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Contents

To Our Readers

The year 2017 is quickly coming to an end. It is the time of the year to reflect on work done and achievements generated over the year and to look forward to 2018. The year 2017 has seen nine successes on the ground, achieved through technical cooperation projects (TCPs); eight of these are reported on our website (see list under Highlights), including drip irrigation in Sudan where nuclear technology helps women farmers move out of poverty. This particular achievement was emphasized also by IAEA Director General Amano in his speech to the recent November Board Meeting.

One of the highlights this year was undoubtedly the side event organised jointly with the FAO/IAEA Plant Breeding and Genetics Section during the IAEA General Conference in September on 'Climate-Proofing Rice Production Systems'. It showcased, through a regional project RAS5073 on 'Climate-Proofing Rice Production', how Asian Member States use nuclear techniques to adapt to the impacts of climate change on rice production. Four Member States presented their experiences and successes during this side event. Among them were Mr Shyful Azizi Abdul Rahman, from the Malaysian Nuclear Agency on 'Improving the resilience of national rice production systems to climate change', and Mr Roland Rallos, from the Philippine Nuclear Research Institute on 'Efficient nutrient and water management for rice production through nuclear and isotopic techniques'.

Another highlight is the large number of TECDOC publications produced this year by our Section. A total of five TECDOCs plus many external publications were produced, one of these being the Springer publication on 'Cosmic Ray Neutron Sensing: Estimation of Agricultural Crop Biomass Water Equivalent'. Many peer-reviewed scientific articles and conference papers were also published, as was a PICO presentations presented at the European Geosciences Union (EGU) General Assembly in April.

In terms of research and development, 2017 was a good year for the SWMCN Laboratory. The work on plutonium isotopes ($^{239+240}Pu$) as soil redistribution tracers has made major progress (see feature articles in both this and the last Newsletter). Similarly, significant work has been carried out in the testing of cosmic ray neutron sensors, especially in terms of its use, calibration and validation for soil moisture estimation. Good progress was also made on the development of the online DSS4NAFA Decision Support System for Nuclear Emergencies Affecting Food and Agriculture, for monitoring radionuclides in food and agriculture production. An infographic video on how DSS4NAFA works has recently been produced and is available in five languages at http://www-naweb.iaea.org/nafa/resources-nafa/multimedia.html.

Work on sediment and cryosphere dynamics from the interregional TC project INT5153 'Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions' is also yielding good results. The group met in November at IAEA Headquarters, to interpret and integrate the scientific results. In the first three years of this four-year project, seven expert missions have yielded over 2000 soil, sediment and water samples that have been analysed for 70 different biogeochemical parameters, as well as glacier surveys and high resolution topographical maps produced by UAV surveys.

The SWMCN Subprogramme will have 36 new TCPs in the 2018-2019 cycles, including an interregional project on the 'Small Island Developing States (SIDS) in Support of the Sustainable Development Goals and the SAMOA Pathway' while the majority of the current projects will be finalized by end of the year. It is envisaged that a total of 52 active TCPs will be running in 2018.

Rauris, Austria, at 1400 m a.s.l. for testing mobile cosmic-ray neutron sensor in upland agro-ecosystems

Inferior water quality due to agricultural pollution is a major problem in both developed and developing countries. The SWMCN Section therefore organized and hosted a consultants' meeting in September 2017 on the use of stable isotopes for monitoring agricultural-derived pollutants and land management practices to address agricultural-related water quality issues. A new CRP to address this topic has now been approved and will start in 2018. It will be using combined stable isotope (δ^2H, $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ and $\delta^{34}S$) techniques to trace and monitor sources and movement of macronutrients and micro-contaminants from the soil to ground and surface waters under different land uses. More information on this new CRP is reported in this issue of the Newsletter.

A new Accelerated Solvent Extractor (ASE) was recently procured for the SWMCN Laboratory to extract fatty acids from soil samples for compound specific stable isotope (CSSI) analysis. Together with the new germanium (Ge) detector purchased last year, this addition will enhance our analytical facilities for erosion assessment and radioactivity monitoring.

We hope that all our equipment, as well as our laboratory staff, will have a new home by the end of 2018 when the new Flexible Modular Laboratory to be completed under the IAEA's ReNuAL (Renovation of the Nuclear Applications Laboratories) project, is targeted for inauguration. As we reported previously, the SWMCN Laboratory is part of this project.

We were able to send Maria Heiling from the SWMCN Laboratory to the Institute for Plant Ecology at the Justus-Liebig University Giessen in Germany for a week's training under Prof. Christoph Müller on the use of advanced stable isotope techniques for nitrogen tracing technologies for nitrous oxide (N_2O) and nitrogen (N_2) emissions studies, to support both R&D activities on greenhouse gas emission studies and CRP D1.50.16 on "Minimizing Farming Impacts on climate Change by enhancing Carbon and Nitrogen Capture and Storage in Agro-ecosystems".

I would like here to congratulate both Maria Heiling and Christian Resch on their receipt of IAEA merit awards in 2017. Maria has been instrumental in assisting in developing greenhouse gas and water quality protocols, while Christian provides excellent support in establishing new laboratory configurations for analysing stable isotopes in water and gas samples.

We would like to welcome Hanlin Zhang, our new cost-free expert from Shanghai Jiaotong University in China, who joined the SWMCN Laboratory in October; and Ms Ilse Jank who joined the Laboratory in September as a temporary team assistant while Ms Joanna Mletzko is on short-term assignment to the Environmental Sample Laboratory of the IAEA's Department of Safeguards. We also welcome Ms Ksenija Ajvazi back to the Section as team assistant after having being away for 1.5 years on mobility assignment to the IAEA Director General's office.

I would like to take this opportunity to thank all our readers for their continuous support and encouragements throughout 2017. Thanks also to my team in the Subprogramme for all the wonderful work and outputs you have contributed. I wish everyone a very relaxing holiday season and a happy and prosperous New Year, and look forward to your continued support in 2018. Best wishes from all of us in the SWMCN team.

Sincerely,

Lee Heng
Head
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	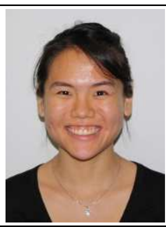		
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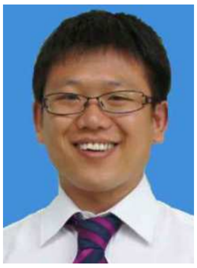
Staff News

Ilse Jank (Austria) joined the SWMCN laboratory in September as team assistant. Before that she was working for UNIDO as project assistant in the Division of Industrial Investment (French-speaking African countries). For the last 3 years she was working for the European Central Bank in Frankfurt as a protocol assistant and senior management assistant for the DG of Market Operations.



Hanlin Zhang (China) joined the SWMCN Laboratory in September 2017 as a International cost-free expert from China for one year. He will be assisting in finalizing the SOP of denitrifying bacteria and laser spectroscopy method for isotopic analyses ($\delta^{15}N$, $\delta^{18}O$) of dissolved nitrate. Hanlin is an associate researcher in Shanghai Academy of Agricultural Science. He obtained his PhD in Environmental Science from Shanghai Jiaotong University. His former researches focus on the microbial driving mechanism of nitrogen cycling in farming ecosystem, integrated management technology of livestock manure, crop straw retention technology and farmland greenhouse gas emission reduction technology.

Maria Heiling and **Christian Resch** received the Merit Award in October 2017 from the Deputy Director General and Head of the Department of Nuclear Sciences and Applications (Mr. Aldo Malavasi) in recognition of their excellent work supporting the Soil and Water Management and Crop Nutrition Subprogramme. This award is to honour specifically their outstanding contributions to the work of the Soil and Water Management and Crop Nutrition Laboratory of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in the field of isotope analyses and techniques for improved carbon and nitrogen management.

Feature Articles

Struggling to find suitable tracers for soil erosion assessment: Are $^{239+240}Pu$ isotopes a suitable solution?

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This extended summary is based on the peer-reviewed contribution recently published in *Earth Science Reviews* i.e.: Alewell, C., Pitois, A., Meusburger, K., Ketterer, M., Mabit, L. (2017). $^{239+240}Pu$ from "contaminant" to soil erosion tracer: Where do we stand? *Earth Science Reviews*, 172, 107–123.

Soil erosion is one of the most crucial threats to fertility and sustainable management of soils and thus to many ecosystem services such as global food and feed production, freshwater yields, flood prevention and ecosystem stability in general. The use of fallout radionuclides (FRN) as soil redistribution tracers is, next to modelling, the most promising approach for assessing soil erosion. In the last decades, the main FRN used as soil redistribution tracers were (a) anthropogenic ^{137}Cs, (b) natural geogenic $^{210}Pb_{ex}$ and (c) natural cosmogenic ^{7}Be. ^{137}Cs is currently by far the most common and mature technique used as soil redistribution tracer for assessing mid- and long-term soil redistribution. $^{210}Pb_{ex}$ requires the application of self-absorption corrections for its determination using gamma-ray spectrometry. In addition, it suffers from high uncertainty of measurement results at low activity concentrations and from its non-applicability as a soil tracer under specific environmental conditions (Mabit *et al.,* 2014). And, because of its short half-life of two months, ^{7}Be cannot be used for evaluating mid- and long-term soil redistribution.

Until recently, there have been relatively few attempts to exploit the full potential of Pu isotopes ($^{239+240}Pu$) as soil redistribution tracers especially when compared to the much more common use of ^{137}Cs. Plutonium was marginally used until the beginning of this century when the potential of Pu as soil redistribution tracer was demonstrated (Schimmack *et al.,* 2001). As highlighted by Alewell *et al.* (2017), it took almost another decade for additional studies to follow. Major obstacle was the analytical limitations connected to the measurements of plutonium at environmental level. Until recent years, it was restricted mostly to the traditional radiometric alpha-particle spectrometry technique and to some extent to the accelerator mass spectroscopy technique (AMS), whose availability was limited to few institutions worldwide. However, the advances in mass spectrometric techniques, in particular with the development and improvement of the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) techniques, and the higher availability of those techniques in laboratories worldwide, opened possibilities of using Pu isotopes for a wide application in tracing soil redistribution and sediment transfer. An additional obstacle in the use of Pu as soil redistribution tracer was the non-availability or the inadequacy of existing conversion models to convert $^{239+240}Pu$ inventories to soil redistribution rates. In 2016, a new conversion model was developed, namely MOdelling Deposition and Erosion rates with RadioNuclides (MODERN) (Arata *et al.,* 2016). Even despite not many studies exist yet, which use $^{239+240}Pu$ has a soil redistribution tracer, this FRN seems to have some major advantages and thus a great potential as a future tracer for soil redistribution assessment. It is generally agreed, that $^{239+240}Pu$ has the advantage of generally not being influenced by fallout originating from nuclear power plant (NPP) accidents (with the exception of specific areas in the close vicinity of the accident site) which results in relatively low variability of Pu reference site inventories. Furthermore, Pu has the advantage that the inventories of both main isotopes, i.e. ^{239}Pu and ^{240}Pu, remains essentially at the same level than when they were deposited because of their long half-lives (see Table 1). The latter is of major advantage in terms of its use as tracer compared to the most commonly used soil redistribution tracer ^{137}Cs and has thus the potential of being a reliable soil redistribution tracer in future studies. $^{239+240}Pu$ seems to be a more applicable tracer approach than $^{210}Pb_{ex}$, as several studies under specific environmental conditions report $^{210}Pb_{ex}$ unsuitability because of low concentrations associated to high uncertainty in its determination. Regarding analytical requirements and feasibility of approaches, $^{239+240}Pu$ has the analytical advantage of higher accuracy as compared to $^{210}Pb_{ex}$ and higher sample throughput, in particular if ICP-MS techniques are used for its measurements.

Table 1. Comparative summary of the two main anthropogenic soil radiotracers ^{137}Cs and $^{239+240}Pu$ (Source: Alewell *et al* (2017).

	^{137}Cs	$^{239+240}Pu$
Elemental characteristic	Alkali metal	Actinide metal
Origin(s)	Anthropogenic (nuclear weapon tests fallout and NPP accidents release)	Anthropogenic (nuclear weapon tests fallout and NPP accidents release in close proximity to nuclear accident sites)
Radioactive half-life	30 years	^{239}Pu: 24110 years; ^{240}Pu: 6561 years
Radiation emission	Gamma emitter (662 keV)	Alphas emitters (^{239}Pu: 5.157 MeV; ^{240}Pu : 5.168 MeV)
Analytical determination	Gamma-ray spectrometry	Alpha-particle spectrometry; mass spectrometry, mainly ICP-MS and AMS
In-situ measurement	Possible using field-portable gamma-ray detector	Not possible
Mobility in soil	Limited in most soils except for acid sandy soils; strong binding to clay and OM	Slightly higher than for the other existing FRNs
Plant uptake	Limited in most soils except for sandy acid soils	Negligible as compared to all other FRNs
Current investigated areas with this tracer	4 decades of worldwide application	Tested and then validated since less than 1 decade ago and only in few countries
Scales of investigation	Plot to region	Field
Fallout distribution	Worldwide with higher deposit in northern hemisphere	Worldwide with higher deposit in northern hemisphere

OM: Organic matter; NPP: Nuclear power plant; ICP-MS: Inductively coupled plasma mass spectrometry; AMS: Accelerator mass spectrometry; FRN: Fallout radionuclides

To summarise, $^{239+240}Pu$ has full potential to become the next generation of soil redistribution tracer because of its long half-life guaranteeing its long-term availability in the environment, its analytical advantage in terms of measurement precision and measurement time and the relatively homogeneous distribution at reference sites because the fallout of bomb-derived Pu was not biased by later releases from NPP accidents.

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Compound specific stable isotopes: A suitable technique to determine sources of soil erosion in upland forest catchments

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This feature article is a summary of the paper that was recently published in the international journal *Science of the Total Environment* (https://doi.org/10.1016/j.scitotenv.2017.09.163), based on data collected through the just finalized IAEA funded regional TC project RLA5064 "Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques".

Challenges

Forestry is one of the main economic activities in Chile using a considerable part of the land of the country. For many years forestry activities have been considered an important source of sediments in Central and Southern Chile. However, until recently no techniques were available to identify precisely the origin of sediments, and hence the erosion control could not focus to hot spods of the catchment. The compound specific stable isotope (CSSI) technique using fatty acids as biomarkers showed to be a method enabling to identify these hot spots.

Principles

The main principle of the CSSI technique is that organic compounds, such as fatty acids, produced by plants and in particular their carbon-13 ($\delta^{13}C$) signature can be used as labels or "biomarkers" for a specific land use type. Therefore the CSSI technique is applied to distinguish sediments originating from different land use types (Hockun et al., 2016; Pisani et al., 2016; Upadhayay et al., 2017). This technique was first introduced to study the origin of estuarine sediments in 2008 (Gibbs, 2008). To define the link between soil or sediments with its land use, the compounds being considered as biomarkers need to be stable, long-lived, strongly bound to the soil particles, abundant, conservative and easily measurable. They also should have a characteristic or unique ^{13}C signature.

