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Nuclear Techniques in Food and Agriculture

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To Our Readers

Save soil for future generations: awareness rising bracelet from FAO's 'Global Symposium on Soil Erosion', 15-17 May, Rome

I am pleased to report that the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture through the Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme co-organized the Global Symposium on Soil Erosion (GSER19), with FAO, the Intergovernmental Technical Panel on Soils (ITPS), the United Nations Convention to Combat Desertification Science-Policy Interface (UNCCD-SPI) in Rome, Italy recently. Lionel Mabit from the SWMCN Laboratory represented the Joint Division at the symposium, which aimed to bring science and policy together to review the status and challenges of soil erosion control for insuring food security and ecosystem services to fulfil the planned achievement of Sustainable Development Goals. The Joint Division also organized a side event on 'Soil erosion assessment: Making a difference with nuclear and isotopic techniques' at the Symposium to highlight the effectiveness of these techniques in evaluating soil erosion magnitude and in identifying the sources of sediments. This side event presented state-of-the-art nuclear and isotopic tools used to investigate soil erosion and recent methods development. Success stories from three colleagues from African Member States (Madagascar, Morocco and Zimbabwe) were also presented. The side-event generated great interest and positive feedback from the participants with more than 50 people attending.

A consultant's meeting was organized in February to develop a new coordinated research project (CRP) on "Assessing radionuclide uptake and dynamics for better remediation of radioactive contamination in agriculture", to replace the recently completed CRP D1.50.15 on 'Response to Nuclear Emergency affecting Food and Agriculture'. For the next 6 months, there will be another consultant's meeting to develop a new CRP on phase two of the greenhouse gas work, and four research coordination meetings (RCMs), these are two first RCMs D1.50.19 'Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture', and D1.20.14 'Enhancing agricultural resilience and water security using Cosmic-Ray Neutron Sensor', third RCM D1.50.17 'Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-Ecosystems' and final RCM D1.20.16 'Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems'.

Several guidelines were published these last six months, this includes the Springer book on 'Assessing Recent Soil Erosion Rates through the Use of Beryllium-7 (Be-7)', which is the first comprehensive guideline that presents and demonstrates the unique traits of the cosmogenic fallout radioisotope beryllium-7 (Be-7) and its use as a short-term soil redistribution budgeting tool in agricultural landscapes. Two other guidelines published were 'Sample Preparation of Soil and Plant Material for Isotope Ratio Mass Spectrometry (IAEA-TECDOC 1870)', and 'Use of Laser Carbon Dioxide Carbon Isotope Analysers in Agriculture (IAEA-TECDOC 1866)', the latter was highlighted on IAEA website: https://www.iaea.org/newscenter/news/new-iaea-publication-use-of-laser-carbon-dioxide-carbon-isotope-analysers-in-agriculture. Both guidelines provide step-by-step and easy-to-follow protocols on their uses.

Similarly, an article was published in FAO's EMPRES Information Sheet on the work relating to 'Decision Support System for Nuclear Emergencies Affecting Food and Agriculture' (DSS4NAFA), which was developed under CRP D1.50.15 on 'Response to nuclear Emergencies Affecting Food and Agriculture'. DSS4NAFA is a cloud-based decision support system to manage large volumes of spatial and temporal data, real-time information processing and visualization, and enhanced aid to response actions and decision-making in case of a nuclear or radiological emergency.

We welcome our visitors and new comers to the SWMCN Sub-programme. Mr Tetsuya Eguchi, from Japan, joined the SWMCN Laboratory as a visiting researcher in May 2019 for 23 months. He will be working on soil mineralogy and its influence on the behavior and interaction between ammonium, potassium, and radioactive caesium using the 15N technique. Ms Mathilde Vantyghem from Belgium joined the SWMCN Laboratory as a PhD-consultant in May 2019, under the recently started Peaceful Uses Initiative Project on "Enhancing Climate Change Adaptation and Disease Resilience in Banana Coffee Production Systems in East Africa", funded by the Belgian Government. Ms Ding Yang joined the SWMCN Laboratory in June 2019 for an eleven-month FAO internship. She will be working on the application of stable isotopes (^{13}C and ^{15}N) for monitoring greenhouse gas emission and carbon sequestration in soil, and on the use of radionuclide techniques for assessing erosion rates. Mr Hami Said Ahmed, from Djibouti, joined the SWMCN Laboratory in June 2019 as the new Technical Officer in agricultural water management. Hami will be providing technical expertise and support through applied and adaptive research and development relating to agricultural water management using isotopic/nuclear techniques.

I would like to take this opportunity to thank all our readers for their continuous support.

Lee Heng
Head
Soil and Water Management and
Crop Nutrition Section

Staff

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

Name	Title	Email	Extension	Location
Qu LIANG	Director	Q.Liang@iaea.org	21610	Vienna

Soil and Water Management and Crop Nutrition Subprogramme

Name	Title	Email	Extension	Location
Lee Kheng HENG	Section Head	L.Heng@iaea.org	26847	Vienna
Mohammad ZAMAN	Soil Scientist	M.Zaman@iaea.org	21645	Vienna
Emil FULAJTAR	Soil Scientist	E.Fulajtar@iaea.org	21613	Vienna
Joseph ADU-GYAMFI	Soil Fertility Specialist	J.Adu-Gyamfi@iaea.org	21693	Vienna
Janine HALDER	Isotope Hydrologist	J.Halder@iaea.org	26844	Vienna
Marlies ZACZEK	Team Assistant	M.Zaczek@iaea.org	21647	Vienna
Ksenija AJVAZI	Team Assistant	K.Ajvazi@iaea.org	21646	Vienna
Gerd DERCON	Laboratory Head	G.Dercon@iaea.org	28277	Seibersdorf
Lionel MABIT	Soil Scientist	L.Mabit@iaea.org	28677	Seibersdorf
Maria HEILING	Senior Laboratory Technician	M.Heiling@iaea.org	28272	Seibersdorf
Christian RESCH	Senior Laboratory Technician	C.Resch@iaea.org	28309	Seibersdorf
Georg WELTIN	Senior Laboratory Technician	G.Weltin@iaea.org	28258	Seibersdorf
Arsenio TOLOZA	Laboratory Technician	A.Toloza@iaea.org	28203	Seibersdorf
Roman GRUBER	Laboratory Technician	R.Gruber@iaea.org	28258	Seibersdorf
Norbert JAGODITSCH	Laboratory Attendant	N.Jagoditsch@iaea.org	28406	Seibersdorf
Joanna M. MLETZKO	Team Assistant	J.Mletzko@iaea.org	28362	Seibersdorf
Sergey FESENKO	Consultant	S.Fesenko@iaea.org	28269	Seibersdorf
Amelia LEE ZHI YI	Consultant	A.Lee-Zhi-Yi@iaea.org	28576	Seibersdorf
Tetsuya EGUCHI	Visiting Researcher	T.Eguchi@iaea.org	28576	Seibersdorf
Mathilde VANTYGHEM	Consultant	M.Vantyghem@iaea.org	28576	Seibersdorf

Soil and Water Management and Crop Nutrition Section
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Vienna International Centre, P.O. Box 100, A-1400 Vienna, Austria
Telephone: (+43 1) 2600+Extension; Fax (+43 1) 26007

Soil and Water Management and Crop Nutrition Laboratory
FAO/IAEA Agriculture and Biotechnology Laboratories, A-2444 Seibersdorf, Austria
Telephone: (+43 1) 2600+Extension; Fax (+43 1) 26007

Soil and Water Management and Crop Nutrition Subprogramme

			
L.K. Heng	**M. Zaman**	**E. Fulajtar**	**J. Adu-Gyamfi**
			
J. Halder	**M. Zaczek**	**K. Ajvazi**	**G. Dercon**
			
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N. Jagoditsch	**J.M. Mletzko**	**M. Vanthygem**	**S. Fesenko**

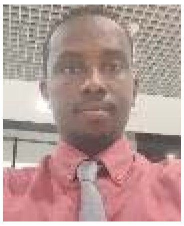
Staff News

Sergey Fesenko (Russian Federation) joined the SWMCNL in February as a consultant. His assignment is to contribute to the development of guidelines for emergency and routine sampling and radioactivity measurement of foodstuff. Sergey also supports the implementation of laboratory R&D activities on the dynamics of radionuclides in food and agriculture. Sergey is the research deputy director of the Russian Institute of Radiology and Agroecology. His field of research relates to the mitigation of impacts of radiation accidents (e.g. Kyshtym, Chernobyl and Fukushima). From 2004 to 2017, Sergey worked at the IAEA, within this period, he published fifteen documents on environmental monitoring, environmental impact assessment and remediation. He was awarded the State Prize of the Russian Federation in 2002 and the IAEA Superior Achievement Award in 2017.

Tetsuya Eguchi (Japan) joined the SWMCN Laboratory in May as a visiting researcher from the National Agriculture and Food Research Organization (NARO), Japan for 23 months. Tetsuya will be working on soil mineralogy and its influence on the behavior and interaction between ammonium, potassium, and radioactive caesium using the ^{15}N technique. His work falls under the new Coordinated Research Project D1.50.19 on “Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture” and the Practical Agreement between the Joint FAO/IAEA Division and NARO, Japan. Tetsuya obtained his Ph.D. degree in Agriculture, focusing on soil science from the University of Tsukuba, Japan. He is a researcher at the Agricultural Radiation Research Center of NARO. His research focus has been on the influence of soil-clay mineralogy on the effectiveness of potassium application as a countermeasure to reduce the radioactive caesium uptake by crops, the diagnosis of soils with high radioactive caesium availability for crops, and the remediation of agricultural fields in Fukushima and surrounding areas by application of natural potassium-bearing minerals.

Yang Ding (China) joined the SWMCN Laboratory in June 2019 as an intern. Yang is a fresh graduate in Microbiology Geochemistry from Peking University, China. She will be working on the application of stable isotopes (^{13}C and ^{15}N) for monitoring greenhouse gas emission and carbon sequestration in soil, and on the use of radionuclide techniques for assessing erosion rates. This opportunity of working on greenhouse gas emission, carbon sequestration and soil erosion within the FAO/IAEA Joint Division will bring her many valuable practical experiences and help her better understand these challenges.

Mathilde Vantyghem (Belgium) joined the SWMCN laboratory as a PhD-consultant in May, under the recently started Peaceful Uses Initiative Project on "Enhancing Climate Change Adaptation and Disease Resilience in Banana Coffee Production Systems in East Africa”, funded by the Belgian Government. She graduated last year from the University of Leuven, Belgium, as a Bioscience Engineer and now enrolled in the PhD-program of that same university. For her MSc thesis research, she focused on Enset, a highly important staple crop in Ethiopia, also referred to as ‘false banana’. After graduating, she continued working on banana during an internship with the International Institute of Tropical Agriculture (IITA) in Rwanda. Building on this experience, in her PhD she will concentrate on the use of stable isotopes (Carbon-13 and Oxygen-18) to evaluate water-use efficiency in intercropped coffee-banana systems, with particular focus on Tanzania. Aside from the work done in Seibersdorf, fieldwork will be carried out at the Nelson Mandela African Institution of Science and Technology in close collaboration with the International Institute of Tropical Agriculture in Arusha, Tanzania.



Hami Said (Djibouti) joined the SWMCN Laboratory in June as the new FAO P3 Technical Officer in agricultural water management. Mr. Hami Said Ahmed holds a PhD in Soil Science from Université D'Orléans in France, a M.Sc in Soil Science and Environmental Management and Agriculture from Université De Pierre Marie Curie Paris 6 (UMPC) in France and a M.sc in Biotechnology from Université de Lille 1 in France. Hami will be providing technical expertise and support through applied and adaptive research and development relating to agricultural water management using isotopic and nuclear techniques.

Feature Articles

Practical Applications of the Cosmic-Ray Neutron Sensor Soil Water Content Data For Estimating Area-Average Rainfall And Root Zone Storage

Franz, T.[1], *Wahbi, A.*[2]

[1] *School of Natural Resources, University of Nebraska-Lincoln, USA*
[2] *Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Vienna, Austria*

Introduction

The Cosmic-Ray Neutron Sensor (CRNS) technique for estimating area-average soil water content (SWC) is now a decade old and has established practical methodology for measurements, detection area, detection depth, installation, calibration, and validation of stationary and mobile applications (see TECDOC 1809 & 1845 and Figure 1). However, the relevance and practical uses of the CRNS technique to estimate both water flux (i.e. rainfall, deep percolation, evapotranspiration) and root zone storage changes require supporting products which need to be developed for further utilization of the technique in hydrology, ecology, and agronomy. In particular, simple methods to estimate daily SWC values at mean areal scales for decision makers and stakeholders interested in utilizing this technique. Moreover, estimating mean areal values are necessary for more comparable comparisons with remote sensing products and further refinement of their algorithms. While remote sensing has made significant progress in recent years, significant gaps in space and time observations still exist (McCabe et al. 2017). In particular, estimates of daily rainfall and root zone soil moisture at 1 to 10 ha field scale remain elusive and impractical with current and planned satellite missions. With the limitation of satellites to directly estimate root zone water storage, indirect methods using a combination of satellites, ground sensors like CRNS, and models are needed for the practical use of their data products.

In preparation for the upcoming RCM of CRP (D1.20.14) ‘Enhancing Agricultural Resilience and Water Security Using Cosmic Ray Neutron Sensor’, the authors explored the use of three well established algorithms to enhance the societal relevance of the CRNS data. The results are summarized here but will be presented in the future as a scientific article and book. The three algorithms aim to: 1) temporal smoothing of neutron intensity and SWC time series, 2) estimate a daily rainfall product using the SM2RAIN algorithm, and 3) estimate a daily root zone SWC product using an exponential filter algorithm. Figure 2 summarizes a flowchart of the various data sources, algorithms, and value-added products. The algorithms were tested on the CRNS site established in 2013 at the Hydrological Open Air Laboratory (HOAL) experiment in Petzenkirchen, Austria (Bloschl et al. 2016). Independent observations of rainfall and SWC data (using Time-Domain Transmissivity (TDT)) at HOAL were used to calibrate and validate the algorithms.

Temporal Filtering of CRNS Data

Due to the inherent counting statistics, plots of hourly neutron counts and SWC from CRNS appear noisy with non-physical up and down fluctuations around a mean value (Figure 3). In order to produce a smoothed more physically meaningful time series, a temporal filter was applied to the neutron data. Here a third order Savitzky-Golay (SG) filter with 25 hourly data points was selected to increase the precision of the data without distorting the signal tendency. The reason the SG filter was selected is that it nicely balances smoothing without distorting the sharp decrease in neutron counts following a rain event. The upper panel of Figure 3 illustrated the hourly corrected neutron counts (black dots) and SG filtered neutrons counts (red line) at the Petzenkirchen site. The lower graph illustrated the daily observed rainfall time series. From Figure 3 the connection between rainfall events and sharp decrease in neutron count rates is evident. Also note that for periods between rainfall events a steady increase in neutron counts was observed as more water was being transported to the atmosphere and soil via soil evaporation and plant transpiration.

