Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Soils Newsletter

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

ISSN 1011-2650

Vol. 40, No. 1, July 2017

Contents

To Our Readers	1	Technical Cooperation Field Projects	13	Developments at the Soil and Water Management and Crop Nutrition Laboratory	28
Staff	3	Forthcoming Events	17	Publications	38
Feature Articles	6	Past Events	17	Websites and Links	40
Announcements	12	Coordinated Research Projects	25		

To Our Readers

The Soil and Water Management and Crop Nutrition (SWMCN) Section has begun implementing the 2018-2019 biennium activities, including forty-five technical cooperation projects (TCPs). Success stories from past TCPs can be found on our website at http://www-naweb.iaea.org/nafa/swmn/index.html. One of these, from Benin, was selected to be presented at the International Conference on the IAEA Technical Cooperation Programme 'Sixty years and beyond – Contributing to development' (30 May - 1 June 2017), whereby the project counterpart, Mr Pascal Houngnandan, Vice Rector of the Benin National University of Agriculture, presented achievements in the use of nitrogen-15 isotopic techniques and the inoculation of legumes to improve soil fertility and increase crop production in Benin.

Another highlight was the featuring of the SWMCN Laboratory, together with the other laboratories of the Joint FAO/IAEA Division, in the National Geographic documentary: *Nuclear Lifeline, a two-part documentary about nuclear technology*. In Episode 2, nuclear technologies in the fight against climate change were highlighted. The documentary (in Dutch and French versions), produced by the Belgian Nuclear Forum in close collaboration with the National Geographic, can be downloaded at https://www.nuclearlifeline.be/.

In April this year, the SWMCN Section participated in the European Geosciences Union (EGU) General Assembly held annually in Vienna, Austria. Six staff members, three interns, two fellows and one consultant attended the conference and reported on their research findings, gave 14 oral, poster and PICO presentations covering topics on carbon and nitrogen cycling, soil erosion and conservation, partitioning evapotranspiration, and food safety strategies in nuclear emergencies. The SWMCN Laboratory's work on large-scale nuclear emergency response in food and agriculture was selected as a solicited submission and highlighted in the EGU session on 'Geoscience processes related to Fukushima and Chernobyl nuclear accidents'. The conference attracted a large number of scientists from all over the world and featured some 17500 oral, poster and PICO presentations in 649 scientific sessions. The SWMCN Section aims at making use of such unique opportunities to share and promote its work and to network with scientists throughout the international community.

Anchoring the Danube Delta natural heritage

The SWMCN Subprogramme continues to generate guidelines and technical documents for use by Member States. 'Managing Irrigation Water to Enhance Crop Productivity under Water-limiting Conditions: A Role for Isotopic Techniques' (IAEA-TECDOC-1813) provides research findings and isotopic methodologies to quantify the soil evaporation component of water losses and to determine the transpiration efficiency under a variety of

environments. 'Guidelines for Developing Wetlands in Agricultural Catchments' (IAEA-TECDOC-1811) provide information on optimizing the capture and storage of water and nutrients using water conservation zones in agricultural landscapes. And IAEA-TECDOC-1809 on 'Cosmic Ray Neutron Sensing: Use, Calibration and Validation for Soil Moisture Estimation' provides background information about this novel technique and explains in detail the calibration and validation process.

The above is made possible partly due to new equipment being procured by the SWMCN Laboratory. A new Isotope Ratio Mass Spectrometer was purchased recently. Together with an existing mass spectrometer, coupled with an elemental analyser, we are now able to substantially increase our analytical capacity, up to 10 000 stable isotope measurements (^{15}N and ^{13}C in plant and soil samples) per year, at both enriched and natural abundance levels. Similarly, a new germanium (Ge) detector was added in late 2016 to improve the Laboratory's analytical facilities for measuring artificially produced and natural fallout and environmental radionuclides in soil and plant samples for erosion assessment and radioactivity monitoring. This new detector will be used to measure lead-210 (^{210}Pb) (low gamma emitter at 46 keV). With further enhancement of gamma spectrometry in the Laboratory in 2017, we hope to further increase our FRN analytical capability.

The SWMCN Section will be organizing a consultants' meeting on the use of stable isotopes for monitoring agricultural-derived pollutants and land management practices for improving water quality, to formulate a coordinated research project (CRP) to address agricultural-related water quality issues. Water quality due to agricultural pollution is a major problem in both developed and developing countries and we hope through this consultants' meeting and the future CRP that we will be able to trace the movement of agricultural pollutants to surface- and ground-water through the use of isotopic techniques.

We would like to welcome back Joseph Adu-Gyamfi as a staff member of the SWMCN Section. Joseph joined the Section in January 2017 as the Soil Fertility Management Specialist and is currently providing technical expertise and inputs to many of the TCPs in the Africa, Asia-Pacific, and Central and Latin America regions. We also welcome several consultants and interns in the SWMCN Laboratory, especially Amelia Lee and Johanna (Hanna) Slaets who were interns before and have now joined as consultants. Amelia will be working on the development of protocols on sampling strategies in large-scale nuclear emergencies affecting food and agriculture as well as on the DSS4NAFA online information system to support decision-making in nuclear emergency situations of relevance to food safety. Hanna will be providing support to the Interregional TCP INT5153 project on 'Assessing the impact of climate change and its effects on soil and water resources in polar and mountainous regions'. We also welcome Leo Mayr, our former staff member, who will be assisting us for two months on the performance and validation of nitrous oxide isotopic measurements and on carbon-13 labelling of plant material. We look forward to their contributions to the SWMCN Subprogramme.

In closing, I would like to thank all of you, our readers, for your continual support. Best wishes from all of us in the team.

Sincerely,

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

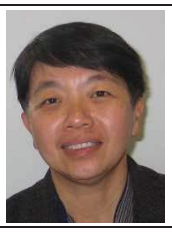
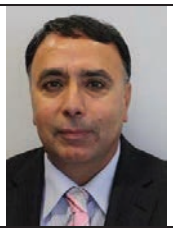
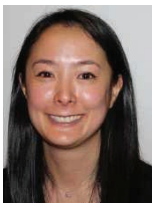
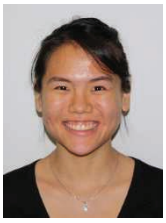
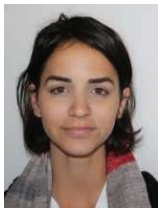
Soil and Water Management & Crop Nutrition Subprogramme

Name	Title	Email	Extension	Location
Lee Kheng HENG	Section Head	L.Heng@iaea.org	26847	Vienna
Mohammad ZAMAN	Soil Scientist/Plant Nutritionist	M.Zaman@iaea.org	21645	Vienna
Emil FULAJTAR	Soil Scientist	E.Fulajtar@iaea.org	21613	Vienna
Joseph ADU-GYAMFI	Soil Fertility Management	J.Adu-Gyamfi@iaea.org	21693	Vienna
Marlies ZACZEK	Team Assistant	M.Zaczek@iaea.org	21647	Vienna
Gerd DERCON	Laboratory Head	G.Dercon@iaea.org	28277	Seibersdorf
Lionel MABIT	Soil Scientist	L.Mabit@iaea.org	28677	Seibersdorf
Ammar WAHBI	Soil Scientist	A.Wahbi@iaea.org	28726	Seibersdorf
Janet CHEN	Climate Change Analyst	J.Chen@iaea.org	28750	Seibersdorf
Maria HEILING	Senior Laboratory Technician	M.Heiling@iaea.org	28212	Seibersdorf
Christian RESCH	Senior Laboratory Technician	C.Resch@iaea.org	28309	Seibersdorf
Georg WELTIN	Senior Laboratory Technician	G.Weltin@iaea.org	28258	Seibersdorf
Norbert JAGODITSCH	Laboratory Attendant	N.Jagoditsch@iaea.org	28406	Seibersdorf
Arsenio TOLOZA	Laboratory Technician	A.Toloza@iaea.org	28203	Seibersdorf
Roman GRUBER	Laboratory Technician	R.Gruber@iaea.org	28258	Seibersdorf
Joanna Malgorzata MLETZKO	Team Assistant	J.Mletzko@iaea.org	28362	Seibersdorf
Leopold MAYR	Consultant	L.Mayr@iaea.org	28576	Seibersdorf
Amelia LEE ZHI YI	Consultant	A.Lee-Zhi-Yi@iaea.org	28576	Seibersdorf
Johanna SLAETS	Consultant	J.Slaets@iaea.org	28576	Seibersdorf
Aamir KHAN	Intern	A.Khan@iaea.org	28576	Seibersdorf
William AVERY	Intern	W. Avery@iaea.org	28576	Seibersdorf
Maria WARTER	Intern	M.Warter@iaea.org	28576	Seibersdorf
Raquel FALCAO	Intern	R. Falcao@iaea.org	28576	Seibersdorf

Soil 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

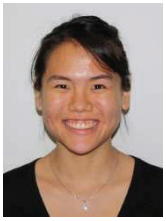
Soil Water Management and Crop Nutrition Laboratory
FAO/IAEA Agriculture & Biotechnology Laboratories, A-2444 Seibersdorf, Austria
Telephone: (+43 1) 2600+Extension; Fax (+43 1) 26007

Soil and Water Management & Crop Nutrition Subprogramme

			
L.K. Heng	M. Zaman	E. Fulajtar	J. Adu-Gyamfi
			
M. Zaczek	G. Dercon	L. Mabit	A. Wahbi
			
J. Chen	M. Heiling	C. Resch	G. Weltin
			
A. Toloza	R. Gruber	N. Jagoditsch	J.M. Mletzko
			
L. Mayr	A. Lee-Zhi-Yi	J. Slaets	W. Avery
			
A. Khan	M. Warter	R. Falcao	

Staff News

Joseph Adu-Gyamfi (Ghana) joined the SWMCN Section on the 15 January 2017 as a specialist in integrated soil fertility management. Joseph worked for 7 years (2006-2013) in the SWMCN Laboratory as a Soil Scientist/Plant Nutritionist. Since leaving , Joseph worked as a Chief Technical Adviser for UNIDO on a soybean value-chain project in Sudan to promote the production, local processing and utilization of soy-based nutritional foods to enhance food security and income generation. In addition, Joseph has been an IAEA expert, conducting hands-on training on the use of ^{15}N and ^{13}C methodologies for several TC projects in Benin, Cameroon, China, Malaysia, Mali, Myanmar, Sudan and Vietnam. He was a consultant at the SWMCN Section for one year where he provided technical expertise in project management for technical cooperation projects relating to integrated soil fertility and crop management practices in the Africa and Asia-Pacific regions. We are pleased to welcome Joseph back and look forward to his continuing dedication to the SWMCN Subprogramme.



Amelia Lee (Malaysia) joined the SWMCN Laboratory on April 2017 as a FAO consultant for nine months under CRP D1.50.15 on 'Response to Nuclear Emergency Affecting Food and Agriculture'. She will be assisting in the development of protocols on sampling strategies in large-scale nuclear emergencies affecting food and agriculture, and on the DSS4NAFA online information system to support decision-making in food safety. Formerly, Amelia was an intern at the SWMCN Laboratory. One of her projects as an intern was to develop decision support tools for agricultural sampling strategies during nuclear and radiological emergencies. Amelia obtained her MSc in Environmental Science from the University of Tokyo.

Leo Mayr (Austria) joined the SWMCN Laboratory on 15 May as a consultant for two months. Leo is a former staff member of the SWMCN Laboratory where he was working as a Senior Laboratory Technician until his retirement in 2014 after almost 39 years of service. In his current assignment, he works on the performance and validation of isotopic nitrous oxide measurements with a laser isotope analyzer at natural abundance and enriched levels over a wide range of mole ratios. In addition, he aims, in the frame of ^{13}C labelling of plant material, to improve the control and stabilization of the ^{13}C enrichment of carbon dioxide in a walk-in growing chamber by the use of a laser isotope analyzer.

Johanna Slaets (Belgium) returned to the SWMCN Laboratory as a consultant in May 2017, providing support to the interregional TC technical cooperation project INT5153 on 'Assessing the impact of climate change and its effects on soil and water resources in polar and mountainous regions.' She previously did an internship at the SWMCN laboratory, focusing on the development of isotopic methods to monitor C and N in agro-ecosystems. Examples include the use of laser spectroscopy for continuous, *in situ* greenhouse gas monitoring, and the use of ^{13}C and ^{15}N to study nitrogen cycling trends with altitude in mountainous grasslands. Johanna obtained her PhD in agricultural sciences from the University of Hohenheim (Germany), studying the movement of sediment, carbon and nitrogen in irrigated rice.

Maria Warter (Austria) joined the SWMCN Laboratory as an intern in April 2017. She will work on determining the effects of water stress on the water use efficiency and biological nitrogen fixation of soybeans, which will form the basis of her MSc thesis in International Land and Water Management, with specialisation in irrigation and water management and a minor in isotope hydrology, at Wageningen University in the Netherlands. She obtained her BSc in Environmental Engineering at the University of Natural Resources and Applied Sciences (BOKU) in Vienna.

Raquel Falcao (Brazil) joined the SWMCN Laboratory as an intern in April 2017 to learn about the use of fallout radionuclides (FRNs) and compound-specific stable isotope (CSSI) techniques to measure soil erosion rates and assess the efficiency of soil conservation measures in controlling erosion. She graduated from the University of Sao Paulo (Brazil) with an Environmental Engineering degree focusing on hydrology. Before starting at the SWMCN Laboratory she was an intern at the Czech Technical University (CTU) in Prague applying ArcGIS analysis to assess the potential soil erosion rates with the use of the universal soil loss equation (USLE) in the Moldau catchment in the Czech Republic.

Feature Articles

Compound-specific stable isotope (CSSI) fingerprinting for sediment source apportionment: A methodological perspective

Hari R. Upadhayay[1,2], Samuel Bodé[1], Marco Griepentrog[1], Dries Huygens[1], Roshan M. Bajracharya[2], William H. Blake[3], Gerd Dercon[4], Lionel Mabit[4], Max Gibbs[5], Brice X. Semmens[6], Brian C. Stock[6], Wim Cornelis[7], Pascal Boeckx[1]

[1]*Isotope Bioscience Laboratory - ISOFYS, Faculty of Bioscience Engineering, Ghent University, Gent, Belgium*
[2]*Aquatic Ecology Centre (AEC), School of Science, Kathmandu University, Dhulikhel, Nepal*
[3]*School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth, UK*
[4]*Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency, Vienna, Austria*
[5]*National Institute of Water and Atmospheric Research (NIWA), Hamilton, New Zealand*
[6]*Scripps Institution of Oceanography, University of California San Diego, San Diego, CA, USA*
[7]*Department of Soil Management, Faculty of Bioscience Engineering, Ghent University, Gent, Belgium*

Compound-specific stable isotope (CSSI) fingerprinting of sediment sources is a recently introduced approach, which combines the ^{13}C isotopic composition of fatty acids ($\delta^{13}C$-FAs) with an isotopic mixing model (IMM) to estimate the proportional contributions of upstream sources to downstream sediments. In an article lately published in the Journal of Soils and Sediments, an international researcher team, lead by the Isotope Bioscience Laboratory (ISOFYS) of Ghent University in Belgium, provided the insights in the methodological perspectives to apply CSSI sediment fingerprinting at catchment scale (Upadhayay *et al.*, 2017). The authors advised the use of saturated long-chain (>20 carbon atoms) FAs as tracers and content-dependent* (Bayesian) IMM for accurate estimation of sediment source contributions.

Long-chain FAs are commonly biosynthesized by higher plants and their isotopic signature records the ecological and hydrological conditions during their biosynthesis. FAs are well suited for water erosion studies because of their high abundances in soils (universal tracers) and their polarity, which allow them to disperse and adsorb to soil particles. The utility of using $\delta^{13}C$-FAs to apportion soil sources in sediment is based on the differences in $\delta^{13}C$-FA values between various land uses (i.e. sources) and the assumption that these isotope signatures are conservative (i.e. do not vary during sediment transport). Long-chain saturated FAs are advised to be used for sediment source discrimination and apportionment, in contrast to short-chain and unsaturated FAs because of their origin (higher plants) and recalcitrance. "This minimises the risks of 1) cross-contamination with microbial and algal FA input, and 2) isotopic fractionation due to degradation of FAs during residence in the catchment", Hari Ram Upadhayay explains.

Belgian and Nepalese researchers used long-chain saturated FAs and the content-dependent Bayesian mixing model (mixSIAR) to apportion the contribution of sources to sediment loads in the Kunchal catchment in Nepal (Figs. 1 and 2).