For the CSSI technique, in the case of fatty acids (FA), the biomarker compounds of choice are the even straight-chain saturated fatty acids (C14:0 to C24:0 or higher. This group of FA is partially water soluble. When rainwater infiltrates ground water, the FA bind to fine soil particles, particularly clays. Degradation of FA produces other compounds which are no longer part of the pool of the FA bound to the soil. Consequently, the isotopic signature of the FA pool in the soil does not change through diagenesis.

Experimental design

Potential sources of sediments in three typical Chilean upland forest catchments with pine tree and eucalyptus plantations were investigated in the pre-harvest phase. Soil samples were collected to obtain the isotopic signature of the potential sources (unpaved roads, native forest, forest plantations, and buffer or riparian zones). The samples were extracted for fatty acids and then analysed to obtain the $\delta^{13}C$ signature for different fatty acids that were used for fingerprinting purposes. The stream channel was sampled in several profiles along its legth. The lowest sample profile was taken in a sediment trap at the outlet of the catchment (Figure 1). This was repeated 3 to 5 times over a period of 5 months to find any difference in sediment source origin due to rainfall intensity.

Figure 1. V-notched weir (sediment trap) at the outlet of the catchments

Main results

The results obtained from this research revealed that unpaved forest roads were the main source of sediment deposited at the outlet of the catchments (ranging between 30 and 75 %). Furthermore, sampling along the stream channel demonstrated that sediments were mainly comprised of eroded soil coming from the unpaved roads in the upper part of the catchments (74-98%). From this, it was possible to identify the location and type of primary land use contributing to the sediment delivered at the outlet of the catchments.

Conclusion and perspectives

The gained information of this study will allow forestry managers to better control soil erosion by improving the runoff features of the forest roads. It may be highlighted that this technique can also be a good complement to other soil erosion assessment techniques, especially when attempting to quantify sediment production. The research team involved in this study is evaluating complementary fingerprinting techniques, such as mid-infrared spectroscopy (DRIFT-MIRS), fallout radionuclides (FRNs) and X-ray florescence. Further, a research project is being proposed to determine sediment sources when wildfires affect forest plantations, a typical scenario in Chile during the dry summer period.

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AquaCrop and ICT to improve irrigation efficiencies

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Introduction

Irrigation is worldwide being considered as one of the means to improve food security. As a result, in many parts of the world the pressure on the available water resources is increasing and is facing its limits. The challenge for the next decades will be how to feed ever more people with ever less water. However, the inefficiencies detected in irrigation processes have driven the development of tools to facilitate farmers to improve irrigation scheduling.

The Food and Agriculture Organization of the United Nations (FAO) has developed AquaCrop, a field-crop-water-productivity simulation model for use as a decision-support tool in planning and analysis (Steduto et al., 2009). The model simulates variation in attainable crop biomass in response to soil moisture variations (and hence irrigation). Although based on basic and complex biophysical processes, AquaCrop uses a relatively small number of parameters to be adjusted according to the case and crop. Often intuitive default input-variables that can be determined using simple methods (Steduto et al., 2009) are sufficient and do not require additional fitting. Freely downloadable at FAO's website, the model contains a default database of the world's major crops (cotton, maize, potato, quinoa, rice, soybean, sugar beet, sunflower, tomato, wheat, barley, sugar cane, sorghum and tef), and a list of crops that is ever growing due to worldwide contributions.

Besides the AquaCrop Windows-version, a plug-in version is also available, performing identical calculation procedures as the AquaCrop standard program. This version comes as a stand-alone executable without the user-interface of the 'classic' AquaCrop. The plug-in version facilitates the inclusion of AquaCrop in external applications where iterative or large numbers of runs are required.

The present article describes how AquaCrop plug-in, embedded in an information and communications technology (ICT) environment, can automatically transmit adapted and updated irrigation calendars to farmers.

AquaCrop plug-in and ICT

Figaro ("Flexible and precise irrigation platform to improve farm scale water production", (Figaro, 2017)), BELCAM ("Belgian collaborative agriculture monitoring", (BELCAM, 2017)) and iPot ("industrial Potato monitoring", (Piccard et al., 2017)) are some recent examples of how AquaCrop plug-in is being integrated in ICT platforms for agricultural advise, mainly focusing on irrigation and yield prediction.

Figure 1 sketches the workflow of this approach. National or regional soil data and near-real time meteorological data are retrieved from existing databases. Canopy cover development is obtained from high resolution (Sentinel-2, Landsat-8, etc.) free satellite images. Additional field observations are received from farmers: crop species, type and phenological stages, and crop management: e.g. with or without mulch, zero tillage, crop rotation, rainfed or irrigated and type of irrigation (supplementary or full; sprinkler, drip or surface). On the server, the necessary input files are automatically generated, the AquaCrop plug-in executable launched and its output (yield provisions and updated optimal irrigation calendars) added to the central database. Depending on the irrigation method, time and depth criteria are specified. Through a web-application, the data and results are available at parcel level for the farmer.

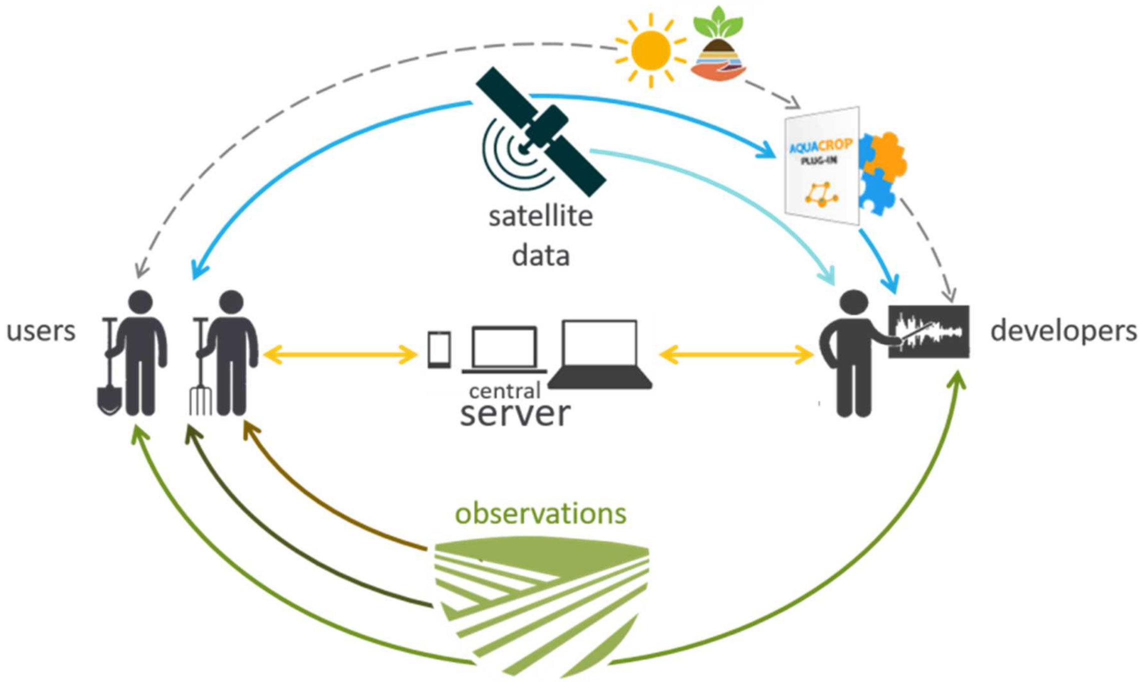

Figure 1. Real-time irrigation advice workflow (Wellens, 2016)

Discussion and Conclusion

By 2030, irrigated land is predicted to increase by 28% and the pressure on the available water resources will be considerable, even disastrous for some regions. The pressure exerted on the agricultural sector by public administration and consumers to shift production from a focus on quantity to sustainability and quality is increasing worldwide. As a consequence, farmers are motivated to invest in technologies (such as decision-support irrigation tools and smart phone apps) for improving water management. Simple and indicative irrigation charts can be developed with AquaCrop in order to promote irrigation efficiency and thus increase overall water availability. The resulting irrigation advice is transmitted in near-real time to farmers by ICT and apps. The centralized approach also counters the problems of training and collection of specific data which are not often available for most potential users.

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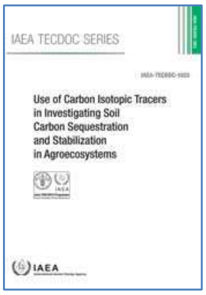
Announcement

New FAO/IAEA Publications:

Use of Carbon Isotopic Tracers in Investigating Soil Carbon Sequestration and Stabilization in Agroecosystems (IAEA TECDOC 1823)

This publication provides an overview of conventional and isotopic methods available for measuring and modelling soil carbon dynamics. It includes information on the use of carbon isotopes in soil and plant research, including both theoretical and practical aspects of nuclear and radioisotope tracer techniques for in situ glasshouse and field labelling techniques to assess soil organic carbon turnover and sequestration, and provides up-to-date information on topics related to soil carbon sequestration and stabilization in agroecosystems. With its focus on practical application of radiotracer and stable isotope tracer techniques, it will be particularly useful for university and national research scientists working to improve soil organic matter management and conservation in agricultural systems.



http://www-pub.iaea.org/books/IAEABooks/11072/Use-of-Carbon-Isotopic-Tracers-in-Investigating-Soil-Carbon-Sequestration-and-Stabilization-in-Agroecosystems

Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments (IAEA-TECDOC 1828)

Current concerns about the projected global population increase and the impacts of climate change on agriculture highlight the importance of the use of improved crop varieties coupled with better soil, water and fertilizer management practices designed to protect the natural resource base. This publication is the outcome of a coordinated research project (CRP) and focuses on the practical application of nuclear and related techniques, such as mutation induction, stable isotopes of nitrogen (^{15}N) and carbon (^{13}C), to improve crop productivity with mutant varieties and best soil management practices in diverse agro-ecological zones affected by drought, high temperatures, water scarcity, and soil salinity. The publication will be highly valuable to agricultural scientists and laboratory technicians of national agricultural research organizations in Member States as a resource for improving soil and crop productivity through the use of nuclear and related techniques.

http://www-pub.iaea.org/books/IAEABooks/12287/Approaches-to-Improvement-of-Crop-Genotypes-with-High-Water-and-Nutrient-Use-Efficiency-for-Water-Scarce-Environments

Springer Publication: "Cosmic Ray Neutron Sensing: Estimation of Agricultural Crop Biomass Water Equivalent": a new SWMCNL research protocol.

Much of the work by the SWMCN laboratory regarding the Cosmic Ray Neutron Sensor (CRNS) has gone to the development of protocols and guidelines on its proper use. This includes a detailed calibration approach that is ultimately the key for the successful implementation of the CRNS technology within any particular environment. However, further details are needed regarding the incorporation of biomass water equivalent (BWE) into the calibration process. 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 are highly correlated with soil water content present in the soil. However, water within growing green biomass can introduce a false signal to CRNS data that must be quantified and removed. During the second half of 2016 development began on a guideline protocol illustrating in detail three different methods for quantifying biomass and ultimately BWE for use in the CRNS calibration process. This external publication explores traditional in-situ destructive sampling of biomass (tailored for the CRNS footprint), the use of satellite based remote sensing data to estimate biomass, and the use of 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. This publication provides detailed, step-by-step, practical instructions for three different methods for the estimation of BWE with clear accompanying illustrations, an essential step for improving the accuracy of area-wide soil moisture monitoring by CRNS.
http://www.springer.com/br/book/9783319695389

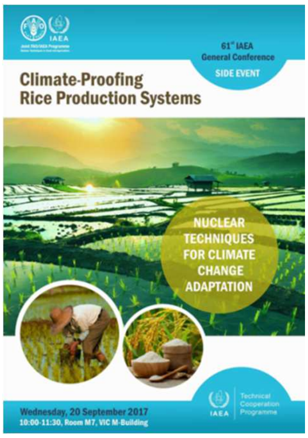
Highlights

IAEA General Conference Side Event: Climate-Proofing Rice Production Systems

20 September 2017, Vienna International Centre, Vienna

Technical Officers: Lee Heng and Ljupcho Jankuloski

Climate change is impacting global rice production through floods, droughts, heat and salinity. Nuclear techniques can create useful germplasm and develop new cultivars tolerant to abiotic and biotic stresses, and improve water and fertilizer-use efficiencies for better adaptation to climate change. Using rice production as an example, this side event showcased sustainable successes by Asian Member States in using nuclear techniques to mitigate the impacts of climate change. It was held on 20 September 2017 in the Vienna International Centre, Vienna during the 61st IAEA General Conference in the week of 18 – 22 September 2017.



Four Asia Member States presented their experiences and successes on work relating to Climate Proofing Rice Production: Nuclear Techniques for Climate Change Adaptation, two on soil and water management and the other two on plant mutation breeding:

- Shyful Azizi Abdul Rahman, Malaysian Nuclear Agency, on 'Improving the resilience of national rice production systems to climate change'
- Roland Rallos, Philippine Nuclear Research Institute, The Philippines on 'Efficient nutrient and water management for rice production through nuclear and isotopic techniques'
- Khanh Nguyen Trong, Field Crops Research Institute, Viet Nam on 'Plant mutation breeding in rice in Viet Nam'
- Totti Tjiptosumirat, National Nuclear Energy Agency (BATAN), Indonesia on 'Plant mutation breeding in rice in Indonesia'.

