces.” The adsorption of C onto minerals protects it from being decomposed by microorganism, which would lead to CO_2 production that ultimately ends up in the atmosphere and leads to Climate Change.

So what is the more important factor for C storage in soils: climate or geology? The answer is, as expected, complex but can be broken down to a few general statements.

“The interesting thing we saw in our analysis is that climate does not act as the sole control on how much C is stored in soils”, Pascal Boeckx explains. Climate acts rather indirectly as a control on those elements in the soil system, such as soil minerals, that directly stabilize C. If global models now focus only on climatic variables for predicting soil C storage, they are excluding the fundamental interactions and feedbacks of the soil geochemistry on the global C cycle.

“Whether Climate Change can trigger a response in soils to either stabilize or release C is, therefore, mostly a question of the geochemical features of a soil and the climatic conditions under which these soils developed.” Doetterl says. For example, in arctic regions, a temperature increase might enhance the stabilization of C in soils with reactive minerals and partly compensate the

increased loss of carbon stored currently in the melting permafrost layers. In hot arid areas, soil C dynamics will most likely not be affected by a temperature increase, but higher amounts of precipitation might stimulate both soil reactivity and biologic activity. In tropical areas, reactive minerals have been washed out and altered into less reactive forms due to millions of years of weathering. Hence, temperature or precipitation changes in the tropics are unlikely to lead to significant changes in soil C dynamics.

"So, we will see a very diverse response of soils to Climate Change, depending on climatic, biologic, and geologic factors. This makes it so important that we don't forget that soils are a very important part of all terrestrial ecosystems" co-author Johan Six from ETH Zurich concludes.

The article, "Soil carbon storage controlled by interactions between geochemistry and climate" is published in Nature Geoscience.

Full title: Doetterl S., Stevens A., Six J., Merckx R., Van Oost K., Casanova-Pinto M., Casanova-Katny A., Muñoz C., Boudin M., Zagal Venegas E., Boeckx P. 2015. Soil carbon storage controlled by interactions between geochemistry and climate. Nature Geoscience, DOI: 10.1038/ngeo2516.

Figure 1. The soil sampling campaign has been conducting across Chile and the Antarctic Peninsula by an international team of Chilean and European scientists. From left to right: Sebastian Doetterl (Univ. Ghent & Univ. Augsburg); Manuel Casanova, Erick Zagal Venegas, Cristina Muñoz (Univ. Santiago & Univ. Concepcion); Pascal Boeckx (Univ. Ghent).

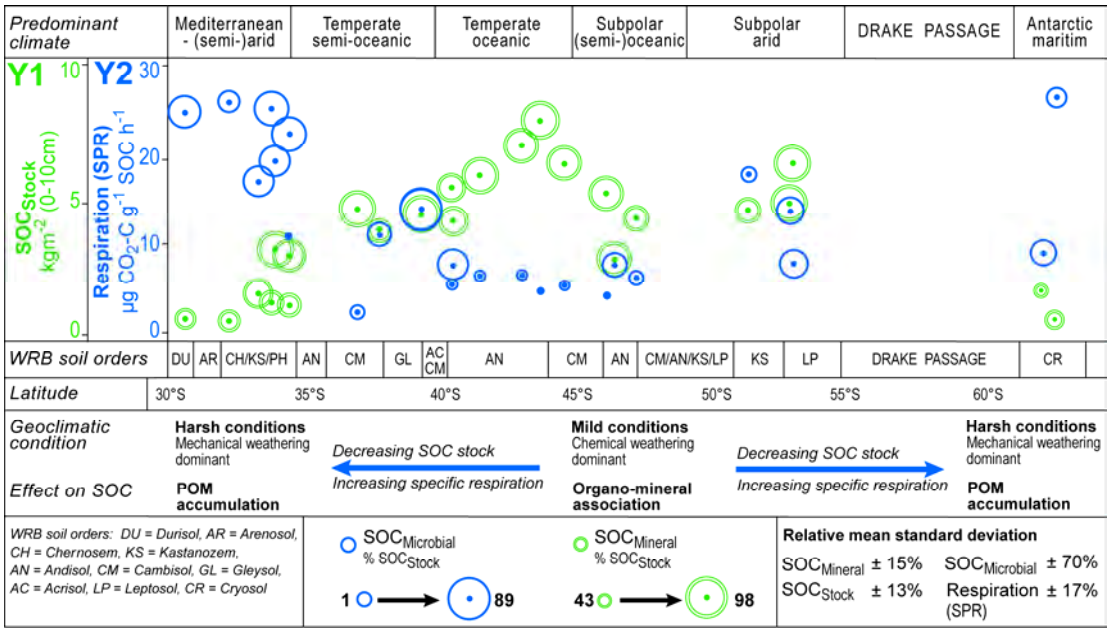


Figure 2. Relationship between soil organic carbon stocks (SOC_{Stock}, Y1), specific potential respiration (SPR, Y2), mineral associated SOC ($SOC_{Mineral}$, green circles on Y1), microbially available SOC ($SOC_{Microbial}$, red circles on Y2) and latitude (X axis). Relative uncertainty is calculated as the mean relative standard deviation of each SOC response variable. Figure taken from Doetterl et al. (2015; NGEO). 136, 261–269.

Announcements

New Coordinated Research Project (CRP): Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems (D1.50.17)

Project Officers: Lionel Mabit and Lee Heng

We are pleased to inform our readers that a new Coordinated Research Project (CRP) entitled "*Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems*'' has been approved.

This CRP aims to (i) develop combinations of nuclear techniques to assess changes in soil erosion, and (ii) distinguish and apportion impacts of climate variability and agricultural management on soil erosion in upland agro-ecosystems. uclear techniques including Fallout Radionuclides (FRNs) such as caesium-137 (^{137}Cs), lead-210 (^{210}Pb), beryllium-7 (^{7}Be) and plutonium-239 and 240 ($^{239+240}$Pu), Compound-Specific Stable Isotope (CSSI) techniques based on the measurement of carbon-13 (^{13}C) natural abundance signatures of specific organic compounds (i.e. fatty acid) and Cosmic Ray Soil Moisture Neutron Probe (CRNP) will be targeted to fulfil the CRP objectives.

This CRP is now open for applications as research and technical contract and agreement holders from Member States. Please submit your proposal directly to the IAEA's Research Contracts Administration Section, using the form templates (http://cra.iaea.org/cra/forms.html) available on the CRA web site (preferably via email): research.contracts@iaea.org.

The following criteria will serve for evaluating submitted proposals:

- Participants should have considerable research experience on land management and its impact on soil erosion/sedimentation;
- Participants should have experimental sites located in agricultural uplands;
- Participants should have at least 5 years of proven research experience and expertise in at least one of the following techniques: ^{137}Cs + ^{7}Be and ^{210}Pb$_{ex}$, $^{239+240}$Pu, CRNP (Cosmic Ray Soil Moisture Neutron Probe), CSSI (Compound-Specific Stable Isotope) and have related analytical facilities;
- Conventional analytical facilities for soil resources are an asset;
- Women as chief scientific investigator are encouraged to participate in this project.

  More information about this call can be found under http://cra.iaea.org/cra/explorecrps/all-opened-for-proposals.html.

Highlights

National Geographic explores Planet Earth: By the Numbers – Saving Soil

The work of the Soil and Water Management and Crop Nutrition Subprogramme, in close cooperation with the Food and Agriculture Organization of the United Nations (FAO) through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, on the use of fallout radionuclides (FRNs) and compound-specific stable isotopes (CSSI) to quantify the magnitude of soil erosion at the landscape level and to determine the exact sources of land degradation was recently published in the December 2015 issue of National Geographic http://dl.yazdanpress.com/MAGAZINES/DOCUMENTARY/NATIONAL-GEOGRAPHIC/NATIONAL_GEOGRAPHIC_DECEMBER_2015.pdf. This work highlights how nuclear techniques can help in endeavours to assess and curtail the worldwide threat of soil erosion.

Technical Cooperation Field Projects

Operational Projects and Technical Officers Responsible for Implementation

Country/Region	TC Project	Description	Technical Officer(s)
Algeria	ALG5028	Preserving Arid and Semi-Arid Agro-Ecosystems and Combating Desertification by Using Advanced Isotopic Techniques, Developing Decision-Making Tools and Supporting Sensitization of the Local Population on the Needs of Desertification Control	G. Dercon and L. Mabit
Angola	ANG5011	Monitoring Soil Fertility in Pasture Areas for Their Improvement and Maintenance	L. Heng
Benin	BEN5007	Soil, Crop and Livestock Integration for Sustainable Agriculture Development through the Establishment of a National Laboratory Network	L. Heng in collaboration with Animal Production and Health Section
Bangladesh	BGD5029	Evaluating Promising Abiotic Stress Tolerant Crop Mutants/Varieties and Measuring the Suitable Management Practices for the Promotion of Sustainable Production at Saline, Submergence and Drought Prone Areas	A. Wahbi
Bolivia	BOL5020	Evaluating Soil Fertility Loss by Water Erosion in the Area and Valleys of Intersalar Boliviano, Using Nuclear Gamma Spectrometry and Environmental Radionuclides	G. Dercon
Botswana	BOT5012	Improving Soil and Water Management Options to Optimize Yields of Selected Crops	K. Sakadevan
Central African Republic	CAF5006	Improving Cassava Production through High Yielding Varieties and Sustainable Soil Fertility Management by Using Isotopic and Nuclear Techniques to Ensure Sustainable Farming	K. Sakadevan in collaboration with Plant Breeding and Genetics Section
Chile	CHI5050	Using Isotope Techniques to Quantify the Contribution of Agriculture in Greenhouse Gas Production	M. Zaman
Cameroon	CMR5020	Improving Maize Based Cropping System Productivity through the Efficient Management of Organic Matter, Water, Nitrogen and Phosphorous Fertilizers	M. Zaman
Costa Rica	COS5029	Strengthening of Good Agricultural Practices (GAP) for Food Safety and Security and Environmental Protection	G. Dercon in collaboration with Food and Environmental Protection Section
Costa Rica	COS5031	Consolidating a National Reference Laboratory for the Measurement of Greenhouse Gases	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
Dominican Republic	DOM7004	Developing Human Resources and Supporting Nuclear Technology for Addressing Key Priority Areas including Biodiversity and Environmental Conservation	L. Heng
Ecuador	ECU5028	Consolidating Food Security and Environmental Sustainability in Palm Oil Production Using Nuclear Applications	L. Heng in collaboration with Food and Environmental Protection Section
Interregional project	INT5153	Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions	G. Dercon and M. Zaman
Ivory Coast	IVC5033	Contributing to Food Security and Combating Poverty by Improving the Productivity of the Coconut Palm, Plaintain and Leafy Vegetables by Means of Studying the Effects of Organic and Mineral Fertilizers	K. Sakadevan
Cambodia	KAM5001	Improving Soil Fertility and Crop Management Strategies in Diversified Rice Based Farming Systems	L. Heng
Kazakhstan	KAZ5003	Increasing Micronutrient Content and Bioavailability in Wheat Germplasm by Means of an Integrated Approach	K. Sakadevan in collaboration with Plant Breeding and Genetics Section
Kenya	KEN5035	Using Nuclear Techniques for Validation of Integrated Soil Fertility and Water Management Technologies for Increased Agricultural Productivity and Climate Change Adaptation in Arid and Semi-Arid Areas	L. Heng
Laos	LAO5001	Enhancing Food Security through Best Fit Soil-Water Nutrient Management Practices with Mutation Induction for Drought Resistant Rice	M. Zaman
Madagascar	MAG5023	Promoting Climate Smart Agriculture to Face Food Insecurity and Climate Change with regard to Basic National Foods (Rice and Maize)	M. Zaman and L. Mabit
Mexico	MEX5030	Improving Phosphorus Use Efficiency and Agricultural Sustainability in the Acidic Soil of the P'urhepecha Plateau, Michoacan	M. Zaman
Mali	MLI5024	Enhancing Sustainable Intensification and Diversification of Sorghum Production Systems in the Southern Zone by an Integrated and Participatory Approach, Phase 2	L. Heng
Mali	MLI7003	Assessing Erosion, Sedimentation and Water Resources in River Basins by Using Isotope Techniques	L. Mabit