FIG. 1. Kunchal catchment in Nepal: (a) potential sediment sources and (b) sediment sampling

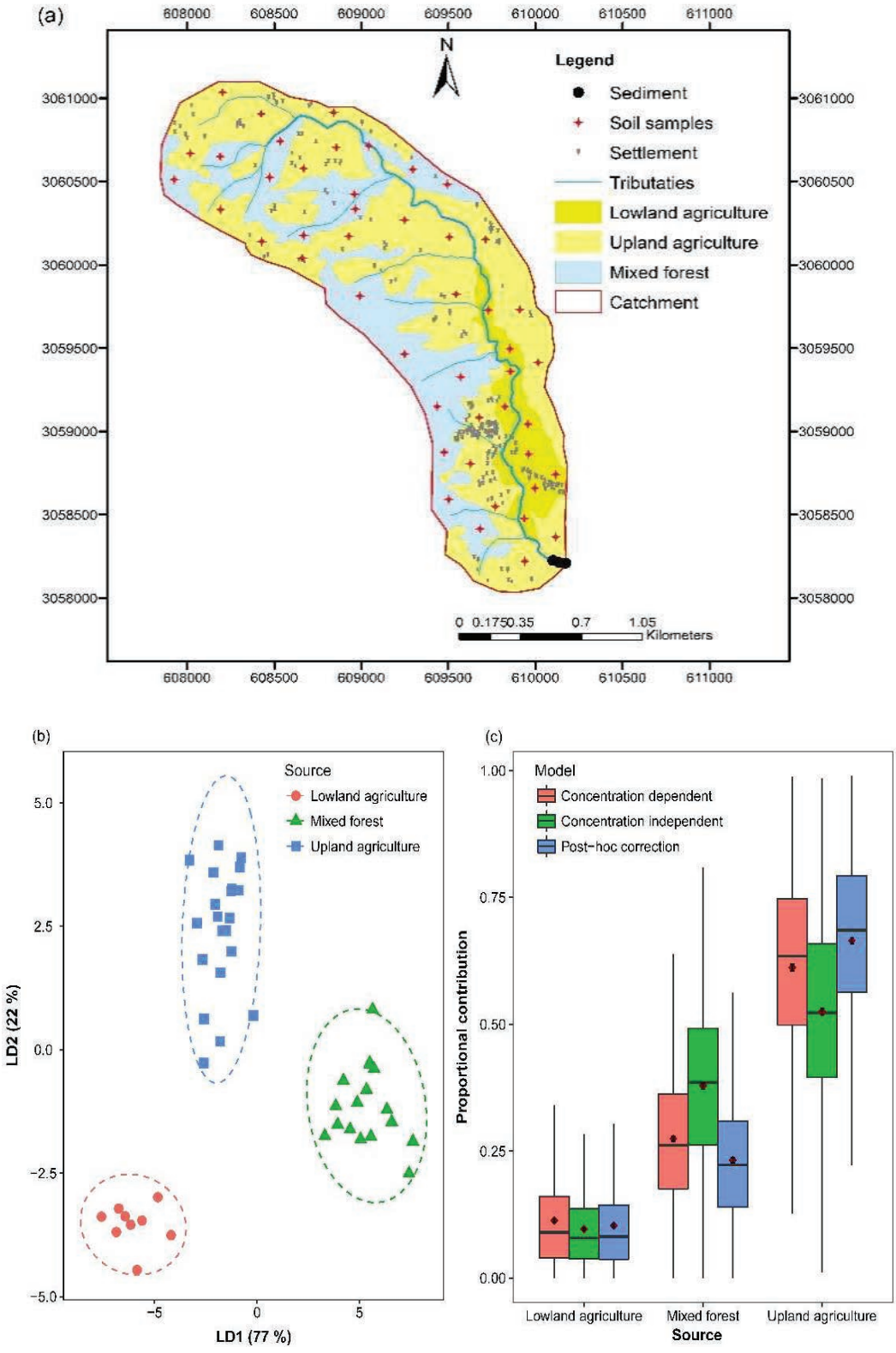


FIG. 2. Coupling δ^{13}C-FAs and MixSIAR for catchment level sediment source apportionment: (a) Soil and sediment sampling locations in the Kunchal catchment in Nepal; (b) Discriminant function plot based on δ^{13}C of a subset of FAs (C_{22}, C_{26}, C_{32}) obtained via Simulated Annealing Algorithm (ellipsoid encompasses 95% of group range); (c) Box plots (dark red rhombus and error bar indicate mean and standard deviation, respectively) of relative contribution of sources (i.e. land uses) to sediment. Estimated mean contribution of each land use is significantly different ($p<0.001$) among model types (see legend).

So far, mixing models applied in CSSI-based sediment fingerprinting did not consider differences in FA content of the sources within the unmixing process (i.e. content-independent mixing models). Instead, a correction for tracer content was applied after the unmixing (post-hoc), to transform isotopic proportions from the mixing model into source (i.e. soil) proportions. Post-hoc correction, for differences in tracer content of the sources, assumes the proportional contribution of the source to the tracers in the mixture to be equal for all tracers used in the IMM. "This assumption is, however, only correct if the tracer composition (i.e. relative FA content) is identical for all sources, which is actually rather an exception than the rule" Samuel Bodé explains. Based on literature and researchers' observations, there exist considerable differences in relative FAs content among soils of various land uses (sources). Hence, sediment sources apportionment using content-independent mixing models followed by post-hoc correction is inappropriate. "This implies that both $\delta^{13}C$ and content of FAs need to be measured precisely in sources and sediments" Pascal Boeckx emphasizes.

Various IMMs have been used in CSSI sediment fingerprinting, including analytical (e.g. IsoSource) and more recently Bayesian mixing models. "CSSI sediment fingerprinting can be highly improved by formulating Bayesian isotopic mixing models that include FA content, $\delta^{13}C$-FA variability, prior information, residual error, and covariates and covariance for source and sediment samples (e.g. seasonal differences in erosion and sediment generation due to rainfall intensity and land cover change)," Brice Semmens highlights.

The authors are currently developing a MixSIAR version that allows hierarchy in data structure to be dealt with, which might prove to be particularly useful in catchments with high complexity. "We envision a hierarchical MixSIAR that will allow dealing with source contributions within individual sub-catchments within a larger catchment," Pascal Boeckx says. The latter means that sampling strategy, catchment knowledge and modelling needs are crucial at the beginning of a sediment fingerprinting investigation. Hence, application of CSSI fingerprinting techniques to complex catchments presents particular challenges. "It is equally important to have adequate information on the hillslope hydrological system under investigation (to decide which sources are likely to be important), connectivity in the sediment cascade and the assumptions and limitations of Bayesian IMMs before attempting to use them", Will Blake concludes.

**Since the sediment transport is assessed on the basis of mass and not volume, the amount of tracer (FA) is to be expressed relative to a mass unit of soil or sediment. For this, 'content' instead of 'concentration' should be used, as 'content' refers to an amount per unit mass, while 'concentration' refers to an amount per unit volume (Flemming and Delafontaine, 2000). Therefore, 'content-dependent IMM' was also used rather than the more commonly used 'concentration-dependant IMM' and we suggest using this terminology in future publications.*

References

Upadhayay, H.R., Bodé, S., Griepentrog, M., Huygens, D., Bajracharya, R.M., Blake, W.H., Dercon, G., Mabit, L., Gibbs, M., Semmens, B.X., Stock, B.C., Cornelis, W., Boeckx, P. (2017). Methodological perspectives on the application of compound-specific stable isotope fingerprinting for sediment source apportionment. *Journal of Soils and Sediments*, 17(6): 1537-1553.

Flemming, B.W., Delafontaine M.T. (2000). Mass physical properties of muddy intertidal sediments: some applications, misapplications and non-applications. *Continental Shelf Research,* 20: 1179-1197.

$^{239+240}$Pu to ^{137}Cs activity ratio: a proxy for comparing vertical and lateral radionuclide mobility

Katrin Meusburger[1], Lionel Mabit[2], Michael Ketterer[3], Ji-Hyung Park[4], Tarjan Sandor[5], Paolo Porto[6], Christine Alewell[1]

[1]*Environmental Geosciences, University of Basel, Basel, Switzerland*
[2]*Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency, Vienna, Austria*
[3]*Chemistry Department, Metropolitan State University of Denver, Colorado, USA*
[4]*Department of Environmental Science and Engineering, Ewha Womans University, Seoul, Republic of Korea*
[5]*Radioanalytical Reference Laboratory, Central Agricultural Office, Food and Feed Safety Directorate, Hungary*
[6]*Dipartimento di Agraria, Università degli Studi 'Mediterranea' di Reggio Calabria, Italy*

Plutonium ($^{239+240}$Pu) fallout, like anthropogenic caesium-137 (^{137}Cs), originates from past aerial nuclear weapons testing and potentially from nuclear power plant (NPP) accidents. Unlike for ^{137}Cs only few published studies have reported about the use of plutonium isotopes ($^{239+240}$Pu) as soil erosion tracers. Although these investigations generally concluded on the suitability of Pu isotopes for erosion assessment, one unknown, when using $^{239+240}$Pu, is related to its specific mobility within the soil and its potential preferential transport during soil erosion. This is the first study to explore whether $^{239+240}$Pu (like ^{137}Cs) is preferentially eroded by water using the activity ratio of $^{239+240}$Pu to ^{137}Cs. Our tested study site is located in the Haean catchment of the Republic of Korea(Fig. 1), where intense agriculture and high rainfall erosivity associated with the Asian monsoon cause recurrent high soil losses.

As highlighted by Meusburger *et al.* (2016), the measured average ^{240}Pu/^{239}Pu atomic ratios in the soils were 0.182 ± 0.015, which agrees well with the integrated atmospheric fallout value of 0.18 ± 0.014.

The $^{239+240}$Pu/^{137}Cs activity ratios (corrected to 1.7.1998) for the bulk reference samples are on average 0.032 ± 0.017 (Fig. 1, solid line). It lies within the reported global fallout ratio of 0.029 ± 0.003, but show considerably higher variation (Meusburger *et al.*, 2016). The greater variation observed for our sites is most likely explained by the different adsorption behaviour of $^{239+240}$Pu and ^{137}Cs in soils. Relatively low ratios and thus higher amounts of ^{137}Cs compared to the global $^{239+240}$Pu/^{137}Cs fallout ratio occur in the upper part of the soil profile and relatively high ratios and low amounts of ^{137}Cs in the deeper layers, respectively. The latter implies a higher mobility and migration rate of $^{239+240}$Pu as compared to ^{137}Cs under our site conditions.

Regarding the lateral mobility of both radioisotopes, we observe a reverse effect with a significantly higher mobility of ^{137}Cs. The $^{239+240}$Pu/^{137}Cs activity ratios for bulk soil samples collected at erosional and deposition sites differ (p = 0.07; t-test) with ratios of 0.079 ± 0.088 and 0.025 ± 0.006, respectively (Fig. 1). Compared to the global fallout ratio, the erosional sites are depleted in ^{137}Cs and the sedimentation sites slightly enriched. These differing ratios between erosion and sedimentation sites indicate that during erosion ^{137}Cs might be mobilized prior to $^{239+240}$Pu and/or to a larger extend. This could be explained by a preferential transport of fine soil particles, to which the major proportion of ^{137}Cs is adsorbed, while $^{239+240}$Pu reflects more than ^{137}Cs the fate of the organic matter during erosion processes because of its strong binding to soil organic matter. The $^{239+240}$Pu/^{137}Cs activity ratios offer a novel approach to determine *in situ* particle size correction factors that can be applied when both ^{137}Cs and $^{239+240}$Pu have the same fallout origin.

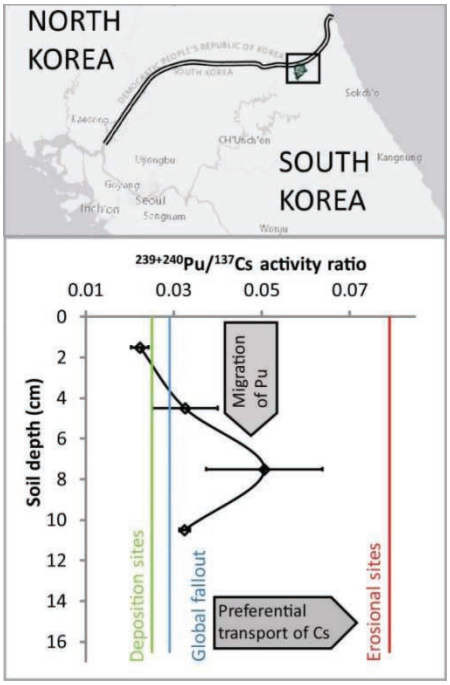


FIG. 1. $^{239+240}$Pu/^{137}Cs activity ratio for 6 reference soil profiles; vertical lines indicate the global fallout ratio (blue), the ratio of deposition sites (green) and erosional sites (red).

References

Meusburger, K., Mabit, L., Ketterer, M., Park, J.H., Tarjan, S., Porto, P., Alewell, C. (2016). A multi-radionuclide approach to evaluate the suitability of $^{239+240}$Pu as soil erosion tracer. *Science of the Total Environment*, 566-567: 1489–1499.

Approaches to reduce zinc and iron deficits in food systems

Peter J. Gregory[1], Ammar Wahbi[2], Joseph Adu-Gyamfi[3], Maria Heiling[2], Roman Gruber[2], Edward J.M. Joy[4], Martin R. Broadley[5]

[1]*School of Agriculture, Policy & Development, University of Reading, PO Box 237, Reading, RG6 6AR, UK.*
[2]*Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency (IAEA), Vienna, Austria.*
[3]*Soil and Water Management & Crop Nutrition Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency (IAEA), Vienna, Austria.*
[4]*Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, Keppel Street, London, WC1E 7HT, UK.*
[5]*School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough LE12 5RD, UK.*

Deficiencies of the more than 20 essential elements required by humans are widespread in global food systems, especially in the global south. A review paper recently published in Global Food Security (Gregory *et al,*. 2017) focuses on zinc (Zn) and iron (Fe), whose entry into food systems depends primarily on soil and crop factors.

The consequences of micronutrient deficiencies (MNDs) may be less obvious than energy or protein deficiencies but at least 1.5 billion people are likely to be affected by one or more MNDs. Quantifying MNDs is problematic because different methods give different estimates. Generally, a combination of approaches is required that includes proxies based on national food supply, dietary intake surveys and health data, and biomarkers. Using food composition data, the prevalence of inadequate dietary Zn supplies was estimated to be 17% globally, with Zn deficiency widespread in low-income countries. The prevalence of Fe deficiency is particularly difficult to determine.

Zinc and Fe are both essential nutrients for plants, and in many low-income countries, plant-based foods provide the majority of dietary Zn and Fe. The quantity of Zn and Fe contained in plant organs depends on interacting soil, crop, environment and management factors. Zinc deficiency in plants is often associated with alkaline and calcareous soils of high pH, and also with highly weathered soils. Iron deficiency in plants occurs on several soil types but is typically associated with low phyto-availability rather than low abundance *per se*. The concentration of Fe in soil solution decreases as the redox potential and/or pH increases so that concentrations in calcareous and alkaline soils are typically 100–1000 times lower than in soils with a pH of 6–7. Generally, the seeds of most cereals (maize, rice and wheat) have lower concentrations of Zn and Fe than seeds of legumes. Zinc and Fe are not readily transported in the phloem so that phloem-fed tissues, such as tubers, fruits and seeds, are frequently poorer sources of Zn and Fe than leaves. Similarly, environmental factors that increase plant growth rates typically reduce the concentrations of mineral elements in plant organs – known as a 'yield dilution' effect. Nevertheless, inputs of nutrients to increase yield are not always associated with decreases in mineral element concentrations of edible plant parts and additions of manures and fertilizers can boost both yield and micronutrient concentrations. One interaction that is particularly important for Zn nutrition of plants is that P fertilizers can decrease the bioavailability of Zn in soil. Good P management is required in intensive agricultural systems to ensure both high cereal yields and high concentrations of Zn in grain.