Success stories

Isotopic Technique Helps Benin Farmers Triple Yields and Improve Livelihoods:
https://www.iaea.org/newscenter/news/isotopic-technique-helps-benin-farmers-triple-yields-and-improve-livelihoods

Cambodian Researchers Use Isotopic Technique to Help Farmers Increase Yields and Revenues:
https://www.iaea.org/newscenter/news/cambodian-researchers-use-isotopic-technique-to-help-farmers-increase-yields-and-revenues

Benin Farmers Inoculate Their Legumes to Improve Soil Fertility and Yield:
https://www.iaea.org/newscenter/news/benin-farmers-inoculate-their-legumes-to-improve-soil-fertility-and-yield

Stable nitrogen isotopes helps scientist optimize water, fertilizer use (IAEA bulletin, June 2017):
https://www.iaea.org/newscenter/news/stable-nitrogen-isotope-helps-scientists-optimize-water-fertilizer-use

Stable nitrogen isotopes and low-cost irrigation technologies help scientists optimize crop and water productivity in Cameroon:
https://www.iaea.org/newscenter/news/stable-nitrogen-isotopes-and-low-cost-irrigation-technologies-help-scientists-optimize-crop-and-water-productivity-in-cameroon

Using nitrogen-15 in agricultural research: Improving crop productivity in Panama:
https://www.iaea.org/newscenter/news/using-nitrogen-15-in-agricultural-research-improving-crop-productivity-in-panama

World Soil Day: Caring for the Planet Starts from the Ground and Nuclear Techniques can Help:
https://www.iaea.org/newscenter/news/world-soil-day-caring-for-the-planet-starts-from-the-ground-and-nuclear-techniques-can-help

Costa Rica Paves the Way for Climate-Smart Agriculture:
https://www.iaea.org/newscenter/news/costa-rica-paves-the-way-for-climate-smart-agriculture

The Science of Soil: using radionuclides to support soil conservation (TC Science for development)

Technical Cooperation Field Projects

Country/Region	TC Project	Description	Technical Officer(s)
Afghanistan	AFG5007	Enhancing Wheat Productivity Through Best Nutrient and Water Management Practices Under Rainfed and Supplemental Irrigation Systems	M. Zaman
Algeria	ALG5030	Contributing to the Implementation of the National Agricultural Development Programme Through Strengthening Soil, Water and Nutrient Management Practices Including Food Safety Using Nuclear and Related Techniques	M. Zaman in collaboration with FEP
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
Benin	BEN5012	Enhancing legume production in cereal-livestock cropping systems for food, wealth and soil health through the use of bio fertilizers (inoculum) in Benin	J. Adu-Gyamfi
Bolivia	BOL5021	Strengthening the Strategic Development Plan for Quinoa Production through Improved Use of Organic Manure, Soil and Crop Management	M. Zaman
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	BKF5019	Improving food and nutrition security using integrated isotopic and breeding mutation on Sorghum, Rice, Cowpea, Bambara nut and sesame in Burkina Faso	J. Adu-Gyamfi in collaboration with PBG
Burundi	BDI5001	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	M. Zaman in collaboration with PBG
Central African Republic	CAF5011	Building National Capacities for Improving the Efficiency of Biological Nitrogen Fixation for Food Security, Fertility Restoration and Rehabilitation of Degraded Soils	M. Zaman
Cambodia	KAM5005	Enhancing Soil, Water and Nutrient Management for Sustainable Rice Production and Optimized Yield	J. Adu-Gyamfi
Costa Rica	COS5033	Assessing and Implementing Biochar Use in Climate Smart and Environmentally Friendly Pineapple Production Using Isotopic Techniques	M. Zaman in collaboration with FEP
Costa Rica	COS5035	Building Capacity for the Development of Climate-Smart Agriculture in Rice Farming	M. Zaman
Dominica	DMI0002	Building National Capacity for the Use of Nuclear Applications in Relevant Sectors	J. Adu-Gyamfi
Gabon	GAB5003	Building National Capacities for Monitoring Sedimentation of Dams and Harbors and the Management of Remediation Operations	E. Fulajtar
Indonesia	INS5043	Intensifying Quality Soybean Production in Indonesia to achieve self-sufficiency	J. Adu-Gyamfi in collaboration with PBG and FEP
Interregional project	INT0093	Applying Nuclear Science and Technology in Small Island Developing States in Support of the Sustainable Development Goals and the SAMOA Pathway	J. Adu-Gyamfi
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
Jamaica	JAM5012	Optimizing Irrigation Water Management to Improve Crop Output and Water Quality Control	L. Heng
Kuwait	KUW5004	Improving Production and Water Use Efficiency of Forage Crops with Nuclear Techniques	A. Wahbi
Laos	LAO5004	Enhancing National Capability for Crop Production and Controlling Trans-Boundary Animal Diseases	M. Zaman in collaboration with APH
Lesotho	LES5008	Improving Soil Fertility for Enhanced Cereal Production in Lesotho	J. Adu-Gyamfi
Madagascar	MAG5025	Biocontrol of Striga asiatica (L.) Kuntze through the development of tolerant rice and maize lines and its impact on microbiological and ecological functioning of soil	J. Adu-Gyamfi in collaboration with PBG
Malawi	MLW5003	Developing Drought Tolerant, High Yielding and Nutritious Crops to Combat the Adverse Effects of Climate Change	E. Fulajtar in collaboration with PBG
Malaysia	MAL5031	Establishing an Environmentally Sustainable Food and Fodder Crop Production System	E. Fulajtar in collaboration with PBG and APH
Mali	MLI5028	Improving Water Use Efficiency, Soil Fertility Management Practices and the Resilience of Cultures to Climate Variability and Change	L. Heng
Mauritania	MAU5006	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques to Water Management and Soil Fertility	M. Zaman in collaboration with PBG
Myanmar	MYA5027	Monitoring and Assessing Watershed Management Practices on Water Quality and Sedimentation Rates of the Inle Lake - Phase II	L. Heng
Namibia	NAM5016	Developing Drought Tolerant Mutant Crop Varieties with Enhanced Nutritional Content	J. Adu-Gyamfi in collaboration with PBG
Oman	OMA5006	Using Isotopes and Nuclear Techniques in Integrated Water, Soil and Nutrients Management to Optimize Crop Productivity	J. Adu-Gyamfi
Pakistan	PAK5051	Developing Isotope-Aided Techniques in Agriculture for Resource Conservation and Climate Change Adaptation and Mitigation	M. Zaman
Philippines	PHI5034	Applying Nuclear Techniques in the Attenuation of Flood and Natural Disaster-Borne Contamination	E. Fulajtar
Qatar	QAT5007	Improving Productivity of Ikhlas and Berhi Date Palm Varieties	A. Wahbi
Regional project Africa	RAF0046	Promoting Technical Cooperation among Developing Countries through Triangular Partnerships and Sustaining Regional Ownership of the AFRA Programme [Bilateral TC project between Morocco and Côte d'Ivoire]	L. Mabit
Regional project Africa	RAF5075	Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides	E. Fulajtar and L. Mabit
Regional project Africa	RAF5079	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for increased Food Production and Income Generation (AFRA)	L. Heng
Regional project Asia	RAS5070	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	M. Zaman in collaboration with PBG

Country/Region	TC Project	Description	Technical Officer(s)
Regional project Asia	RAS5073	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II	L. Heng in collaboration with PBG
Regional project Asia	RAS5080	Developing Sustainable Agricultural Production and Upscaling of Salt-Degraded Lands through Integrated Soil, Water and Crop Management Approaches - Phase III	M. Zaman
Regional project Asia	RAS5083	Reducing greenhouse gas emissions from agriculture and land use changes through climate smart agricultural practices	M. Zaman
Regional project Asia	RAS5084	Assessing and improving soil and water quality to minimize land degradation and enhance crop productivity using nuclear techniques	J. Adu-Gyamfi
Regional project Latin America	RLA5076	Strengthening Surveillance Systems and Monitoring Programmes of Hydraulic Facilities Using Nuclear Techniques to Assess Sedimentation Impacts as Environmental and Social Risks (ARCAL CLV)	E. Fulajtar
Regional project Latin America	RLA5077	Enhancing Livelihood through Improving Water Use Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)	L. Heng
Regional project Latin America	RLA5078	Improving Fertilization Practices in Crops through the Use of Efficient Genotypes in the Use of Macronutrients and Plant Growth Promoting Bacteria (ARCAL CLVII)	J. Adu-Gyamfi
Senegal	SEN5039	Supporting Eco-Intensification of Agriculture in Small-Scale Farming Systems by Improving Water and Nutrient Management	M. Zaman
Serbia	SRB5003	Strengthening the Capacities for Soil Erosion Assessment Using Nuclear Techniques to Support the Implementation of Sustainable Land Management Practices	E. Fulajtar
Seychelles	SEY5011	Supporting Better Sustainable Soil Management as Climate Change Adaptation Measures to Enhance National Food and Nutrition Security	L. Heng
Sudan	SUD5037	Application of nuclear and related biotechnology techniques to improve of crop productivity and lively hood of small scale farmers drought prone areas of Sudan	J. Adu-Gyamfi in collaboration with PBG
Togo	TOG5002	Improving Crop Productivity and Agricultural Practices Through Radiation Induced Mutation Techniques	E. Fulajtar in collaboration with PBG
Zambia	ZAM5031	Improving the Yield of Selected Crops to Combat Climate Change	E. Fulajtar in collaboration with PBG
Zimbabwe	ZIM5021	Assessing and Promoting Sustainable Agricultural Production in Communal and Newly Resettled Farms	L. Mabit in collaboration with PBG

Forthcoming Events

FAO/IAEA Events

Coordination Meeting of Regional TCP RAS5084 on ‘Assessing and Improving Soil and Water Quality to Minimize Land Degradation and Enhance Crop Productivity Using Nuclear Techniques’, 5-9 February 2018, Vienna, Austria.

Technical Officer: Joseph Adu-Gyamfi

Coordination Meeting of Regional TCP RLA5078 on ‘Improving Fertilization Practices in Crops through the Use of Efficient Genotypes, Macronutrients and Plant Growth Promoting Bacteria (ARCAL CLVII)’, 26 February–2 March 2018, Guadalajara, México.

Technical Officer: Joseph Adu-Gyamfi

Coordination Meeting of Regional TCP RLA5077 on ‘Enhancing Livelihood through Improving Water Use

Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)', 5–9 March 2018, San José, Costa Rica.

Technical Officer: Lee Heng

Coordination Meeting of Interregional TCP INT0093 on 'Applying Nuclear Science and Technology in Small Island Developing States in Support of the Sustainable Development Goals and the SAMOA Pathways', 19-23 March 2018, Vienna, Austria.

Technical Officers: Joseph Adu-Gyamfi and Lee Heng

Regional Training Course, RAS 5070 on 'Nuclear Techniques in Soil, Water and Nutrient Management under Marginal Land', 9-13 April 2018, Peshawar, Pakistan.

Technical Officer: Mohammad Zaman

Second Research Coordination Meeting of CRP D1.50.17 *on* 'Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystens', 16-20 April 2018, Rabat, Morocco'

Project Officers: Lionel Mabit and Lee Heng

Coordination Meeting of Regional TCP RLA5076 on 'Strengthening Surveillance Systems and Monitoring Programmes of Hydraulic Facilities Using Nuclear Techniques to Assess Sedimentation Impacts as Environmental and Social Risks', 23-27 April 2018, Habana, Cuba.

Technical Officer: Emil Fulajtar

Regional Training Course, RAS5080 on '^{15}N application, sampling, collection and data interpretation, 6-10 May 2018, Amman, Jordan.

Technical Officer: Mohammad Zaman

First Research Coordination Meeting of CRP D1.50.18 on 'Water, nutrient management for agriculture-driven non-point source pollution', 7–11 May 2018, Vienna, Austria.

Project Officers: Joseph Adu-Gyamfi and Lee Heng

Final Research Coordination Meeting of CRP D1.20.12 'Optimizing Soil, Water and Nutrient Efficiency in Integrated Cropping Livestock Systems', Q2 2018, Vienna, Austria.

Project Officer: Mohammad Zaman

Non-FAO/IAEA Events

20th International Conference on Soil Science and Plant Nutrition, 25—26 January 2018, Paris, France. https://www.waset.org/conference/2018/01/paris/ICSSPN

20th International Conference on Agricultural Water Conservation and Irrigation Water Use Management, Paris, France, 15—16 March 2018. https://www.waset.org/conference/2018/03/paris/ICAWCIWUM

European Geosciences Union General Assembly 2018, 8-13 April 2018, Vienna, Austria. https://www.egu2018.eu/

20th International Conference on Agricultural Soil Management Practices, 17—18 May 2018, Barcelona, Spain. https://www.waset.org/conference/2018/05/barcelona/ICASMP/home

14th International Conference on Monitoring, Modelling and Management of Water Pollution, 22 —24 May 2018, La Coruña, Spain. http://www.wessex.ac.uk/conferences/2018/water-pollution-2018

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

Past Events

Meetings and Training at the IAEA

Scientific meeting for discussing and interpreting data on climate change impacts on sediment redistribution and cryosphere dynamics in high altitude and high latitude regions, INT5153 project, 6-9 November, IAEA, Vienna, Austria

Technical Officer: Dercon, G. and Slaets, J.

Researchers on sediment and cryosphere dynamics from the project INT5153 "Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions" met from 6 till 9 November at IAEA headquarters in Vienna, to interpret and integrate their scientific results.

The INT/5/153 project aims to elucidate the impacts of climate change in fragile high altitude and high latitude regions, where scientific data are scarce. In this meeting, the scientists discussed the integration, meaning and implications of their scientific results on sediment redistribution and cryosphere dynamics - and the

interaction between these two - in high altitude and high latitude regions.
Ten experts and benchmark site representatives from eight countries participated in the meeting, in order to ensure that the results of the encompassing datasets were integrated across locations and disciplines. The meeting thus connected researchers from the seven benchmark sites and from the core expert teams working on sediment and cryosphere dynamics, synthesizing all their results.

Participants of the INT5153 meeting, Vienna, Austria

The meeting resulted in the following achievements:

- Preliminary research findings were presented and discussed: In the first three years of the four year project, seven expert missions have yielded over 2000 soil, sediment and water samples analyzed for 70 different biogeochemical parameters, as well as glacier cryosurveys and very high resolution digital surface models based on UAV mapping. Researchers used the meeting to discuss implications of their results for the other disciplines, to compare results for different sites and to identify processes that could improve models of climate change impacts on glaciers in the future.
- The timeline for follow-up analysis and interpretation was established (for last two expert missions to Elbrus, Russian Federation and Huayna-Potosí, Bolivia).
- The policy implications of the results were discussed with representatives of the benchmark sites. These representatives provided feedback on how they could use the results of the INT/5/153 project to improve policy measures, for example to determine in which dimension climate change impacts could affect local, regional and national water supply and demand.
- A plan for dissemination of the results through conferences and workshops was established. A session on “Soil, water and sediment tracing for unravelling climate change dynamics in pro-glacial areas” has been accepted at the European Union of Geosciences General Assembly 2018, and 15 oral contributions and 14 poster presentations are being prepared in frame of this session.
- Data storage and sharing for the future via the IAEA-hosted CLP4NET platform was discussed.
- Capacity building activities for the final year have been planned. To date, over 40 young scientists have received hands-on field training during these missions, and an additional 23 junior researchers have been trained in training courses or individual fellowships. Six additional individual fellowships and a training course are planned for the final year of the project.

Duty Travel

Austria: Mobile cosmic-ray neutron sensor testing, Rauris, Austria, 22-26 May 2017

Wahbi, A. and Dercon , G.

The aim of this mission was to develop the use of mobile cosmic-ray neutron sensors (CRNS) for area-wide soil moisture monitoring in upland agro-ecosystems (under CRP D1.50.17 "Nuclear Techniques for a Better Understanding of the Impact of climate Change on Soil Erosion in Upland Agro-ecosystems").
Mountainous environments, due to the shallowness of the soils, are vulnerable to changing climate and land use practices, yet are often responsible for the headwaters of major river systems sustaining cultivated lands or supporting important agricultural activity. The use of Cosmic-Ray Neutron Sensors (CRNS) for area-wide soil moisture monitoring in upland agro-ecosystems was tested across three field sites representing three different elevations within the Rauris Valley in Austria, at the beginning of the growing season, as compared to last year's testing at the end of the growing season. These sites were chosen for their management styles and land uses by the local agricultural community (i.e. cattle grazing at 1750 m a.s.l. and hay production at 950 and 1430 m a.s.l.).
The mobile CRNS was calibrated to local environmental conditions following the standard methodologies and procedures regarding proper field calibration of a CRNS device mobile. These methods primarily involve the sampling of soil (total of 108 soil samples per site) within an instruments footprint of about 20 ha.