Country/Region	TC Project	Description	Technical Officer(s)
Myanmar	MYA5020	Strengthening Food Security through Yield Improvement of Local Rice Varieties with Induced Mutation (Phase II)	M. Zaman in collaboration with Plant Breeding and Genetics Section
Myanmar	MYA5023	Evaluating Nitrogen Use Efficiency Using Low Nitrogen Tolerant Rice Varieties	K. Sakadevan
Myanmar	MYA5025	Monitoring and Assessment of Watershed Management Practices on Water Quality and Sedimentation Rate of Inle Lake	L. Heng and M. Zaman
Namibia	NAM5012	Developing High Yielding and Drought Tolerant Crops through Mutation Breeding	L. Heng in collaboration with Plant Breeding and Genetics Section
Nicaragua	NIC5009	Introducing Integrated Environmental Management in the Watershed of the Nicaraguan Great Lakes and the San Juan River: Responding to Future Challenges with Nuclear Techniques	K. Sakadevan
Philippines	PHI5032	To improve the water and land quality in Typhoon Haiyan- devastated areas using nuclear-based and isotope techniques in a monitored natural attenuation cleanup strategy.	L. Heng
Africa	RAF5063	Supporting Innovative Conservation Agriculture Practices to Combat Land Degradation and Enhance Soil Productivity for Improved Food Security	L. Mabit
Africa	RAF5071	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation (AFRA)	L. Heng
Asia	RAS5055	Improving Soil Fertility, Land Productivity and Land Degradation Mitigation	M. Zaman
Asia	RAS5064	Enhancing Productivity of Locally Underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices	K. Sakadevan in collaboration with Plant Breeding and Genetics Section
Asia	RAS5065	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications	L. Heng in collaboration with Plant Breeding and Genetics Section
Asia	RAS5068	Developing Effective Practices for Combating Desertification (ARASIA)	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
Asia	RAS5069	Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	L. Heng and K. Sakadevan in collaboration with Plant Breeding and Genetics, Animal Production and Health and Isotope Hydrology Sections
Latin America	RLA5064	Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques (ARCAL CXL)	G. Dercon
Latin America	RLA5065	Improving Agricultural Production Systems Through Resource Use Efficiency (ARCAL CXXXVI)	K. Sakadevan
Senegal	SEN5034	Using an Integrated Approach to Develop Sustainable Agriculture in a Context of Degrading Soil Fertility, Climate Change and Crop Diversification	G. Dercon in collaboration with Plant Breeding and Genetics Section
Seychelles	SEY5007	Increasing Crop Production through Effective Management of Soil Salinity in the Coastal Area using Nuclear and Related Techniques	L. Heng
Sudan	SUD5033	Enhancing Productivity of Major Food Crops (Sorghum, Wheat, Groundnut and Tomato) under Stress Environment Using Nuclear Techniques and Related Biotechnologies to Ensure Sustainable Food Security and Well-being of Farmers	L. Heng in collaboration with Plant Breeding and Genetics Section
Thailand	THA5051	Evaluating Soil Erosion-Deposition and Soil Quality using Isotopic and Nuclear Techniques in Agricultural Areas Affected by Flooding	M. Zaman
Thailand	THA5054	Increasing Adaptability for Adverse Environment Tolerance in Rice Germplasm Using Nuclear Techniques	K. Sakadevan
Thailand	THA5055	Using Isotope Tracer and Fingerprint Techniques for the Assessment of Sediment Processes	M. Zaman
Yemen	YEM5013	Evaluating Selected Wheat Varieties for Greater Agronomic Characteristics Using Carbon Isotope Discrimination and Improved Soil and Water Management	A. Wahbi
Democratic Republic of Congo	ZAI5020	Assessing and Improving the Assimilability of Natural Phosphates Composted with Organic Matter in Marginal Soils through the Use of Isotope and Nuclear Techniques for Improved Crop Nutrition	M. Zaman and G. Dercon
Zambia	ZAM5029	Evaluating the Impact of Nitrogen and Water Use Efficiency in Upland Rice	K. Sakadevan

Country/Region	TC Project	Description	Technical Officer(s)
Zimbabwe	ZIM5015	Developing Drought Tolerant and Disease/Pest Resistant Grain Legume Varieties with Enhanced Nutritional Content Using Mutation Breeding and Novel Techniques, Phase II	L. Heng in collaboration with Plant Breeding and Genetics Section
Zimbabwe	ZIM5020	Optimizing Water Use and Soil Productivity for Increased Food Security in Drylands (Phase II)	L. Heng

Forthcoming Events

FAO/IAEA Events

RAS5072: First Coordination Meeting of the Regional Technical Cooperation project RAS 5072 "Enhancing the Use of Salt Affected Soils and Saline Water for Crop and Biomass Production and Reducing Land and Water Quality Degradation in ARASIA States Parties", 7-11 February, 2016, Dubai, UAE.

Technical Officer: Mohammad Zaman

The objective of the meeting is to discuss the work plan for the year 2016 for the individual counterparts according to project design. The countries involved are Iraq, Jordan, Lebanon, Oman, Qatar, Saudi Arabia, Syria, UAE and Yemen.

Third RCM of the CRP D1.20.12 on "Optimizing Soil, Water and Nutrient Efficiency in Integrated Cropping Livestock Systems", 14-18 March 2016, Buenos Aires, Argentina

Technical Officer: Karuppan Sakadevan

The purpose of the third research coordination meeting is to review project progress and outputs, and if necessary revise national work plans. It expected that nine research contract and two agreement holders will be attending the meeting.

RAS5070: Coordination Meeting of the regional Technical Cooperation project RAS5070 on "Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques", 15–18 March 2016, Vienna Austria.

Technical Officer: Mohammad Zaman

The purpose of this coordination meeting is to review and finalize the activities stipulated in the project work plan; review the current status of soil and water management practices on marginal land and identify the roles of nuclear and isotopic techniques in the project; and address the gaps and needs for the application of soil and water management techniques for developing bioenergy crops to optimize marginal land productivity.

RAS5069: Mid-Term Review Meeting of RAS5069 on "Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia", 3-6 May 2016, Vienna, Austria.

Technical Officer: Lee Heng

The aim of the mid-term review meeting is to review and report the progress made under the project and to develop work plan for coming years including formulating the design of the field experiments for 2016-2017.

Non-FAO/IAEA Events

European Geosciences Union General Assembly 2016, 17-22 April 2016, Vienna, Austria. http://www.egu2016.eu/

7th International Nitrogen Initiative Conference, 4-8 December 2016, Melbourne, Australia. http://www.ini2016.com/

Past Events

Meetings at the IAEA

Celebration of the 2015 International Year of Soils: Achievements and Future Challenges, 7 December 2015, Vienna, Austria

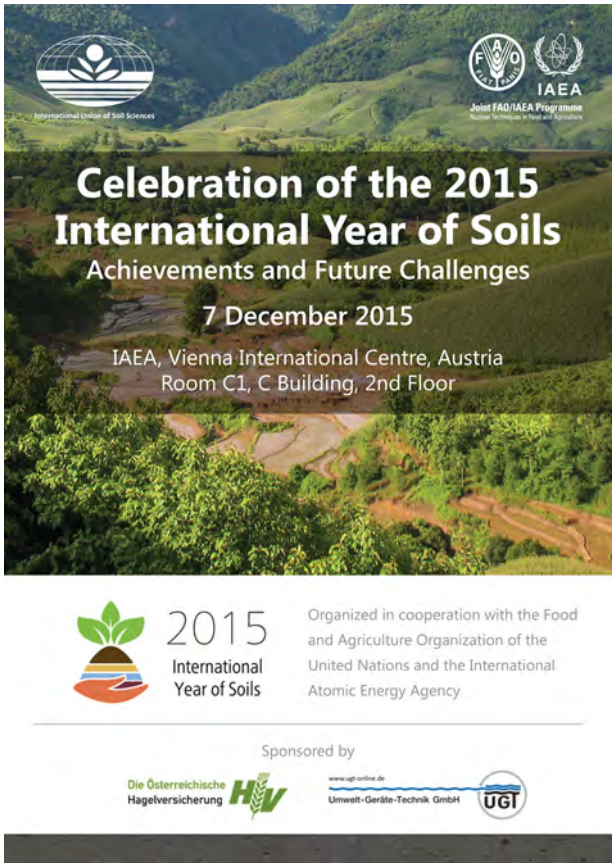
More than one hundred and twenty soil scientists worldwide gathered at the International Atomic Energy Agency (IAEA) Vienna, Austria to celebrate the "2015 International Year of Soils: Achievements and Future Challenges" and to highlight on the achievements and future challenges in soil science The Conference was jointly organized by the IAEA and the International Union of Soil Science (IUSS).

The meeting was attended by representatives from the Food and Agriculture Organization of the United Nations (FAO), the European Commission through the Joint Research Centre (JRC), and the Consultative Group of International Agricultural Research (CGIAR), the President and the Regional Representatives of the IUSS. In their welcome address, Mr Aldo Malavasi, Deputy Director General IAEA, Dep. of Nuclear Sciences and Applications, Mr Moujahed Achouri, Director Land and Water Division, FAO and Mr Christian Holzer, Director General, Austrian Ministry of Agriculture and Environment, stressed the importance of soils and the need to raise awareness and understanding of soils for food security and essential ecosystem functions. Mr Rainer Horn, President of ISUU declared the meeting opened.

During the one-day meeting, working groups on soil research and international partnership discussed future challenges and opportunities for soil research and development in both developed and developing countries. These included (1) sustainable intensification of agricultural production and resource conservation, (2) land degradation and its mitigation, (3) making agricultural production systems resilient to climate change through improved management of the soil, (4) reducing greenhouse emissions from agriculture and increase soil carbon sequestration, (5) reducing environmental footprint of agriculture, (6) improving the nutritional quality of food crops through agricultural interventions. The role of isotopic and nuclear techniques for managing soil to combat land degradation, improve soil fertility and resource use efficiency, reduce environmental impacts of agriculture, and crop nutritional quality was highlighted.

The need to develop international collaboration and partnership to ensure that technologies and practices for sustainable soil management are available to support poor farmers throughout the world was highlighted.

At the event, the participants proclaimed the 'Vienna Soil Declaration: Soil matters for humans and ecosystems', which sets the framework for future research in soil science and links achievements to the United Nations' Sustainable Development Goals and global endeavours to combat climate change. It sends a strong message for The Future We Want. The Vienna Soil Declaration can be downloaded from http://www-naweb.iaea.org/nafa/swmn/Vienna-Soil-Declaration-Dec6-2015.pdf.



IAEA Insight Series: Tackling Problems of Land Degradation Using Isotopic Techniques, 26 August 2015, Vienna, Austria

Technical Officers: Lionel Mabit and Mohammad Zaman

The insight series presentation that took place at the Vienna International Centre on Wednesday 26 August 2015 provided an overview of the development and use of a range of isotopic and related techniques to address soil degradation and highlighted several success stories generated in supporting IAEA Member States. Land degradation is a worldwide threat currently affecting 1.9 billion hectares globally or about 65% of global soil resources. Soil erosion is the main contributor (85%) to such land degradation. Approximately 1.5 billion people - a quarter of the world's population - depend directly on the food production from degraded lands. As much as 75 billion tons of fertile soil is lost from world agricultural

systems each year through soil erosion. The economic cost associated with on-farm and off-farm soil erosion is estimated at US $400 billion per year.
To ensure sustainable agricultural management, there is a clear need to not only quantify the magnitude of soil erosion but also to identify the source (hotspots) of land degradation in the landscape. This essential information can be obtained using fallout radionuclides (FRNs) and Compound Specific Stable Isotopes (CSSI) based techniques.
The Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture aims to optimise these technologies and to strengthen national and regional capacities in using nuclear and isotopic techniques. Through international cooperation in research, training and other outreach activities, including the support of the IAEA's Department of Technical Cooperation, these techniques have been disseminated to 65 Member States where they have resulted in the publication of several national and regional impact reports and success stories.