Estimation of Mean Areal Rainfall Using SM2RAIN Algorithm

Given the challenge of estimating area-average rainfall from ground-based observations and top down approaches using satellites, additional sources of rainfall data are greatly needed. One well established approach is the soil moisture to rain (SM2RAIN) algorithm (http://hydrology.irpi.cnr.it/research/sm2rain/ (Brocca et al. 2014). SM2RAIN assumes that the soil acts like a bucket and that measurements of SWC can be inverted to estimate rainfall from a bottom up approach, using the SM2RAIN algorithm with CRNS SWC data and rain gauge observations, Figure 4 compares the daily rainfall data at Petzenkirchen. The rainfall observations are used to select the 3 free parameters used by SM2RAIN. At the daily level, a correlation of 0.775 is found for the study site and is comparable to other studies (Brocca et al. 2014).

Estimation of Root Zone Soil Water Content Using an Exponential Filter

A common problem with remotely sensed SWC data is that only the near surface (~0-3 cm) is directly observed using microwave and radar wavelengths. In order for these satellite products to be useful, SWC storage must be extrapolated across a plant root zone. This extrapolation can be accomplished in a number of ways using simple linear interpolation to a full data assimilation approach using a physically based water and energy balance model. However, given the computational demands, lack of boundary conditions, initial conditions, and model parameters this approach can be challenging. A fairly simple method to do root zone SWC extrapolation uses the idea of an exponential filter to solve for the time delay between surface soil response and deeper soils. The exponential filter has been used with great success for remote sensing products, in-situ point scale networks, and recently CRNS (Peterson et al. 2016). The exponential filter model considers the water balance model of a two-layer soil profile. Layer 1 has historically been set to the depth of the remote sensing product (0-3 cm) or here the CRNS (0-20 cm). Layer 2 has been set to a root zone depth around 1 to 2 m depending on vegetation type, local soil depths, and local SWC data for calibration. Using the CRNS SWC data as layer 1 and the SWC TDT profile data from 0-30 cm and 0-60 cm data as layer 2, the 3 free parameters for the exponential filter model were estimated. Following calibration, an operational daily SWC product for 0-30 cm and 0-60 cm can be produced. Figure 5 illustrates the CRNS SWC, 0-30 cm SWC, and 0-60 cm SWC exponential filter products. By tracking soil water storage and changes over these depths in real-time stakeholders will be able to make more informed decisions about irrigation and fertilization rates.

Future Directions and Technology Transfer to Member States

The upcoming scientific article and book will provide background, example calculations, and computer code from the Petzenkirchen CRNS study site using three well established algorithms (Figure 2). The algorithms make the essential step of enhancing the CRNS SWC data for providing stakeholders with the value-added products of a smoothed SWC time series, mean areal rainfall, and root zone SWC data in order to make decisions. While the provided examples were written in a computer program mostly used by engineers and academics, next steps require the data and supporting products to be made available on web-based data portals and smartphone applications for use by member states and their stakeholders. This development process and maintenance will require interdisciplinary collaboration between earth scientists, agricultural scientists, CRNS experts, computer programmers, graphic designers, and stakeholders to provide a working, functional, and useful system. The CRP D1.20.14 will continue to develop and enhance these value-added products from the CRNS technique.

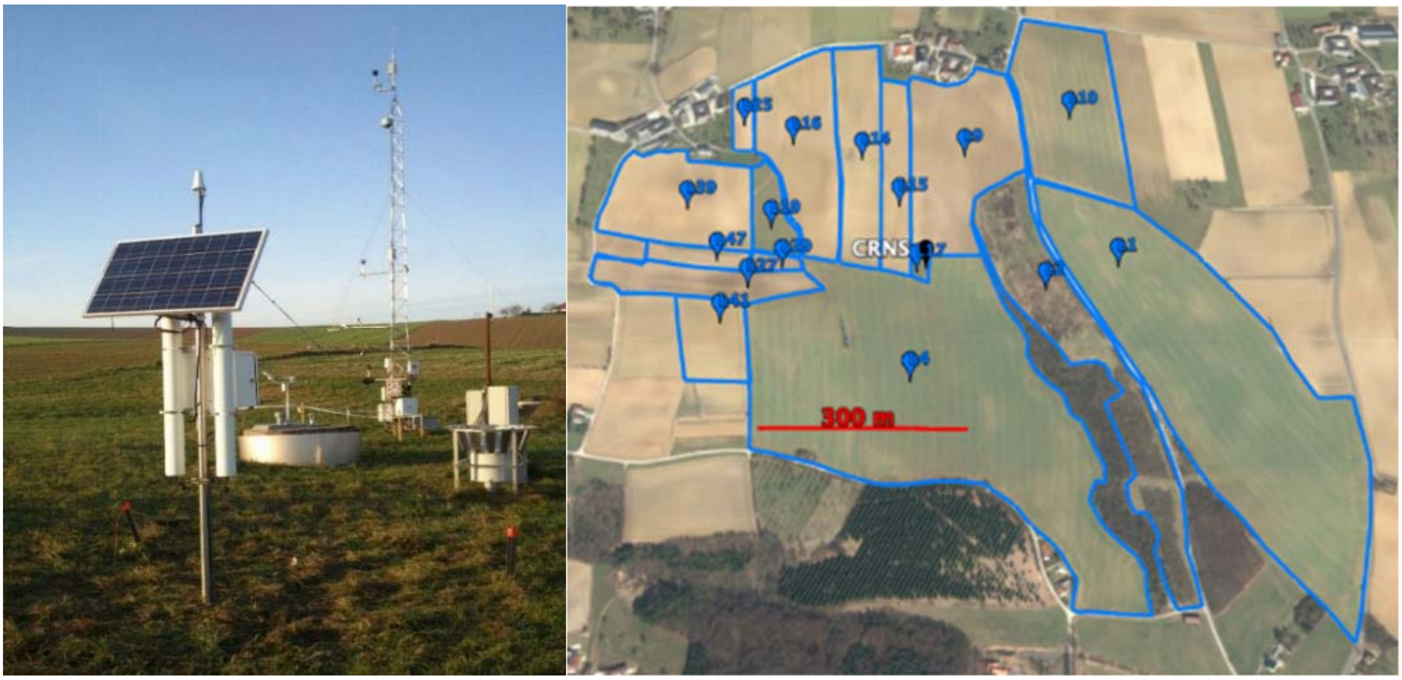


Figure 1. Location of the CRNS within a mixed agricultural land use area at Petzenkirchen, Austria as part of the Hydrological Open Air Laboratory (HOAL) experiment . CRNS collocated with a weather station, eddy covariance tower, and temporary TDT SWC distributed network (See Bloschl et al. 2016 and Franz et al. 2016 for more details).

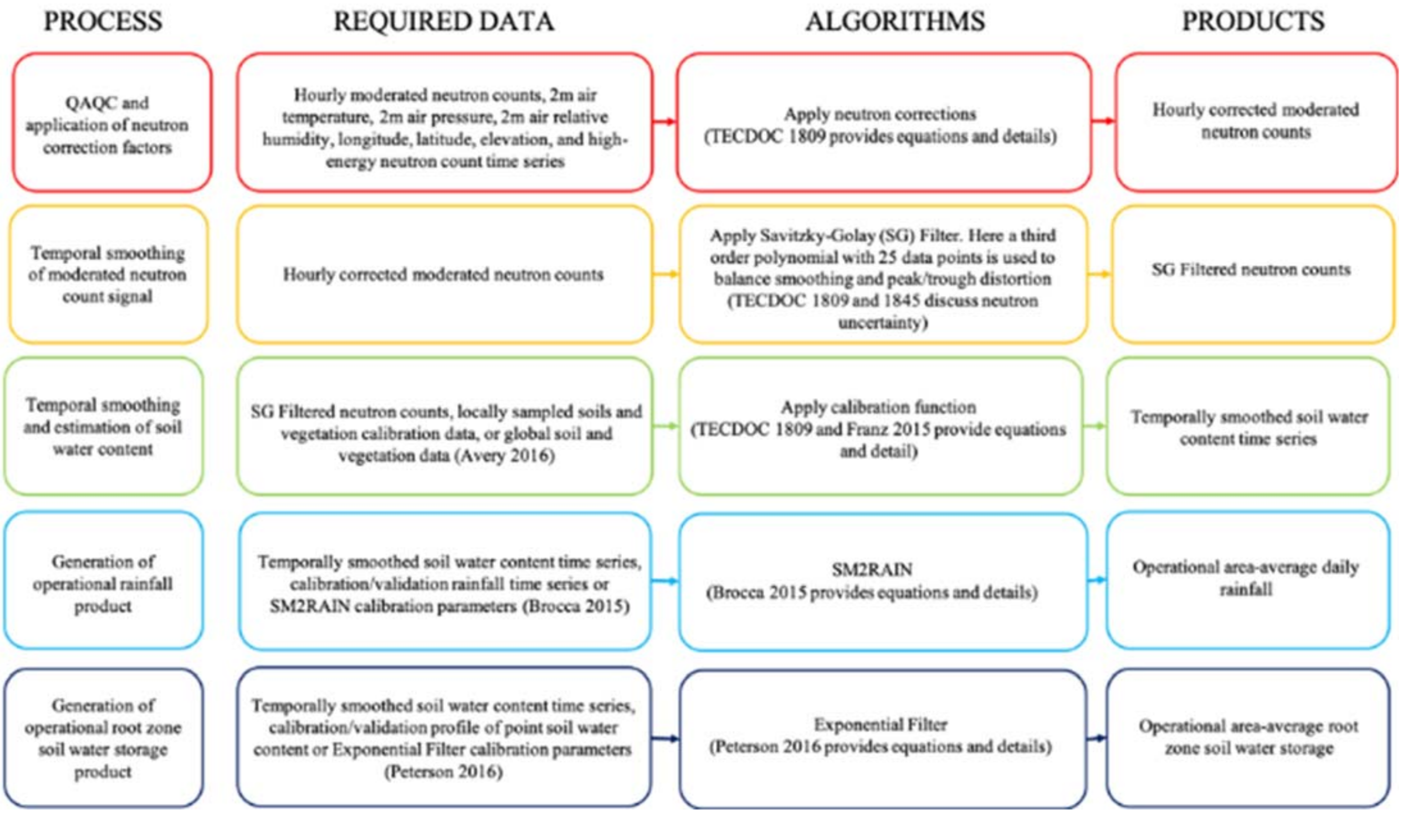


Figure 2. Flowchart describing the different processes, required data, algorithms, and products using CRNS data from Petzenkirchen, Austria. See Figure 3 to 5 for summary of results.

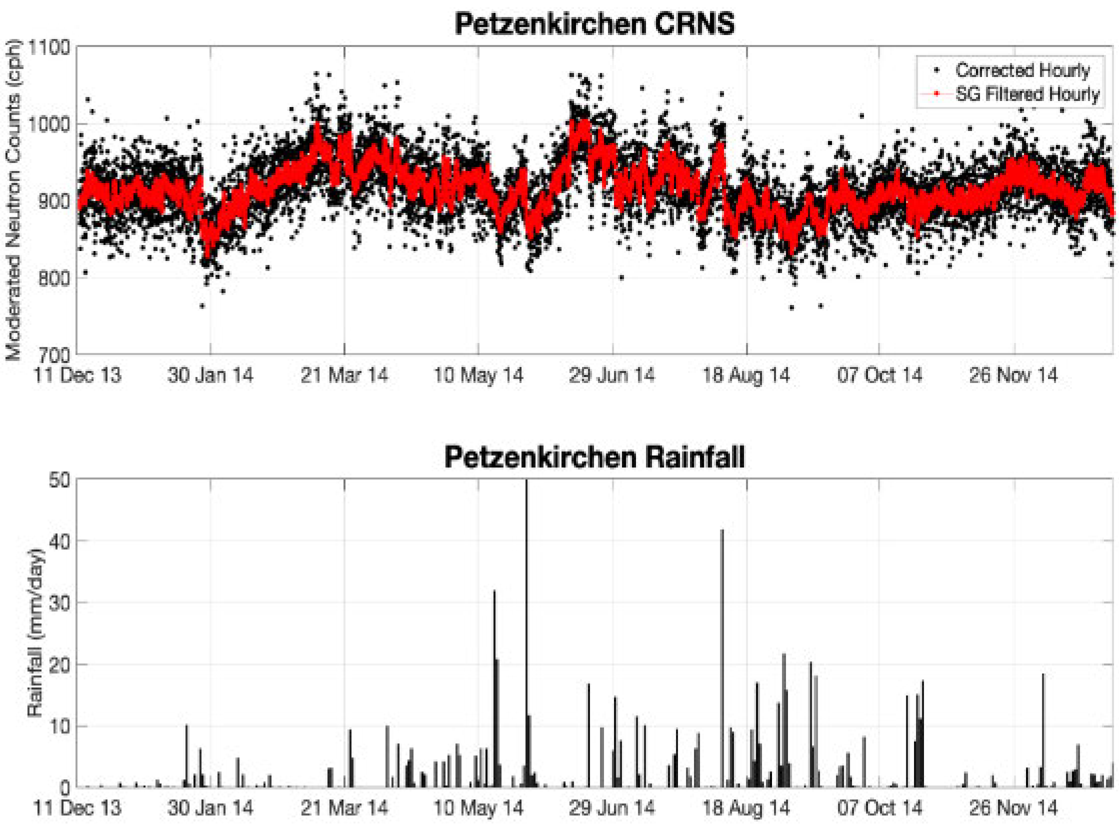


Figure 3. Time series of corrected neutron counts (black dots), SG filtered neutron counts (red line) and daily rainfall time series (lower panel). The SG filter successfully smooths the neutron counts with minimal trough distortion due to rapidly occurring rainfall event.