The effect of altitude (read air pressure) on the accuracy and footprint radius of the backpack CRNS device has yet to be fully understood (important for calibration purposes); yet preliminary results indicate an increase in cosmic ray intensity at higher altitudes (from results of last year monitoring). The data of this year could provide enough evidence for solid conclusions (analysis in progress) on the use of CRNS in upland agro-ecosystems. In addition, we conducted at one site (1400 m a.s.l.) CRNS based measurements at two locations where land use is different (cattle grazing versus hay production) to implement first CRNS applications for comparing land use impact on soil water.

Study site in Rauris, Austria, at 1400 m a.s.l. for testing mobile cosmic-ray neutron sensor in upland agro-ecosystems

Cameroun: CMR5021 To provide technical advice in the design of on-farm trials and to discuss the status of project implementation, 5–9 June 2017, Yaoundé, Cameroun

Adu-Gyamfi, J.

Mr. Joseph Adu-Gyamfi traveled to Yaoundé, Cameroun to discuss with the counterpart institute, Institut de Recherche Agricole pour le Développement (IRAD), the project workplan and future activities. The mission also helped to train counterparts 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. The TO was accompanied by two project counterparts visited a field trial aimed to improve the productivity of the integrated cereal-plantain-tree cropping systems. At the end of the mission, the IAEA NLO was debriefed on the observations by the TO during the mission.

Extracting an access tube that was improperly installed. (Photo: IRAD)

The conclusions from the mission were (1) the project counterpart Mr Roberto Tueche, who was newly selected by IRAD to manage the current and future IAEA/IRAD technical cooperation projects, needs to conduct a field trial using ^{15}N stable isotope fertilizers and water monitoring equipment, as he was trained on both aspects recently, (2) logistic support for the effective implementation of field activities should be considered.

China: RAS5069 Workshop on application of nuclear techniques for flood management in watershed case studies, 12-16 June 2017 Nanning, China

Fulajtar, E.

The workshop was organized under the Regional TCP RAS5069 ‘Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia’. This project is an interdisciplinary project involving nuclear techniques useful for flood management. One of the project components is on soil-related nuclear techniques. 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 and to provide practical exercises on the combination of FRN data on soil erosion rates with soil erosion modelling. It is a follow up of previos workshop held in March 2017 in Chicago. This workshop involved also teleconference with expert Ch. Renschler from University of Buffalo who provided guidance on the exercise with WEPP model. Apart from the indoor session the workshop involved also field work in selected test site – a watershed in Guangxi province where the planning of sampling strategy for FRN sampling, basic soil characteristics, measurements of infiltration and soil core sampling was practiced.

Field test of soil pH.

Botswana: BOT5012 To evaluate project advance, discuss up-scaling the technology to farmers’ field and train counterparts on analysing and interpretation of ^{15}N data collected from experimental trials, 26–30 June 2017, Gaborone, Botswana

Adu-Gyamfi, J.

The purpose of this travel to Gaborone, Botswana was to evaluate the project and train counterparts on the methodology to scale out the project outputs to farmers.

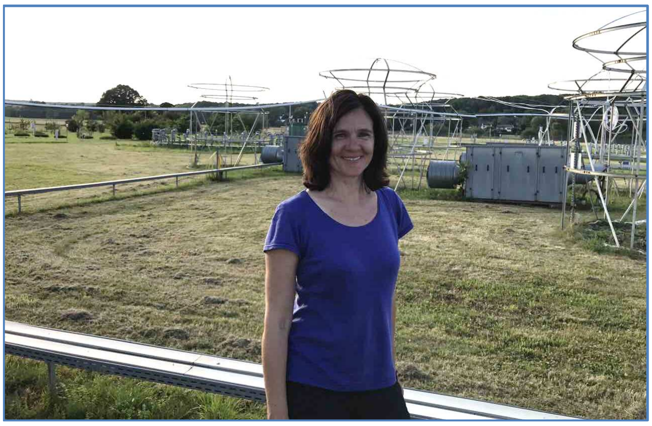
The project 'Improving Soil and Water Management Options to Optimize Yields of Selected Crops" was a 3-year project that started in January 2014 and ended in December 2016. However, at the request of the Government of Botswana, a one year extension at no cost was granted to enable the counterparts to complete some of the pending outputs. The TO paid courtesy calls to the Director, Dr P. O. Mosupi; Chief Agricultural Officer (Crops), Ms M. Ramokapane; and Chief Agricultural Officer (Support Services), Mr D. Machacha; all from Department of Agricultural Research (DAR), Ministry of Agriculture. The TO assisted the project counterparts to finalize the calculations and interpretation of data from ^{15}N-enriched plant samples. The main conclusions were (1) the Government is requested to sustain the project by providing logistic support to help scale out the technology to farmers' field; (2) training enhanced understanding and increased the confidence of the project counterparts to use ^{15}N methodology for on-farm evaluation of legumes for their nitrogen fixing ability; (3) project counterparts need to put into practice the practical training on the on-farm field design received from the TO, and scale out the technology to farmers.

Counterparts trained to carry out ^{15}N methodology in on-farm field trial

Germany: Training on the use of advanced stable isotope techniques for nitrogen tracing at Justus-Liebig University Giessen, 2-7 July 2017

SWMCN Laboratory Staff: Heiling, M.

Maria Heiling visited the Institute for Plant Ecology at the Justus-Liebig University Giessen, Germany, to support R&D activities of CRP D1.50.16 on "Minimizing Farming Impacts on climate Change by enhancing Carbon and Nitrogen Capture and Storage in Agro-ecosystems". She received training in the use of advanced stable isotope techniques for nitrogen tracing technologies to quantify nitrous oxide (N_2O) and nitrogen (N_2) emissions. She was also shown on the use of other relevant greenhouse gases analytical methods which could be useful for the future activities of the SWMCN Laboratory. This visit will further strengthen the collaboration between our laboratory and the Justus-Liebig University Giessen. The SWMCN Laboratory thanks Prof Christoph Müller for his time and hospitality.



*Research site to study climate change impacts: **F**ree-**A**ir **C**arbon Dioxide **E**nrichment Study (FACE)*

Viet Nam: To review the progress made under TC project RAS5070 and to discuss and design future work plan and field trials for 2017-2018, 3-7 July 2017, Hanoi, Viet Nam.

Zaman, M.

Mr Zaman together with another TO, Ms. Fatma Sarsu from Plant Breeding and Genetics, as well as expert Mr. Khalid Mahmood and the Vietnamese counterpart, Mr. LE Huy Ham, also the Director General of Institute of Agricultural Genetics, arranged the five-day coordination meeting in Hanoi, Viet Nam. The meeting was attended by 30 participants, two each from Bangladesh, China, Indonesia, Lao P.D.R., Malaysia, Mongolia, Myanmar, Nepal, Philippines and Sri Lanka, and one each from Cambodia, India, Pakistan, Korea, Republic of Thailand and 5 from Viet Nam. The local organizer welcomed the meeting participants and presented a brief overview of the research activities carried in Viet Nam.

The Technical Officer described the objectives and expected outcome of the coordination meeting, budget, priorities and platforms for collaboration. Mr. Khalid, the expert who was in previous and current meetings, presented a summary of project progress made since 2016. Each counterpart presented summary of his/her ongoing and future field research work on improving crop productivity under marginal land in their respective country followed by feedback from the technical officers and the expert. The Technical Officers and expert also had meetings with individual counterparts to discuss their project activities and future needs for 2017 and provided inputs to the future work plan and field trials for 2017-2018. On the final day, all participants went on a field trip to Agricultural Genetics Institute, Hanoi, where the TO and expert demonstrated ^{15}N application, and the participants visited the plant breeding labs. The meeting was successful and the expected outputs were fully achieved.

Participants of the meeting of RAS5070, Viet Nam

Sudan: SUD5037 To train the project counterparts in best management practices of nutrients and biological N fixation to improve soil fertility and increase crop productivity of cowpea, groundnut and other crops in a sustainable way, 9–13 July 2017, Wad Medani, Sudan

Adu-Gyamfi, J.

On the request of the TO (Mr Mohammad Zaman) and the PMO Mr Lameen Abdul-Malik, the Expert, Mr Joseph Adu-Gyamfi traveled to Agricultural Research Corporation (ARC) in Wad Medani, Sudan to train the project counterparts on best management practices of nutrients and biological N fixation to improve soil fertility and increase crop productivity of cowpea, groundnut and other crops in a sustainable way. Twenty-two participants attended the training which was formally opened by the DDG of ARC, Mr Adel Osman Rahim.

Project counterparts design On-farm experiments

The training included calculations of nutrient from different N inputs (chemical fertilizer, animal manure), practical training of applying ^{15}N techniques in the field, calculation of fertilizer use efficiency and interpretation of data from a case study. The Expert performed field demonstrations of an effective method to apply ^{15}N-labeled fertilizer to the micro-plots and the on-farm designs to scale-out the methodology to farmers' fields. In his closing remarks, the DDG of ARC charged the participants to put to practical use the training received from the Expert, and assured the project counterparts his support for the project. Besides enhancing the capability of the project counterparts to use ^{15}N methodology for on-farm evaluation of legumes for their nitrogen fixing ability and cereals for their N use efficiency, the training also provided an opportunity for researchers and technical staff in the Land and Water Research Center to work together and share ideas on the use of isotopic techniques in soil and water management.

Namibia: NAM5014 To review project implementation and assist technical team design and implement field trials using stable isotope fertilizers aimed at improving nutrient and water use by crops, 31 July–4 August 2017, Windhoek, Namibia

Adu-Gyamfi, J.

Mr Joseph Adu-Gyamfi traveled to Windhoek, Namibia to monitor the progress made on the activities related to the soil and water management. The TO accomapnied by Ms Lydia Horn and Ms Ella Shiningayamwe (main project counterparts) paid courtesy calls to the Director, Directorate of Agricultural Research and Development (DARD), Ms Johanna Andowa. The TO also visited the UN Office and met with the UNDP Resident Representative, Ms. Kiki Gbeho who was also the acting FAO Representative. Discussions focused on exploring collaboration with UNDP and FAO on current projects to scale-out the drip irrigation systems to the rain-fed areas in the northern part of the country. TO met all the project stakeholders to discuss the activities to be implemented before the end of the project in December 2017, and to plan a project kick-off meeting for NAM 5015 (2018-19 TC cycle).

The TO with the UNDP Resident coordinator and Acting FAO Representative in Namibia

The observations and conclusions from the mission were: (1) more progress has been made since the nomination of a Soil Scientist to coordinate the soil and water component of the project. It is envisaged that further progress will be made when all the water monitoring sensors are installed, and on-farm experiments implemented; (2) the project counterparts suggested to concentrate all on-farm activities at Mannheim (400 km from Windhoek) instead of Omahenene (850 km from Windhoek); (3) a national training course (NTC) on water management to be conducted before the end of the year could be planned to coincide with the installation and training of the newly procured "drill and drop" moisture sensors; (4) the current project needs to explore collaboration with UNDP and FAO to use drip irrigation systems to improve crop and water productivity for small holder farmers in the rain fed areas in Namibia.

Spain: Research Coordination Meeting on CRP D15016 'Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems', 1-7 October 2017, Madrid, Spain

Zaman, M.

The aim of this travel was to review the progress made by CRP participants since the second RCM in May 2016, and to develop work plan and activities for 2017-18. The meeting was held in the Technical University, Madrid. Mr. Sanz-Cobena Alberto, professor at the Technical University was the local coordinator of the RCM. Seven research contract holders from Brazil, China, Chile, Costa Rica, Ethiopia, Iran and Pakistan, and technical contract holder from Justus-Liebig University Giessen, Germany, Dr. Luis Lassaletta, CNRS, France /University of Utrecht, the Netherlands and Prof. Agustín del Prado from the Basque Center for Climate Change and participant of IPCC (Inventories) also attended the RCM. The Scientific Secretary presented the objectives of the CRP. During the five-day meeting, each participant presented results obtained since the second RCM held in Justus-Liebig University Giessen, Germany, followed by feedback from the meeting participants, Scientific Secretary and local coordinator. Prof. Agustín del Prado gave an overview of the IPCC inventories enhancing the importance of the results and work of CRP participants in data collection to improve national GHG emission inventories. On the final day of the RCM, all participants presented their work plan for 2017-18 to get further feedback to ensure the accomplishment of the CRP objectives. The CRP participants also visited the Research Station for Irrigation Technologies, Ministry of Agriculture & La Canaleja, Research Station of the Research Institute for Rural development, Food and Agriculture of the Autonomous Community of Madrid, INIA. During the field visit, a new method of ammonia measurement was demonstrated and land and water management reducing nitrous oxide emission was shown.

Participants of the meeting of CRP D1.50.16, Technical University, Madrid, Spain

Myanmar: MYA5025 'Monitoring and Assessment of Watershed Management Practices on Water Quality and Sedimentation Rate of Inle Lake, 16-20 October 2017, Nya Pyi Taw

Heng, L.

Ms Heng travelled to Nay Pyi Taw (NPW) Myanmar to review MYA5025 project progress and achievement since the project started in 2015. Discussion was held with project counterpart Ms Cho Cho Win from Forest Research Institute in Yezin, NPW. Results from field campaign to determine the rate and sources of soil erosion and sedimentation from one major catchment in Inle Lake have been analysed and interpreted. Caesium-137 (^{137}Cs) was used to determine erosion rate and Compound Specific Stable Isotope (CSSI) to identify the sources of erosion. The results showed that degraded and bare soil contributed almost half of the sedimentation in the Lake. Similarly, water and fertilizer samples from Inle Lake are being collected for isotopic data analysis to determine sources of water quality issue.

MYA5025team discussing current and future projects

The trip was also to plan Phase II of the project which will start in 2018, and to participate in a two-day Soil Fertility and Fertilizer Management Conference, hosted by IFDC and the Department of Agricultural Research (DAR) (counterpart MYA5023 and Director of Soil Science, Water Utilization, and Agricultural Engineering Division of DAR, Dr Su Su Win), to discuss how to increase the nation's agricultural productivity and keep its soils healthy. A total of 28 papers presented covering soil fertility and crop nutrient management, environmental impacts of fertilizer, fertilizer quality, fertilizer recommendations, and farmer extension methods. The technical officer gave a presentation on 'Role of Nuclear and Isotopic Techniques in Climate Change Adaptation and Mitigation'. A trip was also made to Mandalay to visit the field site and laboratory at Kyauk Se of RAS5073 project on climate proofing rice production systems (CRiPS) where improved rice mutant varieties and best-fit water and nutrient management were carried out. Ms Khine Zar Linn the counterpart of RAS5073, Dr Myat Minn, the group leader and Ms Nyo Nyo Mar, soil scientist explained the work in the field and laboratory.

Austria: 6th Symposium for Research in Protected Areas, Salzburg, Austria, 2-3 November 2017

Wahbi, A.