Duty Travel

Nicaragua: To review project progress and develop additional work plan for 2015 for the technical cooperation (TC) project NIC5009 on "Introducing Integrated Environmental Management in the Watershed of the Nicaraguan Great Lakes and the San Juan River: Responding to Future Challenges with Nuclear Techniques", 15–19 June 2015, Managua, Nicaragua.

Technical Officer: Karuppan Sakadevan

The Technical Officer (TO) visited CIRA/UNAN in Managua to review project progress, develop a revised work plan and provide technical advice for soil and water sampling and their isotopic measurements for large inland catchments.
The TO discussed detailed project activities–with the counterpart Mr Victor Manuel Martinez and his research team from Universidad Nacional Autonoma de Nicaragua, Centro para la Investigacion en Recursos Acuaticas de Nicaragua (CIRA/UNAN). Following the discussion the TO visited the soil and water laboratories of CIRA/UNAN to identify potential opportunities for fallout radionuclides (FRNs), oxygen-18 and nitrogn-15 measurements in soil and water.
Days two to four were focused on collecting field soil and water samples. Soil samples were collected from four agricultural land uses namely sugarcane, rice, plantain and pasture to a depth of 30 cm along the Rio Chiquito river. Sediment cores from Cocibolka Lake near the mouth of Rio Chiquito river was also collected to a depth of 30 cm. Appropriate reference sites were also identified in the Cocibolka Catchment for FRN measurements.
The TO had a group discussion with the project members on the application of isotopic and nuclear techniques for assessing soil, water and crop dynamics and its importance to land and water management in agricultural catchments. The potential linkage with the regional project RLA5064 on "Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques" was also discussed to provide project continuity.

Soil Sampling in Nicaragua Plantain farm

Norway: Technical support to team expert mission to Svalbard, Norway under INT5153 TC Project 27-31 July 2015, Svalbard, Norway

Technical Officer: Mr Gerd Dercon

Mr Gerd Dercon, technical officer (TO), travelled to Svalbard, Norway, to (i) lead a team of experts for sediment sampling at Svalbard, Norway, one of the 13 benchmark sites of the INT5153 project on "Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions", in close collaboration with the DTM of the project, Mr. Bulat Mavlyudov, (ii) guide technical discussions of the experts on the actions to be carried out in the field and results of the mission, and (iii) support sampling activities for understanding sediment redistribution processes. The TO also planned, together with the expert team and the PMO, the way forward and the strategy of investigations in various benchmark sites.
In total eight experts from Austria, Germany, Spain, UK and Russian Federation plus 6 young Russian scientists participated in this team expert mission.
During this mission the senior and young scientists worked together in the field, to establish sampling stations and collect soil and sediment samples for better understanding of the potential impact of a changing climate (e.g. increasing temperature and glacier retreat) on soil resources. This is in anticipation of the need for long-term monitoring of environmental processes possibly associated with climate change. This approach has been taken in Svalbard and will be promoted to the other benchmark sites.
The mission consisted of discussions of field activities and participation in the actual field sampling in Groenfjord valley and Alegonda proglacial area. The

discussions also focused on the technical and scientific targets of the project, mainly ~~for~~ the requirements for analysis of the samples collected to date in the benchmark sites; their interpretation and publication for wider use. The protocols proposed by the INT5153 expert team have identified various analytical data needs that will respond to the scientific questions agreed to be tackled under the project.

Over 160 kg sediment and soil samples were collected, and sent to Austria, Belgium, Germany, Russia, Spain and Sweden for various analyses as defined in the technical protocols. The interpretation of the scientific results from the analyses will potentially help to cover the gaps in the available data and contribute to improved understanding of the impact of climate change on soil resources (e.g. soil organic carbon dynamics, and sediment redistribution).

Project results are expected in year 2 in 2016. The participation of young scientists in this mission provided an opportunity to transfer capabilities of their continuing work and to ensure sustainability of capabilities. As expressed by one of the experts, "this effort will provide legacy for future scientists who may conduct research at these sites in 10 or 20 years from now; and the initiatives through the project provide the baseline measurements that can be used how the situation changes over time." Such approach will be adopted in the other benchmark sites.

Sampling for understanding sediment redistribution dynamics due to glacier retreat at the Aldegonda Glacier

Sri Lanka: To facilitate regional IAEA/RCA training on advanced knowledge and skills in the use of compound-specific stable isotope (CSSI) techniques and fallout radionuclides (FRNs), 27-31 July 2015, Colombo, Sri Lanka

Technical Officer: Mohammad Zaman

The Technical Officer (TO), together with four experts, Othman Zainudin (Malaysia) and Muhammad Rafiq (Pakistan), who also travelled to Sri Lanka, and Lionel Mabit (SWMCN Lab, Austria) and Max Gibbs (New Zealand) who joined the group through Webex, arranged the five-day regional training course that was held on 27-31 July 2015, in Colombo, Sri Lanka. Champa K. Dissanayake, Senior Scientific Officer, Life Science Division, Sri Lanka Atomic Energy Board was the course Director. The training course was attended by 22 participants from 13 Member States, including Australia, Bangladesh, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, The Philippines, South Korea, Sri Lanka, and Vietnam. The training course was opened by the Minister of Power & Energy for Sri Lanka, Mr Ranawaka, who highlighted the soil degradation issues which currently exist in Sri Lanka. After Mr Ranawaka's speech, Lakshitha Jayawardana, Chairman of Sri Lanka's Atomic Energy Board highlighted the role of RAS5055 in addressing soil erosion in the central highlands of Sri Lanka. The TO described the objectives of the training course which included (i) the training of fellows using nuclear and isotopic techniques, assessing soil erosion and identify its sources. The TO also highlighted key challenges such as land degradation and food security problems which confront the agriculture sector on a daily basis and are due to the intensification of agriculture which is in turn caused by the increase in human population and the effects of climate change.

Lionel gave lectures on quantifying land degradation using FRNs technique; and Max Gibbs provided lectures via Skype from New Zealand, on compound specific stable isotope (CSSI) technique to identify the source of soil erosion in a catchment. Two resource persons (Rafiq and Othman) covered a range of topics, including nuclear and isotopic techniques and conservation agriculture. All participants went on a one day field trip to the central highlands near Kandy, about 160 km from Colombo. The two experts showed the participants how to take soil samples using a scraper plate and bulk core sampling techniques from the reference site, and across the slope from different areas of the catchment. Participants were also shown different conservation practices used in the catchment area. The feedback from participants clearly indicated that all benefited from the five-day training course and had learned new techniques used to assess soil erosion, identify its source and place conservation practices in action for reducing soil erosion. The site demonstration visit in central highlands near Kandy thus provided an excellent opportunity to the participants to see the practical benefits of assessing soil erosion using nuclear techniques and putting into place the appropriate conservation agricultural practices needed to combat erosion. Certificates were distributed to the participants at the end of the course.

Participants at the field site near Kandy observing conservation practices to reduce soil erosion

Brazil: To organize the regional training course on the use and application of isotopic techniques for quantifying biological nitrogen fixation and fertilizer nitrogen use by crops, 10-14 August 2015, Rio de Janeiro, Brazil

Technical Officer: Karuppan Sakadevan

The Technical Officer (TO) organized the regional training course with Mr Segundo Urquiaga, Marcio Martin, and Bruno Alves from Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil. The training course was carried out as part of the regional technical cooperation project RLA5065 on "Improving Agricultural Production Systems through Resource Use Efficiency".
The training course was held during 3-14 August 2015, Rio de Janeiro, Brazil and was attended by sixteen participants from ten countries. During the first week, the three experts provided training focused on nutrient cycling, soil fertility and plant nutrition. The TO provided training on assessing biological nitrogen fixation (BNF) using nitrogen-15 technique during the second week. This included: (i) BNF assessment in different legume based cropping systems; (ii) case studies; and (iii) group practical exercises using data from different agro-eco regions and cropping systems to estimate BNF and nutrient use efficiency. At the end of the training activity, a written test was carried out to assess the effectiveness of the training course. Feedback from the participants showed that the training course helped participants to develop and enhance their skills, knowledge and understanding of using nitrogen-15 technique for BNF and nitrogen use efficiency.

Participants at the training

Mongolia: To train the counterpart of RAS5065 and her team on techniques using plant growth regulators with chemical fertilizers to enhance rice productivity under cold environment in Mongolia, 12–14 August 2015, Darkhan, Mongolia.

Thailand: To discuss and plan future project activities with counterparts, and present data on FRNs and CSSI in an International Soil Conference in Cha Am, Thailand, 17–21 August 2015, Bangkok, Thailand.

Technical Officer: Mohammad Zaman

After arriving in Ulan Bator, Mongolia on August 11, the Technical Officer (TO) travelled to the Mongolian State University of Agriculture Plant Science and Agricultural Institute in Darkhan. In Mongolia, farmers are facing the double challenges of growing crops in a relatively short duration time period (May until September), and the daily abiotic stress due to large day-night temperature differences - challenges which lead to reduced productivity across a range of arable crops. In such a situation the strategic application of plant growth regulators and essential plant nutrients may have the potential to reduce abiotic stress effects and enhance plant growth. From 12 to 14 August, the TO conducted training sessions (lectures as well as a practical demonstration in the laboratory and field) on the potential uses of plant growth regulators (PGRs) and chemical fertilizers to mitigate the negative effects of the day-night temperature differences. The training was attended by 15 researchers from various sections of Agriculture Plant Science and the Agricultural Institute in Darkhan. It covered several different topics: the functions and roles of different plant growth regulators and essential plant nutrients, their application rates, methods of application, plant sampling for chemical analysis and biomass yield production, and finally the use of ^{15}N techniques to determine fertilizer use efficiency. After learning the concepts of PGRs, the Technical Officer showed researchers how to prepare and apply PGRs and chemical fertilizer to a rice paddy field at the research farm in the institute.
After leaving Ulan Bator on 19 August, the TO arrived in Bangkok, Thailand. Here, the TO discussed the planning of future project activities with the three counterparts

from: (1) Thailand Institute of Nuclear Technology (TINT), (2) Land Development Department (LDD) and (3) Hydro and Agro Information Institute. The Technical Officer also attended an International Soil Conference in Cha Am, Thailand and made an oral presentation on assessing land degradation using nuclear and isotopic techniques. The Technical Officer also met with the Thailand National Liaison Officer Ms. Usa Kullaprawithaya, and discussed details of the planned activities of THA5051 and THA5055.

Oman: To review project progress, and provide technical support for analyzing the data collected from field studies on soil-water-crop management for the sustainable use of salt affected soils and saline water for alfalfa forage production under the technical cooperation (TC) project OMA5001 on "Producing Forage Crops Tolerant to Salinity and Drought", 27 September to 1 October, 2015, Muscat, Oman

Technical Officer: Karuppan Sakadevan

The Technical Officer (TO) visited the Directorate General of Agricultural & Livestock Research, Ministry of Agriculture, Muscat, Oman to (1) review project progress, and (2) provide technical support to the counterpart for analysing results–of the data collected from salinity and drought studies carried out for the selection of alfalfa crop accessions under the Technical Cooperation Project OMA5001 since January 2012.

The TO met the project counterpart Mr Hamdan Al-Wahaibi, Director of Soil and Water Science. During this meeting, Mr Al-Wahaibi and the TO discussed details of the field studies on the assessment of salinity, water stress and biological nitrogen fixation (BNF). It was informed in the meeting that the field studies have now been completed, data on alfalfa yield and water use have been collected, and the plant samples have been analyzed for isotopic measurements for both salinity and drought studies. The TO then had a round-table meeting with the project teams to discuss and finalize activities for the duty period. The TO met Mr Hamoud Darwish Salim Al-Hasani, Director General, Agriculture and Livestock Research and apprised him of the purpose of the duty travel. The TO accompanied by the project counterpart visited family farms in the provincial region of Nijwa to discuss strategies and management practices for improving alfalfa production by sustainably using salt affected soils and saline water. On the final day of the mission, the TO discussed more project activities including technical report containing results of salinity and drought studies, possible success stories, and developing guidelines for the sustainable use of salt affected soils and saline water.