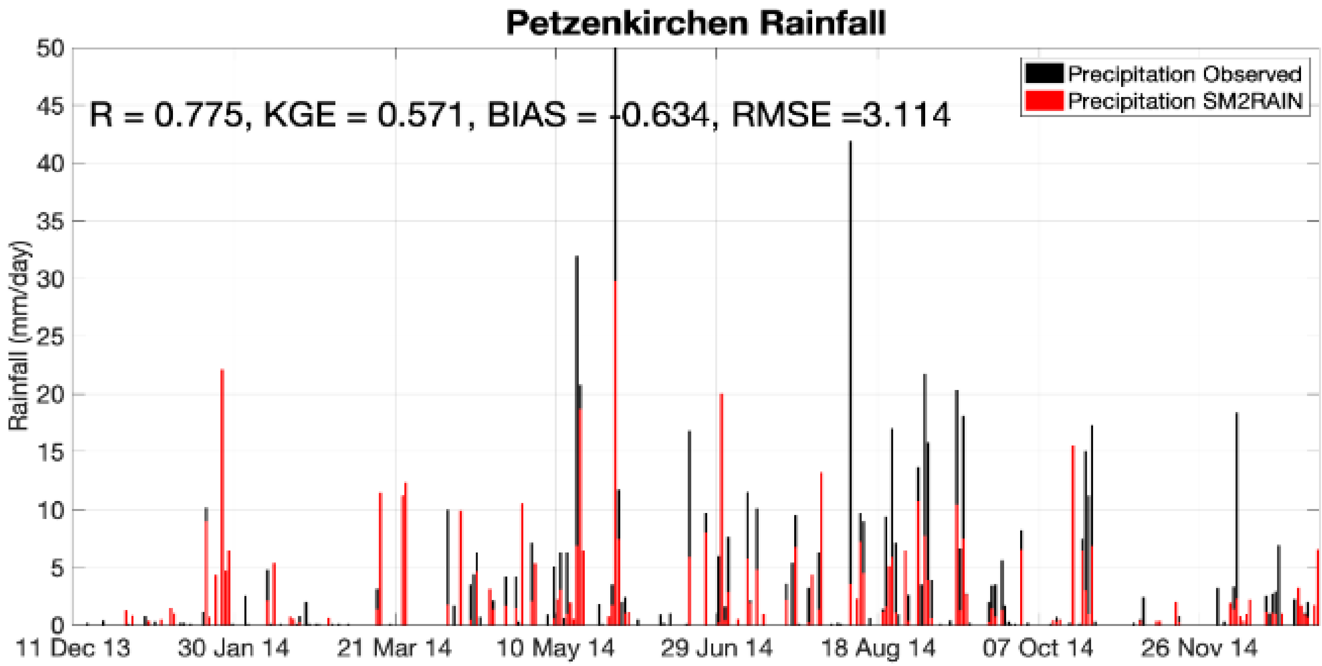


Figure 4. Time series of Petzenkirchen daily rain gauge observations and SM2RAIN algorithm using the CRNS SWC data. A correlation of 0.775 is comparable to other studies of rainfall at the daily level (see Brocca 2014).

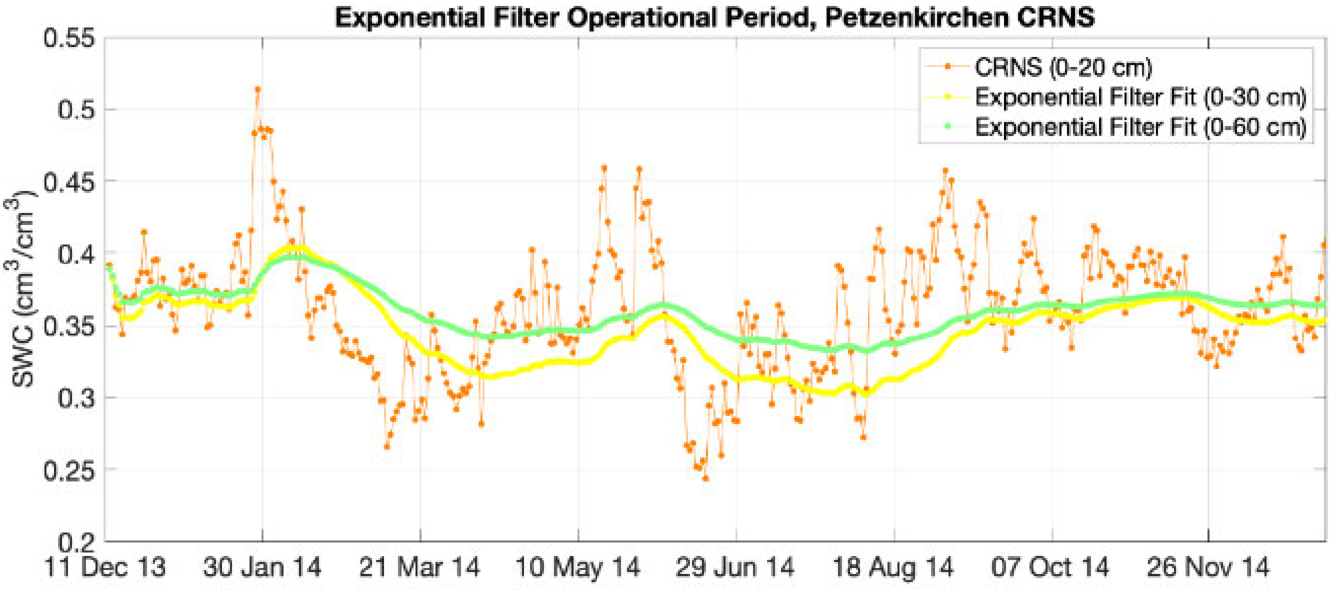


Figure 5. Time series of SWC for CRNS, 0-30 cm exponential filter product, and 0-60 cm exponential filter product for 2013 to 2018.

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A new method of ammonia (NH_3) measurement

Urquiaga, S.[1], Martins, M.R.[1], Jantalia, C.P.[1], Araujo, E.S.[1], Alves, B.J.R.[1], Boddey, R.M.[1], Zaman, M.[2]

[1]*Embrapa Agrobiology, Seropedica, Rio de Janeiro State, Brazil*
[2]*Soil and Water Management & Crop Nutrition, Joint FAO/IAEA Division of Nuclear Techniques in Food & Agriculture, Vienna, Austria*

1. The Challenge

Urea fertiliser accounts for >50% of the total world N consumption; however, urea has been shown to have lower N use efficiency in many cropping and pasture systems compared to other N fertilizers, meaning that a large percentage of the applied fertilizer N is not being used for productive purposes and is essentially lost (Blennerhassett et al. 2006; Zaman et al., 2008;). After surface application, urea fertiliser or urea in animal manure, is quickly converted to ammonium (NH_4^+) within 1 to 2 days of their application leading to a high pH and very high concentrations of NH_4^+ around the urea granule or manure. The sharp rise in soil pH and NH_4^+ concentration around urea granule/manure increases the likelihood of gaseous ammonia (NH_3) losses to the atmosphere. A wide range of NH_3 losses (10% to 56% of the applied N) have been reported under different agroecosystems (Zaman et al., 2013). Such heavy NH_3 losses have both environmental and economic implications. For example, emitted NH_3 causes environmental problems like eutrophication and soil acidification upon deposition on water and soil, respectively. Additionally, NH_3 acts as a secondary source of a powerful greenhouse gas nitrous oxide (N_2O) and thus contributes indirectly to global warming.

Limited field studies have been conducted to measure NH_3 losses worldwide due to the lack of inexpensive and low-tech measuring technique. Many sophisticated methods, such as wind tunnels, cavity ring down spectroscopy and micrometeorological techniques, are already available, but these are expensive and require highly-skilled field technicians to operate. This makes them inaccessible for many developing countries and institutions that want to measure and know the level of NH_3 losses under different agricultural systems.

2. The Study

To develop a low-cost and a robust method for NH_3 measurement, experiments under controlled and field conditions were conducted at the Experimental Station of Brazilian Agricultural Research Corporation (Embrapa Agrobiology) as part of the Coordinated Research Project (CRP) D1.50.16 "Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agroecosystems". After several field and lab testing, a simple NH_3 chamber, made of plastic bottle (Figure 1), was designed by the Brazilian scientists in collaboration with Soil and Water Management & Crop Nutrition Section, Joint FAO/IAEA Division of Nuclear Techniques in Food & Agriculture, Vienna, Austria. The chamber is made by removing the bottom of a large soda bottle and reattaching it to the open top of the bottle. This shields a thin strip of foam that runs along the inside of the bottle from the mouth down to a small plastic cup anchored to the soil with three metal prongs. This foam is presoaked in an acid solution that traps NH_3-N.

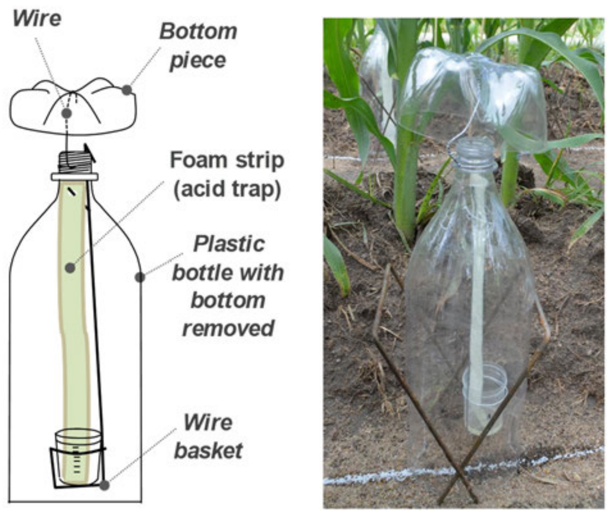

Figure 1. A view of the simple open chamber used to measure NH_3 volatilization. Details of this chamber were described by Araujo et al. (2009) and Jantalia et al. (2012).

3. The Technique

The isotopic technique of ^{15}N was used to test and confirm the accuracy of the newly made chamber method. The ^{15}N-labeled urea was surface-applied to lysimeters installed in the space between maize rows. Open chambers made of PET (polyethylene terephthalate) bottles (Figure 1) were installed on each lysimeter with four different rates of N application, three different distances of the chamber to the soil surface, and with or without relocation of the chamber (static *vs.* dynamic) during the monitoring period. Reference lysimeters without the chamber were used to measure NH_3 losses by ^{15}N-balance (Figure 2).

4. Major Outputs

The NH_3-N losses attained more than 50% of the applied N as determined by the ^{15}N-balance and proportional results were obtained using the chamber technique (Figure 3). The relocation of the chamber had no impact on its NH_3-trapping efficiency, proving to be an unnecessary procedure. On the other hand, our results indicated that the farther the chamber was above the soil surface, the lower the capture of NH_3 by the chamber, but the agreement with the ^{15}N reference method was preserved with values of R^2 higher than 0.98 (Figure 3).

When the position of the chamber was changed as described originally by Araujo *et al.* (2009), that is, static and touching the soil surface, a trapping efficiency of 60% was observed considering the ^{15}N technique as the absolute reference. In other words, a correction factor of 1.66 would be necessary to estimate real NH_3 losses using the chamber. These results are similar to the NH_3 trapping efficiency of 57% reported earlier by Araújo *et al.* (2009) meaning a correction factor of 1.74. Thus, this simple design of open-chamber can be used with satisfactory accuracy, provided that standardized operation procedures are followed. The use of sophisticated methods, such as micrometeorological mass balance, offers indisputable advantages, including the measurements over large areas with high representativeness. Nonetheless, it is unlikely they could be calibrated against a reference technique.

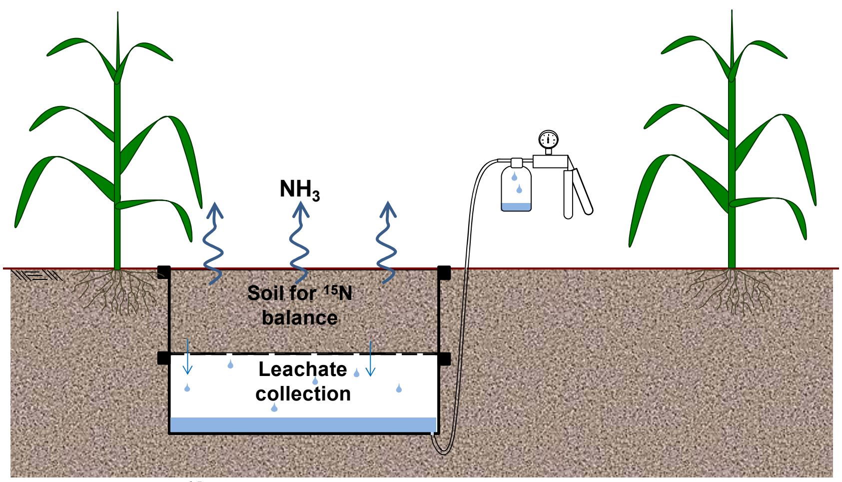

Figure 2. A schematic representation of ^{15}N-balance study used as a reference for calibration of the open chambers based on linear regression.

The use of this simple open-chamber method shown to be a suitable and reliable technique to quantify NH_3 volatilisation losses from agricultural soils, with a building cost under 1 US$. This new method of NH_3 measurement is being rolled out for use by developed and developing countries to help monitor and respond to the environmental impact of NH_3 from the livestock and agriculture industries. This study was described in detail in a manuscript entitled *"A simple and easy method to measure ammonia volatilization: accuracy under field conditions"* recently accepted by Pedosphere (Martins et al., 2019). This cheap and simple method is rapidly gaining recognition for its practicality, accuracy and reliability – see for example Nichols et al (2018).

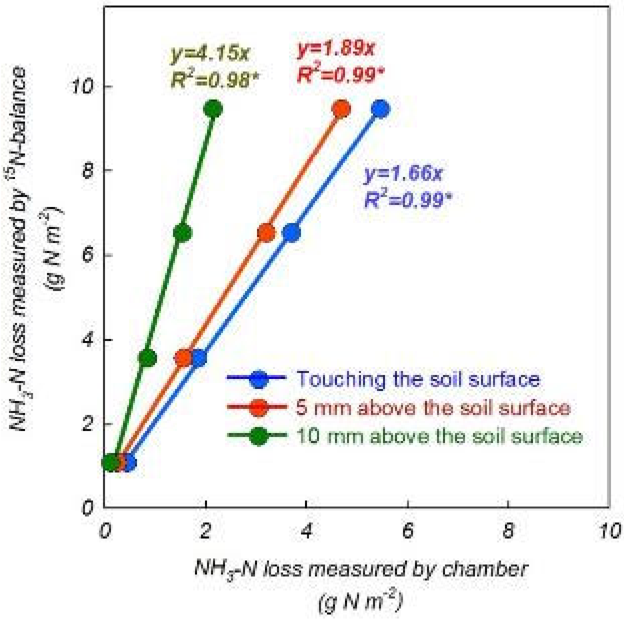

Figure 3. Linear regression between NH_3-N loss determined by ^{15}N-balance (no chamber deployment) and NH_3-N loss trapped by open chambers.

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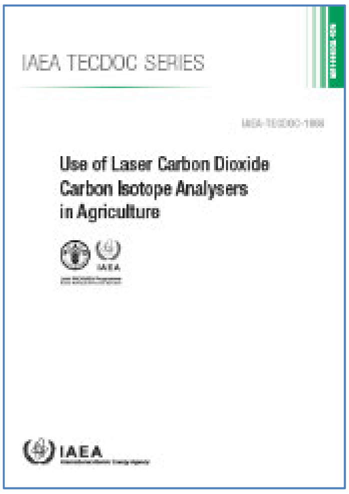
Announcements

New FAO/IAEA Publications

Use of Laser Carbon Dioxide Carbon Isotope Analysers in Agriculture (IAEA-TECDOC 1866)



Laser CO_2 carbon isotope analysis – a relatively new technology- is increasingly used to track CO_2 levels and trace the source of CO_2 emissions through isotope analysis. These measurements can be used to evaluate and select agricultural management practices that reduce its emissions. To ensure accurate measurements and data analysis, the SWMCN laboratory published a TECDOC focusing on how to create reference gases for calibration and its quality control, and how to manage data as well as to enhance accuracy and precision of ^{13}C-CO_2 measurements.