There are four main approaches to increase intakes of bioavailable micronutrients: (1) direct supplementation; (2) food fortification at home or during the processing stage; (3) dietary diversification; and (4) crop biofortification, including breeding and fertilizer-based approaches. Food fortification often occurs during processing and may be mandated by governments or undertaken by individual processers/manufacturers to add value to their products. Staple foods, such as cereal flours, breakfast cereals, cooking oil and salt, are typically chosen for fortification. Although the potential of food fortification for addressing Fe and Zn deficiencies is clear, especially where the consumption of processed food is high, such approaches are likely to be less successful in settings where the majority of households depend on subsistence production, including in much of sub-Saharan Africa and South Asia. Dietary diversification can potentially improve intakes of multiple micronutrients but in poor households, cereals and other starchy staples typically contribute >50% of dietary energy supply with low (or seasonal) consumption of animal products, fruits and vegetables. The greater consumption of fish and other nutrient-dense foods in wealthier households suggests that resource constraints, including household purchasing power, limit dietary diversity. Biofortification produces crops with greater bioavailable concentrations of nutrients in their edible

portions and can be achieved by (1) breeding crops with increased concentrations of the target nutrient, or decreased concentration of molecules that inhibit absorption such as phytate; or (2) applying fertilizers. Breeding crops for increased Zn and Fe concentration, and subsequent take-up by farmers has been successfully achieved through the HarvestPlus programme. Crops released to date include high-Fe bean (*Phaseolus vulgaris*) in Rwanda, high-Fe pearl millet (*Pennisetum glaucum*) in India, and high-Zn wheat (*Triticum*) in India and Pakistan (http://www.harvestplus.org/). However, the efficacy of high-Zn and Fe crops in alleviating dietary Zn and Fe deficiencies can be limited by high concentrations of phytate and polyphenols, which co-occur in the edible tissues of crops. This is likely to remain a major constraint to realising the full potential of crop Zn and Fe biofortification. Agronomic biofortification involves the application of micronutrient-enriched fertilizers to increase their bioavailable concentrations in the edible portion of crops. Micronutrients can be applied in combination with commonly used granular fertilizers applied to soils, or as foliar sprays. For soil-applied Zn, applications of organic nutrients, such as cattle manure and woodland litter in combination with NPK and Zn fertilizers, have provided additional increase in maize grain Zn concentration beyond that expected from the additional Zn inputs from these sources. Typically, lower amounts of Zn and Fe fertilizers are needed if foliar forms are used, albeit at a higher cost of application. Economic analyses of Zn fertilizer use in sub-Saharan Africa, Pakistan and China have shown that Zn fertilizers are likely to be a cost-effective strategy to address widespread Zn deficiency.

Radioactive isotopes of Zn (^{65}Zn) and Fe (^{55}Fe) have long been used as tracers to study the movement of both elements in the food chain, but in recent years a range of stable isotopes of Zn (e.g. ^{64}Zn, ^{66}Zn, ^{70}Zn) and Fe (^{54}Fe, ^{57}Fe, ^{58}Fe) have become the preferred approach. Stable-isotope enriched forms of Zn and Fe have been added to different parts of the food chain (e.g. fertilizers), to track the movement of this 'label' based on the altered ratios compared to natural isotopic abundances. It is now possible to study small differences in the fractionation of stable isotopes of Zn and Fe, across physical and biological boundaries, in their naturally-occurring concentration ranges. This approach has shown, for example, that in soils with low Zn availability, ^{66}Zn was enriched in the shoots of a rice variety tolerant to Zn deficiency (RIL46) compared with the soil and shoots of intolerant plants. This difference was ascribed to the uptake of Zn in the form of complexes with deoxymugineic acid.

In conclusion, deficiencies of both Zn and Fe are widespread, contributing negatively to food security. Several interventions are possible to reduce the incidence of such deficiencies, including increased dietary diversity, food supplementation and biofortification of crops through breeding and more balanced fertilizer practices. Innovative approaches with stable isotopes of Zn and Fe have considerable potential applications in wider food systems studies to quantify flows within the system and to increase understanding of crucial processes and mechanisms contributing to their bioavailability.

References

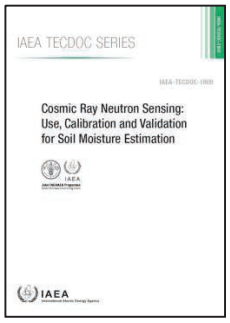
Gregory, P.J., Wahbi, A., Adu-Gyamfi, J., Heiling, M. Gruber, R., Joy, E.J.M., Broadley, M.R., (2017). Approaches to reduce zinc and iron deficits in food systems, Global Food Security. http://dx.doi.org/10.1016/j.gfs.2017.03.003

Announcement

New FAO/IAEA Publications:

Cosmic Ray Neutron Sensing: Use, Calibration and Validation for Soil Moisture Estimation

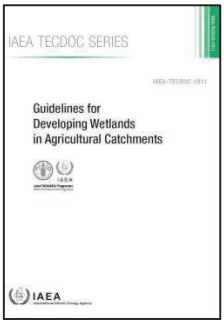
The cosmic ray neutron probe is useful in the development of climate-smart agricultural practices that aim at optimizing water use efficiency as it enables the measurement of soil water content in agriculture. However, most sensors monitor only small areas (less than 1m in radius), so that a large number of sensors are needed to obtain soil water content across a large area. This can be both costly and labour intensive so that larger-scale measuring devices are needed as an alternative to traditional point-based soil moisture sensing techniques. The cosmic ray neutron sensor (CRNS) is such a device that monitors soil water content in a non-invasive and continuous way. This publication provides background information about this novel technique, and explains in detail the calibration and validation process.



http://www-pub.iaea.org/books/IAEABooks/11097/Cosmic-Ray-Neutron-Sensing-Use-Calibration-and-Validation-for-Soil-Moisture-Estimation

Guidelines for Developing Wetlands in Agricultural Catchments

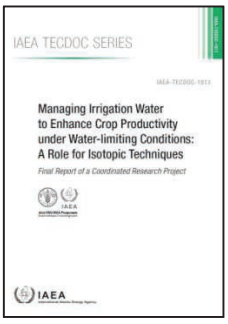
This publication presents the results of an international research project on optimizing the capture and storage of water by assessing nutrient-using water conservation zones in agricultural landscapes. Eight countries from Asia/Pacific, Africa and Europe participated in the project. Field studies were established in all participating countries using isotopic and nuclear techniques to assess three types of water conservation zones that are used to harvest water for irrigation, crop production and improve downstream water quality. In addition, isotopic and nuclear techniques were used to collect data to identify the ideal locations in the landscapes for developing wetlands. The publication provides information to researchers working in the area of soil and water management, natural resource managers, policy makers and farmers. For those working to develop wetlands, information is provided to support planning, monitoring and evaluation.



http://www-pub.iaea.org/books/IAEABooks/11146/Guidelines-for-Developing-Wetlands-in-Agricultural-Catchments

Managing Irrigation Water to Enhance Crop Productivity under Water-limiting Conditions: a Role for Isotopic Techniques

This publication presents the outcome of an IAEA coordinated research project and provides research findings and isotopic methodologies to quantify the soil evaporation component of water losses and determine the transpiration efficiency for several important crop species under a variety of environments. The TECDOC also introduces a simple, fast and portable vacuum distillation apparatus for extraction of water from soil and plant samples for isotopic analyses for the separation of soil evaporation, which helped to reduce the bottleneck in sample throughput for many soil water and hydrology studies.



https://www.iaea.org/publications/12193/managing-irrigation-water-to-enhance-crop-productivity-under-water-limiting-conditions-a-role-for-isotopic-techniques

Highlights

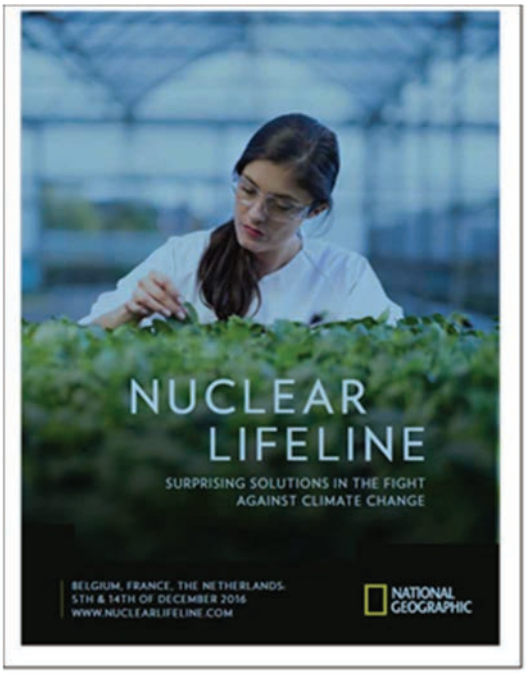
SWMCN Laboratory featured in National Geographic documentary: Nuclear Lifeline

The Soil and Water Management & Crop Nutrition Laboratory together with the other laboratories of the Joint FAO/IAEA Division was featured in a National Geographic Documentary highlighting solutions in the fight against climate change.

This documentary entitled 'Nuclear Lifeline' was a result of a close collaboration between the Belgian Nuclear Forum and the National Geographic. The objective was to demonstrate the crucial role nuclear technologies play in the areas of human health and climate change. The episode can be downloaded at https://www.nuclearlifeline.be/.

The documentary recently received a 'Cuckoo Award', Belgium's top advertising and marketing award that honours excellence in creativity, strategy, response/results and content in marketing campaigns. The Cuckoo Awards are given to campaigns that have the power to change business, and with the perfect combination of visionary strategy, extraordinary content, compelling creativity and breakthrough results.

We are proud to have been part of this documentary and congratulate the Belgian Nuclear Forum and the producers of the documentary to this award.



Technical Cooperation Field Projects

Country/Region	TC Project	Description	Technical Officer(s)
Afghanistan	AFG5006	Developing and Implementing Soil and Water National Management System Using Nuclear Techniques	/M. Zaman
Algeria	ALG5029	Improving Wheat and Legume Yield through Better Water and Fertilizer Management and Introduction of New Vegetal Material	M. Zaman
Bangladesh	BGD5029	Evaluating Promising Abiotic Stress Tolerant Crop Mutants/Varieties and Measuring the Suitable Management Practices for the Promotion of Sustainable Production at Saline, Submergence and Drought Prone Areas	A. Wahbi
Bolivia	BOL5021	Strengthening the Strategic Development Plan for Quinoa Production through Improved Use of Organic Manure, Soil and Crop Management	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
Botswana	BOT5012	Improving Soil and Water Management Options to Optimize Yields of Selected Crops	J. Adu-Gyamfi
Brazil	BRA5059	Strengthening Strategies of Soil and Water Conservation at the Landscape Level in Natural and Agricultural Ecosystems	E. Fulajtar and G. Dercon
Burkina Faso	BKF5016	Using Nuclear Techniques for Improving Rice Yield and Quality	J. Adu-Gyamfi in collaboration with the Plant Breeding and Genetics Section
Burundi	BDI5001	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	M. Zaman in collaboration with the Plant Breeding and Genetics Section
Central African Republic	CAF5008	Cassava androgeneses culture and contribution to soil fertilization	M. Zaman
Cameroon	CMR5021	Developing Best Nutrient and Water Management Practices to Improve Soil Fertility and Productivity and Minimize Land Degradation Using Isotopic Techniques	J. Adu-Gyamfi
Chad	CHD5012	Using Nuclear Technology to Improve Knowledge and Sustainable Agricultural Production to Safeguard Lake Chad	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 the Food and Environmental Protection Section
Cuba	CUB5019	Strengthening National Capacity for Monitoring Heavy Metals to Improve Soil and Food Quality Using Nuclear and Related Techniques	E. Fulajtar in collaboration with the Food and Environmental Protection Section
Ecuador	ECU5028	Consolidating Food Security and Environmental Sustainability in Palm Oil Production Using Nuclear Applications	J. Adu-Gyamfi in collaboration with the Food and Environmental Protection Section
Haiti	HAI5006	Increasing Productivity and Exportability in the Agricultural Sector through Soil and Water Management and Food Safety Monitoring	J. Adu-Gyamfi in collaboration with the Food and Environmental Protection Section
Interregional project	INT5153	Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions	G. Dercon
Iran	IRA5013	Investigating the Effects of Deforestation and Afforestation on Soil Redistribution	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
Iraq	IRQ5020	Restoring Biomass Productivity of Range Land by Using Nuclear Techniques and Advanced Technology	A. Wahbi
Cambodia	KAM5001	Improving Soil Fertility and Crop Management Strategies in Diversified Rice Based Farming Systems	L. Heng
Jamaica	JAM5012	Optimizing Irrigation Water Management to Improve Crop Output and Water Quality Control	L. Heng
Kenya	KEN5036	Developing Soil Fertility and Water Management for Soil, Crop and Livestock Integration in Three Agro-Ecological Zones	J. Adu-Gyamfi
Kuwait	KUW5001	Improving Production and Water Use Efficiency of Forage Crops with Nuclear Techniques	A. Wahbi
Laos	LAO5002	Improving Soil Fertility and Water Use Efficiency in the Cassava-Rice-Soybean Production System under Smallholder Farming Systems	M. Zaman
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 the Plant Breeding and Genetics Section
Myanmar	MYA5025	Monitoring and Assessment of Watershed Management Practices on Water Quality and Sedimentation Rate of Inle Lake	L. Heng
Namibia	NAM5014	Evaluating Efficient Water and Nutrient Use, Molecular Characterization and Nutritional Composition of Mutant Germplasm Populations	J. Adu-Gyamfi in collaboration with the Plant Breeding and Genetics Section
Niger	NER5019	Improving Sesame Plant Productivity by Obtaining High-Yielding Induced Mutants Adapted to Semi-Arid Conditions	J. Adu-Gyamfi in collaboration with the Plant Breeding and Genetics Section
Niger	NER5021	Using Microbial Biotechnology to Improve Productivity and Adapt Cowpea to Climate Change	J. Adu-Gyamfi in collaboration with the Plant Breeding and Genetics Section
Panama	PAN5023	Enhancing Rice Crop Yields by Improving Water and Nutrient Management Using Nuclear and Isotopic Techniques	J. Adu-Gyamfi
Sri Lanka	SRL5045	Establishing a National Centre for Nuclear Agriculture	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
T.T.U.T.J of T. Palestinian A.	PAL5008	Reducing Soil Degradation by Improving Soil Conservation using Fallout Radionuclides (Phase I)	E. Fulajtar
Africa	RAF0046	Promoting Technical Cooperation Among Developing Countries (TCDC) in Africa through Triangular Partnerships (AFRA). [Bilateral TC project between Morocco and Côte d'Ivoire]	L. Mabit
Africa	RAF5071	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation (AFRA)	L. Heng
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
Asia	RAS5069	Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	E. Fulajtar in collaboration with the Plant Breeding and Genetics, the Animal Production and Health and the Isotope Hydrology Sections
Asia	RAS5070	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	M. Zaman in collaboration with the Plant Breeding and Genetics,
Asia	RAS5072	Enhancing the Use of Salt Affected Soils and Saline Water for Crop and Biomass Production and Reducing Land and Water Quality Degradation in ARASIA states parties	A. Wahbi
Asia	RAS5073	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II	L. Heng in collaboration with the Plant Breeding and Genetics Section
Latin America	RLA5064	Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques (ARCAL CXL)	G. Dercon
Latin America	RLA5065	Improving Agricultural Production Systems Through Resource Use Efficiency (ARCAL CXXXVI)	J. Adu-Gyamfi
Seychelles	SEY5007	Increasing Crop Production through Effective Management of Soil Salinity in the Coastal Area using Nuclear and Related Techniques	L. Heng
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	M. Zaman in collaboration with the Plant Breeding and Genetics Section

Country/Region	TC Project	Description	Technical Officer(s)
Uganda	UGA5037	Introducing Integrated Soil Fertility Management for Improved Crop Production and Food Security	E. Fulajtar and L. Mabit
Zimbabwe	ZIM5021	Assessing and Promoting Sustainable Agricultural Production in Communal and Newly Resettled Farms	L. Mabit in collaboration with the Plant Breeding and Genetics Section

Forthcoming Events

FAO/IAEA Events

Coordination Meeting of Regional TCP RAS5070 on 'Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques', 3-7 July 2017, Hanoi, Viet Nam

Technical Officer: Mohammad Zaman

Regional Training Course on The Use of Advanced Nuclear and Related Tools for Agricultural Water Management and Advance Use of Crop Simulation Model (AquaCrop) under the Regional Technical Cooperation Project RAF5071 'Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation', 3-14 July 2017, Seibersdorf, Austria

Technical Officers: Ammar Wahbi and Lee Heng

Regional Training Course on 'Soil sampling strategy, harmonization of the sampling procedures and radionuclide analyses' of Regional Technical Cooperation Project RAF5075 'Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides', 17-28 July 2017, Rabat, Morocco

Technical Officer: Emil Fulajtar

Consultants Meeting on 'Stable isotopes for monitoring agricultural-derived pollutants and land management practices to ensure water quality' 25–29 September 2017, Vienna, Austria

Technical Officers: Joseph Adu-Gyamfi and Lee Heng

Third Research Coordination Meeting of the Coordinated Research Programme D1.50.16 on 'Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems' 7-11 October 2017, Madrid, Spain

Technical Officers: Mohammad Zaman and Lee Heng

Non-FAO/IAEA Events

18th International Plant Nutrition Colloquium (IPNC), 21-24 August 2017, Copenhagen, Denmark
http://www.ipnc2017.org/
http://plen.ku.dk/arrangementer/2017/international-plant-nutrition-colloquium-2017/

Annual Interdisciplinary Conference on Research in Tropical and Subtropical Agriculture, Future Agriculture: Social-ecological transitions and bio-cultural shifts, Tropentag, 20-22 September 2017, Bonn, Germany
http://www.tropentag.de/

6th International Symposium for Research in Protected Areas 2017, 2 - 4 November 2017, Faculty of Natural Sciences, University of Salzburg, Austria
http://www.nationalparksaustria.at/de/pages/6th-international-symposium-for-research-in-protected-areas-2017-d-100.aspx

World Congress of Soil Science, 12 - 18 August 2018, Rio De Janeiro, Brazil http://www.21wcss.org/.