Project counterparts of Oman

Japan: To guide the 2nd RCM of CRP D15015 on "Response to Nuclear Emergencies Affecting Food and Agriculture", 28 September to 2 October 2015, Fukushima-City, Japan

Technical Officer: Mr. Gerd Dercon

The purpose of travel of Mr. Gerd Dercon was to conduct, as scientific secretary, the second Research Coordination Meeting (RCM) of CRP D15015 on *"Response to Nuclear Emergencies Affecting Food and Agriculture"*, held from 28 September until 2 October 2015 in Fukushima-City, Japan. The RCM was jointly hosted by the University of Tsukuba, Japanese Atomic Energy Agency, NARO Tohoku Agricultural Research Centre and Fukushima University, at the premises of the Fukushima Prefecture (Japan).

The objectives of the meeting were:

1. To review and discuss progress made by CRP D1.50.15
2. To present and discuss sampling and analytical strategies and protocols, and data management –geo visualization tools
3. To develop individual and project work plans for the second phase, in accordance with project objectives

The CRP participants presented results and outputs achieved since the first RCM at the end of 2013. These presentations focused on both major topics being addressed in this project, including compilation and development of (i) soil and foodstuff sampling and analytical strategies and protocols, and (ii) environmental data management and geo-visualization tools. Further, the Incident and Emergency Centre of the IAEA showed how information exchange is implemented by the IAEA during nuclear or radiological emergencies. Through group discussions, progress of the project was carefully reviewed and assessed, and challenges and needs for further implementation of the CRP during the second phase identified.

A field visit organized by the Japanese hosts, aimed at demonstrating how Japanese authorities manage foodstuff sampling and analysis, and data management and visualization. During the visit, the CRP participants were also shown how remediation of farmland and forests

affected by the Fukushima Daiichi Nuclear Power Plant Accident has been carried out. Further, research sites were visited that focus on better understanding of the movement of radioactive materials (i.e. fallout radionuclides, such as radio-caesium) in the landscape.
The emphasis of the fourth day was the development of project and individual work plans, and testing and evaluation of the proposed CRP D1.50.15 online food safety information system. On the last day of the meeting, conclusions were formulated, follow-up actions identified and recommendations phrased.

Storage of removed topsoil from rice paddy fields affected by the Fukushima Daiichi Nuclear Power Plant Accident

Morocco: Regional Training Course on ''Fallout Radionuclides Data Treatment and Interpretation with Special Focus on the ^{137}Cs Technique for Assessing Soil Degradation'', 28 September to 9 October 2015, Rabat, Morocco

Technical Officer: Lionel Mabit

The main aim of this fourth regional training course organised under RAF5063 (i.e. Regional Technical Cooperation Project on "*Supporting Innovative Conservation Agriculture Practices to Combat Land Degradation and Enhance Soil Productivity for Improved Food Security*" was to provide the course participants advanced knowledge and information on the use of Fallout Radionuclides (FRNs) and how to process and analyse FRN data-sets with an emphasis on the ^{137}Cs method for assessing soil redistribution in agro-ecosystems. Through lectures, guided exercises and several short workshops and discussion with the participants and the experts involved, this training course covered the following aspects: accurate FRN reference site selection, sampling strategy, gamma spectroscopy analysis, dating and FRN conversion models, data modelling and treatment using Geographic Information Systems, statistics and geostatistics. The second week of the training was devoted to support the participants in data treatment and interpretation.
Twenty-one participants from Africa (i.e. Algeria, Benin, Ivory Coast, Madagascar, Morocco, Senegal, Tunisia, Uganda and Zimbabwe) attended this training course. The training was provided by the IAEA Technical Officer of RAF5063, two international experts (i.e. Dr. Leticia Gaspar from the Museo Nacional de Ciencias Naturales-Consejo Superior de Investigaciones Científicas [MNCN-CSIC] Spain and Dr. Naivo Rabesiranana from the Institut National des Sciences et Techniques Nucléaires [INSTN] Madagascar), several local experts and the Course Director (Dr. Moncef Benmansour, Head of Division Water, Soil and Climate at CNESTEN, Morocco). The Centre National de l'Energie, des Sciences et des Techniques Nucléaires (CNESTEN), Rabat, Morocco hosted this successful regional training course.

Participants of the 4th Regional Training Course of the TCP RAF5063 in front of the CNESTEN Laboratories, Rabat, Morocco

Mexico: To review the project progress since 2014-15, discuss and plan future project activities, 5-9 October 2015, Morelia, Mexico

Technical Officer: Mohammad Zaman

On the first day, the Technical Officer (TO) met Ms. Jeannette S. Bayuelo-Jiménez, main counterpart (CP), and Mr. Guillermo, Director, Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo. After the welcome address by Mr Guillermo, the TO gave a presentation to a group of academics, and post graduate students on integrated crop-soil approaches using nuclear techniques to increase crop productivity in harsh environments and discussed different isotopic and nuclear techniques for studying nutrient dynamics such as nutrient uptake and losses to atmosphere and ground water. After the presentation and discussion, the TO visited different labs in the institute and discussed ongoing research projects with researchers. The TO later discussed project activities with Ms. Jeannette and her team members. On day-2, the TO along with Ms. Jeannette and two postgrad students visited maize trials in Purepecha Basin and Paricutin volcano, Michoacán followed by a visit to Bajío Experimental Station (CEBAJ) in Celaya, on day-3. Here Mr Ernesto from CEBAJ, presented his work on the development of improved P-efficient maize varieties. After the presentation and discussion, Mr Ernesto took us to the nearby field site to see the different maize lines developed by his team and the CP for low P conditions. On day-4, the TO, along with CP and her team travelled from

Morelia to the Instituto Nacional de Investigaciones Nucleares (ININ) to discuss additional project activities with other CP from ININ. After the welcome address by Mr Federico, Mr. Eulogio gave a presentation on using nuclear techniques in plant breeding. This was followed by a glasshouse visit and discussion on the ongoing trial on "assessment of different maize lines for efficient phosphorus uptake through isotopic dilution techniques". After the glasshouse visit, Ms. Esperanza Quintero showed us the laboratory for evaluation of radioactive samples and the newly purchased liquid scintillation counter by IAEA. On day-5, the TO travelled to Mexico city to meet the country national liaison officer, discussed with him the ongoing project activities, expected outputs and the need for future activities.

Visit to the field trials for screening maize lines for efficient phosphorus uptake

Turkey: Special IAEA event on sustainable land management at the 12th session of the Conference of the Parties (COP) to the UN Convention to Combat Desertification (UNCCD), Ankara, Turkey, 19 October 2015

Technical Officer: Lionel Mabit

The twelfth session of the Conference of the Parties to the UN Convention to Combat Desertification (UNCCD COP12) was held in Ankara, Turkey, from 12 to 23 October 2015. Approximately 6000 participants gathered for this two-week meeting, which adopted 35 decisions following deliberations on agenda items related to desertification, land degradation and drought, including how to pursue the target to achieve Land Degradation Neutrality (LDN) and how to align the UNCCD's goals and parties' action programmes with the recently adopted Sustainable Development Goals. A breakthrough agreement was reached, the adoption of LDN as a target to maintain or even improve the amount of healthy and productive land resources over time and in line with national sustainable development priorities.

In collaboration with the Centre National de l'Energie, des Sciences et des Techniques Nucléaires (CNESTEN) Morocco and the Institut National des Sciences et Techniques Nucléaires (INSTN-Madagascar) Madagascar, IAEA organised a side event at COP12 on 19 October 2015 which highlighted opportunities in bridging science and policy for sustainable land management and minimizing land degradation. Several IAEA success stories in the use of isotope technologies to support the development and management of land use policies were presented during this event. More specifically, representatives from Morocco (Mr. Benmansour, CNESTEN) and Madagascar (Mr. Rabesiranana, INSTN) shared their experiences in using nuclear and related techniques in their fight against soil erosion, acquired through collaboration with IAEA's Technical Cooperation Programme and supported technically by the SWMCN Subprogramme of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

Delegates from Madagascar and Morocco chairing, with Susanne Nebel presenting the opening remarks at the IAEA side event of UNCCD COP12

China: To organize the final technical meeting and review project outputs for the regional technical cooperation project RAS5/064 on "Enhancing Productivity of Locally-Underused Crops through Dissemination of Mutated Germplasm and Evaluation of Soil, Nutrient and Water Management Practices", 19-23 October 2015, Beijing, China

Technical Officer: Karuppan Sakadevan

The technical officer organized the final meeting with support from Mr Li Yong, Chinese Academy of Agricultural Sciences (local coordinator) and Mr M.L. Nguyen, Soil Expert and previously Section Head of SWMCN. National counterparts from Bangladesh, Cambodia, China, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka and Thailand attended the technical meeting. The purpose of the meeting was to (1) discuss and review results obtained from field studies, (2) discuss and identify possible outputs from the project, and (3) identify strategies for disseminating improved soil, water and nutrient management practices to farmers identified.

In addition to presenting the results from field studies by national counterparts, a detailed report based on country objectives, methodologies, activities, outputs, lessons learned, support obtained from IAEA, key recommendations, way forward, implementation time period, and constraints was also prepared during the meeting. A spreadsheet summarizing the above

information for each country was developed. The meeting also discussed possible success stories and media products that can be developed from this project. It has been a pleasure to meet both Long and Yong, whom have been committed to the SWMCN subprogramme over the years and also their commitment and dedication during the meeting.

Participants at the meeting

Morocco: Regional Training Course on ‘‘The Use of Oxygen-18 for Separation of Evaporation into Soil Evaporation and Crop Transpiration, and Aquacrop Simulation Modelling’’, 2-6 November 2015, Rabat, Morocco

Technical Officer: Lee Heng

The Technical Officer (TO) Lee Heng travelled to Rabat, Morocco to conduct the first of a two-week regional training course from 2-13 November 2015 on ‘‘The Use of Oxygen-18 for Separation of Evaporation into Soil Evaporation and Crop Transpiration, and Aquacrop Simulation Modelling’’. The course was carried out as part of the AFRA regional project RAF5071 on ‘Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation’. The host was the Centre National de l’Energie, des Sciences et des Techniques Nucléaires (CNESTEN), with Dr. Hamid Marah, Director of Studies and Scientific Research in CNESTEN as the Course Director. Twenty-eight participants from Algeria, Benin, Botswana, Cote d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Senegal, Sudan, Uganda and Zimbabwe, and five local Moroccan participants attended this course. Mr. Khalid El Mediouri, Director General of CNESTEN welcomed the participants at the opening ceremony. Mr. Michael G. Hage, FAO representative in Morocco gave an overview of FAO’s work in Morocco.

The technical officer, together with local expert, Mr. Amenzou Noureddine, provided training on Keeling Plot and the isotopic mass balance methods using oxygen-18 for the separation of soil evaporation and crop transpiration. Both theory and practical sessions including soil and plant sampling, and their extractions for isotopic analysis were demonstrated. Step-by-step calculations with case studies were also provided to ensure the participants fully understand the concept. Two international experts Mr Dirk Raes and Ms Hanne van Gaelen, from KU Leuven University, Faculty of Bioscience Engineering Dept. of Earth and Environmental Sciences provided the AquaCrop training in the second week.

Viet Nam and Malaysia: Combined missions: 1) To participate in the Workshop on the role of Nuclear Techniques in Conservation Agriculture and to provide technical advice on the application of these Nuclear Techniques 1-2 November 2015, Dalat, Viet Nam. 2) To participate and evaluate technical outputs developed at the final coordination meeting 2) RAS 5055, 4-7 November, Kuala Lumpur, Malaysia

Technical Officer: Mohammad Zaman

The Technical Officer (TO) together with the Project Management Officer (PMO), Mr. Mykola Kurylchyk, and the lead country coordinator (LCC) Mr Hendrik Heijnis, arranged a two day Workshop on the role of Nuclear Techniques in Conservation Agriculture in order to provide technical advice to key stake holders/decision makers on the application of these Nuclear Techniques on 1-2 November 2015, in Dalat, Viet Nam.