This TECDOC can be downloaded from: https://www.iaea.org/publications/13479/use-of-laser-carbon-dioxide-carbon-isotope-analysers-in-agriculture

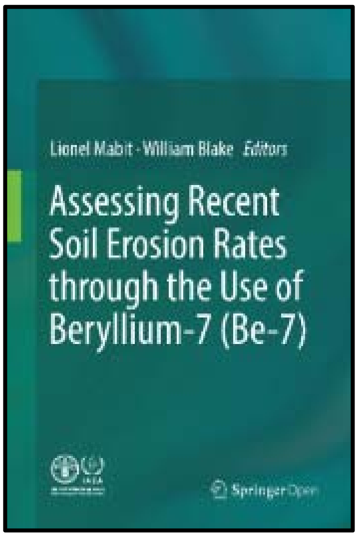
More information on this TECDOC publication can be found on: https://www.iaea.org/newscenter/news/new-iaea-publication-use-of-laser-carbon-dioxide-carbon-isotope-analysers-in-agriculture

Sample Preparation of Soil and Plant Material for Isotope Ratio Mass Spectrometry (IAEA-TECDOC 1870)

This TECDOC provides a detailed guidance on sample preparation for isotope ratio mass spectrometry (IRMS) analysis of plant and soil materials. An appropriate sample preparation is crucial to ensure the quality of stable isotope techniques: often, sample volumes of harvested soil or plant material need to be reduced prior to grinding, cross-contaminations must be avoided, and the final sample must be representative and within the adequate concentration range for IRMS. The Standard Operating Procedures (SOP's) presented in this publication provide comprehensive instructions in quartering/sub-sampling, grinding and weighing samples for IRMS to determine $\delta^{15}N$ and $\delta^{13}C$ composition of plant and soil material.

This TECDOC can be downloaded from: https://www.iaea.org/publications/13482/sample-preparation-of-soil-and-plant-material-for-isotope-ratio-mass-spectrometry

Assessing Recent Soil Erosion Rates through the Use of Beryllium-7 (Be-7)



This open access book provides insights on how nuclear techniques can facilitate the implementation of climate-smart agricultural practices. It is the first comprehensive guideline that presents and demonstrates the unique traits of the cosmogenic fallout radioisotope beryllium-7 (Be-7) and its use as a short-term soil redistribution budgeting tool in agricultural landscapes.

While covering the fundamental and basic concepts of the approach, this book distinguishes itself from other publications by offering step-by-step guidance and easy-to-follow protocols on how to use this isotopic technique effectively with appropriate attention to tracer limitations and uncertainties. It covers experimental design considerations and clear instruction is given on data processing. As accurate laboratory measurement is crucial to ensure successful use of Be-7 to investigate soil erosion, a full chapter is devoted to its specific determination by gamma spectrometry. Further the new developments in the Be-7 technique are described. The concluding chapter highlights the potential of Be-7 method to support the implementation of soil conservation policy.

https://link.springer.com/book/10.1007%2F978-3-030-10982-0

Highlights

'Soil erosion assessment: Making a difference with isotopic techniques' FAO/IAEA Joint Division's Side Event of the FAO's Global Symposium on Soil Erosion

The Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture through the SWMCN Subprogramme organized a side event on 'Soil erosion assessment: Making a difference with isotopic techniques' during The Global Symposium on Soil Erosion (GSER19) organized by the FAO on 15-17 May.

This side event presented state-of-the-art isotopic techniques used to investigate soil erosion as well as some recent methods development and success stories obtained in targeted African countries. More information on this event is provided on page 21.

Achievements in Monitoring Radionuclides in Food and Agriculture

A nuclear incident often leads to disarray, and may have long-term consequences for people, trade and the economy. In April 2019, an EMPRES Information Sheet was published by the FAO on the Decision Support System for Nuclear Emergencies Affecting Food and Agriculture (DSS4NAFA), which was developed under CRP D1.50.15 on 'Response to Nuclear Emergencies Affecting Food and Agriculture'. DSS4NAFA is a cloud-based decision support system to manage large volumes of spatial and temporal data, real-time information processing and visualization, and enhanced aid to response actions and decision-making in case of a nuclear or radiological emergency.
http://www.fao.org/3/ca4291en/ca4291en.pdf

Food and Agriculture Organization of the United Nations

APRIL 2019

AN INNOVATIVE SYSTEM FOR MONITORING RADIONUCLIDES IN FOOD AND AGRICULTURE PRODUCTION

Given the growing number of nuclear power plants and nuclear power stations being built, the aging of existing ones, and the nuclear incidents that have occurred in the past, the improvement of nuclear emergency preparedness and response in food and agriculture has never been more necessary and urgent.

A nuclear incident often leads to disarray, and may have long-term consequences for people, trade and the economy.

In fact, these events can also release significant quantities of radioactive material into the environment that makes water, local produce, milk from grazing animals and other foods unsafe for consumption, thus representing a threat to human health, agricultural production and socio-economic development.

Lessons learned from previous power plant accidents have identified critical areas for improvement – including data sampling and analysis, data management, and data visualization for swift decision-making – which would allow food control and health authorities to respond and disseminate information to all relevant stakeholders on a timely basis. In addition, these improvements form the basis of an effective emergency response system that can protect the food chain and water supply systems and prevent the consumption of contaminated foods.

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture has developed the Decision Support System for Nuclear Emergencies Affecting Food and Agriculture (DSS4NAFA), a cloud-based Information Technology (IT) decision support system with improved capacity to manage large volumes of spatial and temporal data, real-time information processing and visualization, and provide enhanced aid to response actions and decision-making.

A DECISION SUPPORT SYSTEM TO RESPOND TO NUCLEAR EMERGENCIES AFFECTING FOOD AND AGRICULTURE

Past nuclear incidents released radionuclides into the environment, affecting rural communities and agricultural production areas and posing a high risk of contaminated agricultural products entering the food supply chain. In such circumstances, the co-ordination and implementation of relevant procedures and response mechanisms are complex and tedious due to the large areas, the plurality of crop types, the presence of water bodies, and the variety of soils concerned, in addition to the involvement of different branches of government and multiple organizations.

The challenge is therefore multifaceted. It calls for timely delineation of the relevant areas and a swift response to prevent affected produce from

FOOD CHAIN CRISIS | EMERGENCY PREVENTION SYSTEM | INFORMATION SHEETS

KEY FACTS

DSS4NAFA

NUCLEAR AND RADIOLOGICAL EMERGENCIES MAY RESULT IN RADIONUCLIDES BEING RELEASED INTO THE ENVIRONMENT, AFFECTING FOOD PRODUCTION AND SAFETY

A MAJOR CHALLENGE ARISING IN NUCLEAR EMERGENCIES IN AGRICULTURE IS THE LARGE VOLUME OF SPATIAL AND TEMPORAL INFORMATION TO BE HANDLED AND PROCESSED

FAO AND IAEA JOINTLY DEVELOPED DSS4NAFA TO SUPPORT INTEGRATED DECISION-MAKING THROUGH REAL-TIME INFORMATION PROCESSING AND VISUALIZATION

DSS4NAFA IS AN ONLINE INFORMATION SYSTEM THAT COLLECTS, MANAGES AND VISUALIZES DATA GENERATED DURING EMERGENCY RESPONSES AND ROUTINE MONITORING

DSS4NAFA IS CURRENTLY BEING TESTED AND ADJUSTED FOR BELGIUM

IAEA FAO-DSS4NAFA

E-MAIL

Food-Chain-Crisis@fao.org

NAFA.Soil-and-Water-Management-Section-Contact-point@iaea.org

WEBSITES

www.fao.org/food-chain-crisis

https://youtu.be/Ut4GzjKabMc

Food and Agriculture Organization of the United Nations

AN INNOVATIVE SYSTEM FOR MONITORING RADIONUCLIDES IN FOOD AND AGRICULTURE PRODUCTION

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reaching the consumer. This requires monitoring the evolving spatial and temporal distribution of radionuclides, supplying up-to-date information to decision-makers, ensuring coordination among response organizations and effectively communicating intervention plans.

DSS4NAFA is designed to optimize the collection, management and visualization of agriculture-related data during the response process. The system is also designed to link decision-makers with field officers and analytical laboratories.

DSS4NAFA contains modules that help public authorities determine sampling locations and assign sampling, in-situ or laboratory analysis tasks using crop calendars and land use maps, on the basis of standardized protocols.

In addition, upon obtaining data on radionuclide concentration in soil and food, the DSS4NAFA restriction dashboard suggests food and planting restrictions based on the level of risk and specified tolerance levels.

Some of the functionalities of the modules are listed below:

Data management:

- Standardized data input
- Data are stored within one server
- All data collected in the field are sent directly to the server

Data visualization:

- Geo-referenced and time-stamped data visualization, for understanding of the situation of radioactive contamination on the ground
- "Logmap" for at-a-glance sampling and analyses status
- Comprehensive information is intuitively displayed on the dashboard

Logistics and decision support:

- Sampling or in-situ measurement assignments
- Food and planting restrictions

The features of DSS4NAFA

The specific feature that sets DSS4NAFA apart from other similar systems is that it uses mobile tools and advanced geographic visualization to overcome the logistical challenges encountered in a nuclear emergency.

The system's platform is accessible from the field through a mobile application or the office via a desktop interface, allowing for streamlined uge and communications. In addition, it has a user-friendly data analysis component that visualizes the decision support options that decision-makers may consider as response actions. The combination of these functionalities brings together all stakeholders in the process and fosters robust emergency response capabilities.

DSS4NAFA is built in a modular way, including several IT components that are integrated but can be exchanged separately, making the system flexible and adaptable. While it was originally developed as a system for nuclear emergency response management and communication, its ability to discern data quality, provide user-friendly geographic and time-stamped visualizations for decision-makers, and support the production of communication materials makes it a credible candidate tool for natural hazard risk mitigation.

The beta version of DSS4NAFA, which was released in late 2018, was developed through public-private partnerships and in collaboration with nuclear research centres, ministries of agriculture, and national atomic energy agencies from ten Member States, as well as European Commission research institutes. Outreach materials (videos, interviews and articles) have been prepared for disseminating knowledge on efficient preparedness for and response to radiological emergencies in food and agriculture.

Thanks to an extrabudgetary contribution provided by the Belgian Federal Agency for Nuclear Control, in 2019, the DSS4NAFA system is being customized and adjusted for further testing in Belgium. Future work that is also envisaged to serve Member States will consist in developing modules complementary to DSS4NAFA on the remediation of radioactive contamination in agriculture and rolling out pilot tests in other Member States.

Technical Cooperation Field Projects

Country/Region	TC Project	Description	Technical Officer(s)
Afghanistan	AFG5007	Enhancing Wheat Productivity Through Best Nutrient and Water Management Practices Under Rainfed and Supplemental Irrigation Systems	M. Zaman
Algeria	ALG5030	Contributing to the Implementation of the National Agricultural Development Programme Through Strengthening Soil, Water and Nutrient Management Practices Including Food Safety Using Nuclear and Related Techniques	M. Zaman in collaboration with FEP
Benin	BEN5012	Enhancing legume production in cereal-livestock cropping systems for food, wealth and soil health through the use of bio fertilizers (inoculum) in Benin	J. Adu-Gyamfi
Burundi	BDI5001	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	M. Zaman in collaboration with PBG
Central African Republic	CAF5011	Building National Capacities for Improving the Efficiency of Biological Nitrogen Fixation for Food Security, Fertility Restoration and Rehabilitation of Degraded Soils	M. Zaman
Cambodia	KAM5005	Enhancing Soil, Water and Nutrient Management for Sustainable Rice Production and Optimized Yield	J. Adu-Gyamfi
Costa Rica	COS5033	Assessing and Implementing Biochar Use in Climate Smart and Environmentally Friendly Pineapple Production Using Isotopic Techniques	M. Zaman in collaboration with FEP
Costa Rica	COS5035	Building Capacity for the Development of Climate-Smart Agriculture in Rice Farming	M. Zaman
Dominica	DMI0002	Building National Capacity for the Use of Nuclear Applications in Relevant Sectors	J. Adu-Gyamfi
Gabon	GAB5003	Building National Capacities for Monitoring Sedimentation of Dams and Harbors and the Management of Remediation Operations	E. Fulajtar
Indonesia	INS5043	Intensifying Quality Soybean Production in Indonesia to achieve self-sufficiency	J. Adu-Gyamfi in collaboration with PBG
Interregional project	INT0093	Applying Nuclear Science and Technology in Small Island Developing States in Support of the Sustainable Development Goals and the SAMOA Pathway	J. Adu-Gyamfi
Iraq	IRQ5020	Restoring Biomass Productivity of Range Land by Using Nuclear Techniques and Advanced Technology	M. Zaman
Jamaica	JAM5012	Optimizing Irrigation Water Management to Improve Crop Output and Water Quality Control	L. Heng
Kuwait	KUW5004	Improving Production and Water Use Efficiency of Forage Crops with Nuclear Techniques	J. Halder
Laos	LAO5004	Enhancing National Capability for Crop Production and Controlling Trans-Boundary Animal Diseases	M. Zaman in collaboration with APH
Lesotho	LES5008	Improving Soil Fertility for Enhanced Cereal Production in Lesotho	J. Adu-Gyamfi
Madagascar	MAG5025	Biocontrol of Striga asiatica (L.) Kuntze through the development of tolerant rice and maize lines and its impact on microbiological and ecological functioning of soil	J. Adu-Gyamfi in collaboration with PBG