Past Events

Duty Travel

Ecuador: ECU5028 'Consolidating Food Security and Environmental Sustainability in Palm Oil Production Using Nuclear Applications', 10–14 October 2016, Quito, San Lorenzo

Technical Officer: Joseph Adu-Gyamfi

The Technical Officer (TO) traveled to Quito and San Lorenzo to (1) develop a sampling strategy (for soil and soil-water samples) for studying the retention and movement of pollutants (pesticides and nitrate) in commercial oil palm plantations, (2) conduct field hands-on training on soil and environmental samplings to trace the movement of agricultural-derived pollutants at the Soils section of the Instituto Nacional Autonomo de Investigaciones Agropecuarias (INAIP) at Santa Catalina, (3) discuss and make technical adjustments to the work plans, and activities to be implemented during 2017. The commercial farmers were advised by the TO the need to incorporate *Pueraria* spps (a forage legume) into the plantation as a cover crop to control weeds (instead of applying herbicides), and to add nitrogen and soil organic matter to the soil. The TO later visited the Ministerio de Agricultura, Ganaderia, Acuacultura y Pesca (MAGAP) to discuss about the visit of two International Experts who would explore the use of unmanned aerial vehicles (UAVs) to assess their suitability to monitor land use and irrigation efficiency in 3 selected regions of Ecuador.

Soil sampling techniques to determine the movement of pollutants in soil

Ivory Coast: 1st Coordination Meeting of Regional TCP RAF5075 'Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides', 12-16 December 2016, Abidjan

Technical Officer: Emil Fulajtar

The objective of this meeting was to develop the work plan and detailed implementation strategy for the first phase of the RAF5075 project and to discuss the national and regional activities to (i) build human capacity, (ii) enhance laboratory facilities, and (iii) support the future project activities with regards to soil erosion monitoring and soil conservation planning. The RAF5075 project is a follow up of a former regional TC project on land degradation (RAF5063) and the meeting was used also as an opportunity to summarise the results and highlight the major achievements of RAF5063 presented in summarizing country reports. The TO coordinated the discussion and helped to analyse the results and identify achievements and shortcomings of some studies. The initiation of RAF5075 activities were based on country presentations characterizing the newly selected study sites, the erosion problems and the status of erosion research in participating countries. The Programme Management Officer (PMO) together with TO coordinated the discussion on the budget planning and procurement request. The meeting also involved a technical excursion to experimental coconut plantations near Abidjan.

Participants of the meeting at CNRA, together with representatives of the Institute

Afghanistan: AFG 5006 'Developing and Implementing Soil and Water National Management System Using Nuclear Techniques', 9-13 January 2017, Kabul

Technical Officer: Mohammad Zaman

The average yield of wheat grown in Afghanistan under irrigated condition is less than 2 tonnes per hectare (ha). There are a number of reasons for this low yield including poor farming practices, declining soil fertility and continual nutrient mining by crop removal without adequate replacement. Additionally, social, economic and security problems are likely to be contributing factors to the lower productivity seen in Afghanistan. The TO travelled to Kabul, Afghanistan to review the project work plan, provide technical advice in designing field trials with wheat and present lectures and a hands-on training on developing agricultural practices to enhance wheat productivity in a sustainable manner using both nuclear and conventional techniques. Additionally, the TO provided input to the project's conceptual design for a new TC project for 2018-19 cycle. During the visit, the TO discussed project activities for 2017 with the Counterpart and his team at the Directorate of Soil Research, Ministry of Agriculture, Irrigation and Livestock, in Kabul. This was followed by laboratory visits and discussions with the soil science laboratory manager and other researchers to assess their needs for laboratory glassware, chemicals and consumables. The TO then provided a 3 day period of lectures and hands on training to the Afghan researchers. Topics included: the role of nuclear and isotopic techniques in understanding nutrient and water use efficiencies on farms and the best farming practices to use for improving soil fertility, conserving nutrients and enhancing crop productivity through integrated plant nutrient management. The TO then reviewed the conceptual design of the new TCP for the 2018-19 cycle in order to adjust the project activities so that objectives and outputs of the TCP could be accomplished in a timely manner.

Participants in the training course on'best practices' at Badam Bagh research farm, Kabul, Afghanistan

Malaysia: RAS5073 Mid-Term Review Meeting of 'Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II', 6-10 February 2017, Kota Kinabalu, Sabah

Technical Officer: Lee Heng

The TO travelled to Kota Kinabalu, Sabah in Malaysia, together with PMO Mr Ho Seung Lee and technical officer of Plant Breeding and Genetics Mr Ljupcho Jankuloski, to conduct the mid-term review meeting of RAS5073 project. The host organizer was Malaysian Nuclear Agency and the meeting organizer was Mr Shyful Azizi bin Abdul Rahman. The meeting was opened by Dr. Mohd Ashhar Bin HJ. Khalid, DG of Malaysian Nuclear Agency. The meeting was attended by 18 participants from BGD, INS, KAM, LAO, MAL, MON, MYA, NEP, PAK, PHI, THA, VIE, and Mr Jagdish Kumar Ladha, expert from IRRI. The TOs gave presentations on the status and success of nuclear application in food and agriculture and contribution of nuclear techniques to food security. The work done in all participating countries was presented. A general discussion summarizing the results and national needs were collated. A technical visit to Kota Belud, the Rice Bowl of Sabah, and to Kawasan Pembangunan Pertanian Bersepadu (IADA) in Kota Belud was made. Project work plan and training courses for 2017-2018 were agreed. Achievements also include standard methodology on the use of N-15 under flooded rice conditions, and developing methodologies on alternate wetting and drying (AWD).

Participants in the mid-term review meeting of RAS5073 project in Kota Kinabalu, Sabah, Malaysia

Belgium: To participate as key-note speaker on 'Nuclear Applications in Food and Agriculture' at the New Year Event of the Belgian Nuclear Forum, 7 February 2017, Brussels

Technical Officer: Gerd Dercon

As representative for the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Mr Gerd Dercon travelled to Brussels to give a key note, within the New Year event of the Belgian Nuclear Forum, on the use of nuclear applications in food and agriculture and how these applications can be used to improve health, food security, the sustainability of agriculture and the resilience of farmers' communities to climate change. About 200 people attended the New Year event. More information can be found on https://www.forumnucleaire.be/actus/nouvelle/new-year-event-les-diverses-applications-de-la-technologie-nucleaire-dans-la-lutte-contre-le-changement-climatique?_ga=2.221683292.579632675.1494317813-895219306.1481628848 (in French).

Panama: PAN5023 'Enhancing Rice Crop Yields by Improving Water and Nutrient Management Using Nuclear and Isotopic Techniques', 6–10 March 2017, Panama City and Divisa

Technical Officer: Joseph Adu-Gyamfi

Mr Joseph Adu-Gyamfi traveled to Panama City and Divisa to discuss with the counterpart institute Instituto de Investigaciones Agropecuarias de Panamá (IDIAP) the project work plan and future activities. Major items were (1) progress made and an efficient way to accelerate the implementation of the activities and (2) human resource capacity development requirements including fellowships and scientific visits, laboratory infrastructure and logistic support for field studies. The mission also helped to train counterparts on the use of stable isotope of rubidium (^{85}Rb) to evaluate potassium use efficiency in crops. The TO had a meeting with officials of the Ministry of External Relations, Directorate General for special project and international cooperation, and the FAO Subregional Coordinator, Mr Tito Diaz. The travel by the TO coincided with the set-up, installation, and training of project counterparts on newly acquired soil water monitoring sensors from Sentek Technologies by an expert, Mr Peter Buss. The mission helped to install six internet based-soil moisture sensors in two farmers' field and at the experimental station, and trained counterparts on the use of the equipment to advise farmers when to irrigate and the amount of water required for irrigation. The use nuclear and isotopic techniques (^{15}N and ^{85}Rb) coupled with soil water monitoring sensors in the current project would help better soil, water and nutrient management for improved crop yield and save water. The FAO office in Panama was briefed of the on-going and future agricultural and environmental TC related projects in Panama and the TO requested FAO support in the scaling out of the technology to farmers.

Mr Joseph Adu-Gyamfi with the FAO Subregional Representative and staff

USA: RAS5069 Regional Training Course on the Interdisciplinary Application of Isotope Hydrology and Soil Related Isotopic Techniques for Flood Risk Mitigation and Post-Flood Rehabilitation in Asia, 20-24 March 2017, Chicago

Technical Officer: Emil Fulajtar

The Regional TCP RAS5069 'Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia' is a wide interdisciplinary project involving nuclear techniques useful for flood management. The workshop was focused to soil and water isotopes used in pedology, plant nutrition and hydrology. The objective of this workshop was to provide training on nuclear techniques used in isotope hydrology and in soil water and nutrient management for flood management. The participants presented their country reports including the use of FRN methods for soil erosion assessment. The workshop also helped to process the spatial data and erosion modelling (using RUSLE and WEPP model).

Course Participants at Argonne National Laboratory

Italy: Attendance at the UN Food and Agriculture Organization's Global Symposium on Soil Organic Carbon, 21-23 March 2017, Rome

Technical Officer: Janet Chen

This year the Joint FAO/IAEA Soil and Water Management and Crop Nutrition laboratory contributed to the FAO's Global Symposium on Soil Organic Carbon in Rome, Italy, from March 21-23. This symposium highlighted the importance of soil organic carbon (SOC) in climate change adaptation and mitigation, food security, soil stability and sustainability. Over 450 scientists as well as policy and decision makers from 111 countries attended the symposium to share their work and learn about the progress that others are making related to managing SOC in agricultural and natural systeMs Efforts related to measuring, monitoring, mapping, maintaining and increasing SOC in natural ecosystems ranging from peatlands to deserts as well as agricultural systems were shared in oral and poster presentations, with key presentations by notable scientists, politicians and businessmen. The SWMCN presentation, '*Integrated monitoring of carbon storage and loss through emerging isotope technology',* highlighted the importance of stable isotope analysis in identifying plant and soil processes that can increase or reduce SOC. Key SOC research questions were refined and future work identified to maintain and improve SOC levels. The scientific community agreed that the prevention of further SOC loss should be a priority in all soils and that further sequestration of SOC should be pursued in soils with the potential to store more carbon. We also agreed that farmers and governments, including those of Member States, should be empowered to monitor, protect and improve their own SOC levels, as this will improve food security and nutrition, poverty reduction, land degradation neutrality and sustainable development. A summary of the symposium and concluding recommendations were compiled into a final FAO document, '*Unlocking the potential of Soil Organic Carbon',* to improve SOC sequestration and sustainable soil management (http://www.fao.org/documents/card/en/c/25eaf720-94e4-4f53-8f50-cdfc2487e1f8/).

More information on the symposium and media provided can be found at the following:
http://www.fao.org/about/meetings/soil-organic-carbon-symposium/about/en/

Senegal: Final Coordination Meeting of TCP RAF5071 'Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation (AFRA)', 27-31 March 2017, Dakar

Technical Officer: Lee Heng

The TO travelled to Dakar, Senegal together with project managing officer Mr Abdou Ndiath to conduct the final project coordination meeting. The meeting was attended by 16 participating countries: Algeria, Benin, Botswana, Cote D'Voire, Egypt, Ethiopia, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Senegal, Sudan, Uganda and Zimbabwe, and a consultant from Kenya plus local Senegal scientists supporting the project. The host Mr Mamadou Sall is from Institut Senegalais de Recherches Agricoles (ISRA) in Saint-Louis. The meeting was officially opened by Dr El Hadji Traore, the Scientific Director of ISRA followed by welcome speech of Dr Coumba Thiandoume, the NLO of Senegal. The TO and PMO chaired sessions, provided technical and managerial backstopping during the meeting. The TO also gave a presentation on the use of nuclear and isotopic techniques for climate-smart soil and water management and briefed the counterparts on the technical status and expectations from the project. The work done in all sixteen countries was presented. National needs including training courses and procurement were identified and agreed. Summary of results were compiled and a comprehensive project report on guidelines and practical recommendations on water and nutrient requirements under small-scale irrigation technologies in Africa will be developed. Formulation and design of the new follow up regional project for the 2018-2021 cycles was also finalized. The Kenyan consultant Peter Okoth presented results of Information Communication Technologies (ICTs) and outreach achievements on work with the Maasai in Kenya. A technical visit to Saint Louis ISRA HQ was made. The group was welcomed by Dr Abdou Aziz Mbaye, the Director of the ISRA Saint Louis. A visit was also made to Africa Rice Center (AfricaRice), a CGIAR Research Centre situated in Saint Louis.

Haiti: HAI5006 'Increasing Productivity and Exportability in the Agricultural Sector through Soil and Water Management and Food Safety Monitoring', 27–31 March 2017, Port-au-Prince

Technical Officer: Joseph Adu-Gyamfi

Mr Joseph Adu-Gyamfi traveled to Port-au-Prince, Haiti to assess counterparts' infrastructure and laboratory facilities, review and discuss project implementation. His travel coincided with an expert mission of Mr Pascal Houngnandan from Benin to conduct a training course on the use of ^{15}N methodology to evaluate and identify cereal crops for fertilizer nitrogen use efficiency (FNUE) and legumes for their high biological nitrogen fixation.

Accompanied by Mr Donald Joseph from Ministere de l'Agriculture, des Ressources Naturelles et du Developpement Rural (MARNDR) and project counterpart of HAI5006, the TO paid a courtesy call to the Director General of MARNDR, Mr Armoux Severin a former SV to Seibersdorf in 2008. The DG reiterated his support for the on-going project. Twenty-five people participated in the training jointly conducted by the TO and the expert. The TO also visited the experimental farm where 8 rice varieties will be evaluated for their FNUE using ^{15}N fertilizers in 2017 and the new Soils and Food Safety Laboratory at the Veterinary Laboratory and Quality Control of Food in Tamarinier where he met with Mr Alain Louis (main counterpart) and assessed the laboratory facilities. The conclusions from the travel were: (1) the counterparts were enthusiastic to use the training received on the ^{15}N methodology to evaluate and identify nutrient efficient rice and maize varieties with better yield, and legumes with high biological nitrogen fixing ability for farmers to maximize profit through N fertilizer savings, (2) the human resource capacity development requirements for field studies were identified, (3) the modernization of the laboratories by Inter-American Development Bank (IADB) in Tamarinier, for the Soils and Food Safety laboratories has been completed but the laboratories need to be equipped to perform basic soil, plant and water analyses, (4) the FAO office in Haiti would assist to scale up of technologies from the project to farmers in the country.

Participants of the training course in Haiti

Uganda: Mid-term evaluation of TCP UGA5037 'Introducing Integrated Soil Fertility Management for Improved Crop Production and Food Security' 3-7 April 2017, Kampala

Technical Officer: Emil Fulajtar

The major objective of the mission to the National Agricultural Research Laboratories (NARL) in Kampala by the technical officer was to perform the mid-term evaluation of the project implementation, to provide technical advices on data interpretation and to review work plan for 2017. The program of the mid-term review involved also the assessment of the laboratories and the capacities of NARL for implementation of nuclear techniques.

Study site in South-Western Uganda: Mountain agriculture affected by erosion sliding and conservation measures (terracing, erosion furrows, reforestation by eucalyptus trees)

The major part of the work was focused on data interpretation. For that reason a field visit of study site near Kabale (South-Western Uganda) was organized. The site represents intensive small scaled mountain agriculture. Subsistence farming (sweet potatoes, cassava, sorghum, beans) is exploiting steel slopes. The land use structure is constituted by steeply inclined terraces affected by intensive rill erosion, sliding (especially at terrace edges) and occasional gully erosion. The area is a subject of intensive land conservation activities (terracing, reforestation of steepest parts of slopes by eucalyptus forests, digging of erosion furrows below terrace edges and stabilizing of terrace edges by cultivation of bush grows. The field work was for collecting additional background info (slope inclination, soil colour, samples for soil texture and organic matter). After summarizing the result of the mission, revision of work plan was done. Overall assessment of the achievements in Uganda is very positive. The collected data set can be presented as a success story of erosion research with the use of fallout radionuclide methods in Africa.

LAO P.D.R: A meeting to discuss key activities of the TC project LAO5002 on 'Improving Soil Fertility and Water Use Efficiency in the Cassava-Rice-Soybean Production System under Small holder Farming Systems', 3-7 April 2017, Vientiane

Technical Officer: Mohammad Zaman

The purpose of this travel to LAO P.D.R. was to hold meetings with the counterpart and technical staff at the National Agricultural Research Center (ARC) to review project progress and provide guidance as appropriate. The research team presented four seasons of field data from rice trials which showed that by using the 'best practices' (applying the right amount of nutrients at the right time)

approach the grain yield of rice plants can increase by 15% compared with conventional farm practices in Laos.