The Workshop was attended by 10 key stake holders/decision makers from Cambodia, Nepal, The Philippines, Sri Lanka, Thailand, and Viet Nam. The Workshop was opened by Prof. Nguyen Nhi Dien, Vice President of Vietnam Atomic Energy Institute (VINATOM) and Director of Dalat Nuclear Research Institute (DNRI). These opening remarks were followed by a presentation from Mr. Kurylchyk (the PMO) on the role of IAEA in helping Member States through support of national and regional technical cooperation projects. Mr. Zaman, the TO then made a presentation to the key stake holders and decision makers on the role of nuclear and isotopic techniques in assessing soil erosion, in identifying the sources of the erosion, and the best farm practices for reducing soil erosion. This included detailing several success stories accomplished by RAS 5055. The local organizer Mr. Phan Son Hai, Deputy Director of the Dalat Nuclear Research Institute (DNRI), presented the Viet Nam case study. Here, soil erosion was successfully reduced by 50% after Viet Nam put into place appropriate management practices. Later in the afternoon, all participants visited the laboratory for isotopic and nuclear analyses at the Dalat Nuclear Research Institute. A field trip was arranged for all participants to visit several domonstration sites. This provided an opportunity for the stakeholders and decision makers to learn about and observe the benefits of using Nuclear Techniques in measuring and identifying soil erosion rates, and applying

associated conservation measures to reduce soil losses by erosion.

On day 3, the TO, PMO and LCC left Viet Nam to facilitate the final project review meeting, which was held during 4-7 November 2015 in Kuala Lumpur, Malaysia. This final project meeting was attended by 22 participants from 12 Member States, including Australia, Bangladesh, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, The Philippines, South Korea, Sri Lanka, and Viet Nam. This meeting was opened by Professor Dato' Noraini Idris, Deputy Vice Chancellor (Research and Innovation), Universiti Pendidikan Sultan Idris, Malaysia. Professor Idris highlighted the soil erosion/land degradation issues. The TO, described the objectives of this final meeting, and discussed the achievements made since previous meeting, held in Nepal, 2014. Participants from each Member State presented an update on their project activities using nuclear techniques and also described the four project outputs which each Member State has achieved under the RAS 5055 project.

Day-3 discussions focused on the final project report structure. Each Member State was assessed on the basis of 4 project outputs. These included: 1) functional networks using Fallout Radionuclides based (FRNs) and Compound Specific Stable Isotope (CSSI) techniques, 2) capacity building in order to be able to undertake FRNs and CSSI studies for the purpose of this project, 3) the regional database developed on isotopic signatures of crop and soil compounds (isoscapes) and 4), efficient and effective project coordination and networking with regard to the transfer of knowledge to decision makers and farmers. On day-4, there were group discussions which focussed on the draft project report, i.e., lessons learned, strategies for the future use of the FRN/CSSI database, dissemination of information to land users, remaining project activities and follow-up project ideas for the RCA TC cycle of 2018-21.

Scientific Visitors

- Mr Djondang Koye and Mr. Michel Naitormbaide from Chad, visited SWMCN Laboratory, 19-23 October 2015, to explore how isotope and nuclear techniques can help in improving soil and water management.
- Mr Hamdan Al-Wahaibi,, Directorate General of Agricultural and Livestock Research, Ministry of Agriculture, Oman, visited SWMCN Section and Laboratory, 9-13 November 2015, to explore opportunities for collaboration and training water and nutrient management under livestock forage production system.
- Mr Salim Abdullah Rashid Alrasbi, Directorate General of Agricultural and Livestock Research; Ministry of Agriculture, Oman, visited SWMCN Section and the Laboratory, 9-13 November 2015, to discuss work plan and data interpretation of field studies carried out as part of TC project OMA5001.
- Ms Badria Alhosni, Directorate General of Agriculture & Livestock Research, Ministry of Agriculture, Oman, visited the SWMCN Section and the Laboratory, 16-27 November 2015, to discuss results obtained from field work carried out in Oman under the TC national project OMA5001.
- Dr Apichart Jongskul, ex-Director General from Land Development Department, Thailand, visited Mohammad Zaman.
- Mr Pierre Moutonnet, ex-SWMCN staff member and wife Derya, visited Lee Heng, 7 September 2015 from France.
- Keynote speakers at the IAEA Side event on 'Managing Soils for Climate-Smart Agriculture: Celebrating the International Year of Soils' on 16 September:
  - Mr Heitor Evangelista Da Silva, Professor, Universidade do Estado de Rio De Janerio, Brazil, presenting 'Soil and sediments - a natural archive of information on agro-ecosystems'
  - Mr Hoang Anh Tuan, Director General, Viet Nam Atomic Agency, Vietnam, presenting 'Managing soil erosion in Vietnamese tropical mountain areas'
  - Mr Joseph Gichane Mureithi, Deputy Director General of Kenya Agricultural and Livestock Research Organization (KALRO) presenting 'Nuclear science applications in soil and water management in Kenya'

Coordinated Research Projects

Project Number	Ongoing CRPs	Scientific Secretary
D1.20.12	Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems	Karuppan Sakadevan
D1.20.13	Landscape Salinity and Water Management for Improving Agricultural Productivity	Lee Heng and Karuppan Sakadevan
D1.50.12	Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems in Sub-Saharan Africa	Mohammad Zaman and Gerd Dercon
D1.50.13	Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments	Karuppan Sakadevan and Pierre Lagoda
D1.50.15	Response to Nuclear Emergencies Affecting Food and Agriculture	Gerd Dercon and Lee Heng
D1.50.16	Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems	Mohammad Zaman and Lee Heng
D1.50.17	Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems	Lionel Mabit and Lee Heng

Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems (D1.20.12)

Technical Officer: Karuppan Sakadevan

This CRP is in its third year and the second renewals for all national projects have been completed. The CRP was started in July 2013 with nine research contract holders from eight countries (Argentina, Brazil (two), China, India, Indonesia, Kenya, Uganda and Uruguay) and three agreement holders from France, Nigeria and United States of America. The second RCM was held in Kenya from 17-21 November 2014. The main objective of the project is to enhance food security and rural livelihoods by improving resource use efficiency and sustainability of integrated crop-livestock systems under a changing climate. The specific objectives are:

1. optimize water and nutrient use efficiency in integrated crop-livestock production systems,
2. identify the potential for improving soil quality and fertility in integrated crop-livestock systems,
3. assess the influence of crop - livestock systems on GHG emissions, soil carbon sequestration and water quality,
4. assess socio-economic and environmental benefits of crop-livestock systems,
5. strengthen the capacity of Member States to use isotopic and nuclear techniques as tools for improving the management of crop-livestock systems, and
6. develop soil, water and nutrient management options in integrated crop-livestock systems for potential adoption by farmers.

Major research activities accomplished during 2014-2015 include:

1. Comparative soil fertility assessment for agricultural production systems in the Pampas under no-till summer crops and crops integrated with livestock;
2. Assessment of greenhouse gases (nitrous oxide and methane) under integrated crop-livestock systems in the subtropics and tropics;
3. Resource use efficiencies and soil erosion management under integrated crop-livestock systems;
4. Livestock production, soil quality and fertility under rotational integrated crop-livestock management systems
5. Assessment of agronomic and environmental effects of different tillage practices in integrated crop-livestock systems.

Landscape Salinity and Water Management for Improving Agricultural Productivity (D1.20.13)

Technical Officers: Lee Heng and Karuppan Sakadevan

This project is in the third year and the contract renewal for 2016 has just been completed. The CRP was started with the first RCM held in July 2013, in Vienna. The objectives of this CRP are to: a) identify ways to improve crop productivity and sustainability through water and salinity management, b) define approaches and technologies to assess and monitor soil water content and salinity at field and area-wide scales, and c) reduce impacts of climate change and variability on the widespread increase in landscape salinity. Currently the project has seven research contract holders (Bangladesh, China (two participants), Iran, Pakistan and Vietnam (two participants), two agreement holders (Germany and Spain) and one technical contract holder from USA. The second RCM was held in Beijing, China in September 2014 where results from the first year's findings were presented. The third RCM is planned in mid-2016 in Ho-Chi Minh City in Vietnam, after mid-term review in early 2016.

Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems in Sub-Saharan Africa (D1.50.12)

Technical Officers: Mohammad Zaman and Gerd Dercon

This Coordinated Research Project (CRP) is already in its 4th year of implementation. The CRP aims to improve the livelihoods of farmers with a low level of socio-economic development in rural communities in Sub-Saharan Africa through restoration of degraded soils and ecosystems and the development of productive and resilient agricultural practices. There were 15 participants, including seven research contract holders from Benin, Kenya, Madagascar, Mauritius, Mozambique, Pakistan and Zimbabwe, three technical contract holders from China, the Czech Republic and the United Kingdom, and five agreement holders from Austria, Belgium, Kenya, New Zealand and United States of America. The first RCM was held at the IAEA's headquarters in Vienna, Austria, from 30 January to 3 February 2012, the second RCM, was held in Antananarivo, Madagascar, from 14 to 18 October 2013 and the third RCM held on 4 to 8 May, 2015 in Harare, Zimbabwe. Seven research contracts have been renewed based on their progress project report and renewal proposals in October 2015. Progress reports indicated that:

- Overall the 3 year results from field trials in Sub-Saharan countries showed that mulching must cover 30% of the soil surface area in order to achieve the benefits of conservation agriculture. However, due to the practice of subsistence farming, low soil fertility and acidic soil pH, farmers are not able to produce enough biomass to apply it as mulch. However, after the correction of soil pH through liming, and the application of animal manure with a co-application of mulch and N fertilizer under a zero tillage system led to an appreciable increases in crop productivity. Associated with the increased crop productivity were a conservation of soil moisture, increased soil nutrients and improved soil microbial activity (soil enzymes) and enhanced production of biomass.
- In Benin, tillage, inoculation and mulching significantly improved soybean nodulation.
- In Zimbabwe, minimum tillage tended to improve soil organic carbon and soil moisture retention.
- In Pakistan, co-application of mulch and application of a nitrogen fertilizer led to an appreciable improvement in water use efficiency.
- Each CRP project participant will submit one draft manuscript for publication in an IAEA Tecdocl by 31 December, 2015.

The SWMCN Laboratory team has further followed up research activities to support this CRP. Based on samples collected from several long-term experiments in Austria, Belgium, Kenya, Senegal and China, a protocol has been produced to assess soil organic carbon stability using ^{13}C and ^{15}N stable isotope techniques. These results of three years of intensive research also resulted in a research paper, which has been accepted for publication in the Soil Biology and Biochemistry Journal. The final RCM will be held in Vienna, Austria, during the third quarter of 2016.

Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments (D1.50.13)

Technical Officers: Karuppan Sakadevan and Pierre Lagoda

This CRP is in its final year. Ten research contract holders (Bangladesh, China, Kenya, Malaysia (two participants), Mexico, Pakistan, Peru, South Africa, Uganda and Vietnam), one technical contract holder (Peru) and one agreement holder (South Africa) are participating in the CRP. The research project was started in December 2011 and three RCMs have been carried out so far to review project progress and present preliminary results. The overall objective of this CRP is to increase crop productivity and food security by developing improved crop varieties and soil, water, nutrient and crop management technologies and making them available to farmers, and ensure their cropping systems are resilient to biotic and abiotic stresses in water scarce environment. The specific objectives are to:

- Increase the productivity of crop varieties tolerant to environmental stresses under existing soil and climatic conditions, and
- Enhance nitrogen and water use efficiencies of crops tolerant to environmental stresses through best practice soil, water, crop and fertilizer management practices.

The final renewal for the national projects are completed and the final project closure will be in the fourth quarter 2016

Key outputs of the CRP until December 2014 include:

1. Ratooning rice cultivars (one planting and two harvests) have been introduced in more than 40,000 ha in China with yield up to 14,500 kg/ha over two harvests.
2. Three mutant sorghum varieties with yield increase up to 7% were implemented in farmers' field under rainfed conditions.
3. Elite potato varieties were successively evaluated for yield and fertilizer use efficiency.
4. Three varieties and one advanced mutant line of barley, and five improved genotypes of quinoa that are suitable for high altitude were evaluated for yield and water and nutrient use efficiencies.
5. A series of field studies have been carried out to evaluate and select two improved rice varieties MR219-4 and MR219-9 which are tolerant to aerobic conditions
6. Genotypes of quinoa, Huauzontle and Chia were evaluated for yield performance for drought and salinity tolerance in Mexico;
7. Three gynotypes of wheat for water and nutrient use efficiencies and two varieties of wheat tolerant to UG99 were evaluated for different levels of nitrogen and phosphorus fertilizer application under rainfed conditions.
8. Three mutant soybean varieties have been evaluated for water and nutrient use efficiencies during spring and summer periods.