Malawi	MLW5003	Developing Drought Tolerant, High Yielding and Nutritious Crops to Combat the Adverse Effects of Climate Change	E. Fulajtar in collaboration with PBG
Malaysia	MAL5031	Establishing an Environmentally Sustainable Food and Fodder Crop Production System	E. Fulajtar in collaboration with PBG and APH
Mali	MLI5028	Improving Water Use Efficiency, Soil Fertility Management Practices and the Resilience of Cultures to Climate Variability and Change	L. Heng
Mauritania	MAU5006	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques to Water Management and Soil Fertility	M. Zaman in collaboration with PBG
Myanmar	MYA5027	Monitoring and Assessing Watershed Management Practices on Water Quality and Sedimentation Rates of the Inle Lake - Phase II	L. Heng
Namibia	NAM5016	Developing Drought Tolerant Mutant Crop Varieties with Enhanced Nutritional Content	J. Adu-Gyamfi in collaboration with PBG
Oman	OMA5006	Using Isotopes and Nuclear Techniques in Integrated Water, Soil and Nutrients Management to Optimize Crop Productivity	J. Adu-Gyamfi
Pakistan	PAK5051	Developing Isotope-Aided Techniques in Agriculture for Resource Conservation and Climate Change Adaptation and Mitigation	M. Zaman
Panama	PAN0008	Strengthening Capacity to Enhance the Use of Nuclear Applications for Development	J. Adu-Gyamfi
Philippines	PHI5034	Applying Nuclear Techniques in the Attenuation of Flood and Natural Disaster-Borne Contamination	E. Fulajtar
Qatar	QAT5007	Improving Productivity of Ikhlas and Berhi Date Palm Varieties	M.Zaman
Regional project Africa	RAF0046	Promoting Technical Cooperation among Developing Countries through Triangular Partnerships and Sustaining Regional Ownership of the AFRA Programme [Bilateral TC project between Morocco and Côte d'Ivoire]	L. Mabit
Regional project Africa	RAF5075	Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides	E. Fulajtar and L. Mabit
Regional project Africa	RAF5079	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for increased Food Production and Income Generation (AFRA)	L. Heng
Regional project Asia	RAS5073	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II	L. Heng in collaboration with PBG
Regional project Asia	RAS5080	Developing Sustainable Agricultural Production and Upscaling of Salt-Degraded Lands through Integrated Soil, Water and Crop Management Approaches - Phase III	M. Zaman
Regional project Asia	RAS5083	Reducing greenhouse gas emissions from agriculture and land use changes through climate smart agricultural practices	M. Zaman
Regional project Asia	RAS5084	Assessing and improving soil and water quality to minimize land degradation and enhance crop productivity using nuclear techniques	J. Adu-Gyamfi
Regional project Latin America	RLA5076	Strengthening Surveillance Systems and Monitoring Programmes of Hydraulic Facilities Using Nuclear Techniques to Assess Sedimentation Impacts as Environmental and Social Risks (ARCAL CLV)	E. Fulajtar

Regional project Latin America	RLA5077	Enhancing Livelihood through Improving Water Use Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)	L. Heng
Regional project Latin America	RLA5078	Improving Fertilization Practices in Crops through the Use of Efficient Genotypes in the Use of Macronutrients and Plant Growth Promoting Bacteria (ARCAL CLVII)	J. Adu-Gyamfi
Senegal	SEN5039	Supporting Eco-Intensification of Agriculture in Small-Scale Farming Systems by Improving Water and Nutrient Management	M. Zaman
Serbia	SRB5003	Strengthening the Capacities for Soil Erosion Assessment Using Nuclear Techniques to Support the Implementation of Sustainable Land Management Practices	E. Fulajtar
Seychelles	SEY5011	Supporting Better Sustainable Soil Management as Climate Change Adaptation Measures to Enhance National Food and Nutrition Security	L. Heng
Slovenia	SLO5004	Improving Water Quality in Vulnerable and Shallow Aquifers under Two Intensive Fruit and Vegetable Production Zones	J. Adu-Gyamfi and J. Halder
Sudan	SUD5037	Application of nuclear and related biotechnology techniques to improve of crop productivity and lively hood of small scale farmers drought prone areas of Sudan	J. Adu-Gyamfi in collaboration with PBG
Togo	TOG5002	Improving Crop Productivity and Agricultural Practices Through Radiation Induced Mutation Techniques	E. Fulajtar in collaboration with PBG
Zambia	ZAM5031	Improving the Yield of Selected Crops to Combat Climate Change	L. Heng in collaboration with PBG

Forthcoming Events

FAO/IAEA Events

Final Research Coordination Meeting of CRP D1.50.16. 'Minimizing farming impacts on climate change by enhancing carbon and nitrogen capture and storage in Agro-Ecosystems', 8 – 12 July 2019, Vienna, Austria.

Project Officers: M. Zaman and L. Heng.

Consultant Meeting to develop a new CRP on greenhouse gas phase-2 "Developing Climate Smart Agricultural practices for mitigation of greenhouse gases" 15 – 19 July 2019, Vienna, Austria.

Project Officers: M. Zaman and L. Heng.

First Research Coordination Meeting of CRP D1.20.14 'Enhancing agricultural resilience and water security using Cosmic-Ray Neutron Sensor' 26-30 August 2019, Vienna, Austria.

Project Officers: E. Fulajtar and J. Halder

First Research Coordination Meeting of CRP D1.50.19 'Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture', 30 September - 4 October 2019, Vienna, Austria.

Project Officers: G. Dercon and A. Lee Zhi YI

Third Research Coordination Meeting of CRP D1.50.17 'Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems' 14-17 October 2019, Vienna, Austria.

Project Officers: L. Mabit and L. Heng

Training Course of Interregional Technical Cooperation Project INT0093 on 'Applying Nuclear Science and Technology in Small Island Developing States in Support of the Sustainable Development Goals and the SAMOA Pathway', 07 – 18 October 2019, Koror, Palau**.**

Technical Officers: J. Adu-Gyamfi and J. Halder

Second Coordination Meeting for Regional Project RAS5084 'Assessing and Improving Soil and Water Quality to Minimize Land Degradation and Enhance Crop Productivity Using Nuclear Techniques' (RCA), 02-06 December 2019, Tsukuba, Japan.

Technical Officer: J. Adu-Gyamfi

Second Regional Training Course of RLA5076 'Strengthening Surveillance Systems and Monitoring Programmes of Hydraulic Facilities Using Nuclear Techniques to Assess Sedimentation Impacts as Environmental and Social Risks' on 'Integration of FRN, CSSI and water isotope techjniques for assessment of sedimentation in water reservoirs', 4-12 November, 2019, Valdivia, Chile.

Technical Officer: E. Fulajtar

Regional training course of RAS5073 project 'Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II' on 'Enhancing Agricultural Water Management Practices', 9-13 December 2019, Vientiane, Lao PDR.

Technical Officer: L. Heng

Non-FAO/IAEA Events

Soil Conservation Day - Let's not compromise the future, let's keep the soil. 9 July 2019, Balcarce, Buenos Aires, Argentina.

3rd Annual Congress on Soil, Plant and Water Sciences. 11-12 November 2019, Madrid, Spain.

World Soil Day: Stop Soil Erosion, Save our Future! 5 December 2019, Worldwide

Past Events

FAO/IAEA Events

National Training Course and Workshop with Farmers of RAS5080 'Developing Sustainable Agricultural Production and Upscaling of Salt-Degraded Lands through Integrated Soil, Water and Crop Management Approaches - Phase III' and RAS5083 'Reducing greenhouse gas emissions from agriculture and land use changes through climate smart agricultural practices', 6-13 January, 2019, Saudi Arabia

Technical Officer: Mohammad Zaman

The technical officer (TO) along with the project counterpart and four project team members went to Hofuf in Al-Hassa region for two days and visited alfalfa, date palm and rice trials which have been set up on farmer's field using best practices to combat salinity and mitigate greenhouse gases (GHGs). On the rice farm, the TO organised a one-day workshop for a group of farmers, and researchers using best farm practices to enhance rice productivity with lower emission of GHGs; followed by a practical demonstration of measuring GHGs. The TO along with the project team then left Hofuf for Riyadh. In Riyadh, the TO visited the CP's institute "Nuclear Science Research Institute (NSRI), King Abdulaziz City for Science and Technology (KACST)", met Mr Nasser Alkhomashi, the Director of KACST, and briefed him about Saudi Arabia's collaboration with IAEA in the two regional projects. During KACST's visit, the TO and the CP reviewed the project work plan, designed field trials, and discussed field and lab activities for the two projects. The TO then organized training event and provided lectures and hand-on training to equip the project team members of the two projects with the knowledge and understanding of using saline land for sustainable crop production and protect the environment by emitting less GHGs from agriculture. Lectures delivered by the TO covered assessment of different types of salinity, the role of isotopic and related techniques to develop climate smart agricultural practices to combat salinity and mitigate GHGs, and best soil, nutrient and water management practices for rice and wheat. During a field visit to the research station of KACST in Al-Muzahimia region, the project team members learnt how to apply ^{15}N-labelled fertiliser and measure GHGs under field condition.

RLA5077 'Enhancing Livelihood through Improving Water Use Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)' Mid-term Coordination Meeting, 18 – 21 March 2019, Montevideo, Uruguay

Technical Officer: Lee Heng

The purpose of this travel to Montevideo, Uruguay was to review project work progress and provide technical guidance for project activities, as well as technical discussions on the application of AquaCrop model. The host of the meeting is Ms Veronica Berriel, from Universidad de la República, Facultad de Agronomía Uruguay. After the official opening by the Uruguayan NLO and FAO Representative Mr Vicente Plata Suiffet. The PMO Ms Zapata thanked the delegation and welcomed the participants, and presented the agenda and the objectives of this meeting. She also emphasized the importance of the coordination meeting to discuss challenges, adjust implementation strategies, and agree on project workplan for 2019 and 2020.

During the first two days, countries presented their results obtained in the achievement of their workplan. After country presentations, Ms Heng led a technical discussion reviewed the experimental protocols, and responded questions related to AquaCrop and field experiment designs. A summary of the workplan of the project and results achieved so far were presented by the DTM. A thorough review of the workplan for 2019-2020 took place aligning with changed circumstances and expressed needs. During the last day, the participants were divided into groups to prepare the meeting report. In summary, the capacity building activities planned during 2018/begin 2019 have been implemented (two regional training courses organized). Some challenges have been encountered by the countries in relation to the field experiments (climate variability and unexpected events with excess rain or drought, external factors such as animals attacking the field trials, problems with equipment). Also, delays in receiving some key equipment needed for the field experiments caused delays to start the field experiments. For this reason, most countries will start field experiments in 2019. In order to obtain two data sets from the field, it is planned to request a no-cost extension of the project and have the final coordination meeting in first quarter of 2021.

RAS5084 Regional Training Course on the 'Application of Stable Isotopes for Soil and Water Quality Investigations', 25 – 29 March 2019, Guangxi University, Nanning, China.

Technical Officer: Joseph Adu-Gyamfi

The purpose of this one-week RAS5084 regional training course was to provide basic practical training on the use of multiple stable isotope techniques to monitor the source and transport of agricultural non-point source pollutants (fertilizers and pesticides) in agro-ecosystems. The training was attended by 18 participants from 13 countries.

Participants were trained on (1) basic principles in the use of multi- stable isotope techniques to track the origin and transport of agro-contaminants from soil to water bodies, (2) mixing models to identify source of contaminants, (3) conceptual experimental design and sampling strategies, (4) field site selection, sample preparations, measurements, data analysis and interpretation. In the opening ceremony, Prof. Haiyan Wu, Vice President of the College of Agronomy, Guangxi University welcomed all the participants and stressed the importance of the training course in terms of controlling the use of agro-chemicals to provide safe food for the public. The participants visited the Nala watershed, 130 km southwest of Nanning city where there were five monitoring stations equipped with sensors that directly measured total dissolves carbon (TDC), NO_3, PO_4 and SO_4 in the field, and a Cavity Ring Down Laser Spectrometer (Picarro Inc.) set up to continuously monitor $\delta^{2}H$ and $\delta^{18}O$ in water. In conclusion, the participants were requested to (1) share their training experience and knowledge with other national project teams, and (2) develop partnership and opportunities for outreach.

RAS5084 Participants visiting Nala Watershed

National Training Course of CAF5011 'Building National Capacities for Improving the Efficiency of Biological Nitrogen Fixation for Food Security, Fertility Restoration and Rehabilitation of Degraded Soils', 25-29 March 2019. Central Africa Republic

Technical Officer: Mohammad Zaman

The technical officer, together with an expert, Mr. Vyizigiro Ernest, travelled to Bangui to participate in a National Training Course to equip the participants with advanced knowledge and skills to successfully grow cassava and maize in Central Africa Republic. The vice-chancellor of Bangui university, Mr Syssa Magalie Jean Laurent opened the training event and welcomed the training participants. The technical officer explained the objective of the training course followed by a detailed presentation on the role of isotopic and nuclear techniques in developing climate-smart agricultural practices for efficient use of soil, nutrient and water resources. The training was attended by 18 (7 female and 11 male) researchers, extension workers, NGO workers and staff members from Bangui university. During the first three days, the technical officer and the expert provided lectures and hands-on training which covered a range of topics: a) best soil, nutrient and water management practices for cassava and maize production; b) challenges of nutrient and water management and their conservation on farm; c) strategic application of both chemical and organic fertilizers to minimize nutrient losses and reduce farm cost; d) using leguminous and cover crops to capture atmospheric nitrogen and carbon to improve soil fertility; and e) the use of ^{15}N technique to measure fertiliser use efficiency.

Practical demonstration on the Best Management Practices of Cassava Production in CAR.

All participants went on a field visit to learn the application of ^{15}N labelled urea, best agronomic practices of cassava. On the final day of the training, each participant was assessed by making a short oral presentation to show what new knowledge he/she learnt during the training. All trainees received certificates from Prof. Silla Semballa, Dean of the Faculty of Sciences. The participants acknowledged the IAEA and the Bangui University for hosting and organizing this training and committed to share their experience and knowledge with fellow colleagues for further capacity building. The CP, project team members and Vice Chancellor thanked IAEA for organizing this event and committed to communicate regularly to ensure that the project will meet its objectives.

World Bank Food and Agriculture Global Practice Forum, 31 March 31 – 2 April, Saly, Senegal.

Technical Officer: Lee Heng

The purpose of this travel was to represent the IAEA at the World Bank Food and Agriculture Global Practice Forum on Food Security Under Climate Change: Strategy into Action, and to identify opportunities for collaboration between the stakeholders (FAO, WHO, World Bank).

Mr Simeon Ehui, the Director of World Bank Food and Agriculture Global Practice who visited the IAEA earlier in the year and invited IAEA's participation, gave the opening remarks and a session on 'Strategy and Role of Agriculture on Eradicating Poverty and Boosting Shared Prosperity in Africa'. Other keynote presentations included 'African Agriculture Strategy on Operationalizing Food Security Under Climate Change' and 'Game Changing Initiatives in Transforming Africa's Agriculture: reflections and perspectives'.

Ms Lee Heng presented NAFA's work on Food Security Under a Changing Climate: The Roles of Nuclear Science, Technology & Applications, in the session on 'Partners Panel: Feedback on strategy and opportunities for collaboration', together with other partners from IFC, FAO, IFAD and ILRI. She gave the five core areas of NAFA and possible areas for IAEA/WB AG GP Partnership. These include the scaling up and dissemination of proven technologies such as: Farmer-preferred mutant varieties/seeds; ICT-based technologies for irrigation management; Climate-smart agriculture technologies (mutation induction for novel genetic diversity; pollution sources for peri-urban agriculture; pastoralism, livestock disease and insect pest control and value change and capacity building for food safety). Some possible Innovation & Development partnership: Innovative technologies for forecasting dry-spells and extreme weather events; speed breeding through innovative biotechnologies; enhancing VETLAB & Africa Food Safety networks and extending applications of SIT, with focus on field applications.