Technical Officer with project team on a rice field visit in ARA

The TO organized a one day workshop at ARC and trained six researchers to implement best practices for rice, cassava and maize using nuclear, isotopic and conventional techniques. This was followed by a practical demonstration of field trial layout, and also techniques on the application of ^{15}N labelled fertilizer. On the request of the Project Management Officer, the Technical Officer also met with the CP of the animal health project (LAO5003) to help him in designing the new joint TCP (LAO2016001) on 'soil and plants' scheduled for 2018-19. During the last two days of the meeting, the Technical Officer worked together with the two CPs to design the new project (LAO2016001) and to link the activities of the ongoing projects with the new project for 2018-19.

Belgium: To attend a Kick-off meeting between EC and IAEA, following the signing of a Practical Arrangements, 5 April 2017, Brussels

Technical Officer: Gerd Dercon

Mr Gerd Dercon travelled with a delegation of the Department of Nuclear Sciences and Applications of the IAEA, under the guidance of Mr Jean-Pierre Cayol, to Brussels to attend the kick-off meeting between the European Commission and the IAEA following the signing of a Practical Arrangements during the EU-IAEA Senior Officials Meeting held in February 2017, in Brussels. The kick-off meeting was hosted by the Joint Research Centre at its headquarters and aimed at identifying venues for immediate cooperation between the two organizations.

The meeting was chaired by Mr Abousahl on behalf of the Joint Research Centre. A presentation was given by the JRC on the timeline of the Nuclear Science Applications (NSA) Practical Arrangement highlighting the importance of identifying the different EU instruments that may be applicable to nuclear science and applications.

An overview was given of the work of the IAEA in nuclear sciences and applications. The following themes relevant to food and agriculture were discussed with a view to illustrate the respective activities of the two organizations and to identify potential venues for cooperation: (i) Food applications (e.g. food safety and authenticity), (ii) Agricultural applications (animal health, plant breeding, sterile insect pest control), (iii) Earth observation (soil erosion assessment and soil moisture monitoring at landscape level) and (iv) nuclear emergency preparedness and response in food and agriculture.

Participants of the kick-off Meeting between EC and IAEA as part of Practical Arrangements

Follow-up meetings with the JRC – Earth Observation group have been held in the meanwhile in spring 2017 to further identify specific fields of potential collaboration in soil and water management and crop nutrition, such as (i) joint work on analyzing satellite data imagery and linking with nuclear data to characterize land use, improve land and water management, and (ii) complementary work on emergency preparedness and response (e.g. support for guiding large-scale sampling through the use of satellite imaginary under nuclear emergencies).

Kuwait: To facilitate the RAS5072 Regional Training Course on 'Integrated Agricultural Production Systems', 7-11 May 2017, Kuwait Institute of Scientific Research (KISR)

Technical Officer: Ammar Wahbi

Under regional TC Project RAS5072 on 'Enhancing the Use of Salt Affected Soils and Saline Water for Crop and Biomass Production and Reducing Land and Water Quality Degradation in ARASIA States Parties', a regional training activity was conducted on 'Integrated Agricultural Production Systems' at the Kuwait Institute for Scientific Research (KISR), Safat, Kuwait, from 7-11 May 2017. The training included topics such as soil, water, crop and nutrient management, and integrated production systems for optimizing on-farm production. During the mission, the technical officer also visited the KISR experimental farms and attended different lectures delivered by KISR scientists on using of ^{15}N stable isotope techniques in agriculture. The course was attended by twenty-two scientists from eight Member States.

Participants of the regional training course in Kuwait

Costa Rica: COS5033 'Assessing and Implementing Biochar Use in Climate Smart and Environmentally Friendly Pineapple Production Using Isotopic Techniques', 8-9 May, 2017, San Jose

Technical Officer: Mohammad Zaman

The purpose of this travel was to review and evaluate the progress of project, provide technical inputs to future field trials on biochar and the design of the project for 2018-19. Technical inputs on project design of the new project (COS2016010) were also provided. The counterpart (CP) and his team presented an overview of the project activities and demonstrated that, after receiving IAEA support for capacity building through fellowship training and equipment (provided under the national TC project), the CP successfully produced high quality biochar from crop residues of pineapple, palm oil fiber and coffee husk on a laboratory scale. After characterization and testing in the laboratory, the CP and his team wanted to test the biochar technology under field condition to investigate the impact of biochar on improving soil fertility and quality. If successful, the use of biochar would offset the impact of climate change by sequestering carbon in the soil and minimizing the leaching of nutrients and toxic chemicals (pesticides and insecticides) into the groundwater. To assist the CP and his team in conducting such field studies, the Technical Officer provided technical guidance in helping design two experiments. One study will be conducted under laboratory conditions, with the objectives being to quantify greenhouse gases and the leaching of pesticides using nuclear and isotopic techniques. The other study, performed under field conditions was designed to determine the impact of biochar on soil quality and health.

The TO worked together with Ms Ana Gabriela Pérez and her team members to review and finalize the design of the new proposed TC project (COS2016010) which is scheduled for the 2018-2019 TC cycle. The Technical Officer and the project team members visited a pineapple field in the Pital district of Alajuela province and had discussions with the pineapple grower about the forthcoming field trial which was designed to demonstrate the benefit of biochar added to soils which are under a pineapple cropping regime. Finally, the CP and CICA management acknowledged the IAEA contribution in capacity building, and in developing biochar technology in Costa Rica Both committed to communicate with IAEA regularly to ensure that the ongoing and new project will meet its objectives.

Romania: To participate in an International Conference on 'Blue Waters & Green Agriculture: Challenges and perspectives in Nutrients Pollution Control', 10–13 May 2017, Bucharest

Technical Officer: Joseph Adu-Gyamfi

Mr Joseph Adu-Gyamfi was invited by Ms Naiana Milea, Ministry of Waters and Forests to share the IAEA experience on the innovation solutions for nutrients monitoring using nuclear techniques. The objectives of the integrated nutrient pollution control (INPC) project financed by the World Bank, UNEP (through the Global Environmental Facility) and the EU are to reduce the nutrient discharge in water bodies, promote behavioural changes and strengthen institutional and regulatory capacity. The main interventions are to reduce the discharge of nutrients (nitrogen and phosphorus) on the long term into the water bodies reaching the Danube and the Black sea through an integrated soil and water management. At the opening ceremony, the Ministers of Water and Forests, Environment, and Agriculture & Rural Development expressed the need for the three ministries to work together to implement the EU Nitrates Directives. Representatives from the World Bank, the EU and UNEP commended the Government of Romania for successfully implementing the project. Mr Joseph Adu-Gyamfi made a presentation under Session 7 'Innovative solutions for nutrients monitoring' with a title 'Stable isotopes for monitoring agricultural-derived pollutants and land management practices to ensure water quality'. This presentation that showed the success stories in the use of isotopes to monitor nitrates in Myanmar and Slovenia generated a lot of interest among the participants. It was agreed that the project collaborates with IAEA to use nuclear techniques for nutrient monitoring. On the final day, there was a field trip to the project sites and the Danube Delta.

Anchoring the Danube delta natural heritage

Belgium: To attend the European Development Days (EDD), 7-8 June 2017, Brussels

Technical Officer: Arsenio Toloza

Mr Arsenio Toloza from the SWMCN Laboratory attended the 2017 European Development Days https://www.eudevdays.eu/ as part of the IAEA's team to showcase how science is supporting development. The work in Benin on the pulses and in Sudan on small-scale irrigation were highlighted. The EDD are Europe's leading forum on development and international cooperation. Organised by the European Commission, the forum brings the development community together each year to share ideas and experiences in ways that inspire new partnerships and innovative solutions to the world's most pressing challenges.

The IAEA stand in action at the European Development Days 2017, Brussels

Scientific Visitors

Ms Julia Maria von Chamier Glisczinski and **Ms Gudrun Heidemarie Schaeffer** from the Department of Catchment Hydrology, Helmholtz Centre for Environmental Research, Germany, visited the SWMCN Laboratory and Section to learn more on the use of laser isotope analysers for measuring the ^{15}N signature of nitrate in water samples, from 2 to 4 May 2017.

Mr Nahimana Dieudonne, Ms Jacqueline Ndayihanzamaso and **Mr Bacanamwo Ferdinand**, from the Institut des Sciences Agronomiques du Burundi (ISABU); Ministry of Agriculture and Livestock, Burundi, visited the SWMCN Laboratory and Section to learn more on the use of isotope and nuclear techniques to improve soil, water and nutrient management, from 19 to 23 May2017.

Mr Baba Ahmed Naghra, Director General of CNRADA, Mauritania along with two researchers visited the SWMCN Section and Seibersdorf Laboratories on 29 May to 2 June, 2017 to discuss and plan project activities of Mauritani national TC (MAU 5006).

Scientific visitors from Mauritania with Ms Lee Heng and TO

Mr Kauser Abdulla Malik, Professor of Biotechnology from Forman Christian College Lahore Pakistan visited the SWMCN Section on 1 June to discuss the use of stable isotopes of phosphorus for assessment of P fertilizer efficiency.

Mr Takashi Muraoka, University of Sao Paulo, Brazil, visited the SWMCN Section on 2 June to discuss research areas in soil fertility, biological N fixation and greenhouse gas emission for possible collaboration.

Meetings and Training at the IAEA

Austria: Third Research Coordination Meeting (RCM) for CRP D1.50.15 on 'Response to Nuclear Emergencies Affecting Food and Agriculture', 20-24 February 2017, IAEA, Vienna

Technical Officers: Gerd Dercon and Lee Heng

The third RCM was held to review the progress made until present and develop the work plans of the last phase of the CRP. In particular emphasis was put on how to disseminate the results of the project with regard to sampling and analytical protocols and data management and visualization. Three research contract holders from Morocco, the Russian Federation and Ukraine, four technical contract holders from France, Japan (2) and Macedonia, and three agreement holders from Belgium, India and Japan and one observer from Belgium participated in this RCM. Presentations were also given by the JRC of the European Commission and IEC/IAEA. More information about this CRP can be found in the below section on 'Coordinated Research Projects'.

Coordinated Research Projects

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

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

Technical Officer: M. Zaman

This CRP is in its fourth year and the fourth year renewals for all national projects will be completed in July 2017. The main objective of the project is to enhance food security and rural livelihoods by improving resource use efficiency and sustainability of integrated crop-livestock systems under a changing climate. The specific objectives are to: (1) optimize water and nutrient use efficiency in integrated crop-livestock production systems, (2) identify the potential for improving soil quality and fertility in integrated crop-livestock systems, (3) assess the influence of crop - livestock systems on GHG emissions, soil carbon sequestration and water quality, (4) assess socio-economic and environmental benefits of crop-livestock systems, (5) strengthen the capacity of the Member States to use isotopic and nuclear techniques as tools for improving the management of crop-livestock systems, and (6) develop soil, water and nutrient management options for use in integrated crop-livestock systems so that they can be adopted by farmers. The CRP began in July 2013 with nine research contract holders from eight countries (Argentina, Brazil (two), China, India, Indonesia, Kenya, Uganda and Uruguay) and three agreement holders from France, Nigeria and the United States of America. The final RCM will be held in the second quarter of 2018.

Key outputs of the project over the first four years are explained below:

- Integrated crop-livestock system (ICLS) increased soil C storage, reduced GHGs and improved crop productivity and animal health.
- In India, compared to conventional system, ICLS increased C storage, gain in calf weight, 15% more cow milk, improved animal reproduction performance by shortening calving interval by 2 months, increased rice yield (15%) and 24 to 37% water saving in paddy.
- Compared to continuous cropping system, ICLS increased soil organic C in Argentina, China and Brazil as well as 45% reduction of N_2O in Brazil.
- In Kenya, ICLS led to 9% increase in maize yield and conservation of soil water.

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

Technical Officer: Lee Heng

This project is in its 4th year and the 3rd Research Coordination Meeting was just held in Ho Chi Minh City, Viet Nam in Dec 2016. All participants presented results from their field studies. Under coastal zone situation as in the Red River and Mekong Delta in Viet Nam, participants used ^{18}O isotopic technique to determine the contribution of seawater intrusion for the salinity of the irrigation water used for rice production, and develop ways to improve water management. Under dryland ecosystem such as Xinjiang province in China and central part of Iran, agronomic measures including plastic

mulching, deep plowing, straw returning and organic fertilizer, had higher desalination rate than chemical modifier; also flooding irrigation before sowing was necessary for the sustainable development of saline cotton field drip-irrigated under mulch in Xinjiang. In Amu Darya River Basin of Uzbekistan, agroforestry-based management of salt-affected irrigated croplands is a promising approach. Salt tolerance of tree species is studied using ^{13}C isotopic signature as the indicator of water and salt stress in agricultural landscape. Simulation modelling using both HYDRUS and AquaCrop models were used to simulate the field salinity results. The development of cosmic ray neutron sensor for area-wide soil water monitoring was reported in China, IAEA Seibersdorf and USA. During the meeting, project work plan and activities for the coming years were revised. This CRP which started in July 2013, has the following objectives: a) to identify ways to improve crop productivity and sustainability through water and salinity management, b) to define approaches and technologies to assess and monitor soil water content and salinity at field and area-wide scales, c) to reduce the impacts of climate change and variability on the widespread increase in landscape.

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

Technical Officers: Mohammad Zaman and Gerd Dercon

This Coordinated Research Project (CRP) was completed in November 2016. The CRP counterparts are now preparing manuscripts from their 5 years field data. A brochure on general mulch application and relates it to the Sub-Sharan Africa farming conditions, highlights the key benefits, challenges and management issues of mulch application under changing climate. The brochure is planned to be completed by Q4 2017.

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

Technical Officers: Gerd Dercon and Lee Heng

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

The objectives of the CRP are:

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

Four research contract holders from China, Morocco, the Russian Federation and Ukraine, four technical contract holders from France, Japan (2) and Macedonia, three agreement holders from Belgium, India and Japan and one observer from the European Commission participate in this CRP. Close collaboration has been established as well with IEC/IAEA.

To date, Standard Operating Procedures (SOPs) are being compiled for sampling and analysis of soil and foodstuffs in case of a nuclear or radiological emergency affecting food and agriculture, protocols for supporting large-scale sampling and radionuclide concentration analysis of foodstuffs are being prepared, and an advanced prototype of an online information system to support decision-making in food safety in case of a nuclear emergency has been developed (called DSS4NAFA). The decision-support system DSS4NAFA is currently being further improved, and a Beta version for extended independent testing is expected to be available in July 2018. The Information Technology Advisory Group (ITAG) of the IAEA has approved the development of DSS4NAFA, and an independent review of the system has been carried out by KPMG in close collaboration with the IAEA - MTIT department to ensure sustainable implementation and information security.

Major efforts are made to integrate the data management and visualization part of DSS4NAFA, and a prototype of the dashboard for decision support with regards to the implementation of food and planting restrictions is available (see for more information in the July 2017 Newsletter section on 'Developments at the Soil and Water Management & Crop Nutrition Laboratory').

The third RCM was held from 20-24 February 2017 in Vienna. The last RCM will be held in Q4-2018 or Q1-2019.

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

Technical Officers: Mohammad Zaman and Lee Heng

This CRP is in its third 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, one each from Brazil, Chile, China, Costa Rica, Ethiopia and Pakistan, two agreement holders from Estonia and Spain, and one technical contract holder from Germany.

Data on N_2O emissions from different cropping systems were presented earlier, during the second RCM, which was held on 23 to 27 May 2016, at Justus-Liebig University Giessen, Germany. Seven research contracts and one technical contract will be renewed in October, 2017 based on their project progress reports and renewal proposals. The key results obtained since the beginning of this CRP include:

- Co-application of urea fertilizer with either N process inhibitors or biochar reduced N_2O emissions (20 to 76%), while increasing crop productivity (0 to 23%).
- Converting natural forest or agroforestry to agricultural lands increase C, N and GHGs losses (Ethiopia).
- Three papers were published in peer review Journals.
- A simple method of ammonia emission was developed which is being validated further using N-15 labelled urea.
- A network of GHG experts established to update the current guideline for GHGs by Q4, 2017

Five research papers on the effects of land use changes and farm management practices on emissions of greenhouse gases and soil quality have been published in refereed scientific journals. The third RCM will be held in the Technical University, Madrid from 7-11 October 2017. The objectives of this RCM are to review project progress and develop work plans for the remaining two years. The CRP is expected to continue for five years (2014–2019).