Response to Nuclear Emergencies Affecting Food and Agriculture (D1.50.15)

Technical Officers: Gerd Dercon and Lee Heng

This CRP aims to develop and assess systems of innovative data collection, management and geovisualization platforms that can be used for both routine monitoring and also in emergency response to nuclear and radiological incidents that could affect food and agriculture. Through this CRP network, institutions and governments involved in nuclear emergency response for food and agriculture will be strengthened. The CRP will also assist in compiling Standard Operating Protocols (SOPs) for actions required in case of a nuclear emergency affecting food and agriculture, as well as sampling analytical SOPs for activity measurements.
The objectives of the CRP are:

1. To identify sampling and analytical strategies in nuclear emergencies affecting food and agriculture
2. To determine how online geo-visualization tools can influence emergency response strategies, approaches to learning from nuclear accidents, and end-users ability to generate future short-term and long-term scenarios about the impact of nuclear accidents on food and agriculture
3. To ensure that systems use common or standardized protocols that can be shared across different software platforms
4. To produce low-cost computer-based platforms that are robust and can be used both routinely to monitor everyday sampling as well as in nuclear emergency situations
5. To produce decision support tools that will help rapid analysis of the situation in radionuclide contamination of food stuffs.

Four research contract holders from China, Morocco, the Russian Federation and Ukraine, four technical contract holders from France, Japan (2) and Macedonia and four agreement holders from Belgium, European Commission, India and Japan participate in this CRP.

To date, protocols for supporting sampling and radionuclide concentration analysis of foodstuffs are being prepared, and an advanced prototype of the online information system to support decision-making in food safety in case of a nuclear emergency is available. This information system is currently being further improved based on comments from the CRP participants. Also suggestions for improvement, made during presentations at several international meetings and workshops, were taken into account. Further significant progress has been made as well to link this system with existing data exchange platforms of the IAEA, such as the Unified System for Information Exchange on Incidents and Emergencies (USIE) and International Radiation Monitoring Information System (IRMIS) managed by IEC.
The second RCM was held from 28 September to 2 October 2015 in Fukushima, Japan to review progress made and plan for the second phase of the CRP. The third RCM is planned for the last trimester of 2016.

Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems (D1.50.16)

Technical Officers: Mohammad Zaman and Lee Heng

The objective of this CRP is to mitigate nitrous oxide (N_2O) emissions and minimize nitrogen (N) losses from

agricultural systems, whilst enhancing agricultural productivity and sequestering soil carbon (C). The first Research Coordination Meeting (RCM) was held in Vienna, Austria from 3 to 7 November 2014 to review individual experimental plans of the research contractors in line with the objectives of the CRP, and to provide the contractors with suggestions for the next 18 months. Ten participants, with seven research contract holders from Brazil, Chile, China, Costa Rica, Ethiopia and Pakistan, two agreement holders from Estonia and Spain, and one technical contract holder from Germany attended the RCM. Since the first RCM, all CRP participants have established field trials to assess the effects of nitrogen process inhibitors on N_2O emission and also on C sequestration under different agro-climatic condition. Measurements of N_2O emissions and collection of soil and plant samples for chemical analyses are underway. Seven research contracts have been renewed based on their progress project report and renewal proposals in October 2015. Data on N_2O emissions from different cropping systems will be presented during the second RCM, which will be held in Estonia in the second quarter of 2016. The CRP is expected to continue for five years (2014–2019).

Developments at the Soil and Water Management and Crop Nutrition Laboratory

Sediment Origin Determination in the Sub-Catchment of Mistelbach (Austria) using Fatty Acids Biomarkers and Compound-Specific Stable Isotope Techniques

L. Mabit[1], X. Chen[1], C. Resch[1], A.Toloza[1], K. Meusburger[2], M. Gibbs[3], A. Klik[4], A. Eder[5], P. Strauss[5], C. Alewell[2]

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[3]National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand
[4]Institute of Hydraulics and Rural Water Management, University of Natural Resources and Life Sciences, Vienna, Austria,
[5]Institute for Land and Water Management Research, Petzenkirchen, Austria

Compound-specific stable isotope (CSSI) signatures of inherent soil organic biomarkers allow discriminating and apportioning the source of soil contribution from different land uses. Plant communities label the soil where they grow by exuding organic biomarkers. Although all plants produce the same biomarkers, the stable isotopic signature of those biomarkers is different for each plant species.

For agri-environmental investigations, the CSSI technique is based on the measurement of carbon-13 (^{13}C) natural abundance signatures of specific organic compounds such as natural fatty acids (FAs) in the soil. By linking fingerprints of land use to the sediment in deposition zones, this approach has been shown to be a useful technique for determining the source of eroded soil and thereby identifying areas prone to soil degradation.

The authors have used this innovative technique to investigate a 3 hectares sub-catchment of Mistelbach situated 60 km north of Vienna. Using the ^{137}Cs technique, Mabit et al. (2009) reported a local maximum sedimentation rate reaching 20 to 50 t ha^{-1} yr^{-1} in the lowest part of this Austrian catchment. To test the ability of the CSSI technique to discriminate different sediment sources of these deposited sediments, representative soil samples from four main agricultural fields of the site were analyzed (see Figure 1).

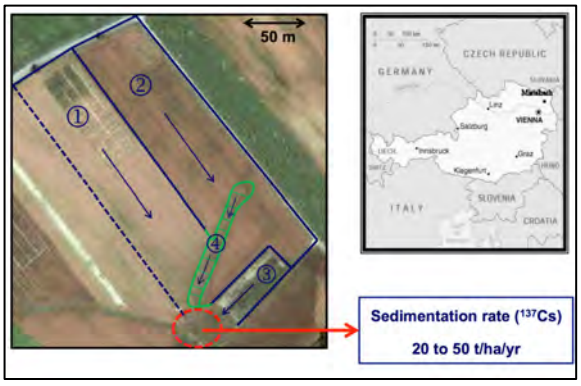

Figure 1. Location of the sub-catchment of Mistelbach (4 agricultural fields [sources: 1, 2, 3 and 4], sedimentation area [mixture] in red)

TABLE 1. ^{13}C Signatures of the FAs Present in the Four Soil Sources and the Sediment Mixture

Sample - ID	Organic C	Bulk C	Myristic Acid (C14:0)	Palmitic Acid (C16:0)	Palmitoleic Acid (C16:1)
	(%C)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)
Source 1	1.36	-25.05	Not measurable	-21.84	Not measurable
Source 2	1.70	-24.16	Not measurable	-26.26	Not measurable
Source 3	2.53	-14.89	-26.33	-22.85	Not measurable
Source 4	3.82	-18.65	Not measurable	-26.88	-27.72
Mixture	**3.19**	**-17.32**	**-37.37**	**-27.70**	**-29.26**

Sample - ID	Stearic Acid (C18:0)	Oleic Acid (C18:1)	Linoleic Acid (C18:2)	Arachidic Acid (C20:0)	Behenic Acid (C22:0)	Lignoceric Acid (C24:0)
	($\delta^{13}CC$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)	($\delta^{13}C$ ‰)
Source 1	-24.36	-26.02	-23.52	Not measurable	-32.44	-30.09
Source 2	-27.80	Not measurable	-26.29	Not measurable	-33.39	-31.44
Source 3	-22.92	-22.66	-22.49	-27.74	-30.73	-28.89
Source 4	-25.73	-30.23	-38.96	-32.70	-32.53	-32.24
Mixture	**-29.75**	**-29.78**	**-26.67**	**-34.54**	**-33.23**	**-32.99**

Using the results presented in Table 1, a biplot approach was used to select the best FAs to identify the sediment origin. In complement to the information provided by the bulk delta ^{13}C of the samples, both long-chain FAs C22:0 (i.e. Behenic Acid) and C24:0 (i.e. Lignoceric Acid) allowed the best statistical discrimination.

Values of ^{13}C signatures of these two specific FAs and the bulk ^{13}C of the sediment mixture and potential source soils were analyzed with the Phillips and Gregg (2003) mixing model IsoSource (see Figure 2).

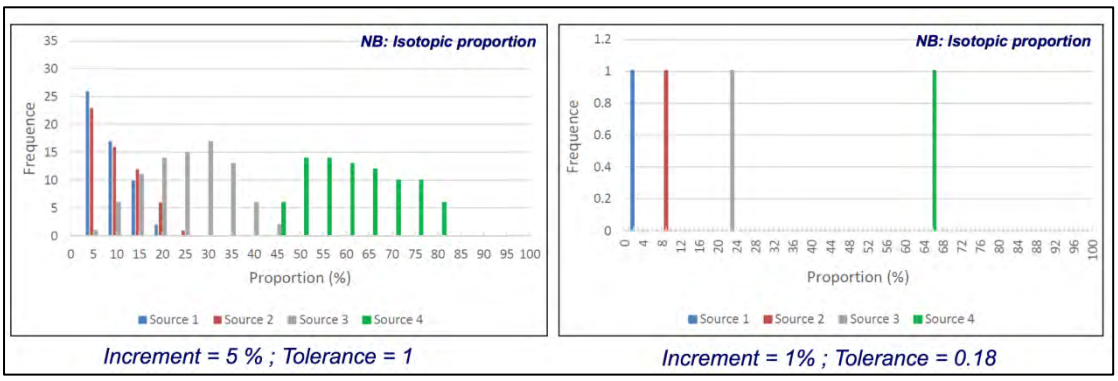

Figure 2. Isotopic proportion of the sources obtained with the IsoSource model (Raw data on the left side and computed data on the right side)

Using the isotopic proportion determined by the IsoSource model and the organic carbon content of each source allowed quantification of the different soil sources (see Gibbs, 2008). As recently suggested by Alewell et al. (2015), when available, it is recommended to use the abundance of the respective FAs for conversion into soil proportion.

Our preliminary results suggest that the agricultural fields i.e. sources 1, 2, 3 and 4 (i.e. the main grassed waterway of the sub-catchment) contributed ~~to~~ 4, 15, 26 and 55% to the sediment deposited at the catchment outlet, respectively.

This study, that will require further refinement and discussion, highlights that CSSI techniques and FRNs are complementary as fingerprints and tracers of land sediment redistribution. While in our study the ^{137}Cs technique provided information on the sedimentation magnitude at the outlet of the sub-catchment, CSSI techniques applied for FAs provided information about the origin of those sediments.

As climate change is expected to further accelerate soil erosion, a better understanding for reducing soil erosion and sedimentation-related agri-environmental problems represents a key requirement for mitigating the expected impact of climate change. Jointly applied, these isotopic techniques (i.e. CSSIs and FRNs) can provide key information for optimized decision-making to land managers to ensure the sustainability of agro-ecosystem management.

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Laser Carbon-13 and Nitrogen-15 Isotope Analysis for Greenhouse Gases now available at the SWMCNL

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Agriculture, forestry, and other land use (AFOLU), contribute 20-24% to the total anthropogenic emission of greenhouse gases (GHG) such as nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4). This contribution makes the AFOLU globally the largest emitting sector after energy, and even more important in developing countries (IPCC Fifth Assessment Report 2013-2014).

IPCC estimates annual GHG emissions (mainly CH_4 and N_2O) from agricultural production in 2000─2010 at 10─12% (5.0─5.8 $GtCO_2eq/yr$), and annual GHG flux from land use and land use change activities at 9─11% of global emissions (4.3─5.5 $GtCO_2eq/yr$). The same IPCC report indicates that a combination of supply-side and demand side options can reduce up to 80% the emissions from the sector by 2030.

To develop technologies for greenhouse gas emission reduction in agriculture, it is imperative to have the expertise and capability of measuring and tracing GHG to get further insights about their sources in soil. For this purpose, in 2015, the SWMCN Laboratory purchased two laser isotope analysers to measure the Carbon-13 and the Nitrogen-15 signatures of CO_2 and N_2O. The two new analysers are now being tested and calibrated under field and laboratory conditions, to offer training and analytical services to our Member States.