Mr Wahbi attended the "6th Symposium for Research in Protected Areas" and deliver a poster presentation on SWMCN Laboratory R&D activities on the use of cosmic ray neutron sensor techniques in upland agro-ecosystems, carried out in Rauris, one of the villages linked to the National Park Hohe Tauern, Austria. The title of the poster was "Mobile Soil Moisture Management in High Elevations: Applications of the Cosmic Ray Neutron Sensor Techniques for Estimating Field Scale Soil Water Content".

From 2 to 3 November about 400 scientists from 20 countries came together at the symposium hosted by the Faculty of Natural Science, University of Salzburg, to discuss the ways to preserve protected areas and how to deal with long term management of such areas. Over 130 oral presentations in 4 parallel sessions were given on topics related with land use, stakeholder interaction, management and biodiversity. More information on the related research can be found in the section on "Developments at the Soil and Water Management and Crop Nutrition Laboratory" of this Newsletter.

Malaysia: RAS5070 To facilitate and provide regional IAEA/RCA training on "Best Practices to Improve Soil Fertility and Crop Productivity under Marginal Lands using Conventional and Isotopic Techniques" 13-17 November, 2017, Kuala Lumpur, Malaysia

Zaman, M.

Mr Zaman together with an expert, Mr. Mr. Khalid Mahmood, travelled to Kuala Lumpur, Malaysia to facilitate and provide regional training organized by the IAEA, in cooperation with the Government of Malaysia, through the Malaysian Nuclear Agency, Ministry of Science, Technology and Innovation. The training course focused on the issues and challenges of marginal land in Asia and Pacific region and the role of nuclear and related techniques to develop climate smart agricultural practices to enhance nutrients and water use efficiencies improve soil fertility and quality and increase crop productivity of marginal land. The training was attended by participants from Bangladesh, Cambodia, China, Indonesia, India, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Thailand, Sri Lanka, and Vietnam and included presentations and hands on training on the subject. The training session was opened by the Director General of the Malaysia Nuclear Agency, Mr Mohd Ashhar Bin HJ Khalid, who gave an overview of the challenges of marginal lands in Malaysia. The TO and the invited expert provided lectures and hands-on training which covered a range of topics. These include: a) identifying and assessing different types of marginal land; b) challenges of nutrient and water management and their conservation due to poor soil quality and health of marginal land; c) strategic application of both chemical and organic fertilizers to minimize nutrient losses and reduce farm cost; d) using leguminous and cover crops to capture atmospheric nitrogen and carbon to improve soil fertility; and e) retention of crop residues after harvest and minimum tillage to improve soil quality and health. Maximizing productivity and fertility of marginal land requires careful management of nutrients from chemical and organic fertilizers and legumes therefore all participants were trained using the stable isotopic technique of N-15 to quantify fertilizer use efficiency and biological nitrogen fixation (BNF). Different methods of applying irrigation water and its conservation strategies were also covered. All participants went on a field visit to set up trials for assessing fertilizer use efficiency and BNF using N-15, followed by lab visits where they were shown soil and plant sample preparation for N-15 analysis on IRMS. At the end of the training course, each participant was assessed by making a presentation to show what new knowledge they learnt during the regional training. The participants acknowledged both IAEA and the Malaysian Nuclear Agency for hosting and organizing this training and committed to share their experience and knowledge with fellow colleagues for further capacity building.

Training participants in Kuala Lumpur, Malaysia

Samoa: FAO Subregional meeting for the Pacific Islans, 27 November - 1 December 2017, Apia, Samoa

Heng, L.

Ms Heng travelled to Apia, Samoa to represent the IAEA at the FAO Subregional meeting for the Pacific Islands. The trip was to attend the review and discussion on the multi-country Programme Framework with all country representatives for the Pacific Islands, and to discuss and seek possible coordination and collaboration with FAO regional and country representatives. Ms Heng provided a presentation on Nuclear Applications in Food and Agriculture and on IAEA's activities in the region. Upon the request of FAO's Member Countries, she also provided a presentation on procedure to join the IAEA as a Member State.

FAO Subregional meeting with all member countries in Apia, Samoa

Malaysia: RAS5073 To facilitate regional training course on "Precision Technology for Sustainable Agriculture & Measurement of GHG Under Field and Laboratory Conditions" 4-8 December, 2017, Kuala Lumpur, Malaysia

Heng, L.

Ms Heng travelled to Kuala Lumpur, Malaysia to facilitate the above regional training course, in cooperation with the Government of Malaysia, through Malaysian Nuclear Agency. The purpose of this training course was to strengthen the project participants on the measurement of greenhouse gases (GHG) using conventional and isotopic techniques and its analysis. The training is also on the mapping of soil variability using electromagnetic induction method, precision technology for sustainable agriculture. A total of 29 participants attended this training course, from Bangladesh, Cambodia, Indonesia, Lao P.D.R., Myanmar, Philippines and Malaysia. Mr Shyful Azizi Abdul Rahman from Malaysian Nuclear Agency is the oordinator of this course. Prof. Christoph Müller was the expert on the GHG component of the course, where measurement of GHG under ponded conditions was practiced and a standard protocol for the analysis of field based GHG emissions was established as well as a user-friendly spreadsheet for the calculation of its fluxes developed. Dr Aimrun and Mr. Ridzuan from Universiti Putra Malaysia were the local experts for the training on the mapping of soil variability using electromagnetic induction method. Malaysian Nuclear Agency was acknowledged for hosting and organizing this training to build capacity in this field.

Scientific Visitors

Mr Emmanuel Chikwari, Chief Research Officer at the Chemistry and Soil Research Institute, Harare (Zimbabwe), counterpart of ZIM5021 project visited the SWMCN Laboratory from 31 July to 4 August 2017 to learn about the nuclear techniques used to study soil degradation and how to reduce erosion impact. He also discussed the follow-up activities of the project.

Mr. Emmanuel Chikwari (back left) discussing stable isotopic techniques with SWMCN Laboratory staff and fellow

Mr Ibrahim Bakri Abdurazzaq and **Ms. Suad Abduljabbar Abdulzahra Al-Saedi** from the Ministry of Science & Technology, Iraq, and **Mr. Mirza Mofazzal Islam** from the Bangladesh Institute of Nuclear Agriculture visited the SWMCN Laboratory to discuss and plan project activities of Iraq and Bangladesh national TC projects respectively (IRQ5020 and BGD5029), from 15 to 18 August 2017.

Mr Yassine Doudoua, scientific director from the Chad Institute for Agricultural Research and Development (ITRAD) and project counterpart of CHD5012, visited the SWMCN laboratory and section to learn more about the use of isotope and nuclear techniques for improving soil and water management, from 16 to 20 October 2017.

Coordinated Research Projects

Project Number	Ongoing CRPs	Project Officer
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
D1.50.15	Response to Nuclear Emergencies Affecting Food and Agriculture	Gerd Dercon and Lee Heng
D1.50.16	Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems	Mohammad Zaman and Lee Heng
D1.50.17	Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems	Lionel Mabit and Lee Heng
D1.50.18	Multiple isotope fingerprints to identify sources and transport of agro-contaminants	Joseph Adu-Gyamfi and Lee Heng

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

Project Officer: Adu-Gyamfi, J.

Agriculture is the main source of pollution in rivers and streams and this has a direct negative impact on human health. A major knowledge gap regarding pollution in agro-ecosystems is source identification and apportionment, which requires more data, research and integration of approaches. When pollutants from multiple sources to an agro-ecosystem occur, traditional techniques cannot help in evaluating the relative contribution of the different sources. Complementarily to conventional monitoring and mass balance approaches, stable isotopes of major biogenic elements (H, C, N, O and S) have the potential to characterize and quantify sources and transport of solutes through soil and water bodies in agro-ecosystems. The integrated approach in analysis of solutes and water allows separation of the pathways of the pollutant dispersal and water flow. Accurately identifying the sources and transport (from soil to water) of pollutants from agriculture would help to develop appropriate soil and water management practices to minimize pollutants to surface and ground waters.

A Consultant Meeting (CM) on "Stable Isotopes for monitoring agricultural-derived pollutants and land management practices to ensure water quality was held at the IAEA Headquarters in Vienna, Austria on 25–28 September 2017. After the unanimous recommendation of the external consultants it was amended to '*Multiple isotope fingerprints to identify sources and transport of agro-contaminants*' Six scientists with international expertise in water pollution from agriculture and monitoring the source and movement of pollutants from agriculture were invited as consultants. In addition, the staff from the Soil and Water Management and Crop Nutrition (SWMCN) Section and Laboratory of the Joint FAO/IAEA Division on Nuclear Techniques in Food and Agriculture, participated in the meeting.

Nuclear Component

Combined stable isotopes ($\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ and $\delta^{34}S$) techniques will be used to trace and monitor sources and movements of macronutrients and micro-contaminants from the soil to the ground and surface waters under different land uses.

Explanation / Justification

The Consultants suggested to focus on:

(i) evaluating and standardizing an integrative isotope approach for identifying and apportioning sources of contaminants in agro-ecosystems and

(ii) providing guidelines for applying the toolbox.

The recommendations from the Consultants were that the IAEA shall:

1. promote and coordinate building networks to exchange experience on the use of stable isotope techniques to evaluate agro-systems for sustainable agriculture and environmental protection,
2. promote research on isotopic techniques to identify sources and apportion pollutants in agro-ecosystems in relation to land use and resource management,
3. continue to promote synergy between stable isotope and conventional approaches,
4. select relevant participating institutions in developing countries on the basis of recommended criteria regarding existing capacity, infrastructure, monitoring records and significance of proposed study site. For the sustainability of the project the potential participants shall identify upfront national

policies (e.g. directives, frameworks) they attempt to inform with the CRP,

5. request end-of-project feedbacks from the participants on the progress and benefits of the CRP covering lesson learnt and existing gaps for future CRP. IAEA shall disseminate knowledge from the CRP to initiate new TC projects addressing local/regional needs,
6. endeavor publications, which shall highlight the support/funding by IAEA in the frame of the CRP.

Within the budget constraints, this CRP plans for seven (7) research contract holders), one (1) technical contract holders and three (3) agreement holders.

Participants at the Consultants meeting in Vienna, Austria

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

Project Officer: Zaman, M.

This CRP is in its final year and the final year renewals for all national projects were 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 (2), 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 results of the project over the first four years are described below:

- The carbon isotopic signature data in Argentina field trials showed that C3 plants (soybean and pasture) led to more carbon storage in soil than that of C4 plants in integrated crop-livestock farm ICLS and continuous cropping system (CCS). These results suggest that rotation with legumes could contribute to more carbon accumulation than pasture.
- The three years field data in Brazil suggest that integrated crop-livestock system have the most potential to reduce N_2O emission from soil but no effect on CH_4 emissions and on soil organic C stocks.
- The results from China field trials showed that, compared with the grazing exclusion, light grazing not only reduced soil respiration but also enhanced the soil erosion resistance. The mechanism may be associated with the inhibited plant biomass production and the increased soil compaction by animal trampling under regular grazing. This grazing effect, however, was only significant during the growing season whereas during the non-growing season soil temperature was the dominant factor controlling soil respiration.
- The field studies in India showed that integrated crop-livestock system led to a significant increase in organic carbon content in the soil, making it healthier and better for growing crops. Organic carbon content increased in three out of the four project locations; in the Kancheepuram area, for example, the organic carbon content increased from 0.18% to 0.73%. Livestock reproductive performance has also gone up, including a 15% increase in the cattle's milk production as well as increase in the size of goats.
- In Kenya, potential farm practices for improving soil nutrient and water use efficiencies in crop-livestock systems for adoption by farmers have been identified. Socio-economic and environmental benefits of crop-livestock systems have also been assessed. Stakeholders' capacity to use nuclear techniques in soil water management has been strengthened.

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

Project Officer: Heng, L.

This project is in its final year and the last RCM will be held in Q2 2018 in Vienna, Austria. Eight research contract holders from Bangladesh, China (two participants), Iran, Korea, Pakistan and Vietnam (2 participants) and agreement holder from USA will participate in the final meeting. The results obtained throughout the implementation of the project (2013-2018) will be reviewed and discussed, and the main achievements will be evaluated in accordance with the project objectives. The last contract extension was successfully renewed recently.

The CRP 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.

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

Project Officers: Dercon, G. and Heng, L.

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 in emergency response to nuclear and radiological incidents affecting 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:

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

Four research contract holders from China, Morocco, the Russian Federation and Ukraine, four technical contract holders from France, Japan (2) and Macedonia, 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.

The CRP is in its final year of implementation. 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).

Work is being done to disseminate the knowledge gained in this CRP through an IAEA Technical Document (TECDOC) and a Special Issue in a scientific journal. With the collaboration of CRP participants from France, Japan and Macedonia, an advanced draft of a TECDOC highlighting challenges and solutions in data management and visualization has been prepared. A virtual special issue titled “Sampling, analysis and modelling technologies for large-scale nuclear emergencies affecting food and agriculture” has received the IAEA’s Approval in Principle and is now in the process of concept review with a peer-reviewed journal.

Validation of the advanced prototype of DSS4NAFA has been performed by interns and interest is being generated amongst MS volunteers for testing. DSS4NAFA has received approval of the IAEA-MTIT department to be placed on the IAEA’s Azure Cloud for further development with the planned beta release slated for July 2018 (see more information in the section on “Developments at the Soil and Water Management and Crop Nutrition Laboratory”).

The third RCM was held on 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)

Project Officers: Zaman, M. and Heng, L.

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.

After the first RCM, which was held on 3 to 7 November 2014 in Vienna, Austria, all CRP participants have established field trials to assess the effects of applying N process inhibitors (urease and nitrification) on N_2O emission, and also on C sequestration under differing agro-climatic conditions. Measurements of N_2O emissions and collection of soil and plant samples for chemical analyses are going on for over 2 years. 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 were renewed in October, 2017 based on their project progress reports and renewal proposals. The third RCM was held in the Technical University, Madrid from 7-11 October 2017. The key results obtained since the beginning of this CRP include:

The field data of Brazil, China, Chile, Iran and Pakistan showed that N_2O emissions from different N inputs were reduced by approximately 50% by adopting best soil nutrient management practices. In Ethiopia, the soil carbon and nitrogen stocks decreased by 23% and 40%, respectively, in conversion of natural forest to crop field. However, after 17 years of afforestation, the crop field showed no change of C or N stocks. In addition, agroforestry was estimated to contribute to mitigating 27±14 t CO_2 equivalents ha^{-1} y^{-1} at least for the first 14 years after establishment. The ^{15}N technique identified 2 more microbial processes of N_2O production which include co-denitrification and conversion of organ N to mineral N. This provided us more insights on how to exert more control on N_2O production processes to reduce its emission from soil to the atmosphere. The GHG manual (IAEA TECDOC-674) has been initiated and is underway. The first updated chapters have been submitted and are currently being revised. The outline of the updated GHG manual.

Ten 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 scientific journals. Five more manuscripts on the effects of farm management practices are being currently under preparation. These manuscripts will be submitted to peer-reviewed journals by February 2018. 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)

Project Officers: Mabit, L. and Heng, L.