The presentation created awareness and interest among the WB staff including managers working on Africa to understand IAEA's agricultural activities and the roles and applications of nuclear and isotopic techniques in food and agriculture. Interest was expressed on the use of Sterile Insect Techniques (SIT) in addressing some of the insect and pest problems in Africa. Other interests include the use of stable isotopes for tracing sources relating to food safety and water quality, fallout radionuclides for soil erosion and land degradation. The discussion at this Forum also laid the foundation and background information for subsequent meetings organized by WB which IAEA would be attending, e.g. Food Security Leadership Dialogue (FSLD) in Nairobi or Kigali, as interest was expressed to work with IAEA towards enhancing food security.

Group picture at World Bank Food and Agriculture Global Practice Forum, Saly, Senegal

RAS5073 'Supporting Climate-Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications Regional Workshop & Farmers Field Day. 29 April – 3 May 2019, Kuantan, Malaysia.

Technical Officer: Lee Heng

Lee Heng together with Ljupcho Jankuloski from Plant Breeding and Genetic Section, travelled to Kuantan Malaysia to conduct the RAS5073 regional workshop and farmers field day to disseminate technologies packages on improved varieties, and nutrient and water saving technologies. The workshop was opened by DG of Malaysian Nuclear Agency, with the signing of an MoU between Malaysian Nuclear Agency and Bayer Co. (Malaysia) SDN. BHD on a collaborative agreement in Plant Breeding Programme. Malaysia counterparts then led the country presentations on their work on rice mutant varieties and water-saving and fertilizer use efficiency and their Socio-Economic Impact. On Wednesday the group travelled to Rompin, south of Kuantan for the field demonstration whereby farmers' rice package on mutant lines and nutrient use efficiency, and drone technology for crop health monitoring, weather data and forecast system were all demonstrated. On the final day, separate discussion was held for both plant breeding and soil, water and nutrient components. The group would like to conduct one more ^{15}N field experiment using standard technical protocol developed at the Manila training two years ago to obtain additional ^{15}N nitrogen use efficiency data for all countries. Due to this additional experiment, the final meeting of this project will be postponed to mid-March 2020 and Indonesia will be the host of the meeting. The group also proposed to extend the current RAS5073 project into the 3rd phase.

Group picture at RAS5073 Regional Workshop & Farmers Field Day, Kuantan, Malaysia

Final assessment meeting of INT5153 project, 1-5 April, IAEA, Vienna, Austria

Technical Officers: Gerd Dercon and Johanna Slaets

From 1st to 5th April 2019, 20 scientists from 16 countries gathered at IAEA headquarters in Vienna to evaluate the results of the Technical Cooperation Project INT5153 '*Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions'*. The project which started in 2014, was closed at the meeting, improved monitoring of the impacts of climate change on soil, water and cryosphere in polar and mountainous ecosystems. The knowledge generated by the project, resulting from expeditions to high-altitude and high-latitude sites on every continent, was synthesized at the final meeting. Participants discussed the lessons learned, best practices from the INT5153 project; future follow-up actions and reviewed and finalized the proposal for the second phase of the project.

The final report of the project is now available, reflecting the results of all seven study sites and four associated sites. Project results can help decision makers to predict the size and magnitude of changes in downstream sediment transport due to climate change impacts on glaciers. For example, in King George Island, Antarctica, a two-degree temperature increase was enough to cause an order-of-magnitude increase in sediment transport as well as a shift in sediment sources. Even under a conservative two-degree warming scenario, policy makers must prepare their communities for large changes in sedimentation, for example through increased budgets to dredge reservoirs for irrigation water and hydropower, as well as emergency preparedness for mud flows. In Elbrus (Russian Federation), freshly exposed proglacial sediments contained heavy metals, potentially affecting water quality. Monitoring is required to safeguard quality of agricultural and drinking water supplies for local communities. Land use must also be taken into account to accurately reflect glacier dynamics. In Bolivia, biomass burning in the Amazon Basin was identified as an additional process contributing to melting of Zongo glacier. These data may provide more accurate information for future water availability trends and governmental water managements. All these project findings were relayed to Andean stakeholders at a policy workshop held in La Paz, Bolivia from 21 to 24 May 2018.

Additional to these implications for local populations, INT5153 results provide critical information to global climate change models. In all studied sites, soil carbon cycling showed a smaller response to temperature increase than expected, except for wet soils. This suggests that high altitude soils may be less susceptible to future climate change than previously thought. Soil properties further masked the impact of warming on carbon dioxide emissions. As soils form the largest terrestrial carbon stock, they form a crucial component to obtain reliable modelling scenarios.

Participants of the INT5153 final assessment meeting, Vienna, Austria (left figure) and the two future coordinators of the second phase of the project, Mr Yanhong Wu from China and Mr Edson Ramirez from Bolivia (right figure)

At the meeting, participants also finalized the full proposal and work plan for an interregional TC project consolidating and extending the network built by INT5153. The project, titled "*Capacity building to cope with climate change impacts on land and water in mountainous regions*", plans to focus on watersheds in the Andes and Himalaya where there is a strong dependence of local populations on the ecosystem services provided by mountains. The proposal is currently being reviewed and upon approval the project would start in 2020.

INT5153 in numbers:

7 expert missions from the Arctic to the Antarctic

Bringing together **50** scientists from **12** countries

Over **2700** soil, sediment and water samples collected

Analyses of **70** biogeochemical parameters

Publication of **3** peer reviewed papers

INT5153 experts hosted **1** session during EGU2018: “Soil, water and sediment tracing for unravelling climate change dynamics in proglacial areas”

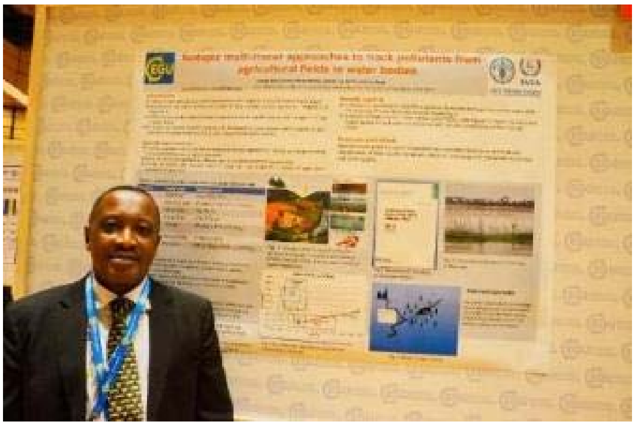
32 conference presentations

Training of **75** scientists through fellowships, training courses and expeditions

Invitation to Convene a Session on “Identification of Agro-contaminants in Surface and Groundwater Using Stable Isotope Techniques” at the European Geosciences Union (EGU 2019, HS.2.3.3) 7-12 April 2019, Vienna Austria

Project Officers Joseph Adu-Gyamfi and Lee Heng

The visibility of the current CRP D1.50.18 “Multiple isotope fingerprints to identify sources and transport of agro-contaminants” and a TC project RAS5084 ‘Assessing and improving soil and water quality to minimize land degradation and enhance crop productivity using nuclear techniques’ was enhanced during the EGU 2019 in April. A session on “Identification of Agro-contaminants in Surface and Groundwater Using Stable Isotope Techniques was convened by G. Skrzypek (University of Western Australia Australia), G. Imfeld (University of Strasbourg, France), J. Adu-Gyamfi (IAEA, Austria) and L. Heng (IAEA, Austria). Fourteen posters and 7 oral presentations took place on 9 April 2019. Approximately 80 EGU participants visited the poster session and 100 were present during the oral presentations. The session provided an opportunity to highlight on the challenges posed by pollutants released from agroecosystems, and the transfer through waterways degrading water quality in the natural environment. The role of stable multi-isotope and hydro-chemical techniques to trace their source and transport, and to develop appropriate policies and strategies for reducing agro-contaminants in surface and groundwater bodies were discussed. Selected manuscripts will be compiled in a virtual special issue, ‘Agro-contaminants sources, transformation, and transport in agroecosystems’ to be published in May 2020. For those interested to submit your manuscript to the above special issue, please visit the journal website (https://www.journals.elsevier.com/agriculture-ecosystems-and-environment) and follow the procedures for manuscript submission. In the section 'Enter Manuscript Information' you can select this Special Issue (Agro-contaminants) from the drop-down menu. Author Guidelines can be found at https://www.elsevier.com/journals/agriculture-ecosystems-and-environment/0167-8809/guide-for-authors



A poster on isotopic multi-tracer approached to track pollutants from agricultural fields to water bodies

The Global Symposium on Soil Erosion (GSER19), FAO Headquarters, Rome, Italy, 15-17 May 2019

Technical Officer: Lionel Mabit

As reported by FAO, 95% of our food is grown in soils but we are losing our fertile soil resource at an alarming rate as every 5 seconds the equivalent of one soccer pitch is eroded!

Soil erosion associated with the irreversible loss of fertile soil, reduced soil productivity, increased siltation and pollution of water bodies represents one of the most pressing environmental issues of our time and therefore combating soil erosion is one of the greatest challenges for sustainable soil management.

The Global Symposium on Soil Erosion (GSER19) was held from 15 to 17 May 2019 at FAO HQ in Rome, Italy. This Symposium was jointly organized by the FAO and its Global Soil Partnership (GSP), the Intergovernmental Technical Panel on Soils (ITPS), the United Nations Convention to Combat Desertification Science-Policy

Interface (UNCCD-SPI) and the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture through the SWMCN Subprogramme. Participants included scientists, practitioners, economists, policy makers, government officials, private businesses, research institutes, NGOs, civil society, farmers associations, and land users.

Based on the existing scientific knowledge on soil erosion assessment and management, the symposium addressed soil erosion prevention and control. The symposium aimed to bring science and policy together to review the status and challenges of soil erosion control for insuring food security and ecosystem services to fulfil the planned achievement of the Sustainable Development Goals 2, 3, 6, 13 and 15.

This three-day international meeting, that comprised 20 sessions and more than 100 presentations, focused on three main themes: use of data and assessment tools for soil erosion control (theme 1), practices and policies in action to address soil erosion (theme 2) and the economics of soil erosion and soil erosion control (theme 3).

The first day of the symposium a side event on '*Soil erosion assessment: Making a difference with isotopic techniques'* was also organized by the Joint FAO/IAEA Programme to highlight the effectiveness of isotopic techniques in evaluating soil erosion magnitude and in identifying sources of sediments. This side event presented state-of-the-art isotopic tools used to investigate soil erosion as well as some recent methods development and success stories obtained in targeted African countries (i.e. Madagascar, Morocco and Zimbabwe).

The moderator of the side-event was Lionel Mabit and the four invited speakers were Christine Alewell, Professor at Environmental Sciences, University of Basel, Basel, Switzerland, Moncef Benmansour, Head of Division Water Soil and Climate, National Centre for Nuclear Energy, Sciences and Technology (CNESTEN), Rabat, Morocco, Naivo Rabesiranana, Technical and Development Director, National Institute for Nuclear Science and Technology (INSTN-Madagascar), Antananarivo, Madagascar and Emmanuel Chikwari, Chief Research Officer and Head of Chemistry at the Chemistry and Soil Research Institute, Harare, Zimbabwe.

The side-event generated great interest and positive feedback from the symposium participants with more than 50 people attending. The four technical presentations were followed by a lively questions & answers session between the audience and the panel. The light lunch offered by the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture allowed to pursue the discussion.

As part of the organizing and scientific committee, the SWMCN Subprogramme also contributed significantly to the preparation of the different working documents presented during the symposium to the participants.

In addition to the planned proceedings in which the SWMCN Subprogramme will have several contributions, the symposium output will be an FAO document highlighting the scientific evidence on the status of soil erosion and its impacts. It will also provide recommendations for developing sound environmental policies and programmers to encourage the use of sustainable soil erosion control practices.

Participants of the side-event organized by the SWMCN subprogramme of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture (Photo from Matteo Sala, FAO)

Following the symposium, social media coverage by IAEA was done through two tweets:

https://twitter.com/iaeaorg/status/1129643531751100417

https://twitter.com/iaeaorg/status/1129377754170966017

Agenda of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture side-event: http://www.fao.org/fileadmin/user_upload/GSP/docs/1_side_event_IAEA_Final.pdf

Symposium main page and working documents:

http://www.fao.org/about/meetings/soil-erosion-symposium/en/

http://www.fao.org/3/ca4394en/ca4394en.pdf

Fourth Regional Training Course of RAF5075 'Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides' on Gamma Spectrometry and Use of the Monte Carlo Simulation, 16-20 June 2018, Cairo, Egypt

Technical Officer: Emil Fulajtar

The main purpose of this course was to train the project partners in using the Monte Carlo simulation for calibration of HPGe gamma detector. In addition the study programme involved the standard calibration approached based on radionuclide sourses and refernce materials. This training was organized only for those project partners, which have already established gamma spectroscopic laboratory (Algeria, Egypt, Madagascar, Morocco, Senegal, Tunisia, Zimbabwe). The major achievement was that the lecturers for this training course were coming from the region (Algeria, Egypt and Morocco). This is a result of more than two decades of Joint FAO/IAEA Division's effort in building gamma spectroscopy capacities in Africa.

Coordinated Research Projects

Project Number	Ongoing CRPs	Project Officer
D1.20.14	Enhancing agricultural resilience and water security using Cosmic-Ray Neutron Sensor	Emil Fulajtar and Janine Halder
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
D1.50.18	Multiple isotope fingerprints to identify sources and transport of agro-contaminants	Joseph Adu-Gyamfi and Lee Heng
D1.50.19	Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture	Gerd Dercon and A. Lee Zhi Yi

Enhancing agricultural resilience and water security using Cosmic-Ray Neutron Sensor (D1.20.14)

Technical Officer: E. Fulajtar and Janine Halder

This five-year CRP (2019-2023) is aimed to test the potential of cosmic ray neutron sensor (CRNS) for applications in agriculture and environment protection, especially on irrigation scheduling and management of extreme weather events. Measurement and understanding of soil water dynamics are of paramount importance in relation to soil water and irrigation management, water conservation, improvement of soil fertility and the development of crop management strategies. CRNS provides soil moisture data in a large-scale and real-time, which has a great value for land and water management. The objectives of the CRP are: (1) Advancing the capabilities of CRNS for Best Management Practices (BMP) in irrigated and rainfed agricultural production systems; (2) Integrating CRNS, Gamma-ray spectrometry (GRS), remote sensing and hydrological modelling for improving agricultural water management and its resilience at regional scales; and (3) Developing the approaches using CRNS and GRS for long-term soil moisture monitoring in agricultural systems and early warning systems for flood and drought management. This CRP was approved in March 2019. The call for proposals was closed in May and five research contract holders (Brazil, Mexico, South Africa and 2 from China), three research agreement holders (United Kingdom, Denmark and India) and three technical contract holders (Italy, Netherlands and USA) formed the project team. The First Research Coordination Meeting will be held on 26-30 August 2019, Vienna, Austria. The final output of the CRP should be a set of methodological tools practically applicable in irrigantion scheduling and flood prediction and drought management.