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

Technical Officers: Lionel Mabit and Lee Heng

The Coordinated Research Project (CRP) D1.50.17 planned for the next 5 years (2016-2021) is aimed at: (i) identifying and testing combinations of nuclear and conventional techniques to assess the impacts of changes occurring in upland agro-ecosystems, (ii) distinguishing and apportioning the impact of climate variability and agricultural management on soil and water resources in uplands, and (iii) supporting adaptive agricultural management for soil and water conservation in uplands to reduce impacts of climate variability. Nuclear techniques will be used to fulfil these specific objectives, including Fallout radionuclides (FRNs) such as caesium-137 (^{137}Cs), lead-210 (^{210}Pb), beryllium-7 (^{7}Be), plutonium-239 and 240 ($^{239+240}Pu$), Compound-Specific Stable Isotope (CSSI) techniques and Cosmic Ray Neutron Probe (CRNP).

The first Research Co-ordination Meeting (RCM) of the CRP D1.50.17 was successfully held in Vienna, Austria, from 25-29 July 2016. Since then, significant progress related to the first objective of the CRP was made in refining FRN and CSSI techniques to deepen our understanding of erosion processes affecting upland agro-ecosysteMs Already six publications reporting these new developments were produced acknowledging explicitly the CRP D1.50.17. The main milestone of the first year activity of the CRP was without a doubt the development of the new and unique FRN conversion model MODERN (see our previous Soils Newsletter). For your information, the second RCM of the CRP D1.50.17 will be hosted in Rabat (Morocco) end of March 2018.

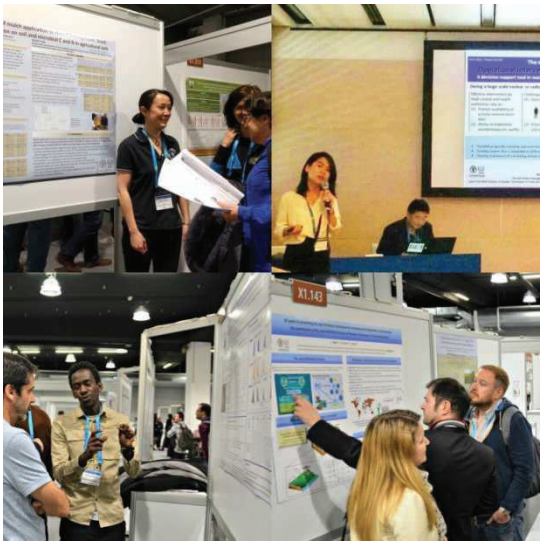
Developments at the Soil and Water Management and Crop Nutrition Laboratory

Sharing the SWMCN Laboratory's research at the 2017 European Geosciences Union (EGU) General Assembly in Vienna, Austria

Amelia Lee Zhi Yi

From 23-28 April, 14,500 scientists from 107 countries came together at the European Geosciences Union (EGU) 2017 General Assembly held in Vienna, Austria. With close to 17,500 oral, poster and PICO (i.e. Presenting Interactive COntent) presentations shared in 649 scientific sessions, the assembly was a unique opportunity to share scientific work with scientists from around the world.

The SWMCN Section and Laboratory's activities were reported by 6 staff members in 14 oral, poster and PICO presentations covering topics on carbon and nitrogen cycling, soil erosion and conservation, quantification of water evapotranspiration, and food safety strategies in nuclear emergencies. The SWMCN Laboratory's work on large scale nuclear emergency response in food and agriculture was selected as a solicited submission and highlighted in the EGU session on 'Geoscience processes related to Fukushima and Chernobyl nuclear accidents'.



Six staff members shared the work of the SWMCN Section and Laboratory at the 2017 EGU General Assembly

All details about the contributions from the SWMCN Subprogramme can be found in our list of publications at the end of this Newsletter and more information regarding EGU 2017 can be found at: http://www.egu2017.eu. We would like to inform our readers that the next EGU General Assembly will take place again in Vienna from 8 to 13 April 2018.

Final findings in investigating sediment origin in an Austrian sub-catchment study using compound-specific stable isotope (CSSI) techniques

Modou Mbaye[1] *and Lionel Mabit*

[1]*Institute of Applied Nuclear Technology, University of Cheikh Anta Diop, Dakar, Senegal*

The above study, which aimed to identify the origin of sediments deposited at the outlet of the Austrian Mistelbach sub-catchment through the compound-specific stable isotope (CSSI) techniques, has finally finished (see previous SWMCN Newsletters for a detailed description of the experimental site).

The studied sub-catchment consists of four sediment contributing areas or so-called 'sources', i.e. three agricultural fields (S1; S2; S3) and one grassed waterway (S4), and one sediment deposition zone at the outlet also termed the mixture.

Our updated CSSI dataset was processed using the mixing model SIMMR (i.e. Stable Isotopes Mixing Model in R). The output of the model, which is expressed as isotopic proportions, was converted into soil proportion using the bulk organic carbon % of each source. Fig. 1 shows the probability density function of the soil proportion of the four sources to the mixture. S4 and S3 are the main contributing sources to the sediment deposited at the outlet (i.e. the mixture) with 54% ± 5% (mean ± se) and 27 % ± 4%, respectively.

To discuss the results obtained, the temporal land use record over 22 years, from 1990 until 2012 (year of sampling), of the four contributing fields or 'sources' was provided by our Austrian partners.

Both S1 and S2 sources had land uses clearly dominated by C3 plants confirmed by our measured $\delta^{13}C$ values of

the bulk soil carbon of -25.1‰ and -24.2 ‰, respectively. In addition, these sources showed high similarity in term of plant species rotation (Fig. 1).

In term of land uses, as well as in the resulting overall $\delta^{13}C$ bulk soil carbon values, these sources differ significantly from S3 (-14.9‰) and S4 (-18.7‰). Indeed, as presented in Fig. 2, the agricultural field S3 was under a C_3 and C_4 crop rotation, with maize - the only C_4 species cultivated in this watershed - having been cultivated 6 years over the last 22 years. The source S4, until the installation of a grassed waterway (pure C_3 grass) in 2003, had the same land use than S3 and therefore presents a more negative $\delta^{13}C$ bulk value as compared to S3. The findings of this research are consistent with the land use information and the distance of the sources to the outlet. Almost 80% of the sediment deposited at the watershed exit originates from the sources S3 and S4 which had maize cultivation, one of the land uses triggering erosion, in particular at the beginning of the maize growing season.

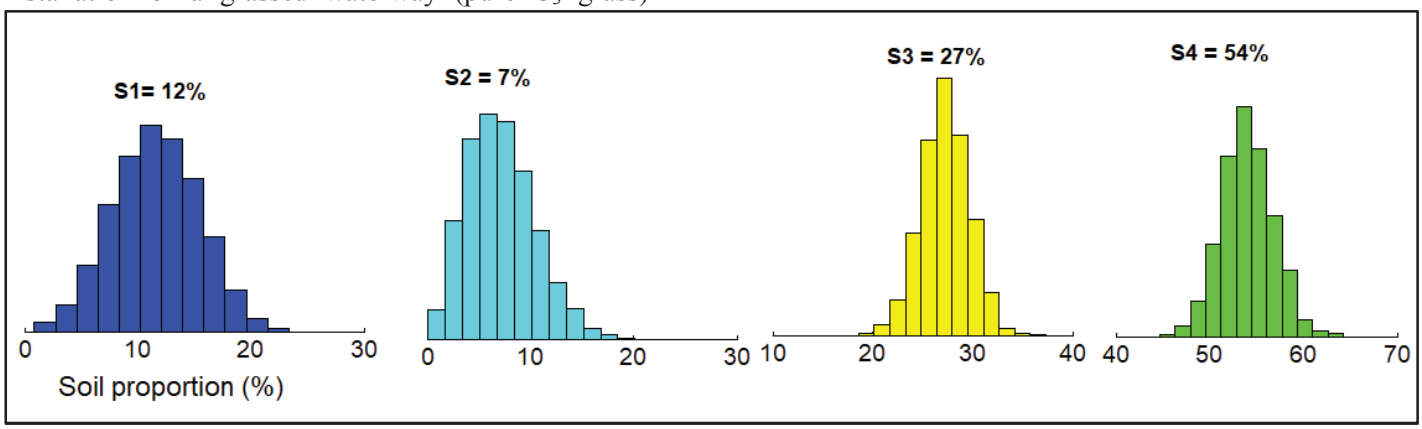


FIG. 1. Soil contribution of each source to the sediment mixture

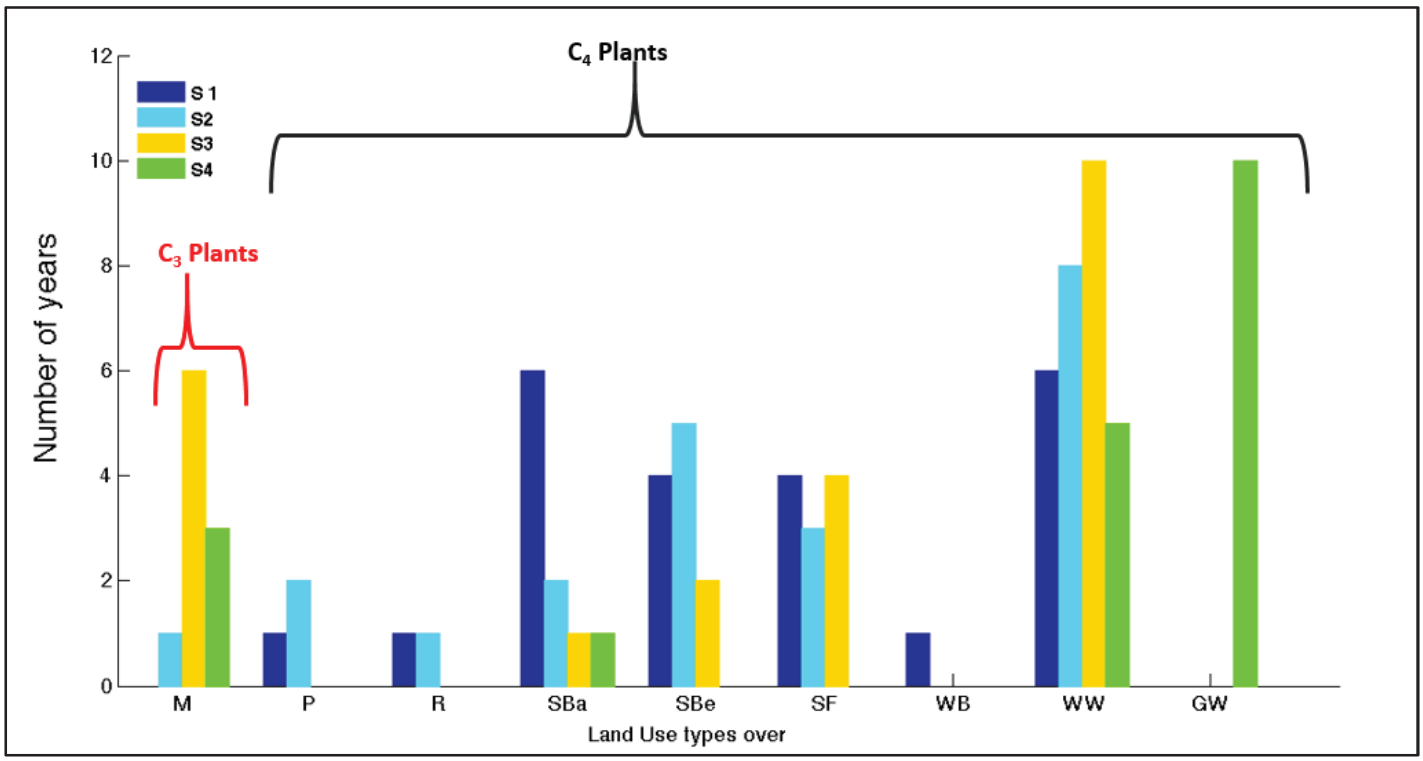


FIG. 2. Mistelbach land use frequency of each field ('source') over 22 years (1990 to 2012)

M = Maize; P = Pea; R = Rapeseed, SBa = Spring barley; SBe = Sugar beet; SF = Sunflower; WB = Winter barley; WW = Winter wheat; GW = Grassed waterway

Evaluating mixing modelling for soil erosion hot spot identification through the use of artificial soil mixtures

Romina Torres Astorga[1,2,*], *Hugo Velasco*[1], *Gerd Dercon, Lionel Mabit*

[1]*Grupo de Estudios Ambientales, IMASL-CONICET-UNSL, San Luis, Argentina*
[2]*Soil and Water Management and Crop Nutrition Laboratory, FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency, Vienna, Austria*

Soil erosion and associated sediment redistribution are key environmental problems in Central Argentina. Several land uses and management practices, such as intensive grazing and crop cultivation, are considered to drive and increase significantly these processes.

To prove the above hypothesis, a mixing modelling approach (CSSIAR v1.00), using Energy Dispersive X Ray Fluorescence (EDXRF) data as fingerprint of sediment sources and sinks, is aimed to identify critical hot spots of erosion in a typical Argentinian agro-ecosystem. The study site is an Estancia Grande subcatchment with an area of 1235 hectares, located 23 km north east of San Luis (in the center of Argentina) and which is characterized by highly erodible Haplic Kastanozem soils.

However, before the mixing modelling approach can be used, validation is needed. This can be achieved by the composition of artificial soil mixtures based on existing sediment sources collected from the targeted studied subcatchment. The proportion of these sources in the artificial mixtures is estimated by the mixing model, whose result is then compared with the true values of the apportionment.

Four artificial soil mixtures were created using known quantities of the most representative sediment sources of the studied catchment. The first mixture (MIX 1) was composed of four sources characterised by crop cultivation in rotation. The second (MIX 2) and the third mixture (MIX 3) were built using different proportions of four different soil sources including soils from a feedlot, a rotation crop, a walnut forest and a from a native pasture for grazing. The last tested mixture (MIX 4) contained the same sources as MIX 3 but with the addition of a fifth source collected along the river banks.

The geochemical element content analysis of the mixtures and sources samples was performed by EDXRF. For determining the best suitable fingerprint elements of the sources, a four-step selection process was developed and tested. After applying a traditional approach for fingerprint selection which includes statistical tests such as Kruskal–Wallis H-test and Discriminant Function Analysis (DFA), we used (1) the known information on the source proportions in the mixtures and (2) the subset of tracers that passed the previous mentioned tests, to select the specific elemental tracers that are in agreement with the expected mixture contents. Our selection process was completed after a final test using the mixing model CSSIAR v1.00 to compute all possible combinations of the reduced number of tracers obtained. Alkaline earth metals especially Barium (Ba) and Strontium (Sr) were identified as the most effective elemental fingerprints which provided a reduced Mean Absolute Error (MAE) of around 2% when reconstructing the four artificial mixtures.

This study, which has been presented during EGU 2017, demonstrates that the elemental fingerprinting approach using EDXRF performed very well to reconstruct our original mixtures, especially in identifying and quantifying the contribution of the 4 rotation crop soil sources in MIX 1 as well as in recognizing the major and minor source contributors in MIX 3 (Fig. 1).