This CRP is in its second year of implementation and it aims 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. Several nuclear techniques are used to fulfil these specific objectives, including fallout radionuclides (FRN) such as ^{137}Cs, ^{210}Pb, ^{7}Be and $^{239+240}Pu$, and Compound-Specific Stable Isotope (CSSI) and cosmic ray neutron probe.

The first Research Co-ordination Meeting (RCM) was held in Vienna, Austria, from 25 to 29 July 2016. Since that, significant progress related to the first objective of the CRP was made in refining fallout radionuclides (FRN) and CSSI techniques to deepen our understanding of erosion processes affecting upland agro-ecosystems. Already 10 peer-reviewed publications reporting these new developments were produced within the first two years acknowledging explicitly the CRP D1.50.17. As reported in previuos Soils Newsletter, the main milestone of the first year of the CRP was the development of the new and unique FRN conversion model MODERN. In 2017, significant progress has been achieved:

- in testing and validating the use of plutonium isotopes ($^{239+240}Pu$) as soil tracer versus other more mature FRN techniques (e.g. ^{137}Cs and $^{210}Pb_{ex}$) under different agro-environments (i.e. Switzerland, South Korea, Austria);
- in providing new guidance to select reference sites when applying FRN techniques;
- in improving self-attenuation corrections for ^{210}Pb determination by gamma spectrometry;
- in proposing, through the use of a $^{210}Pb_{ex}$ re-sampling approach (test performed in southern Italy), the assessment of changes in soil redistribution rates.

The second RCM will take place in Rabat (Morocco) from 16 to 20 April 2018. According to the original work plan of the project, the internal mid-term review of the CRP is planned for the first quarter of 2019.

Developments at the Soil and Water Management and Crop Nutrition Laboratory

Testing and validation of the use of Pu isotopes as soil redistribution tracers in Grabenegg (Austria)

Step 1: Establishing background fallout of anthropogenic ^{137}Cs and Pu radioisotopes at the Grabenegg reference site

***Falcao, R.*[(1)], *Benmansour, M.*[(2)], *Toloza, A.*[(1)], *Lee Zhi Yi, A.*[(1)], *Mabit, L.*[(1)]**

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The first part of our study to evaluate the potential in using Pu isotopes as soil tracers was carried out in Lower Austria at Grabenegg, at the experimental research station of the Austrian Agency for Health and Food Safety (AGES). The yearly precipitation at the study site is approximately 686 mm. Relief is characterised by gentle to fairly steep slopes. Soilscape is represented by Cambisols.
Upon selection of a suitable reference site (i.e. ~100 m^2 undisturbed flat pasture), one detailed soil profile for precise incremental radioisotopic determination (3cm increments until depth of 24 cm) and 12 bulk cores (0-30 cm) were collected. The soil of this reference site has been characterised as silt loam with an average content of 19% sand, 62% silt and 19% clay. All soil samples were analysed for ^{137}Cs content using gamma spectrometry at the SWMCN Laboratory and for $^{239+240}Pu$ (as well as for ^{238}Pu) content using alpha spectrometry at CNESTEN in Morocco.
Preliminary results showed that in terms of areal activity (i.e. Bq m^{-2}), 79% of the ^{137}Cs and 73% of the $^{239+240}Pu$ are concentrated in the top 12 cm of the soil profile.
As expected at a suitable reference site, the vertical distribution for both isotopes shows an exponential decrease of their content with depth (see Figure 1).

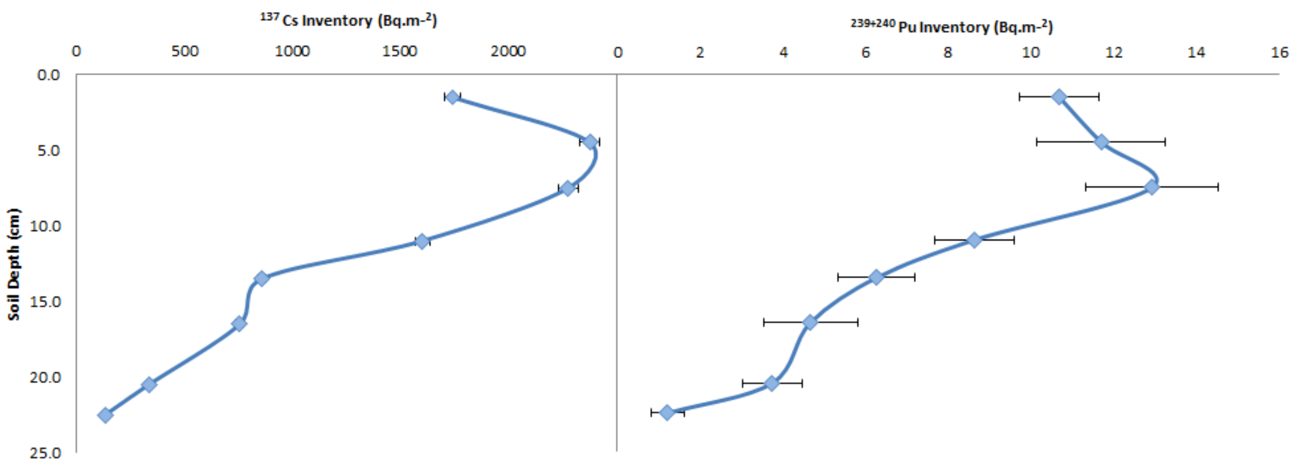

Figure 1. Depth distribution for ^{137}Cs (left) and for $^{239+240}Pu$ (right) at the reference site of Grabenegg AGES research station. For both radioisotopic profiles, the error bars represent the measurement uncertainty at 2 sigma

The initial ^{137}Cs and $^{239+240}Pu$ fallout in 12 core samples collected at the reference site was calculated to 8179 ± 1794 Bq m^{-2} (mean ± SD) with a coefficient of variation (CV) of 21.9% and at 56.1 ± 15.8 Bq m^{-2} with a CV of 28.1%, respectively.

Under our experimental conditions, the ^{137}Cs and the $^{239+240}Pu$ baseline inventories were established with an allowable error (AE) of 12.0% and 14.6% at 90% confidence level, respectively.

Our first step study in the reference site confirms the possibility to use $^{239+240}Pu$ as soil tracer due to its behaviour similar to ^{137}Cs (specific vertical distribution and reduced spatial variability).

In addition, using the information provided by the ratio of ^{238}Pu to $^{239+240}Pu$ of the samples (overall $^{238}Pu/^{239+240}Pu \sim 0.06$), it can be stated without any doubt that the Pu deposited at study site originates from the global fallout and not from the Chernobyl nuclear power plant accidental fallout. Indeed a ratio close to 0.03 is representative of the global fallout and a ratio around 0.42 indicates a Chernobyl fallout.

An agricultural site under crop rotation was identified at around 600 m from our reference site and will be further investigated in 2018 for multi-radioisotopic determination and for assessing soil redistribution rates along its main slope direction.

This research is being performed as one of the contributions of the SWMCN Laboratory to the CRP D1.50.17 and we would like as well to acknowledge AGES for their help and support.

Using laser spectroscopy to evaluate soil carbon loss and storage and soil rejuvenation techniques

Chen, J., Heiling, M., Resch, C., Gruber, R., Weltin, G., Dercon, G.

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

To characterize soil carbon loss, soil respiration rates often need to be measured *in situ* or at least measured in the lab using freshly collected soils. This restricts analysis of archived samples or samples that require longer transportation from farther away destinations. Using SWMCNL newly produced standard gases and laser spectroscopy techniques that can accurately measure CO_2 produced by soil respiration, we are evaluating if we can rejuvenate archived soils to measure soil carbon loss when mulch application is applied. By comparing CO_2 production from archived soils, rejuvenated soils and freshly collected soils, we can determine if we can restore soil processes so that we can, in the future, perform similar analysis on soils that may be submitted to our laboratory by counterparts in faraway member states.

To evaluate our soil rejuvenation technique, respiration rates of three different soil types are being compared after mulch application in an incubation study. This is to follow up on our previous study investigating the effectiveness of mulch application to store carbon belowground in agricultural soils and in greenhouse mesocosm soils. In this controlled soil incubation study, we applied non-labelled mulch or mulch labelled with carbon-13 (^{13}C) that was produced in our laboratories to differentiate between soil and mulch-derived CO_2 production. Specifically, by comparing the ^{13}C signature of CO_2 emitted from soils that were given ^{13}C-labelled mulch, we can identify the amount of additional respired soil CO_2 derived specifically from the applied mulch (Figure 1).

In an additional aspect to this soil incubation study, we applied ^{13}C-labelled mulch that was either grown with a continuous supply of ^{13}C-enriched CO_2 that produced a homogenous ^{13}C-label throughout the plant material or a pulse supply of ^{13}C-enriched CO_2 at the end of growth that produced a heterogenous ^{13}C-label of recent photosynthates in plant material. By comparing the difference in ^{13}C signatures of soil respired CO_2, we will be able to compare between the time and proportion of mulch-derived carbon lost from either recent photosynthates or more recalcitrant plant material.

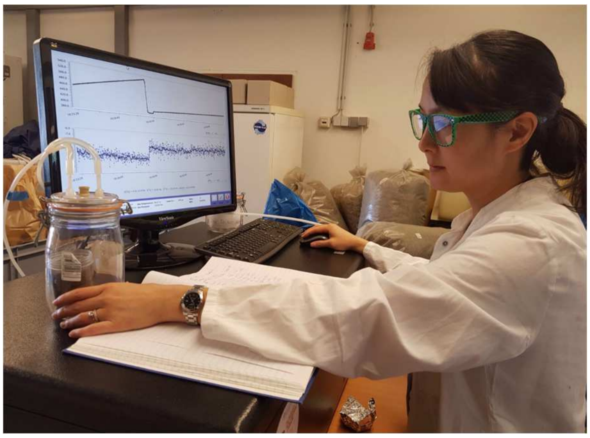

Figure 1. Soil respiration rates and ^{13}C signature of respired CO_2 were measured using laser spectroscopy

Ultimately, these ongoing soil incubation studies will provide information on whether stored soils can be rejuvenated to gain information on rates of soil carbon loss without having to take measurements *in situ* or on freshly obtained samples. This will allow for analysis to be performed on many soils that might normally be considered too distant from our IAEA laboratory. Additionally, the mulch application studies will provide more information on the rates of mulch-derived carbon loss as well as carbon inputs into soils and whether certain forms of plant carbon are more responsible for carbon loss or storage in soils.

Influence of water stress on the water use efficiency and biological nitrogen fixation of soybean by means of stable isotopes

Warter, M., Heiling, M., Dercon, G.

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

Between April – October 2017 Maria Warter joined the SWMCNL for her MSc thesis on the effects of water stress on the water use efficiency and biological nitrogen fixation of soybeans. Limited water resources and prolonged periods of water stress can have severe effects on crop growth and production. Current research efforts are directed towards finding and selecting more drought tolerant species and a better understanding of drought on crop performance. A pot experiment was conducted in a climate chamber, using the soybean variety *Sigalia* and summer wheat (*Triticum aestivum*) as a reference crop. The experiment consisted of two watering regimes, one optimal and one stressed, with 12 replicates each. There were two stages of treatments; from 0-15 days all plants were well watered to ensure plant growth and from 15-42 days crops were subjected to either optimal or stress treatment. Plants were weighed daily and weight changes recorded to determine irrigation gifts (Figure 1). Stress symptoms became visible after 14 days of the start of the second treatment stage. Plants were harvested after a total growing period of 42 days. The aim of the experiment was to test carbon isotopic discrimination (*CID*) and the isotope dilution method by using the stables isotopes of ^{13}C and ^{15}N and to determine the effects of drought stress on water use efficiency (*WUE*) and biological nitrogen fixation (*BNF*). The isotope dilution method was used as a tool to determine the amount and source of N within the crops. The $\delta^{13}C$ values varied in the range of -27 to -30‰ for well-watered and -25 to -28‰ for stressed soybeans, indicating a clear and significant effect of water treatments on the isotopic signature. BNF was ultimately not measurable in soybeans at the point of harvest. Instead the same data were used to assess the fertilizer N utilisation rate of the applied starter fertilizer, in both soybean and wheat. Water treatments showed a significant influence on the N utilisation rate with average values of 76% for well-watered and 27% for stressed soybeans. WUE was highest for well-watered plants with an average of 2.2 kg/m^3 and 1.1 kg/m^3 for stressed plants. This result is unusual and could be an effect of the application of the water treatments and the N availability in the crops.

Figure 1. Daily gravimetric analysis. The pot surface is covered with blue plastic beads to minimize soil evaporation

Area-wide soil moisture sensing in high elevation heterogeneous terrain through the use of mobile cosmic ray neutron sensor technique

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The use of the Cosmic Ray Neutron Sensor (CRNS) for the monitoring of area-wide soil moisture (footprint of about 20 ha) has been the subject of multiple studies over the past decade. However, the CRNS technology exists in both a stationary and mobile form. The use of the recently developed mobile CRNS opens possibilities for application in many diverse environments. This study addresses the use of a mobile 'backpack' CRNS device in high elevation heterogeneous terrain in the alpine mountains of western Austria. It demonstrates the utilization of established calibration and validation techniques associated with the use of the CRNS within difficult to reach landscapes that are either inaccessible or impractical to both the stationary CRNS and other more traditional soil moisture sensing technology. Field work was conducted during the summer of 2016 and 2017 in the Rauris valley of the Austrian Alps at three field sites located at different representative elevations within the same Rauris watershed. Calibrations of the 'backpack' CRNS were performed at each site along with data validation via in-situ Time Domain Reflectometry (TDR) and gravimetric soil sampling. Validation data show that the relationship between in-situ soil moisture data determined via TDR and soil sampling and soil moisture data determined via the mobile CRNS is strong (RMSE ~ <2.5 % volumetric). The efficacy of this technique in remote alpine landscapes shows potential for watershed hydrology and high elevation agricultural water management. However, further research is being carried out to fine-tune the use of this technique for these fragile agro-ecosystems.

Sharing joint SWMCN, Iraq and Bangladesh research findings at the XVIII International Plant Nutrition Colloquium in Copenhagen, Denmark.

Wahbi, A.[1]

[1]*Soil and Water Management and Crop Nutrition Subprogramme, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture*

From 19-24 August, 2017, three scientists from SWMCN TC counterparts came together at the XVIII International Plant Nutrition Colloquium held in Copenhagen, Denmark. Two posters and one oral presentation were delivered by Mr. Mirza Islam from Bangladesh (TC project BGD 5029) and Mr. Ibrahim B. Razaq and Ms. Suat Al-Saedi from Iraq (TC project IRQ5020) co-authored with Mr. Ammar Wahbi. Titles of the presentations can be found in the list of publications at the end of this newsletter, and full proceedings of the colloquium under following link: http://www.ipnc2017.org/the-proceedings-book.

Comparing and linking mobile and stationary cosmic-ray neutron sensor monitoring of area-wide soil water content: a case study from Petzenkirchen, Austria

Wahbi, A.[1]***, Avery, W.A.***[1]***, Franz, T.E.***[2]***, Dercon, G.***[1]***, Heng, L.***[1]***, Strauss, P.***[3]***, and Oismueller, M.***[3]

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Understanding the dynamics and condition of soil moisture within agricultural systems is an important aspect of modern agriculture. Effective use of water resources is dependent on informed decision making by farmers and managers of natural resources. The incorporation of new technologies and techniques in the developed and developing world carries great advantage towards forwarding the objective of sustainable agriculture.