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

Technical Officer: Gerd Dercon and Lee Heng

The CRP D1.50.15 (2013-2019) on enhancing response capabilities of authorities during nuclear and radiological incidents affecting food and agriculture, through sampling and analytical methodologies, and development of IT tools, was successfully concluded in March 2019.

Two major outputs of the project – (1) a protocol for sampling and analysis of food and agriculture samples during a nuclear or radiological emergency, and (2) an IT system to improve and optimize sampling and decision-making processes during routine monitoring and emergency response – were produced through collaborative partnerships formed with the 10 Member States (MS) in this project.

The publication of the CRP, titled 'Sampling, analysis and modelling technologies for large-scale nuclear emergencies affecting food and agriculture' includes 11 papers from project counterparts, which are now under review. The final papers are planned to be disseminated as an open Virtual Special Issue (VSI) in the Journal of Environmental Radioactivity.

A Peaceful Use Initiative (PUI) funding of 50,000 EUR was generously provided by the Federal Agency for Nuclear Control (FANC) of Belgium for work on adjusting the final prototype of the Decision Support System for Nuclear Emergencies Affecting Food and Agriculture (DSS4NAFA) to the Belgian conditions. With strong support of the Belgian Nuclear Research Centre (SCK-CEN), the FANC, the Federal Agency for the Safety of the Food Chain (FAVV), the testing plan was developed and implemented in March and May 2019, with full participation by the involved stakeholders.

Finally, developments made by the SWMCN laboratory in this research area were recognized at the EGU General Assembly 2019, whereby the poster presentation was once again highlighted in the session programme. Due to the positive response and demand driven needs from the MS, a follow up CRP D1.50.19 was developed and will be implemented starting Q3 2019. Further details on the project can be found in the following pages.

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

Project Officers: Mohammad Zaman and Lee Heng

This CRP is in its final year of implementation. The objective of the CRP is to mitigate the effects of nitrous oxide (N_2O) emissions and minimize nitrogen (N) losses from agricultural systems, whilst enhancing agricultural productivity and sequestering soil carbon (C). Ten Member States are participating in this CRP, including seven research contract holders (Brazil, Chile, China, Costa Rica, Ethiopia and Pakistan), two agreement holders from Estonia and Spain, and one technical contract holder from Germany. The third RCM was held in the Technical University, Madrid from 7-11 October 2017 to assess the results obtained since the beginning of this CRP.

The field data of Brazil, Chile, China, Iran and Pakistan showed that N_2O emissions from different N inputs were reduced by approximately 50% by adopting best soil, nutrient and water management practices. In Ethiopia, soil carbon and N accumulation decreased by 23% and 40%, respectively, in conversion of natural forest to crop field. However, after 17 years of afforestation, the cropping field showed no change of C or N stocks. In addition, agroforestry was estimated to contribute to mitigating 27±14 t CO_2 equivalents ha^{-1} y^{-1} at least for the first 14 years after establishment. The ^{15}N technique identified 2 more microbial processes of N_2O production which include co-denitrification and conversion of organ N to mineral N. A simple and robust method of ammonia (NH_3) emission was developed with a device that costs less than $1 to make. The small plastic assembly was designed by Brazilian scientists in collaboration with the Joint FAO/IAEA Division. After isotopic technique of ^{15}N was used to test and confirm its accuracy, the new tool is being rolled out for use by developed and developing countries to help monitor and respond to the environmental impact of NH_3 from the livestock and agriculture sectors.

Ten manuscripts on the effects of land use changes and farm management practices on emissions of GHGs and soil quality have been submitted to a special issue of Pedosphere international journal. The final RCM will be held on 8 – 12 July 2019, Vienna, Austria to present and discuss the results obtained since the beginning of the CRP and evaluate progress report in the light of project objectives and expected outputs.

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

Project Officers: L. Mabit and L. Heng

This project was initiated in April 2016 with the objectives to develop nuclear techniques to assess the impacts of changes in soil erosion occurring in upland agro-ecosystems, and to distinguish and apportion the impact of climate variability and agricultural management on soil resources in upland agro-ecosystems. Isotopic methods such as fallout radionuclides (FRN) and compound-specific stable isotope (CSSI) techniques as well as cosmic ray neutron probe (CRNP) are used to fulfil these two specific research objectives.

Since the start of the CRP, FRN and CSSI techniques have been developed or refined to deepen our understanding of erosion processes affecting upland agro-ecosystems. A new and unique FRN conversion model MODERN was developed, and several investigations were performed to test and validate the use of CRNP as well as plutonium isotopes ($^{239+240}Pu$) as new soil tracer versus other more mature FRN techniques under various agro-environments in Switzerland, South Korea and more recently in Austria.

To date, key activities carried out within this CRP have led to the publication of:

(a) open-access handbook of 5 chapters detailing how to use cosmogenic ^{7}Be to evaluate recent soil erosion magnitudes;

(b) IAEA TECDOC publication reporting soil moisture mapping with portable cosmic ray neutron sensor (i.e. IAEA-TECDOC-1845) and

(c) 16 peer-reviewed publications and 19 presentations at scientific events.

By the end of 2019, an additional IAEA publication providing guidance for sediment tracing using CSSI technique based on the measurement of $\delta^{13}C$ signatures of fatty acids should be available.

Currently, the CRP is focusing to test the ^{137}Cs resampling approach which appears to be one of the most suitable techniques for monitoring or erosion prcesses. Commitments and on-going activities from several participants to test and validate this innovative approach are encouraging.

The first Research Co-ordination Meeting (RCM) was held in Vienna, Austria (25 to 29 July 2016) and the second RCM took place at the Centre National de l'Energie, des Sciences et des Techniques Nucléaires (CNESTEN) in Rabat, Morocco, from 16 to 20 April 2018. The IAEA mid-term review of the CRP that took place on 13 March 2019 praised the results reached so far. As planned, the third RCM of the CRP will be held in Vienna, Austria from 14 to 17 October 2019.

Multiple isotope fingerprints to identify sources and transport of agro-contaminants (D1.50.18)

Project Officers: J. Adu-Gyamfi and L. Heng

This five-year CRP (2018-2022) aims to develop protocols and methodologies for using multiple stable isotope tracers to monitor soil, water and nutrient pollutants from agriculture, establish proof-of-concept for an integrated suite of analytical stable isotope tools, and create guidelines to adapt the new toolkit to a variety of agricultural management situations. Nuclear techniques are used to achieve the objectives including a combined stable isotope ($\delta^{18}O$' $\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$,' $\delta^{13}C$-DIC, $\delta^{15}N$-NO_3 $\delta^{18}O$-NO_3 $\delta^{18}Op$, $\delta^{34}S$) techniques and compound specific isotope (CSIA)-based monitoring approach for evaluating in-situ degradation, transport, transformation and fate of pesticides.

The following draft guidelines were presented and discussed: (1) for designing a water sampling program for stable isotopes studies of agricultural pollution, (2) on compound specific isotope analysis for investigation the source and transport of pesticides from soils to water bodies, and (3) on oxygen isotopes in phosphate for tracing sources of P in soil and catchment. Individual workplans were discussed and finalized. On the last day of the meeting, participants made the following recommendations: 1) A perspective review paper, presenting the complexity of local situations with respects to agro-contaminants and the relevance of a multiple-isotope approach, may help to present the CRP concept and the diversity of the consortium; (2) Different studies should all include traditional measurements of ions and target pollution, and may integrate at least stable isotopes of NO_3, PO_4 or pesticides, and combine them whenever possible; (3) The consortium may establish databases of isotope values from fertilizers and pesticides and use inter-laboratory measurements whenever required to provide end-members values. The first year of the CRP was dedicated to consolidating the existing observation sites and prepare them for soil and water monitoring in the next years of the CRP. The second RCM is expected be held in Ghana during the first quarter of 2020. This CRP was featured in an European Geosciences Union (EGU) Session HS2.3.3 on '*Identification of agro-contaminants in surface and groundwater using stable isotope techniques' during the upcoming EGU meeting on* 7-12 April 2019, Vienna, Austria. The Conveners were Grzegorz Skrzypek, Gwenaël Imfeld, Joseph Adu-Gyamfi and Lee Heng.

Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture (D1.50.19)

Project Officers: G. Dercon and A. Lee Zhi Yi

The CRP D1.50.19 was developed as a follow up to CRP D1.50.15. The objective of this new CRP is to enhance readiness and capabilities of societies for optimizing remediation of agricultural areas affected by large-scale nuclear accidents through innovative monitoring, decision-making and prediction techniques.

The specific objectives are (1) to combine experimental studies with field monitoring and modelling to understand and predict the role of environmental conditions on radiocaesium and radiostrontium transfer in the food chains and their dynamics at landscape level in particular for under-explored agro-ecological environments such as arid, tropical and monsoonal climates and (2) to customise the remedial options in agriculture to these under-explored agro-ecological environments and to adapt and develop innovative decision support systems for optimizing remediation of agricultural lands affected by nuclear accidents, based on machine learning and operations research techniques.

This CRP, which was formulated on the basis of recommendations from a consultants meeting held at the IAEA, Vienna, 20-22 February 2019, will be holding the first Research Coordination Meeting (RCM) in October 2019. Expert consultants from Belgium, Japan, Ukraine and Russia noted the importance of optimisation of remediation based on monitoring and prediction of the fate of radiocaesium and radiostrontium in agriculture is essential in the return of the affected territories to normal life conditions.

New field, laboratory and machine-learning modelling tools will be developed, tested and validated for predicting and monitoring the fate of radionuclide uptake by crops and related dynamics at the landscape level. Protocols will be developed and adapted for innovative spatio-temporal decision support systems for remediation of agricultural land, based on machine learning and operations research integrated with Geographic Information System (GIS) techniques.

Developments at the Soil and Water Management and Crop Nutrition Laboratory

Sharing SWMCNL's research progress at the 2019 European Geosciences Union (EGU) General Assembly in Vienna, Austria

Lee Zhi Yi, A.

Soil and Water Management and Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear techniques in Food and Agriculture

From 7-12 April, approximately 16,300 scientists from 113 countries came together at the European Geosciences Union (EGU) 2019 General Assembly held in Vienna, Austria. Close to 16,250 oral and poster presentations were shared in 683 topic sessions in this unique opportunity for scientific sharing and global networking.

The SWMCN Section and Laboratory's activities were reported in presentations covering topics in radionuclide tracers for soil erosion investigations, area-wide soil moisture screening, climate resilient crop production, remediation of radioactive contamination of agricultural land and multi-isotope approaches to tracing pollutants. Eight staff members, two interns, and one consultant attended the conference to share the research work performed in the past years. The SWMCNL's work on large scale nuclear emergency response in food and agriculture was highlighted in the EGU session on 'Geoscience problems related to massive release of radioactive materials by nuclear accidents and other human activities'.

Details of contributions from the SWMCN Section and Laboratory can be found in the publication list at the end of this Newsletter while more information regarding EGU 2019 can be found at: http://www.egu2019.eu. The EGU 2020 General Assembly will take place again in Vienna from 3 to 8 May 2020.

Eleven members of the SWMCN Subprogramme attended the 2019 EGU General Assembly to share R&D results from 2018

Counteracting drought effects in cassava production systems: An update on the CIALCA activities at SWMCNL

Van Laere, J.[1,2], Munyahali, W.[2,4], Birindwa, D.[1,2,3,4], Heiling, M.[2], Resch, C.[2], Gruber, R.[2], Weltin, G.[2], Jagoditsch, N.[2], Toloza, A.[2], Slaets, J.[2], Merckx, R.[1], Dercon, G.[1]

[1]Division of Soil and Water Management, Faculty of Bioscience Engineering, University of Leuven, Belgium
2 Soil and Water Management and Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear techniques in Food and Agriculture
3 International Institute of Tropical Agriculture (IITA), Bukavu, Democratic Republic of Congo
4 Université Catholique de Bukavu, UCB, Bukavu, Democratic Republic of Congo

Under the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA, www.cialca.org), funded by the Belgian Government, the SWMCNL team has now implemented a wide range of R&D activities in Seibersdorf and in the targeted countries in Africa.

To assess water use efficiency (WUE) and stomatal conductance (linked to $\delta^{13}C$ and $\delta^{18}O$, respectively) in cassava (*Manihot esculenta* Crantz) via stable isotope techniques, the question remains whether to do isotope analyses on single components like cellulose rather than analyse the bulk sample, which uses less time and resources. Preliminary tests were conducted in August 2018 to optimize the cellulose extraction process (see Soils Newsletter Vol. 41, No. 2, January 2019), which was used for this experiment. This paper provides a comparison of the $\delta^{13}C$ and $\delta^{18}O$ values for extracted cellulose and bulk samples (Fig. 1).