**Support from the STEP fellowship programme is kindly acknowledged. Through its Sandwich Training Educational Programme (STEP), ICTP and its UN partner, the International Atomic Energy Agency (IAEA), offer fellowships to PhD students from developing countries in the fields of physics and mathematics.*

SMWCN Laboratory STEP fellow preparing sample for EDXRF analysis

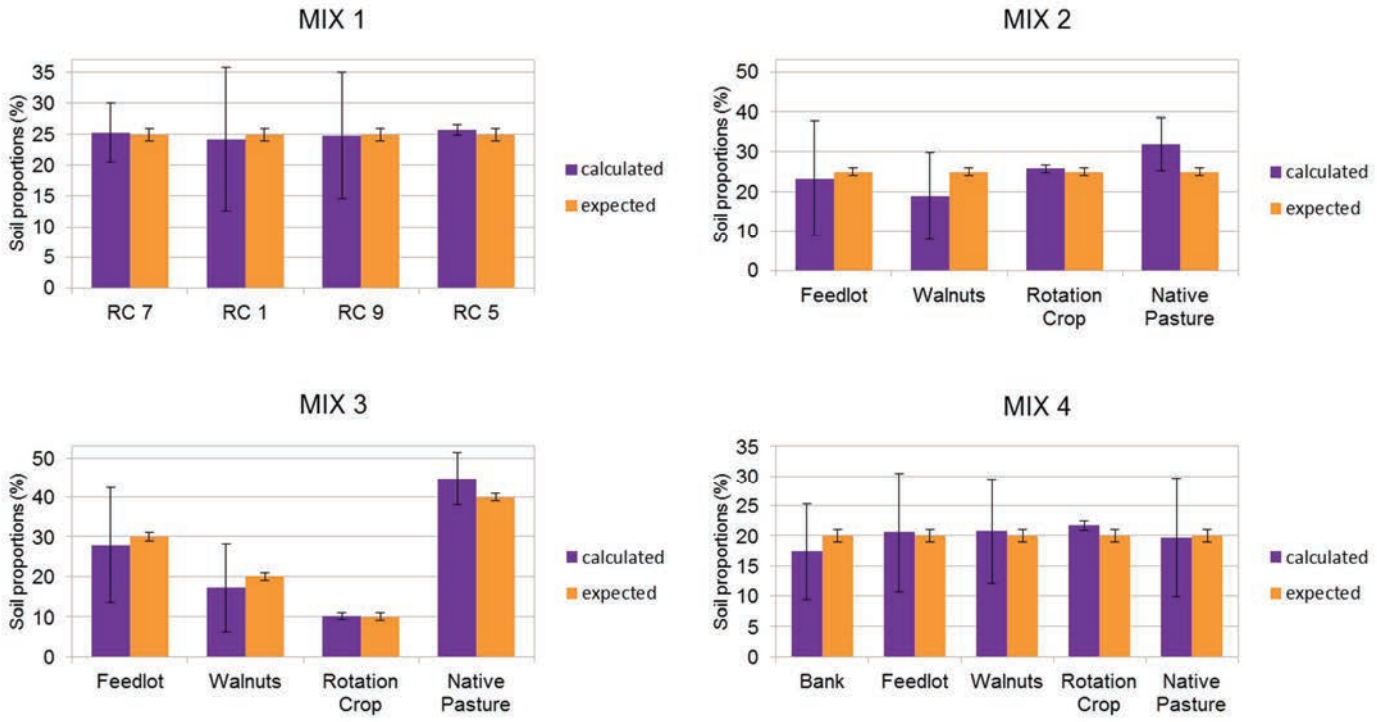


FIG. 1. Comparison of the expected and calculated proportion contribution of the different sources for each tested artificial mixtures

Evaluating the effectiveness of mulch application to store organic carbon in agricultural soils

Janet Chen, Maria Heiling, Christian Resch, Roman Gruber, Gerd Dercon

Soils contain more carbon than plants and the atmosphere combined and increased soil carbon content provides multiple benefits including climate change mitigation, improved soil quality and larger plant production. Depending on the type of farming techniques applied, agricultural soils can either store more carbon belowground, or further release carbon, in the form of CO_2, into the atmosphere. Mulch application is a farming technique that is frequently proposed to increase carbon content belowground and improve soil quality and it can be used in efforts to reduce greenhouse gas levels, such as in the '4 per 1000' Initiative. To test the effectiveness of mulch application to store carbon belowground in the short term, we maintained agricultural soils with low and high organic carbon content (disturbed top soil from local Cambisols and Chernozems, respectively) in greenhouse mesocosms with controlled moisture (Fig. 1) as well as in agricultural field Cambisols (Fig. 2). A legume-maize rotation was maintained in the mescosms and a legume-maize rotation as well as sole maize production or legume production was maintained in the agricultural field experiment. Plant residues from these productions were reapplied to soils after harvest as mulch to mimic procedures a farmer would apply. After 4 years of maintenance in the mesocosms and 2 years maintenance in the field, soil were sampled to measure carbon and nitrogen pools and isotopic composition in the top 15 cm. Mulch was expected to increase carbon and nitrogen content and ho have a greater effect on soils with low organic matter than soils with high organic matter.

Fig. 1. Maize and soybean were grown yearly in rotation in greenhouse mesocosms and mulch was removed or applied after harvest at 2 ton/ha dry matter. Soil disturbance was kept to a minimum, with only surface disturbance of a few centimeters to keep soil free from weeds.

In mesocosm Cambisols with low organic carbon content and larger predicted potential to increase soil carbon, mulch application did not increase soil carbon or nitrogen pools. However, mulch application significantly

increased the $\delta^{13}C$ of soil organic carbon by 0.55‰, indicating a shift in belowground processes, such as increased decomposition coupled with increased ^{13}C-enriched maize carbon inputs. In mesocosm Chernozems with higher organic carbon content and lower potential to increase soil carbon, mulch application decreased microbial carbon by 44%. Mulch application also increased $\delta^{13}C$ of soil organic carbon by 0.51‰, likely indicating a decrease in decomposition and increased maize carbon inputs. Field plots in Cambisols confirmed these greenhouse mesocosm results and showed that legume-maize rotations with mulch application do not increase soil or carbon nitrogen pools but do increase $\delta^{13}C$ of soils. Interestingly, however, sole maize production in the field resulted in an increase in soil organic carbon by 30-32% with mulch application but $\delta^{13}C$ did not increase. Sole legume did not increase soil carbon or $\delta^{13}C$ with mulch application. Contrary to initial presumption, mulch application did not increase soil carbon pools with legume-maize rotation or sole legume Mulch application only increased soil organic carbon pools in maize plot. This, in combination with the increase in $\delta^{13}C$ in mesocosm and plot with legume-maize rotation indicates that mulch application under maize contributes to an increase of organic carbon but that this is muted with the addition of legumes to soils as well. This was largely explained by the decrease in the soil C:N ratio by legumes that likely stimulates increased decomposition and carbon loss.

Fig. 2. Maize and vetch were grown in the field in agricultural Cambisols with low organic carbon content. Plant production was maintained for 2 years.

International networking for improving stable isotope methods to quantify isotopic composition of nitrates in water samples

Amelia Lee Zhi Yi, Maria Heiling, Christian Resch, Georg Weltin

Dr. David Soto, a Marie Curie Fellow from the Department of Earth and Environmental Sciences, University of Leuven, Belgium, was at the SWMCN Laboratory on 13-17 February 2017 as a short-term consultant. An expert in bacterial denitrification and laser spectroscopy, Dr. Soto assisted the SWMCN laboratory team in the calibration and experimental setup of the Los Gatos N_2O Analyzer, as well as in streamlining the bacterial denitrification method set up in the lab. The training benefitted the SWMCN Laboratory's work in quantifying the isotopic composition of nitrate, in particular $\delta^{15}N$ and $\delta^{18}O$, which in turn could assist in improving soil and water management practices.

During the week-long training by Dr. Soto, the specific focus was on (1) implementation of improvements to experimental processes established in the laboratory, (2) training on usage of the Los Gatos N_2O Analyzer, including machine calibration and measurement, and (3) training on data extraction, management and bias corrections. Experiments were also initiated to explore the effects of sonification of samples on $\delta^{18}O$ measured.

SWMCN Laboratory team being trained or calibration of the Isotopic N_2O Analyzer

Through this consultant visit, the SWMCN Laboratory staff learnt how to reduce the number of processes performed in laminar hood, which would assist Member States in eliminating costs when implementing the bacterial denitrification method. The method was also further refined such that the process is more streamlined and can be completed from water sample inoculation to analysis in a shorter period.

Cosmic ray neutron sensor technique for estimating field scale soil moisture at high elevations

William Alexander Avery, Ammar Wahbi, Gerd Dercon, Lee Heng, Trenton E. Franz[1], and Peter Strauss[2]

[1]*School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583, USA*
[2]*Federal Agency for Water Management, Institute for Land & Water Management Research, 3252 Petzenkirchen, Austria*

Meeting the demands of a growing global population is one of the challenges of the 21st century. As such, the expansion of agricultural activity will place additional pressure on freshwater resources. Currently, approximately two thirds of freshwater use by humans is devoted to agricultural production. As such, the expansion of agricultural activity will place additional pressure on freshwater resources. The incorporation of novel soil moisture sensing technologies into agricultural practices carries the potential to make irrigation more precise thus increasing water use efficiency. One such technology is known as the Cosmic Ray Neutron Sensor (CRNS). The CRNS technique is capable of quantifying soil moisture on a large spatial scale (~ 30 ha) compared with traditional point based in-situ soil moisture sensing technology. Recent years have seen the CRNS performing well when deployed in agricultural environments at low to mid elevations. However, the performance of the CRNS technique in higher elevations, particularly alpine environments, has yet to be demonstrated or understood. Mountainous environments are more vulnerable to changing climates and land use practices, yet are often responsible for the headwaters of major river systems sustaining cultivated lands or support important agricultural activity on their own. As such, the applicability of a mobile version of the CRNS technology in high alpine environments needs to be explored. This research details the preliminary efforts to determine if established calibration and validation techniques associated with the use of the CRNS can be applied at higher elevations. Field work was conducted during the summer of 2016 in the mountains of western Austria. Initial results indicate that the relationship between in-situ soil moisture data determined via traditional soil sampling and soil moisture data determined via the mobile CRNS is not as clear, as compared to lowlands. It is possible that the increasing intensity of incoming cosmic rays at higher altitudes may have an effect on the signal of the CRNS, however, more work is required to fully understand this phenomenon and is scheduled to resume in the spring of 2017.

Protocol development for the estimation of crop biomass water equivalent to improve cosmic-ray neutron sensor (CRNS) based area-wide soil moisture measurement

Ammar Wahbi, William Avery, Lee Heng, Gerd Dercon, Trenton E. Franz[1]

[1]*School of Natural Resources, University of Nebraska-Lincoln, Nebraska, United States of America*

Much of the work by the SWMCN laboratory in regards to the application of CRNS for soil moisture measurement has gone to the development of protocols and guidelines on its proper use. This includes a detailed calibration process that is ultimately the key for the successful implementation of the CRNS technology within a particular environment. Besides using in-situ soil moisture data, this calibration process also considers the incorporation of biomass water equivalent data. The CRNS technology measures soil moisture through the detection of cosmic rays in the atmosphere near the soil surface. These rays have a great affinity to be absorbed by hydrogen atoMs As such, the CRNS can produce data that is highly correlated with soil water content (SWC) present in the soil. Water within growing green biomass can, however, introduce a false signal to CRNS data that must be quantified and removed. During the second half of 2016 development began on a protocol illustrating in detail three different methods for quantifying biomass and ultimately biomass water equivalent for use in the CRNS calibration process. This protocol explores traditional in-situ destructive sampling of biomass (tailored for the CRNS footprint), and the use of satellite based remote sensing data and the CRNS device itself (only stationary CRNS) for estimating biomass. These three techniques are applicable to the proper use of the CRNS technology, particularly in agricultural environments where homogeneous vegetation is the norm. In spring 2017, SWMCN Laboratory staff carried out field based research exploring the aforementioned techniques in biomass estimation for incorporation into the calibration process for both a stationary and mobile 'backpack' CRNS.

Operational Intervention Levels (OILs) for Soils – A decision support tool for food and agriculture in nuclear and radiological emergency response

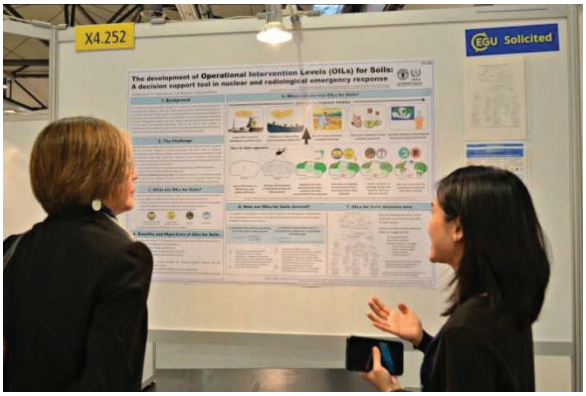
Amelia Lee Zhi Yi, Gerd Dercon, Carl Blackburn[1], Lee Heng

[1]Food and Environmental Protection Section, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency, Austria

In the event of a large-scale nuclear accident, the swift implementation of response actions to protect food and agriculture is imperative. Effective intervention relies on the prompt availability of radioactivity concentration data and the ability to implement countermeasures. However, sampling in food and agriculture can be demanding because it may involve large areas and many sample types. In addition, there are finite resources available in terms of manpower and laboratory support. Emergency tools and response protocols exist to assist food control and health authorities but they tend to focus on radioactivity concentrations in food products as a means of restricting the distribution and sale of contaminated produce. Few, if any, emergency tools or protocols focus on the food production environment.

To respond to this need, the SWMCN laboratory developed the Operational Intervention Levels for Soils (OIL for Soils) concept, an optimization tool to facilitate agricultural decision making and to improve nuclear emergency preparedness and response capabilities. OILs for Soils are pre-determined reference levels of air dose rates linked to radionuclide concentrations in soils that can be used to trigger response actions particularly important for agricultural and food protection. Key considerations in the development of the OILs for Soils are: (1) establishing a pragmatic sampling approach to prioritize and optimize available resources and data requirements for decision making in agricultural sites: (2) creating a system that is adaptable to different countries, and; (3) developing a framework to calculate default values of OILs for Soils for application during an emergency.

The OILs for Soils reference levels are calculated using a mathematical model. Empirical equations, paired with radionuclide data (e.g. ^{134}Cs, ^{137}Cs and ^{131}I) from the ICRU 53 report, are utilized to determine soil contamination from aerial monitoring air dose rate data. Modelling allows soil contamination values to be readily approximated and this is used to prioritize soil and food sampling sites. Reference levels will be determined by a model, yet to be developed, that considers radionuclide transfer factors for up-take into plants, soil density, and soil sampling depth. Decision actions for determined reference levels are suggested for processed foods, animal products, animal feed and crop products (including plants at the growing stage, mature stage, fallow farmland, and forestry products). With these steps, OILs for Soils provide practical guidance that will equip authorities to respond efficiently and help maintain the safety of the food supply during large-scale nuclear or radiological emergency situations.



A member of the SWMCN Laboratory sharing the development of OILs for Soils at the EGU 2017 General Assembly, an event attended by 14 500 scientists from 107 countries.

Developments made by the SWMCN laboratory in this research area were recognized at the EGU General Assembly 2017, whereby the poster presentation was selected as an EGU Solicited contribution and highlighted in the session programme.

Developing DSS4NAFA interface for food restriction implementation during nuclear emergencies

Franck. Albinet, Lazar Adjigogov[1], Amelia Lee Zhi Yi, Gerd Dercon

[2]EduSoft IT Company for Software Development and Implementation, Skopje, Republic of Macedonia

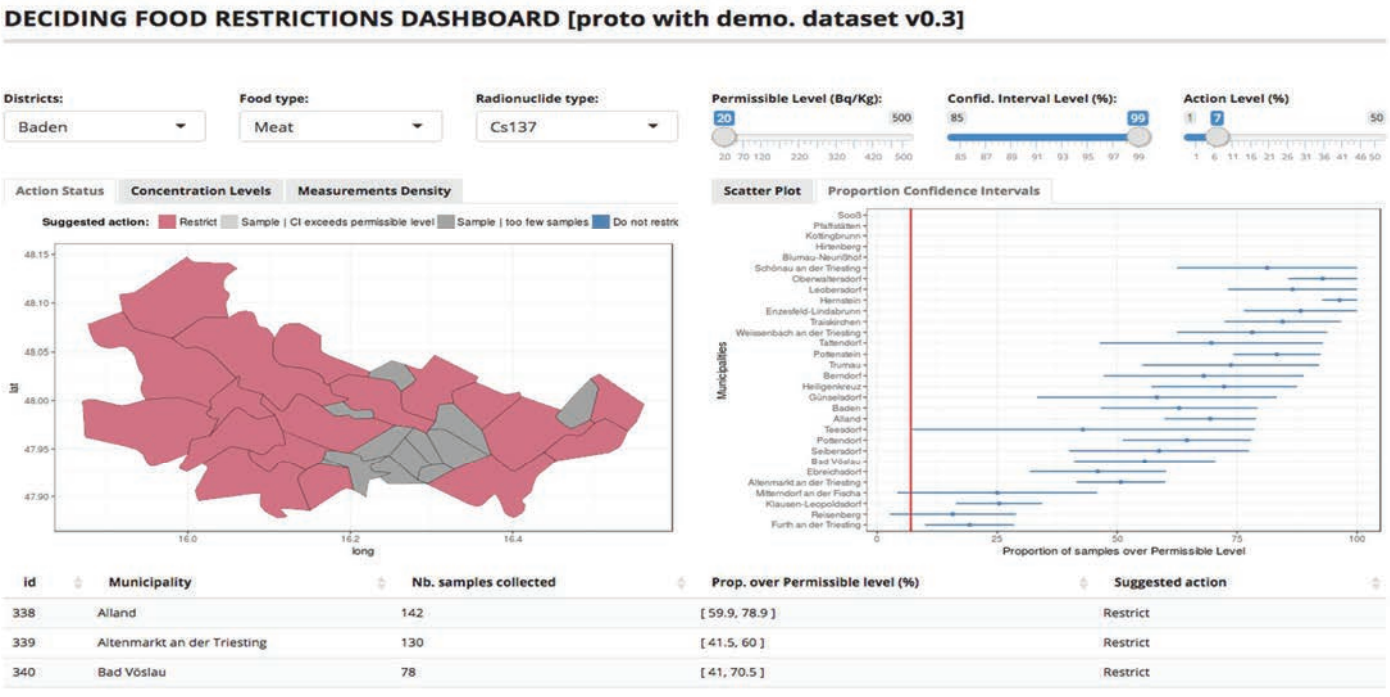
The management and visualization of data on radioactive contamination during a large-scale nuclear emergency can be a major bottleneck for swift and appropriate decision making in food and agriculture. To address this issue, since 2013, the SWMCN Laboratory has been developing in partnership with many member states an online decision-support system named DSS4NAFA: 'Decision Support System for Nuclear Emergencies Affecting Food and Agriculture'.