These activities are also linked to CRP D1.50.16 on "Minimizing farming impacts on climate change by enhancing carbon and nitrogen capture and storage in Agro-Ecosystems". The SWMCNL in Seibersdorf will play a key role in providing technical support in using stable isotopic technique of ^{15}N and ^{13}C at natural abundance to unveil the C-N interaction to optimise both C and N capture as well as to reduce GHG.

First specific protocols, using the ^{15}N-N_2O laser isotope analyser, are now being developed to assess the efficiency of the use of N process inhibitors mixed with urea fertilizer to reduce the emission of N_2O. N_2O fluxes are measured through the ^{15}N isotopic signature of the N_2O. In addition, first tests have been made to use the ^{13}C-CO_2 analyser in carbon dynamics studies (Figure 1). Besides these tests the ^{13}C-CO_2 analyser is also being used in the optimization of walk-in growth chamber based ^{13}C labelling of plant materials (Maize) (Figure 2). This analyser helps to stabilize the ^{13}C enrichment of the CO_2 in the growth chamber to ensure the homogeneity of the plant labelling. The ^{13}C-labelled material is then used in organic carbon decomposition studies to trace the source of CO_2.

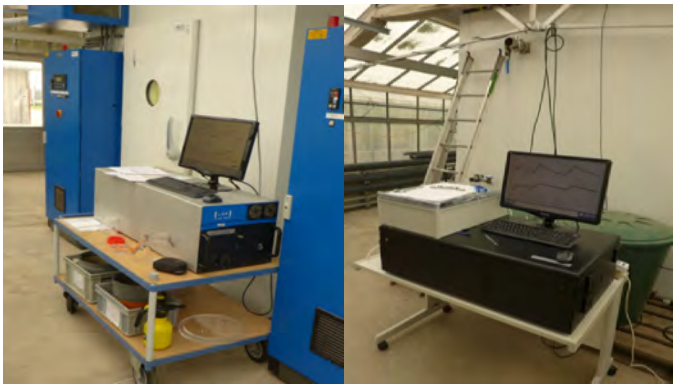

Figure 1. a. Nitrogen-15 N_2O laser isotope analyser for screening the efficiency of N process inhibitors in reducing N_2O emission from urea-fertilized applied to lysimeters in growth chamber (left); b. Controlling Carbon-13 enrichment of CO_2 in the growth chamber during Carbon-13 labelling of maize (right)

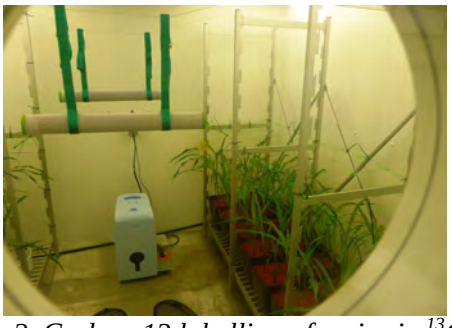

Figure 2. Carbon-13 labelling of maize in ^{13}C-CO_2 analyser controlled walk-in growth chamber at the SWMCN Laboratory

Using Cosmic-ray Neutron Probes to Monitor Soil Water Content at Landscape level

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The Cosmic-Ray Neutron Probe (CRNP), a passive and non-invasive method to monitor soil water contents in the top 50 cm and covers an area of about 40 hectares. After the first field calibration in 2013, further calibration was carried out using the method of Desilets et al. (2010) modified by Bogena et al. (2013). For this purpose, soil sampling were collected for gravimetric water content in July, August and October 2015 from a field site located at the Petzenkirchen research station of the Federal Agency for Water Management and the Technical University, Vienna. This field site is located about 100 km west of Vienna. These campaigns aimed to calibrate the soil water content (SWC) for different soil wetness and cropping patterns.

The N_0-method (gravimetric sampling) is a site-specific calibration parameter that depends mainly on the physio-chemical characteristics of the surroundings soil. The area wide-average soil moisture is used in the calibration which is obtained from a large number of soil samples collected within the footprint. Table 1 shows N_0 values of soil sampling carried out in 2013 and 2015. The N_0 values were higher at low gravimetric water content, indicating the importance of determining the N_0 for different SWC. In addition to a weather station and CRNP, (raw data available in real-time at http://cosmos.hwr.arizona.edu/Probes/StationDat/087/index.php), a network of Time-Domain Transmissivity (TDT) sensors were also installed within the CRNP measurement area to record hourly volumetric SWC.

At each site 4 TDT sensors were installed at 4 depths (0-5 cm, 5-10 cm, 15-20 cm, and 45-50 cm). The network TDT sensors were used to validate the CRNP observations of landscape SWC. Comparison of the daily data between the landscape TDT and CRNP showed that Root-Mean-Square-Error (RMSE) is in the same order of magnitude (~0.02 m^3/m^3) as the standard error of the mean of the TDT probes for each depth. In addition, two Time domain Reflectometry (TDR) campaigns were done in April 2014 over the CRNP footprint area which showed that volumetric SWC was similar to the values measured by CRNP (Figure 1).

TABLE 1. Calculated N_0 Obtained from the Independent Gravimetric Sampling in 2013 And 2015 at Petzenkirchen Research Station.

Date	N readings (MOD in COSMOS network)	Gravimetric water content (g/g)	Calculated N_0	Cropping pattern and stages
11-12 Dec. 2013	2008	0.274	1398	n.a.
2-3 July 2015	2146	0.217	1477	Barley (45%, maturity), maize (45%, stem elongation), and trees (forest; 10%)
27-28 Aug. 2015	2197	0.197	1700	Bare soil (45%), maize (45%, early maturity), and trees (forest; 10%)
28 Oct. 2015	2167	0.236	1659	Rape seed (45%), barley (30%, 2 leaf stage), bare soil (15%), and trees (forest; 10%)

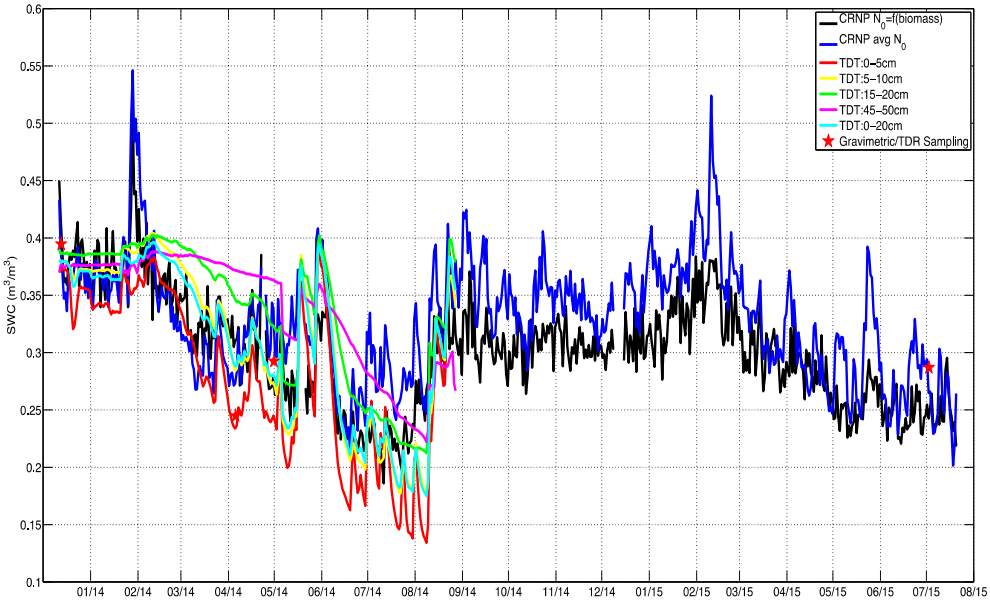

Figure 1. Time series of site average soil water content (SWC) of Time Domain Transmissivity (TDT) values by depth, SWC from the Cosmic-Ray Neutron Probe (CRNP), and independent gravimetric (12 December 2013) and Time Dain Reflectometry (TDR) sampling campaigns (5 and 30 April 2014) at Petzenkirchen research station.

This research is carried out under CRP D1.20.13 focusing on agricultural water management at field and area-wide scale, to develop a generic protocol for using CRNP in agricultural water management.

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Combined use of FRN and CSSI techniques: SWMCN Laboratory PICO experience during the European Geosciences Union (EGU) General Assembly 2015, Vienna, Austria

Technical Officers: L. Mabit [1], A. Toloza [1] and C. Resch [1]
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The European Geosciences Union (EGU) General Assembly 2015 that took place at the Austria Center of Vienna, from 12-17 April 2015, was a big success with 4870 oral, 8489 poster, and 705 PICO (Presenting Interactive COntent™) presentations as well as 11837 scientists attending from 108 different countries.

This year again, the activities of the SWMCN Laboratory were well represented with 3 PICO presentations during the SSS12.10 session (i.e. Soil and sediment tracing techniques for understanding environmental processes).

As defined by the EGU organisers, PICO is bringing the advantages of both, oral (‘‘*2-minutes-madness presentation*’’) and poster (through the PICO screens allowing extensive viewing of the short oral presentation), together into an innovative type of presentation which opens the opportunity to be interactive.

All details about the contributions from the SWMCN Subprogramme can be found in our list of publications at the end of this Newsletter. Additional information about EGU 2015 is available at the following website: http://www.egu2015.eu.

For your information, next EGU General Assembly will be held in Vienna from 17 to 22 April 2016.

Lionel Mabit on behalf of Dr. Benmansour (Morocco, CNESTEN) performing a PICO presentation about soil degradation in Morocco and its impact evaluated through isotope techniques

Online Food Safety Information System for Nuclear or Radiological Emergencies

Franck Albinet, Lazar Adjigogov, Gerd Dercon

Over the last year, the protocol with regards to data management and visualization requirements for food safety decision-making, developed under CRP D1.50.15 on "*Response to Nuclear Emergency Affecting Food and Agriculture*", was further implemented. The development team moved away from early series of disconnected prototypes to a more advanced Information System integrating both data management and visualization components outlined in the agreed protocol.

The Data Management component of the information system "realized" the vision developed by the CRP participants in terms of appropriate workflow: (i) assignments of roles, (ii) data collection tasks management (Figure 1), (iii) mobile data collection, (iv) data aggregation, and (v) data validation, analysis and sharing.

The Data Visualization component ensures that data flow smoothly from small to large scale and that analysts and decision makers gain valuable insights into the data by visualizing. In addition, a resource analysis tool was included (Figure 2). Through this tool, called "Log Map", decision-makers can optimize the use of the available resources, such as sample collectors and laboratories. It assists in having a direct overview of the implementation rate and efficiency of food sampling campaigns.

Both components have been integrated this last year providing an advanced prototype receiving growing attention from a variety of partners. This prototype will now be tested further by the CRP participants.

The objective of the targeted information system will integrate main actions to be taken further a nuclear or radiological emergency for assessing radionuclide concentrations in agricultural products (soil, water, fruit, vegetable, etc.) and ensuring food safety. The final system will assist in assigning sampling and analytical tasks to sample collectors and laboratories, provide geographic indications to the sampling sites including where to take samples, and what to take, and food restriction information.

The system is also envisaged to be adaptable to other emergency situations managing time-stamped and geo-referenced information, such as animal disease and plant pest emergencies.