The SWMCN Laboratory study presented here builds upon ongoing research on the use of stationary Cosmic-Ray Neutron Sensor (CRNS) techniques that began in December 2013, to monitor Soil Water Content (SWC) within an agricultural system located in north central Austria. Past work at this study site at Petzenkirchen, Austria (100 km west of Vienna) has focused on the calibration and validation of the CRNS technology. It has shown the CRNS to reliably estimate SWC on a large scale (circle with radius of approximatelly 250 m) when compared to other methods of estimating SWC

As already indicated in previous contributions in our newsletters, the SWMCN Laboratory is now moving into the new domain of mobile (backpack) CRNS techniques, which are capable of estimating SWC at the same spatial resolution as a stationary CRNS. However, the mobile CRNS has the advantage that area-wide SWC information can be provided from more sites to farmers and natural resource managers. A backpack and thus mobile version of the CRNS is currently in use by the SWMCN Laboratory in various field sites located across Austria. Besides testing the use of a mobile backpack CRNS in high altitude terrain with difficult accessibility (reported above in this newsletter), this study reports the comparison between data derived from the stationary and mobile CRNS together with in-situ data, Time domain reflectometry (TDR), and Time domain transmission (TDT) (Figure 1).

In addition, the SWMCN Laboratory team started to test the use of mobile CRNS to map the heterogeneity of soil moisture availability in the field. Such application would be extremely useful for improving agricultural water management in a cost-effective way. For this purpose, a campaign of 5 measurements will be completed by the end of December 2017. The transect, located in Illmitz, Austria, is about 3 km long and is characterised by high spatial variability in soil texture and soil moisture. A specific program is being developed for this heterogeneity mapping and will be accessible through customised Apps. The first results will be shown in the next soil newsletter.

Further, the mobile CRNS was tested at eight different altitudes from 300 m a.s.l. to 2600 m a.s.l. to assess the effect of the atmosphere on cosmic rays. From the data collected it is clearly noted the increase in signal noise (percentage-wise) as elevation decreases, illustrating the influence of a thicker atmosphere on the CRNS technique (Figure 2).

Finally, as part of the calibration process, CRNS soil moisture data were corrected for the water within the soil lattice structure (lattice water; LW) that cannot be accessed by plants nor evaporated in a soil oven. Additionally, CRNS data were corrected for the water equivalent contained within soil organic material (Soil Organic Carbon; SOC). These values rarely contribute by much error to the overall CRNS signal but change from site to site and as such should be accounted for. However, Figure 3 shows a comparison of soil moisture data obtained from the CRNS and soil moisture data obtained from in-situ soil sampling both before and after correction for the aforementioned calibration parameters. Note the very slight differences illustrating the small influence of LW and SOC.

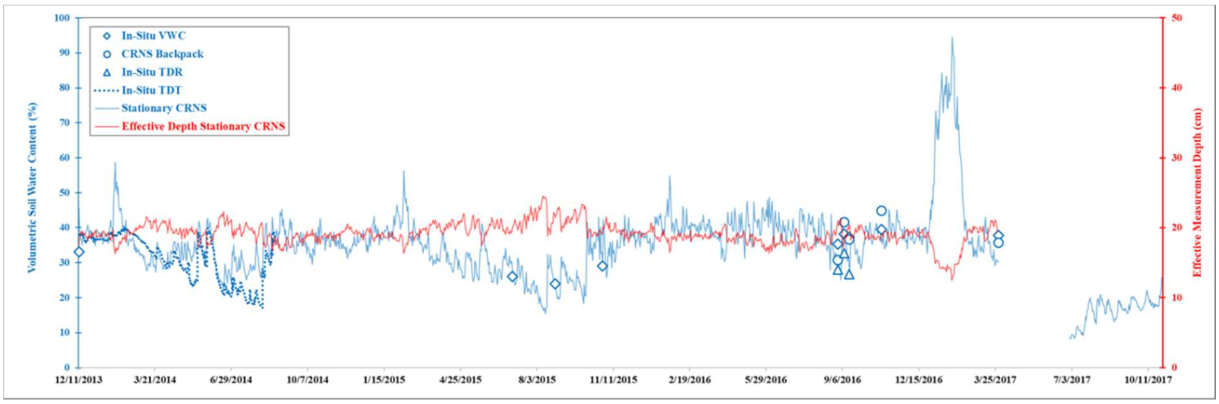
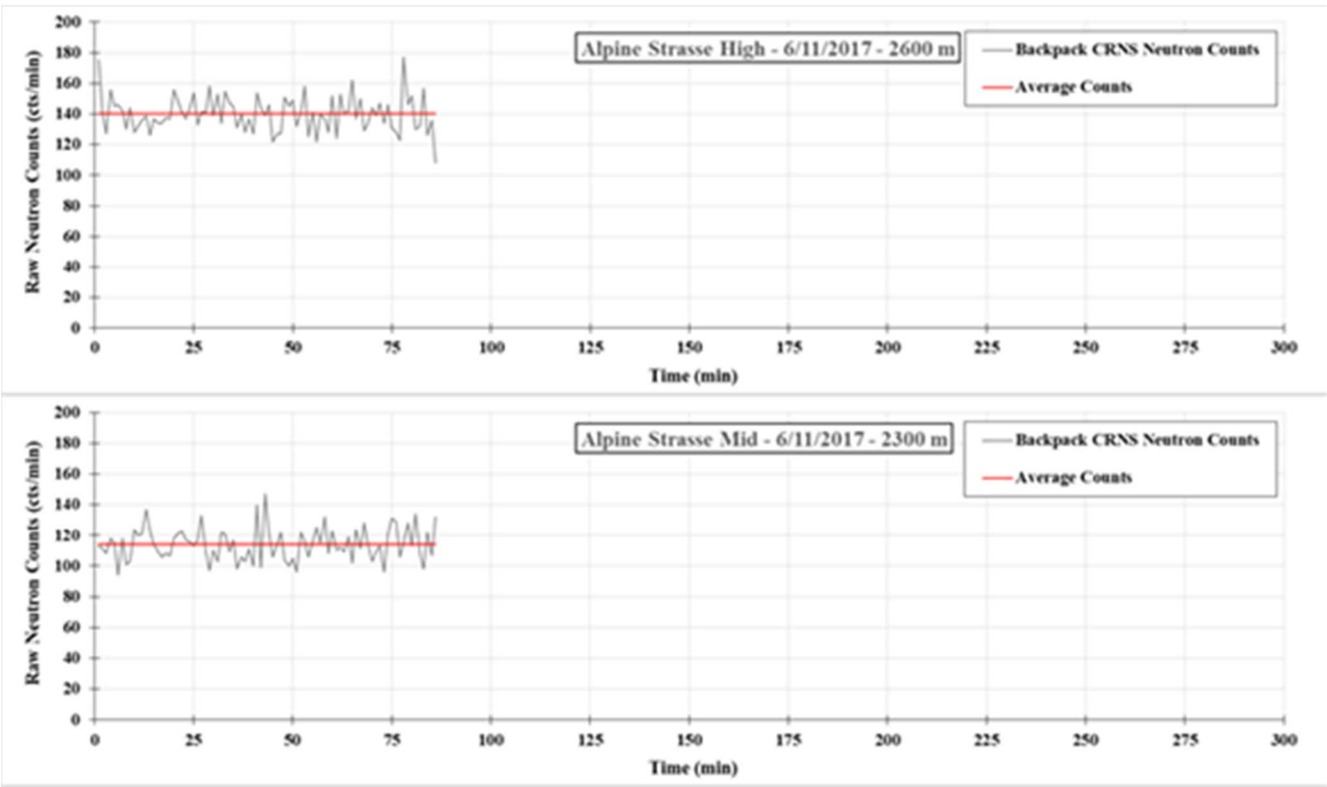


Figure 1. Time series of mean SWC values (24 hr) derived from a stationary CRNS (Petzenkirchen, Austria), Time domain transmissivity (TDT) values in the top 10 cm, in-situ Time Domain Reflectometry (TDR), CRNS backpack values, and in-situ soil sampling SWC values, the effective depth at which the CRNS can detect soil moisture is included (note inversely proportional behaviour to SWC)



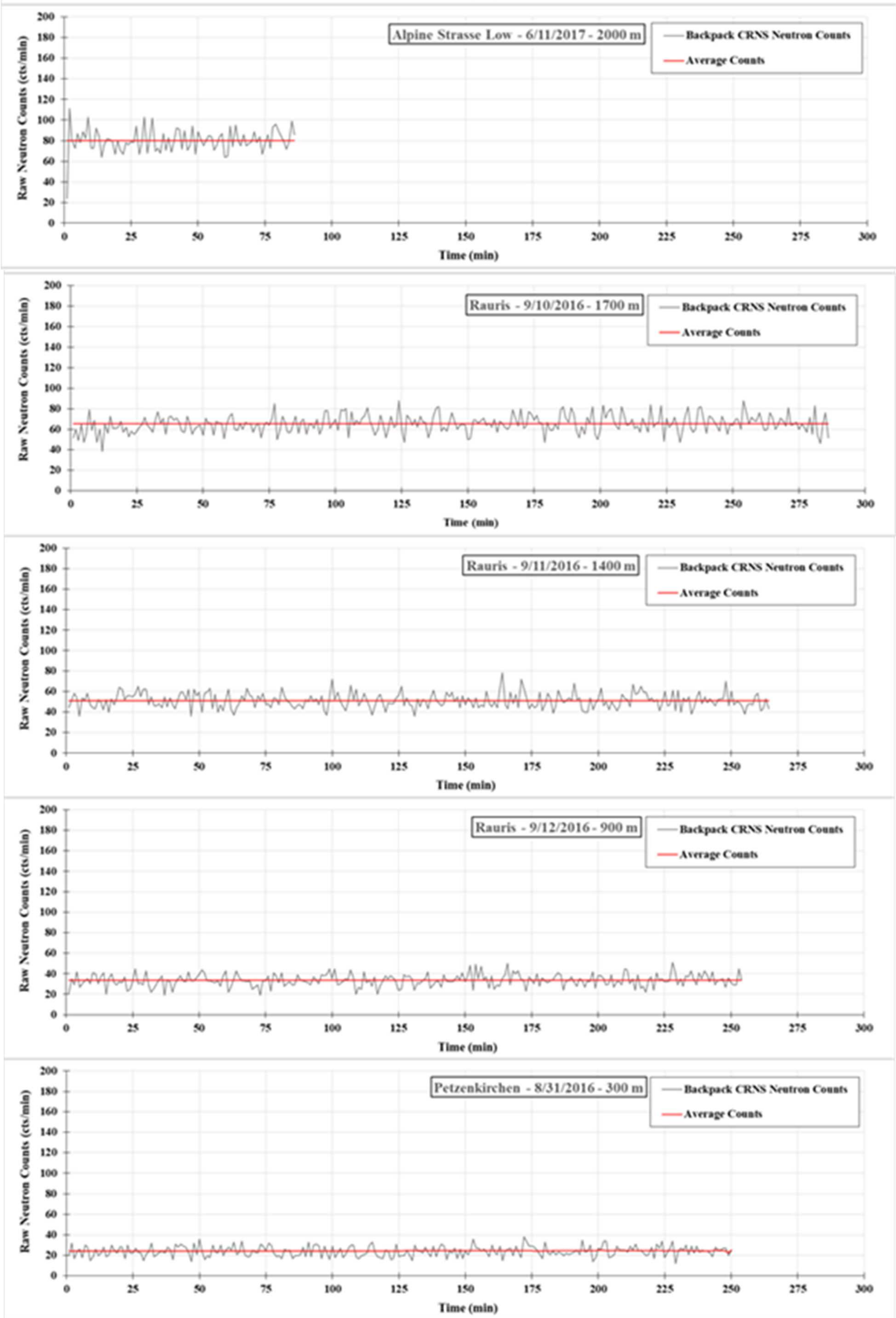


Figure 2. Graph depicting the signal of the mobile CRNS backpack neutron counting rates over time for four different surveys conducted at different elevations (300-2,600 m) at three study sites in Austria

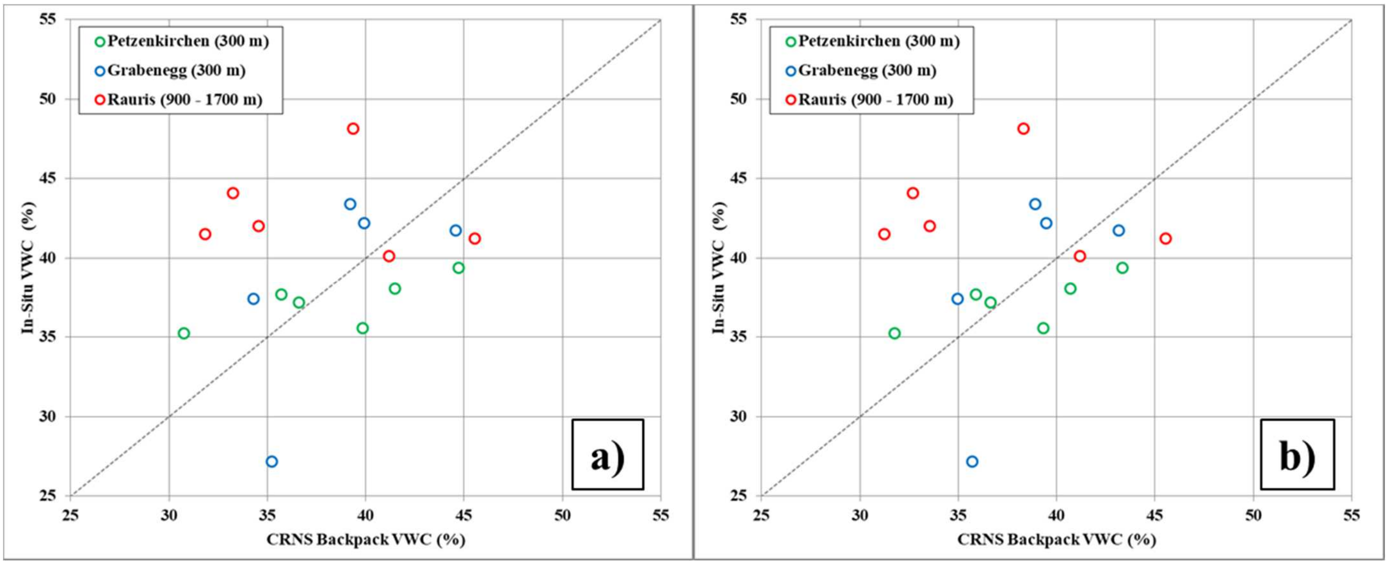


Figure 3. Mobile backpack CRNS SWC vs. SWC determined via in-situ soil sampling shown corrected (a) and not corrected (b) for soil lattice water and soil organic carbon water equivalent

Validation of space borne soil moisture imaginary using a cosmic ray neutron sensor

Wagner, W.[1,2], Vreugdenhil, M.[1], Pfeil, I.[1,2], Wahbi, A.[3], Heng, L.[3], Dercon, G.[3], Oismüller, M.[2,4], Strauss, P.[4]

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The purpose of this study is to validate the quality of satellite-based soil moisture imaginary through Cosmic Ray Neutron Sensor (CRNS) derived data, along the assessment of the effect of vegetation on these satellite-based soil moisture data retrievals. This study is being carried out at the research watershed of TU Vienna and BAW in Petzenkirchen, Austria, where SWMCN Laboratory's CRNS is installed since December 2013. As part of this study, Sentinel-1 and ASCAT data are being processed to provide soil moisture time series for the period of 2014-2017, for which CRNS data are available for the study site. The role of vegetation is being assessed through plant moisture measurements in time under different vegetation stages. To compare the satellite data to the CNRS recordings and traditional *in situ* soil moisture measurements, different methods and analysis techniques are applied (scaling, temporal matching, climatology and anomaly calculation and splitting of the data into different vegetation stages). The outcome of this collaboration between FAO/IAEA, TU Wien and BAW will be reported in an IAEA TECDOC document to be published in 2018. The TECDOC will underline, besides the importance of CRNS techniques in the validation of space borne soil moisture monitoring, also the role of vegetation in this kind of monitoring. A short summary of the results of this study will be provided in the next Soil Newsletter.