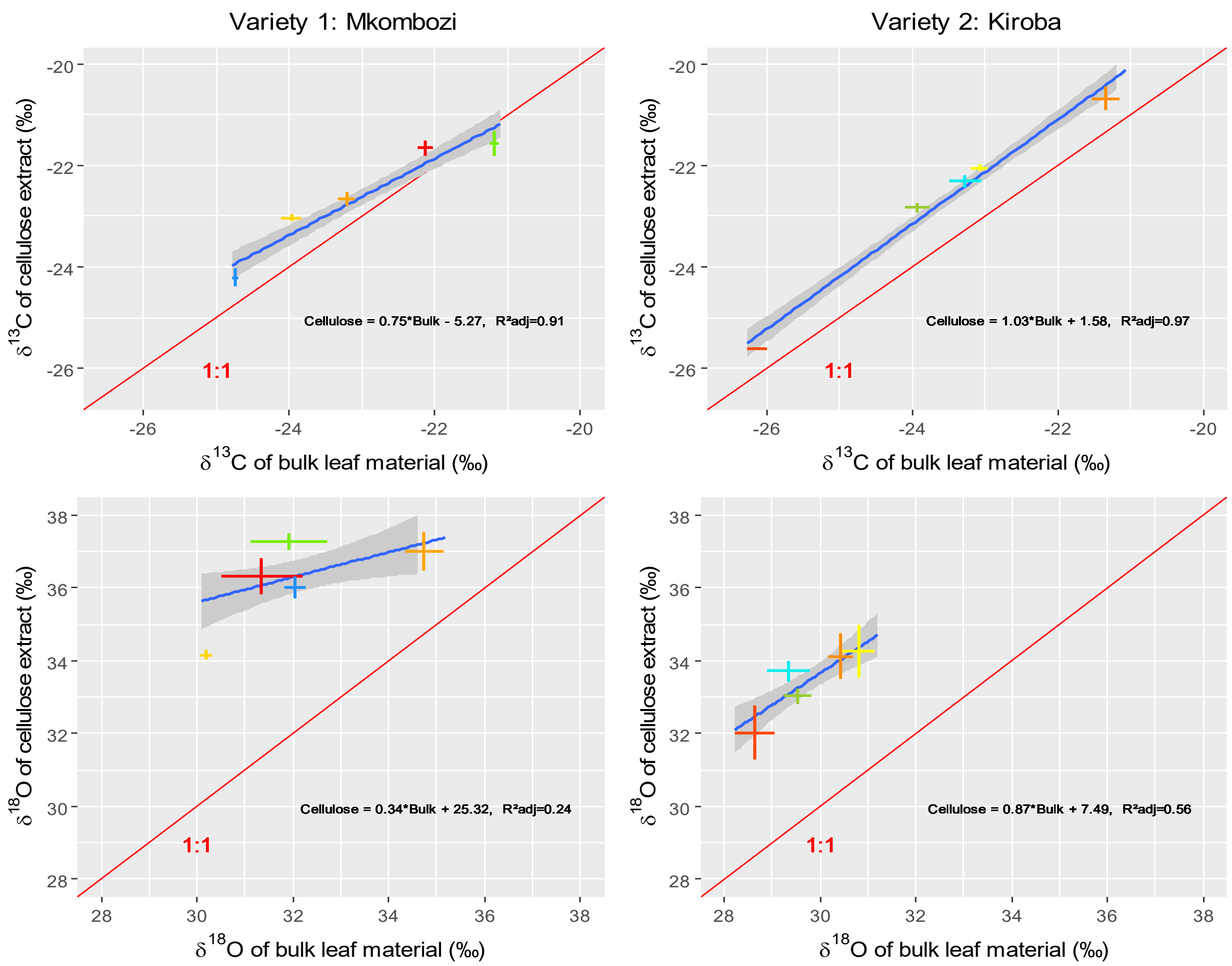


Figure 1. ^{13}C and ^{18}O analysis of 10 shoot samples (9 with 4 replicates, 1 with 2 replicates) from Mkombozi (Lake Zone) and Kiroba (Southern Zone). Grey shade is 95% confidence interval of linear regression line. Each colour represents a different sample. Error bars show standard deviations

Ten samples were taken from field trails in ACAI-fields in Tanzania (African Cassava Agronomy Initiative, IITA) of which 5 originating from the Lake Zone (Mkombozi variety) and 5 from the Southern Zone (Kiroba variety). Each sample was subsampled 8 times (4 for cellulose extraction and 4 for bulk analysis). If a lower variability was found for $\delta^{13}C$ and $\delta^{18}O$ values for cellulose compared to bulk samples and a non-constant difference between $\delta^{13}C$ and $\delta^{18}O$ values between cellulose and bulk, there would still be a need to extract cellulose instead of analysing the bulk sample.

As a first result, no significant difference was found between the coefficients of variation of bulk samples and corresponding extracted cellulose for both $\delta^{13}C$ and $\delta^{18}O$. Based on this result, it can be concluded that to decrease the variability between subsamples there is no need to extract cellulose. Second, it can be seen in Fig 1. that the slopes of the regression lines for the Kiroba variety are not significantly different from Mkombozi variety, indicating a constant difference between the extracted cellulose and bulk samples for both isotopes. However, this is not the case for the Mkombozi variety, where there is a decreasing difference with increasing $\delta^{13}C$ and $\delta^{18}O$. Based on this data, we can make no conclusion whether to omit the cellulose extraction process and analyse isotopic composition on bulk samples, since we cannot separate the environmental (different zones in Tanzania) from the varietal (Mkombozi versus Kiroba) effect on $\delta^{13}C$ and $\delta^{18}O$ and more tests are currently carried out.

A second preliminary test was conducted in the SWMCNL growth chamber where the atmosphere was enriched with $^{13}C\text{-}CO_2$ (Fig. 2). This test could be used to assess translocation speed of cassava varieties under different watering and fertilizer regimes. A total of 19 plants (7 of Bailo variety and 12 of V8) were put in the growth chamber, which was then closed airtight. $^{13}C\text{-}CO_2$ was added to the growth chamber, which had a final $\delta^{13}C$ of 43 836‰. The growth chamber was opened to let the $^{13}C\text{-}CO_2$ escape after 2 days. Plants were harvested 3, 7, 10 and 21 days after labelling and separated into the different components, after which they were analysed for $\delta^{13}C$.

92% of the $^{13}C\text{-}CO_2$ was taken up by the plants just before opening the growth chamber. Even at the first harvest, some enrichment was found in the roots, although, still very low. Translocation speed to the storage roots then increases somewhere after 10 days after labelling. It is therefore advised to decrease the sampling times before 10 days after planting and sample around 15th and 25th day. These tests will be carried out during the summer of 2019.

To enhance further our understanding of how cassava deals with periods of water shortage with the aid of novel stable isotope techniques, activities have been also initiated through field trials in various African countries, such as DRC, Burundi, Rwanda, Nigeria and Tanzania. Initial steps were taken to obtain information on how $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios vary in cassava plants under the influence of water and nutrient availability for different cassava varieties. As such, at least 331 Nutrient omission trials (NOT), 13 scheduled planting trials (SPT) and 3 multiplication fields have been installed in Burundi, DRC and Rwanda by the CIALCA team (Fig. 3) and also in Nigeria and Tanzania by the African Cassava Agronomy Initiative (ACAI) team of the IITA. Different varieties of cassava (improved and/or landrace variety) were used for the different countries. Cassava leaves, and soil and plant water samples are being collected from these experiments, leaf and water samples which will be analyzed for stable isotope ^{13}C and ^{18}O, to measure water use efficiency in different cassava varieties. Youngest fully expanded leaf (YFEL) blades without petioles (the YFEL is usually the 4th or 5th leaf from the apex, depending on the variety) are sampled (Fig. 4), three times during the growth of the plant at 4.5, 8 and 10 month after planting (MAP). Cassava leaf samples have been collected in the ACAI trials, oven dried at 60°C during 72h then ball milled to a fine powder pending stable isotope analysis. Sampling of cassava leaves is being done in the CIALCA and VLIR-IAEA trials and oven dried. Soil and plant water samples have not yet been collected in all field trials.

Figure 2. Cassava plants in SWMCNL growth chamber during

pulse labelling experiment

Figure 3: Cassava plants at 4MAP in the nutrient omission trials in Burundi (left); Fertilizer application at 4.5 MAP in the nutrient omission trials in Rwanda (right)

Figure. 4: Sampling of cassava youngest fully expanded leaves (YFEL) blades at 4.5 MAP in the NOT trials in Burundi

SWMCNL started R&D on enhancing climate change adaptation in banana - coffee production systems in East Africa

Vantyghem, M.[1,2], Merckx, R.[2], Swennen, R.[2,3], Resch, C.[1], Gruber, R. [1], Weltin, G.[1], Heiling, M.[1], Dercon, G.[1]

[1] Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Vienna, Austria
[2] Division of Soil and Water Management, Faculty of Bioscience Engineering, University of Leuven, Belgium.
[3] International Institute of Tropical Agriculture (IITA), Arusha, Tanzania

Under the guidance of the Soil and Water Management & Crop Nutrition (SWMCNL) and the Plant Breeding and Genetics (PBGL) Laboratories of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, a new Peaceful Uses Initiative (PUI) project, funded by the Belgian Government, has been initiated in 2019 to better understand how soil and water management and crop varieties can be improved for better climate change adaptation and enhanced disease resilience of banana-coffee cropping systems in Sub-Saharan Africa.

Banana and coffee are widely cultivated in East-Africa. Banana is a major staple crop, whereas coffee serves as a cash crop. Both are however sensitive to drought and their cultivation is being threatened by climate change. Interestingly though, smallholders sometimes intercrop them whereby banana provides shade for the coffee shrubs. This system requires careful management but is much more stable under varying weather conditions. Despite this important characteristic of being considered drought tolerant, the intercropped system has received very little attention in research.

Using isotope techniques, the adaptation of these cropping systems to climate change impacts can be accelerated. They help improve banana and coffee varieties, and soil, water and crop management, but also establish recommendations for policies, enabling environments and a transformational adaptation in which farmers substitute varieties and explore alternative farming strategies.

In May 2019 the SWMCNL started under this PUI project R&D at PhD level, in close collaboration with the University of Leuven (Belgium), on how stable isotopes (^{13}C and ^{18}O) can be used to better understand and compare the water-use efficiency (WUE) in banana-coffee intercropped systems and monocultures. Isotope and related modelling techniques will be developed and optimized for this purpose.

Fieldwork will be carried out in the Kilimanjaro region (Fig 1) in Tanzania, in close collaboration with the Nelson Mandela African Institution of Science and Technology and IITA. Mono-cropped and intercropped systems will be studied, and growth and water will be closely monitored. For this purpose, weather information will be combined with growth models (e.g. AQUACROP) to calculate the water balance. Plants samples will then be taken and analysed at the SWMCNL, which will allow us to link stable isotope content in the plants with their growth and water use. As such, isotope content can serve as a proxy for WUE. Different water management scenarios and agronomic practices can then easily be compared. Finally, we should be able to optimize water management and eventually make the system more resilient towards climate change.

A first one-week exploratory mission to Arusha Tanzania was carried out in February 2019, through the University of Leuven and IITA (Fig. 2). Further, a first extended field mission of close to two months is planned for the summer of 2019.

Figure 1. Banana fields on the slopes of Mt. Kilimanjaro, Tanzania (Feb, 2019).

Figure 2. Exploratory visit to a banana-coffee farm in Kilimanjaro region, Tanzania (Feb, 2019).

Implementation of DSS4NAFA in Belgium has started

Dercon, G.[1], Albinet, F.[1], Adjigogov, L.[2], Lee Zhi Yi, A.[1]

[1] *Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Vienna, Austria*
[2] *EduSoft, IT Company for Software Development and Implementation, Skopje, Republic of North Macedonia*

In 2019, a new Peaceful Uses Initiative (PUI) project on "Global Networking for Improved Radiological and Nuclear Emergency Preparedness and Response in Food and Agriculture" has started at the SWMCNL. This project, partially funded by the Federal Agency of Nuclear Control (FANC) of Belgium, aims to establish a global network enhancing worldwide and national capabilities of competent authorities responsible for monitoring radionuclides in food, soil, water and agriculture, with initial focus on the adaptation and testing of the Decision Support System for Nuclear Emergencies Affecting Food and Agriculture (DSS4NAFA).

DSS4NAFA has been created under CRP D1.50.15 on 'Response to Nuclear Emergency affecting Food and Agriculture' by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. It is a system for monitoring radionuclides in food and agriculture production that was developed to resolve major challenges during the emergency response process. The IT system can handle different steps in monitoring of an emergency, going from the assignment of the sampling/monitoring tasks, data collection and management up to the visualization of the monitoring data in time and space based on various selection criteria and finally support in decision-making regarding food and planting restrictions.

Usage of DSS4NAFA during or in the aftermath of a large-scale nuclear emergency can speed up and alleviate the logistical burden placed on the response authorities in Member States.

A workshop was held from 26-28 March at the Headquarters of the Belgian Nuclear Research Centre in Brussels, Belgium, under the PUI project. During the workshop, the plan for including DSS4NAFA into the Belgian nuclear and radiological emergency response system has been discussed and prepared. The implementation of DSS4NAFA by Belgium is the first implementation of the tool by an IAEA Member State. In this way, the flexibility and limitations of the tool can be tested.

Ten decision-makers and scientists involved in nuclear emergency response in the Belgian context attended the workshop, from following organizations: (i) Federal Agency of Nuclear Control (FANC), the regulatory body of Belgium in matters of ionising radiation, (ii) Belgian Nuclear Research Centre (SCK-CEN), (iii) Federal Agency for the Safety of the Food Chain (FASFC) and (iv) Civil Defence.

This workshop has laid the basis for the customization of DSS4NAFA to the Belgian conditions of nuclear emergency response. This experience will serve also for other Member States potentially interested in the use of DSS4NAFA.

More information on DSS4NAFA can be found in FAO FCC-EMPRES Information Sheet, published in April 2019 (http://www.fao.org/3/ca4291en/ca4291en.pdf).

Clay mineralogy and its influence on the behavior and interaction of ammonium, potassium, and radioactive caesium

Eguchi, T.[1,2], Lee Zhi Yi, A.[1], Shinano, T.[3], Smolders, E.[4], Dercon, G.[1]

[1]*Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Vienna, Austria*
[2]*Agricultural Radiation Research Center, Tohoku Agricultural Research Center, National Agriculture and Food Research Organization (NARO), Fukushima, Japan*
[3]*Faculty of Agriculture, Hokkaido University, Faculty of Agriculture, Japan*
[4] *Faculty of Bioscience Engineering, University of Leuven, Belgium*

The overall objective of this study, recently started in May 2019, is to develop new isotope techniques for assessing how to effectively remediate radioactive contamination of agricultural soils using commercially available clay mineral amendments, such as vermiculite, bentonite and zeolite. The direct focus will be on the understanding the interaction of clay minerals with ammonium, potassium and radioactive caesium (RC), using stable isotopes of caesium in combination with stable isotope nitrogen-15 techniques. In the first year, the team will conduct laboratory incubation and pot cultivation experiments to evaluate the influence of clay mineralogy and applied amendments on caesium uptake by crops.

Since the Fukushima Daiichi Nuclear Power Plant accident in March 2011, it has become necessary to establish countermeasures to reduce radioactive caesium uptake by crops. The application of potassium (K) to soil is one of the most effective countermeasures to reduce the uptake of RCs by crops. Therefore, Food Safety Authorities of Fukushima and the surrounding prefectures recommended to increase soil exchangeable K levels by applying additional K before the conventional application of K.

Despite the K application, there are upland fields and grasslands (Fig. 1) in these areas in which crops have relatively high concentrations of radioactive caesium because of limited occurrence of soils containing clay minerals with high caesium and potassium affinity. In the soils with low caesium and potassium affinity, the applied potassium is easily leached out and, radioactive caesium concentration in the soil solution, from which crops directly takes up nutrients, may be high. The behavior of caesium is influenced also by nitrogen which is applied to agricultural land as a fertilizer in the affected region mainly as ammonium. Ammonium application may further increase caesium concentration in soil solution through competition on the sorption sites of clay minerals. Besides the potential reducing effect of clay mineral application on radioactive caesium uptake by crops, clay mineral application may also negatively affect nitrogen-fertilizer efficiency through reduction of ammonium level in soil solution and/or promotion of nitrification.

This study, with a duration of close to two years, supports the new Coordinated Research Project D1.50.19 on 'Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture' and the Practical Agreement between the Joint FAO/IAEA Division and the National Agriculture and Food Research Organization (NARO), Japan.

Figure 1. Grassland in Fukushima prefecture

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Websites and Links

- Soil and Water Management and Crop Nutrition Section:
  http://www-naweb.iaea.org/nafa/swmn/index.html
- Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture:
  http://www-naweb.iaea.org/nafa/index.html
  http://www-naweb.iaea.org/nafa/news/index-ss.html
- Food and Agriculture Organization of the United Nations (FAO):
  http://www.fao.org/about/en/
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