In a nutshell, this system provides large scale data management and visualization features in an integrated way enabling multiple stakeholders (i.e. data collectors, task managers, data analysts, food safety competent authorities) to collect, validate, analyse and finally facilitate sound decision making to guarantee food safety in the context of nuclear emergency.

These last months, based on consultation with DSS4NAFA's partners, new visual analytics features have been prototyped and showcased to assist stakeholders in making informed decisions as regards food restrictions (Fig. 1). This 'food restriction dashboard', upon gaining radionuclide concentration data of samples from the laboratories, collates the information into a single user interface, incorporating visually, the spatial distribution and temporal evolution of the accident. Depending on the risk aversion of the DSS4NAFA user, arithmetic and statistical tools such as threshold values or confidence intervals can be used to create dynamic maps that will be useful for decision makers in deciding further action, as well as in public communication, on restrictions to be implemented. All prior data are stored so that the historical restrictions can also be viewed.

Technology has one and the same overall role here; to assist decision makers to handle the complexity of the emergency context: multi-dimensionality of the information, high degree of uncertainty - i.e lack of compliance with statistical assumptions, and impact of different levels of conservatism. As such, the food restriction dashboard aims at presenting information in a way that reduces the cognitive load of decision makers while proposing a series of 'digital knobs' making it possible to assess the consequences of possible decision strategies. Technology is harnessed to help decision makers to think about a problem and is not meant to be a substitute to knowledge domain of trained and emergency management experts.

This initiative has received particular attention recently and will be further developed in future phases of the project.



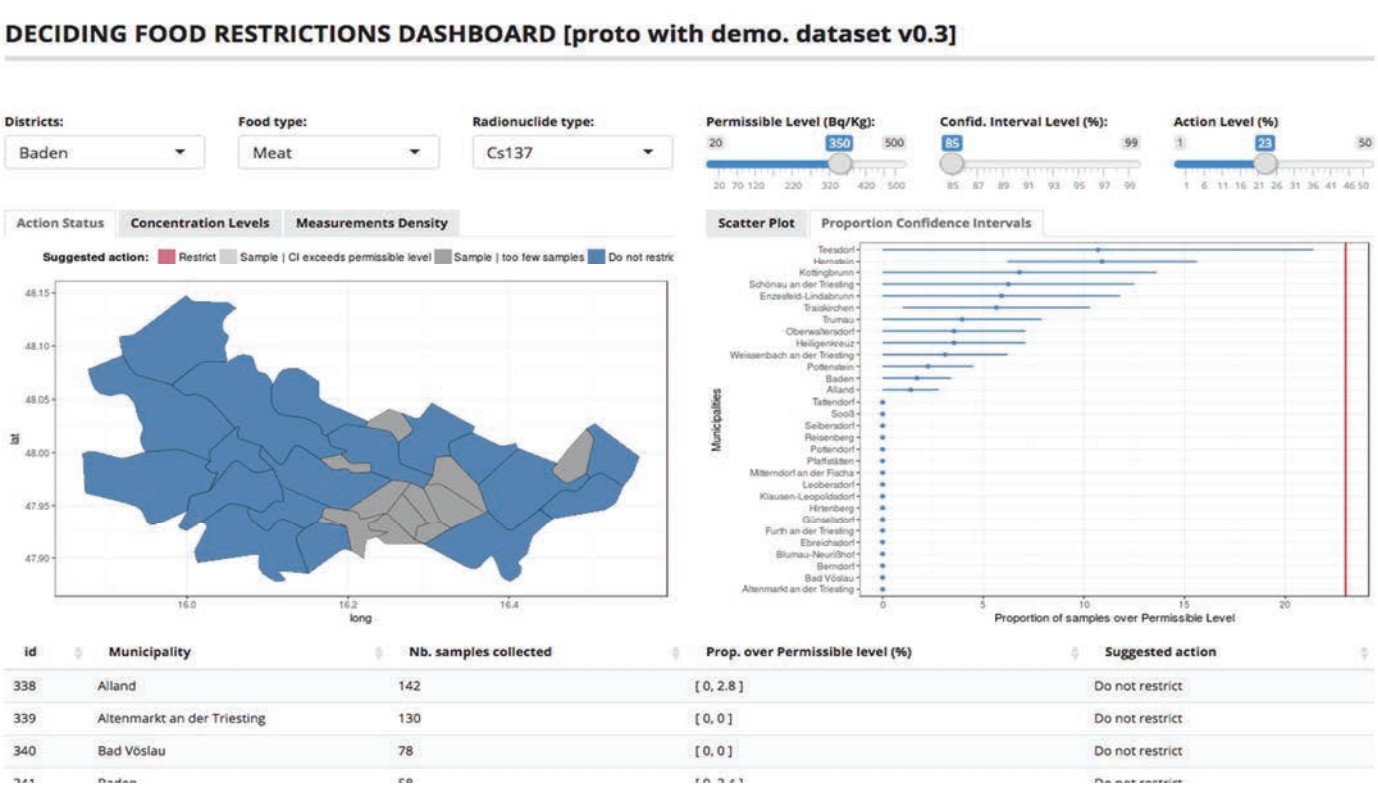


FIG. 1. DSS4NAFA Food Restriction Dashboard Prototype with digital knobs making it possible to assess the consequences of possible decision strategies

Increasing analytical capacity of SWMCN Laboratory for developing guidelines and protocols in soil, water and nutrient management

Christian Resch, Roman Gruber, Arsenio Toloza, Lionel Mabit, Gerd Dercon

At the end of 2016, the SWMCN Laboratory purchased a new Isotope Ratio Mass Spectrometry (IRMS) system. After several months of fine-tuning and intensive testing, this system has become in 2017 an essential tool for determination of ^{15}N and ^{13}C in plant and soil samples. Together with the existing SWMCN Laboratory mass spectrometer, coupled with an elemental analyser, we were able to increase significantly our analytical capacity with up to 10.000 stable isotope measurements per year, at enriched or natural abundance level.

New Isotope Ratio Mass Spectrometry facilities

Further, an extended range coaxial Ge detector was put in operation in late 2016, helping to improve the SWMCN Laboratory analytical facilities for measuring environmental radionuclides including ^{210}Pb (low gamma emitter at 46Kev). in soil and plant samples for erosion assessment or radioactivity monitoring. Further enhancement of gamma spectrometry in 2017 will increase our capacity to 350 analyses per year.

New coaxial Ge detector gamma spectrometry system

Through these improvements the SWMCN Laboratory can support not only significantly more research for development leading to guidelines and protocols in the field of soil, water and nutrient management for our Member States, it is also able to assist other already supported laboratories of the Joint FAO/IAEA Division such as the Plant Breeding and Genetics, Insect Pest Control and Food and Environmental Protection Laboratories in stable isotope analysis. The SWMCN Laboratory has thus become an important logistic hub for stable isotope analysis at the FAO/IAEA Seibersdorf Laboratories.

SWMCN Laboratory collaborates with Giessen University on ^{15}N tracing technologies to quantify nitrous oxide (N_2O) and dinitrogen (N_2)

Aamir Khan, Kristina Kleineidam[1], Maria Heiling, Christoph Müller[1], Mohammad Zaman

[1]Department of Plant Ecology Justus-Liebig University Giessen, Germany

Agriculture is considered to be a major driver of climate change. Increased greenhouse gas emissions, which contribute to climate change and global warming, are having a profound impact on the sustainability of agricultural production. Yet intensive farming is adding to the problem, particularly in countries struggling to meet the food demands of rapidly growing populations. Increased animal waste, use of chemical fertilizers and land use changes account for approximately 22% of the total greenhouse gas emissions.

Under a joint collaboration between the SWMCN Laboratory and Justus-Liebig University Giessen, Germany, Mr Aamir Khan went to the Plant Ecology Department Justus-Liebig University Giessen, Germany for a two month collaborative research work with Prof Müller's group. Aamir will learn ^{15}N tracing technologies and carry out a study to quantify nitrous oxide (N_2O) and non-greenhouse gas di-nitrogen (N_2) and their ratio using ^{15}N techniques. He has set up a laboratory experiment to investigate the effect of nitrification inhibitors on N_2O and N_2 emissions and identify their microbial source for better management of these gases.

Aamir Khan analyzing greenhouse gas samples in Plant Ecology Department, Justus-Liebig University, Giessen, Germany.

Publications

Aulakh, M., .Garg, A., Manchanda, J., Dercon, G., Nguyen, ML., 2017. Biological nitrogen fixation by soybean and fate of applied N-15-fertilizer in succeeding wheat under conventional tillage and conservation agriculture practices. Nutrient cycling in agroecosystems, 107, 79-89.

Avery, W. A., Wahbi, A., Dercon, G., Heng, L., Franz, T., and Strauss, P. 2017. Mobile soil moisture management in high elevations: Applications of the cosmic ray neutrons sensor technique for estimating field scale soil water content. In: Geophysical Research Abstracts, Volume 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-4921. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-4921.pdf

Chen, J., Dercon, G., Heiling, M., Slaets, J., Resch, C., Weltin, G., Mayr, L., Gruber, R., Zaman, M., Adu-Gyamfi, J., Heng, L., 2017. Integrated Monitoring of Carbon Storage and Loss through Emerging Isotope Technology. Global Symposium on soil organic carbon, Rome, Italy, 21-23 March 2017

Chen, J., Heiling M., Gruber, M., Resch, C., Dercon, G., 2017. Evaluating the effectiveness of mulch application to store carbon belowground: Short-term effects of mulch application on soluble soil and microbial C and N in agricultural soils with low and high organic matter. In: *Geophysical Research Abstracts,* Vol. 19*, European Geosciences Union – General Assembly 2017.* Abstract EGU2017-6181 http://meetingorganizer.copernicus.org/EGU2017/EGU2017-6181.pdf

Chen, J., Hofmockel, K.S., Hobbie, E.A.,2016. Isotopic Analysis of Sporocarp Protein and Structural Material Improves Resolution of Fungal Carbon Sources. Frontiers in Microbiology. doi:10.3389/fmicb.2016.01994

de los Santos-Villalobos, S. , Bravo-Linares C., Meigikos dos Anjos R., Cardoso R., Gibbs M., Swales A., Mabit L., Dercon G., 2017. The CSSIAR v.1.00 Software: A new tool based on SIAR to assess soil redistribution using Compound Specific Stable Isotopes. SoftwareX, 6, 13-18

Gregory, P., Wahbi, A., Adu-Gyamfi, J., Heiling, M., Gruber, R., Joy, E., Broadley, M., 2017. Approaches to reduce zinc and iron deficits in food systems, Global Food Security, http://dx.doi.org/10.1016/j.gfs.2017.03.003

Griepentrog, M., Bodé, S., Boudin, M., Dercon, G., Doetterl, S., Matulanya, M., Msigwa, A., Vermeir, P., and Boeckx, P., 2017. Effects of climate and geochemistry on soil organic matter stabilization and greenhouse gas emissions along altitudinal transects in different mountain regions. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. EGU2017-15036 http://meetingorganizer.copernicus.org/EGU2017/EGU2017-15036.pdf

Hobbie, E.A., Chen, J., Hanson, P.J, Iversen, C., Mcfarlane, K.J., Thorp, N.R., Hofmockel, K.S.. 2016. Long-term Carbon and Nitrogen Dynamics at SPRUCE Revealed through Stable Isotopes in Peat Profiles. Biogeosciences Discussions. Doi:10.5194/bg-2016-261, 2016.

Hogan, P., Parajka, J., Oismüller, M., Strauss, P., Heng, L., Blöschl, G., 2017. Stable isotope measurements of evapotranspiration partitioning in a maize field. In: Geophysical Research Abstracts, Volume 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-10695. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-10695.pdf

IAEA, 2017. Cosmic Ray Neutron Sensing: Use, Calibration and validation for Soil Moisture Estimation. pp. 38. IAEA-TECDOC-1809 IAEA publication. http://www-pub.iaea.org/books/IAEABooks/11097/Cosmic-Ray-Neutron-Sensing-Use-Calibration-and-Validation-for-Soil-Moisture-Estimation.

Khamzina, A., Kumar, N., Heng, L., 2017. Agroforestry-based management of salt-affected croplands in irrigated agricultural landscape in Uzbekistan. In: *Geophysical Research Abstracts,* Vol. 19*, European Geosciences Union – General Assembly 2017*. Abstract EGU2017-7216. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-7216.pdf

Khan, A., Heiling, M. , Zaman, M., Resch, C., 2017. Nitrous oxide emissions from soil amended with 15N-labelled urea with nitrification inhibitor (Nitrapyrin) and mulch. In: *Geophysical Research Abstracts, Volume 19, European Geosciences Union – General Assembly 2017*. Abstract EGU2017-14436. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-14436.pdf

Lee Zhi Yi, A., Dercon, G., Blackburn, C., Heng, L., 2017. The development of Operational Intervention Levels (OILs) for Soils – A decision support tool in nuclear and radiological emergency response. In: Geophysical Research Abstracts, Volume 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017- 6319. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-6319.pdf

Mabit, L., Toloza, A., Heng, L., 2017. 15 years in promoting the use of isotopic and nuclear technique for combating land degradation and soil erosion: the contribution of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-3586. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-3586.pdf

Mbaye, M., Mabit, L., Gibbs, M., Meusburger, K., Toloza, A., Resch, C., Klik, A., Swales, A., Alewell, C., 2017. Test of a new stable isotopic fingerprinting technique (i.e. Compound Specific Stable Isotope) in an Austrian sub-catchment to establish agricultural soil source contribution to deposited sediment. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-4965. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-4965.pdf

Meusburger, K., Arata, L., Birkholz, A., Ketterer, M., Mabit, L., Porto, P., Alewell, C., 2017. The manifold ways to use isotopic signatures as soil degradation and sediment transport indicators. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-9570. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-9570.pdf

Meusburger, K., Borelli, P., Evrard, O., Ketterer, M., Mabit, L., van Oost, K., Alewell, C., Panagos, P., 2017. Baseline Caesium-137 and Plutonium-239+240 inventory assessment for Central Europe. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-8580. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-8580.pdf

Torres Astorga, R., Velasco, H., Dercon, G., Mabit, L., 2017. Fingerprinting selection for agroenvironmental catchment studies: EDXRF analysis for solving complex artificial mixtures. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-3601. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-3601.pdf

Upadhayay, H., Bodé, S., Griepentrog, M., Huygens, D., Bajracharya, R., Blake, W., Dercon, G., Mabit, L., Gibbs, M., Semmens, B., Stock, B. Cornelis, W., Boeckx, P., 2017. Methodological perspectives on the application of compound-specific stable isotope fingerprinting for sediment source apportionment. Journal of Soils and Sediments, 17 (6), 1537-1553

Wahbi, A., Weltin, G., Heng, K.L., Dercon, G., Avery, W., Vreughenhil, M., Oismueller, M., Strauss, P., Franz, T.E., Desilets, D., 2017. Field Calibration and Validation of Cosmic Ray Soil Moisture Sensor. In: Cosmic Ray Neutron Sensing: Use, Calibration and validation for Soil Moisture Estimation. pp. 28-38.

Warter, M.M., Blok, K., Peeters, M., Kuppen, E., Dilly, L., 2017. Estimating soil erosion on hiking trails in the Sierra Mariola Natural Park in southern Spain. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-81-2. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-81-2.pdf

Warter, M.M., Jimenez Rodriguez, C., Coenders-Gerrits, M., Teuling, A., 2017. Groundcover influence on evaporation and stable water isotopes in soil water. In: *Geophysical Research Abstracts*, Vol. 19, European Geosciences Union – General Assembly 2017. Abstract EGU2017-10119-3. http://meetingorganizer.copernicus.org/EGU2017/EGU2017-10119-3.pdf

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/
- FAO Agriculture and Consumer Protection Department
  http://www.fao.org/ag/portal/ag-home/en/
- FAO Land & Water: http://www.fao.org/land-water/en/ l
- New communication materials outlining successes in the area of nuclear techniques:
  http://www-naweb.iaea.org/nafa/resources-nafa/IAEA-success-Stories-3.pdf
  http://www-naweb.iaea.org/nafa/resources-nafa/ProgBrochure-2014.pdf
  http://www-naweb.iaea.org/nafa/resources-nafa/LabBrochure-2014.pdf

Impressum

Soils Newsletter Vol. 40, No. 1

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

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, July 2017

17-22881