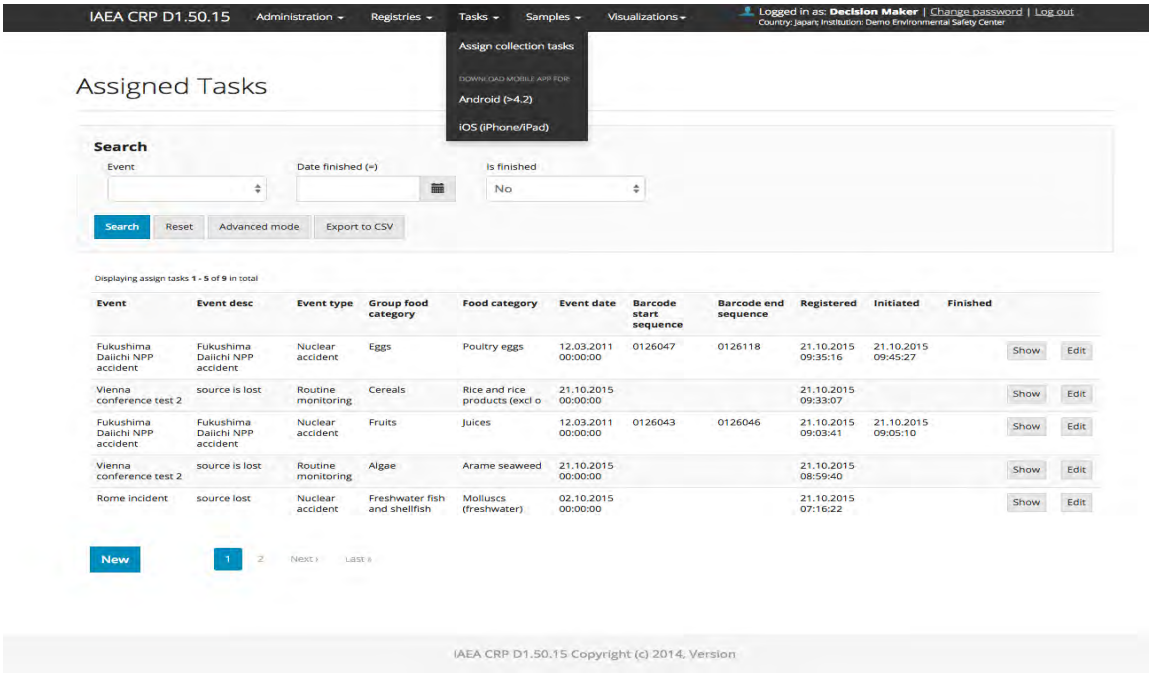

Figure 1. - General overview of platform user interface and task assignment view

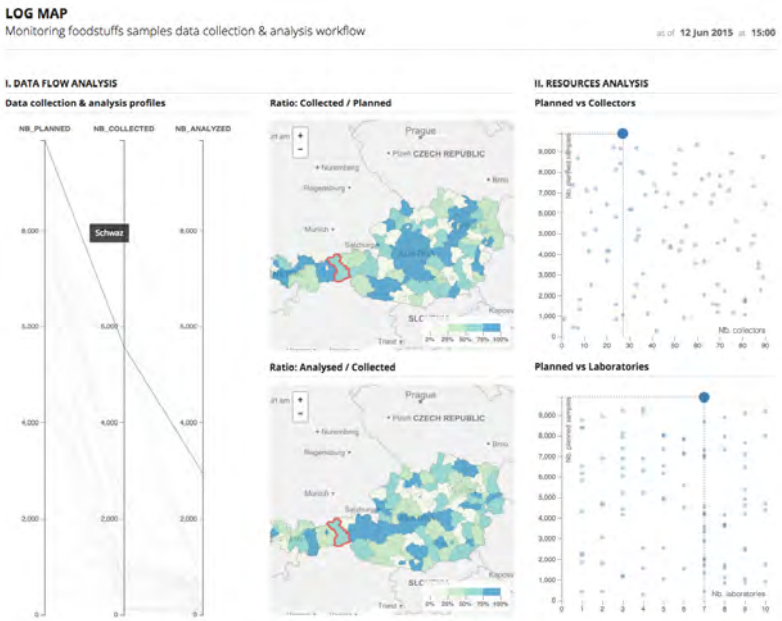

Figure 2. - Example of Log map monitoring data collection and analysis flows

Analytical Services

Christian Resch and Arsenio Toloza

In 2015, the Soil and Water Management & Crop Nutrition (SWMCNL) Laboratory analysed 2700 samples for stable isotopes and 180 samples for fallout radionuclides. These soil and plant samples were mainly from ongoing activities at the SWMCNL focusing on the design of affordable isotope and nuclear techniques to develop climate-smart agricultural practices. Analytical support for isotopic analyses was also provided to the Plant Breeding and Genetics Laboratory and Insect Pest Control Laboratory of the Joint FAO/IAEA Division, with 600 and 200 samples analyzed respectively.

External Quality Assurance: Annual Proficiency Test on ^{15}N and ^{13}C isotopic abundance in plant materials

Christian Resch

The worldwide comparison of stable ^{15}N and ^{13}C isotope analyses provides confidence in the performance of laboratories which measure stable isotopes of N and C in plant tissues. Hence, it is an invaluable tool for external quality control.

The 2015 Proficiency Test on ^{15}N and ^{13}C isotopic abundance in plant materials, organized by the University of Wageningen, in The Netherlands, and funded by the SWMCN Laboratory, has been successfully completed. The Wageningen Evaluating Programs for Analytical Laboratories (WEPAL, http://www.wepal.nl) is accredited for the organization of Inter-laboratory Studies by the Dutch Accreditation Council.

Every year, one ^{15}N-enriched plant test sample is included in one round of the WEPAL's International Plant-Analytical Exchange program. To accomplish this, a bulk amount of uniformly ^{15}N-enriched plant material is produced by the SWMCN Laboratory and sent to WEPAL for processing. The ^{15}N-enriched plant sample is sent together with three other plant tissue samples which are not enriched with ^{15}N. Participants are invited to perform analysis of any type offered in the WEPAL International Plant-Analytical Exchange (IPE) program, including ^{15}N (enriched and/or natural abundance), total N (N-elementary), Kjeldahl-N, ^{13}C and total C (C-elementary).

A special evaluation report for IAEA participants on the analytical performance in the stable isotope analysis is issued by the SWMCN Laboratory. This evaluation report is sent to the participants together with a certificate of participation. The participation fee for one round of analysis for each year is covered by the IAEA.

Participants registered in the program were provided with WEPAL test sample set, IPE 2015.2, which consisted of four samples, each sample containing 20 g of plant material. In total, 13 stable isotope laboratories participated in this round, including laboratories in Africa (Morocco), Asia (Pakistan and The Philippines [2 laboratories]), Europe (Austria, Belgium and Germany), South America (Argentina, Brazil [2 laboratories], Chile and Uruguay) and the South Pacific (New Zealand).

Nine out of 11 laboratories participating in the N analysis reported ^{15}N-data within the control limits for the enriched plant sample (Figure 1). Nine out of 10 participating laboratories in the C analysis reported ^{13}C isotopic abundance results within the control limits (Figure 2).

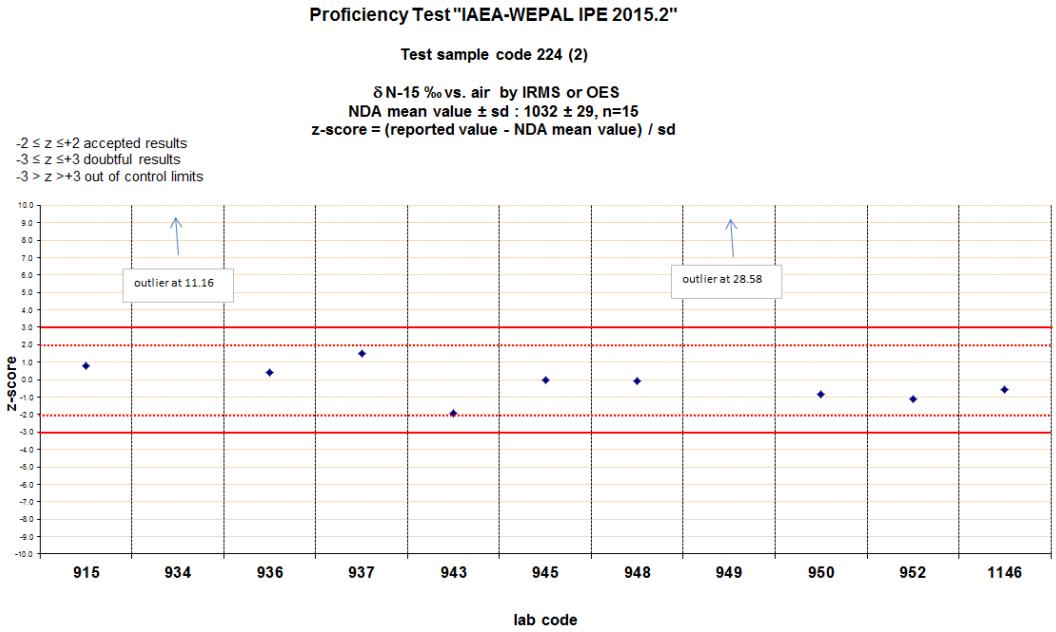

Figure 1: Z-score evaluation of the ^{15}N analysis

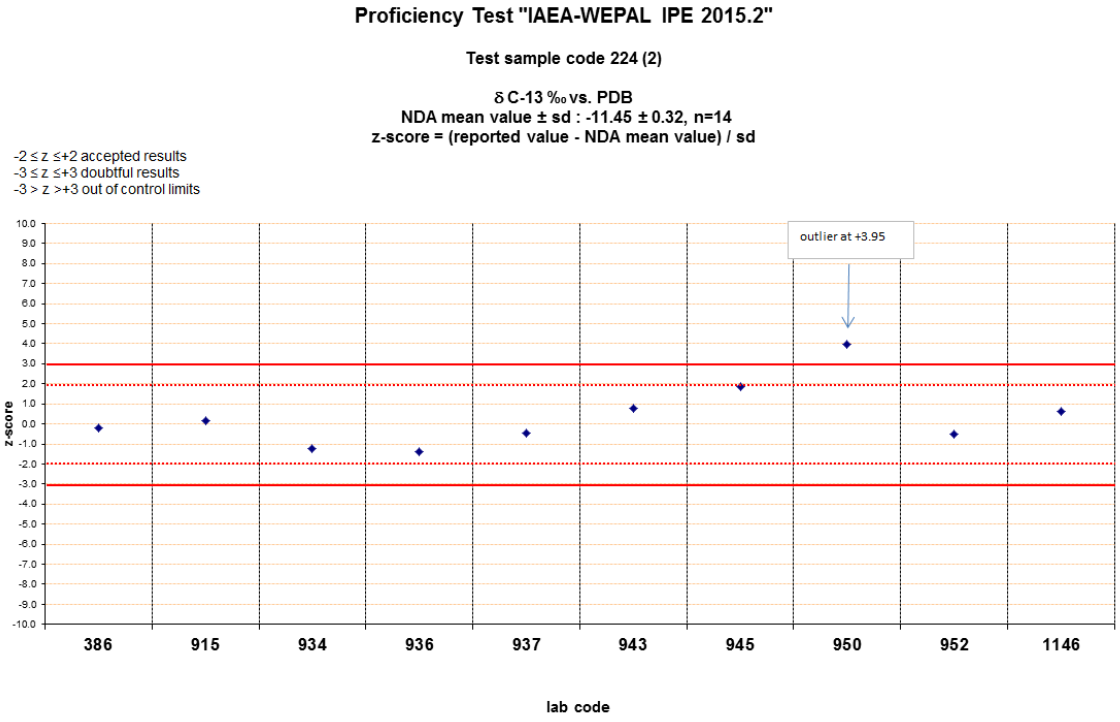

Figure 2: Z-score evaluation of the ^{13}C analysis

"Supporting Sampling and Sample Preparation Tools for Isotope and Nuclear Analysis"

This FAO/IAEA publication on Standard Operating Procedures (SOP) was developed to provide illustrated, step by step, comprehensive guidance for sampling and processing of soil, water and plant materials. It assists scientists, technicians and students in implementing procedures and tools to take and prepare samples for isotope and nuclear analysis. Member States require this step-by-step guidance to develop climate-smart agricultural practices for improved soil, water and nutrient management and to prepare and respond to nuclear emergency in food and agriculture. This SOP is expected to be available in early 2016.

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Impressum

Soils Newsletter Vol. 38, No. 2, Jan 2016

The Soils Newsletter is prepared twice per year by the
Soil and Water Management & Crop Nutrition Section,
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and
FAO/IAEA Agriculture & Biotechnology Laboratory, Seibersdorf.

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, February 2016

16-01531