Evaluation and validation of DSS4NAFA, updates on the development of a decision support tool for food and agriculture in nuclear and radiological emergency response

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Since 2013, the SWMCN Laboratory has been, in close collaboration with member state experts from CRP D1.50.15, developing DSS4NAFA: 'Decision Support System for Nuclear Emergencies Affecting Food and Agriculture'. DSS4NAFA is an online information system for monitoring radionuclides in food and agriculture production in order to facilitate agricultural decision making and to improve nuclear emergency preparedness and response capabilities of food control and health authorities.

To date, an advanced prototype of the system, incorporating data management, data visualization, and decision support components has been developed. This report serves as an update to the work published in the July 2017 Soils Newsletter Vol. 40, No. 1 titled "Developing DSS4NAFA interface for food restriction implementation during nuclear emergencies" and will detail the progress of system development and preparations for the system's beta release in July 2018.

In partnership with SCK-CEN, the Belgian nuclear research centre, and the Phoenix Leadership Programme of Hiroshima University of Japan, two interns were hosted by the SWMCN Laboratory in August and September for two weeks and one month, respectively. The interns were tasked in evaluating DSS4NAFA, and provided valuable inputs by identifying technical bugs, suggesting improvements to the User Interface and usage flow of the system, and providing feedback on the evaluation form for system testing. System modifications based on this feedback are being performed and expected to be completed before the beta release.

The DSS4NAFA linked Advanced Sampling Task Assignment (ASTA) module that enables further optimization of the sampling assignment based on land use and crop calendar was jointly developed with the agricultural monitoring experts of the Joint Research Centre, the European Commission's science and knowledge service. Utilizing remote sensing images from the Sentinel-2A Satellite, land use maps were created for the test site, paired with simulated data and input into the system. The system was able to integrate this new data successfully and discussions are underway to explore new case study areas with high population density, where strong support in remote sensing is expected. Emphasis will be placed on small-scale, high-density farming areas with multiple crops in high rotation or intercropping practises.

Progress has been made on implementing the DSS4NAFA system on the IAEA's Azure cloud environment. The creation of a testing environment has been approved by IAEA and developers are in discussion with the IAEA's IT systems engineers to outline details of this arrangement.

To increase project visibility in preparation for the beta release, a video infographic on DSS4NAFA has been produced. The DSS4NAFA system has also been actively presented internally and to visiting delegations. Notably, officials visiting from the Chinese Academy of Agricultural Sciences (CAAS) were given a presentation, in addition to several presentations on nuclear emergency response at the Incidence and Emergency Centre (IEC). Deep interest was generated and several member states have volunteered to participate in evaluating the system after the initial release.

^{15}N standard gases for a laser based nitrous oxide isotopic analyzer: preparation and measurement

Mayr, L. [1]

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Nitrous oxide (N_2O) is a highly influential greenhouse gas with a global warming potential of 300 compared to carbon dioxide. The present concentration in air is about 320ppb with main contributions from agricultural soil management and livestock. To determine the origin of N_2O emissions the isotope ratio measurements are a useful tool. Isotope ratio mass spectrometry (IRMS) is still the reference method for light stable isotope analyses, but it is an expensive, laboratory based method which requires experienced staff to operate. IRMS requires pure N_2O for isotopic measurements. Because of the low concentration of N_2O in ambient air relatively large amounts (>250mL) have to be proceeded in a suitable sample preparation system to concentrate and purify the nitrous oxide.
Laser based isotope analyzers promise to simplify isotopic greenhouse gas measurements. They are able to measure isotope composition and mole ratio of N_2O in ambient air directly without pre-concentration. For calibration of the instrument it is necessary to use standard gases with about the same isotopic ratio and concentration of N_2O as the sample. Unfortunately, isotope reference nitrous oxide is not commercially available neither as pure gas nor as an air mixture at ambient concentration levels which could be used in laser based isotopic analyzers for calibration and drift correction.

1. The Soil Science Unit in Seibersdorf is equipped with a laser-based isotopic nitrous oxide analyzer from LGR, Los Gatos Research, US, model N_2OIA-23e-EP. In order to produce gas mixtures which can be used directly for standardization on this instrument a preparation line to dilute N_2O down to suitable concentration ranges was built (Figure 1). The same line can also be used to produce mixtures with other gases like CO_2. The line was used to produce standard gas mixtures by implementing a three step procedure: Evacuation of standard gas cylinder using a rotary pump. Gas containers of different volumes and shapes can be used as long they comply with the maximum pressure specifications. For security reasons the filling pressure was limited to 10 bar.
2. Introduction of a small amount of pure nitrous oxide into pre-evacuated cylinder. The amount depends on the mole ratio (ppm) requested, the volume of the standard gas container and the fill-up pressure. The line is equipped with a septum port through which the required volume of N_2O can be injected. Alternatively, a tube cracking device for 6 mm glass tubes is also attached.
3. Filling up of sample cylinder with synthetic air to 10 bar.

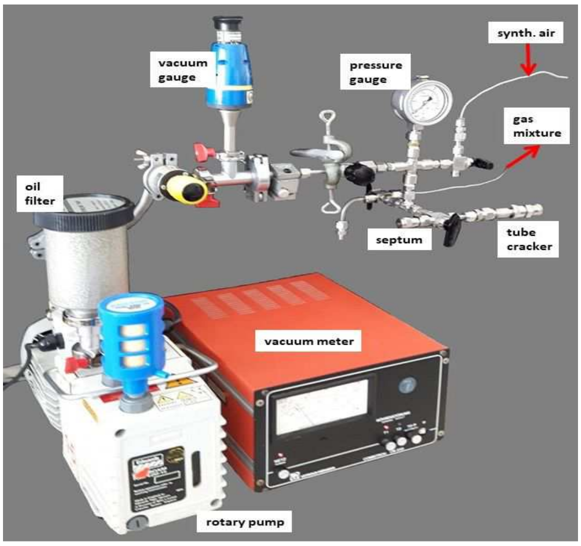

Figure 1. Preparation line for gas mixtures

The preparation line was used to produce several mixtures of N_2O with synthetic air:

- 3 gas mixtures at natural abundance ^{15}N level with mole ratios of 39 ppm, 3.4 ppm, 0.4 ppm of nitrous oxide in synthetic air were prepared by injection of different volumes of commercially available N_2O.
- 5 gases at ^{15}N enriched level with mole ratios of 7.0 ppm, 2.4 ppm, 1,9 ppm, 1.0 ppm and 0.4 ppm of nitrous oxide in synthetic air were prepared by thermal decomposition of dual labelled NH_4NO_3 2 atom% ^{15}N (4550 $\delta^{15}N$). The conversion was done by sealing off evacuated glass tubes with small amounts of solid NH_4NO_3 and subsequent heating the tubes in a muffle furnace to 280°C for 12 hours.

The acquisition rate of the instrument is 2.1 seconds per measurement. Each single measurement has a rather high σ but a much better precision can be achieved by averaging measurements. To determine the optimum averaging time with the best precision Allan standard deviation was used. Each of the standard gases was measured on the LRG instrument in flow through mode (flow ≈ 100 mL/min) for 4 hours to determine the Allan standard deviation for $\delta^{15}N$ and ppm. An example can be seen in Figure 2.

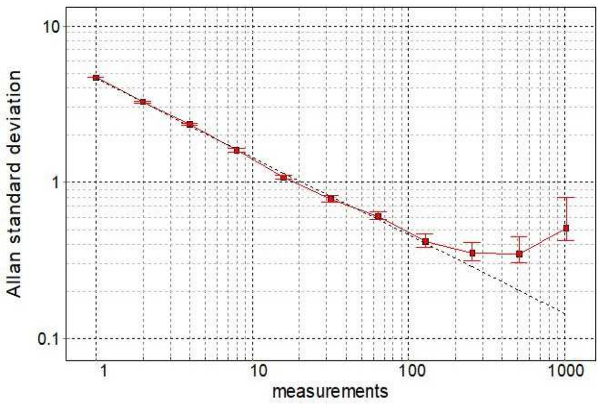

Figure 2. Overlapping Allan standard deviation of δ ^{15}N values from a standard gas (2.4 ppm N_2O, 4423 δ^{15}N) versus number of measurements. Best precision of 0.35 δ^{15}N is reached at 256 measurements (540 seconds). The dotted line represent the theoretical white noise line with a slope of -0.5

Analyzing the Allan plots of the ppm values of the gas mixtures showed that a relative standard deviation (RSD) of 0.1% is reached by averaging only 2 measurements (with the exception of the 39 ppm N_2O gas where it is 7 measurements). Best achievable RSD of 0.01% is reached by averaging 250 measurements (again with the exception of 39 ppm N_2O).

Best achievable precision (1σ) of gases with natural abundance ^{15}N of ±0.3 δ^{15}N (ambient air N_2O concentrations) and ±0.1 δ^{15}N (elevated concentrations) was at 512 measurements (18 minutes). Gases with 2 atom%^{15}N showed best precision of ±0.0002 atom%^{15}N at 256 measurements.

A precision of ±0.5 δ^{15}N for natural abundance N_2O can be archived with 160 measurements (ambient air concentration) and 12 measurements (elevated concentrations). Gases with 2 atom%^{15}N showed a precision of ±0.001 atom%^{15}N at 9 measurements.

The high precision of the ppm values makes the instrument very suitable for flux measurements. ^{15}N values give a good precision with exception of gases with natural abundance ^{15}N and ambient ppm (like chamber measurements without enriched fertilizer) where the long measuring time limits the usability.

Analytical Services

Resch, C., Gruber, R., Toloza, A.

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

As of November 2017, 3850 plant, soil and water samples were analysed for stable isotopes and 200 samples were measured for fallout radionuclides in the SWMCN Laboratory. Most analyses were carried out to support Research and Development activities at the SWMCNL focusing on the design of affordable isotope and nuclear techniques to improve soil and water management in climate-smart agriculture. Analytical support has also been given to the Food and Environmental Protection Laboratory with about 65 samples analysed. In 2017, major focus of the SWMCN Laboratory has been on stable isotope measurements of greenhouse gases (^{13}C-CO_2 and ^{15}N-N_2O) through laser isotope analysers.

External quality assurance: annual proficiency test on ^{15}N and ^{13}C isotopic abundance in plant materials

Resch, C.

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The worldwide comparison of stable ^{15}N and ^{13}C isotope measurements provides confidence in the analytical performance of stable isotope laboratories and hence an important tool for external quality control.

The 2017 Proficiency Test (PT) on ^{15}N and ^{13}C isotopic abundance in plant materials, organized by the University of Wageningen, the Netherlands, and funded by the SWMCN Laboratory has been successfully completed. The Wageningen Evaluating Programs for Analytical Laboratories (WEPAL, http://www.wepal.nl) is accredited for the organization of Inter-laboratory Studies by the Dutch Accreditation Council.

Every year, one ^{15}N-enriched plant test sample is included in one round of the WEPAL IPE (International Plant-Analytical Exchange) programme. A special evaluation report for IAEA participants on the analytical performance in stable isotope analysis is issued by the SWMCN Laboratory and sent to the participants together with a certificate of participation, in addition to the regular WEPAL evaluation report. The participation fee for one round per year is covered by the IAEA.

In total eleven stable isotope laboratories participated in the PT-round 2017: **Africa (1)**: Morocco, **Asia (3)**: Pakistan and Philippines (2 labs), **Europe (3)**: Austria, Belgium and France, **Latin America (3)**: Argentina, Brazil and Chile and **South Pacific (1)**: New Zealand.

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

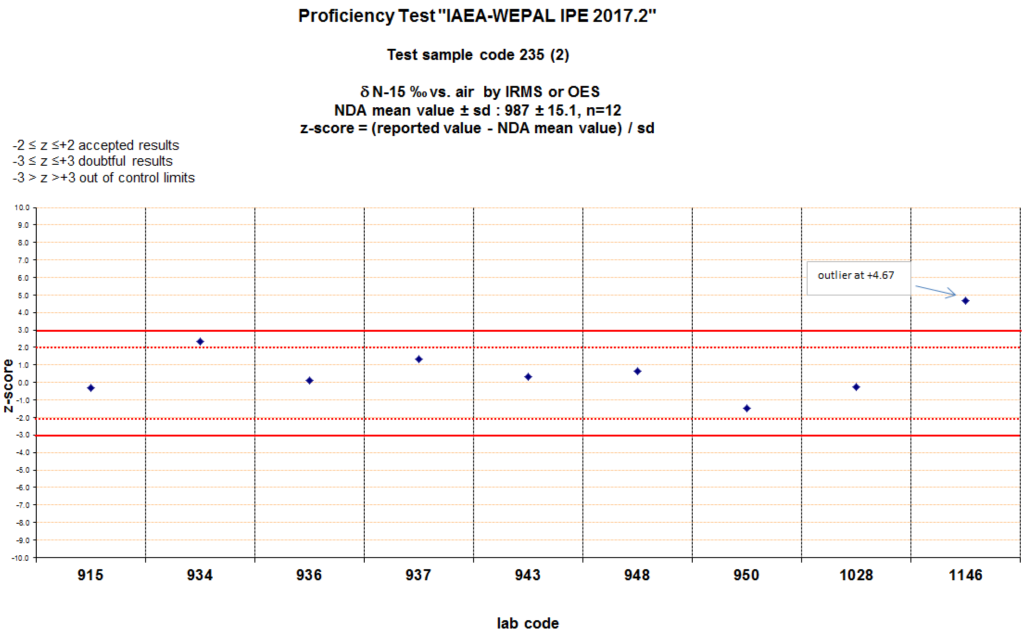

Figure 1. Z-score evaluation of the ^{15}N analysis

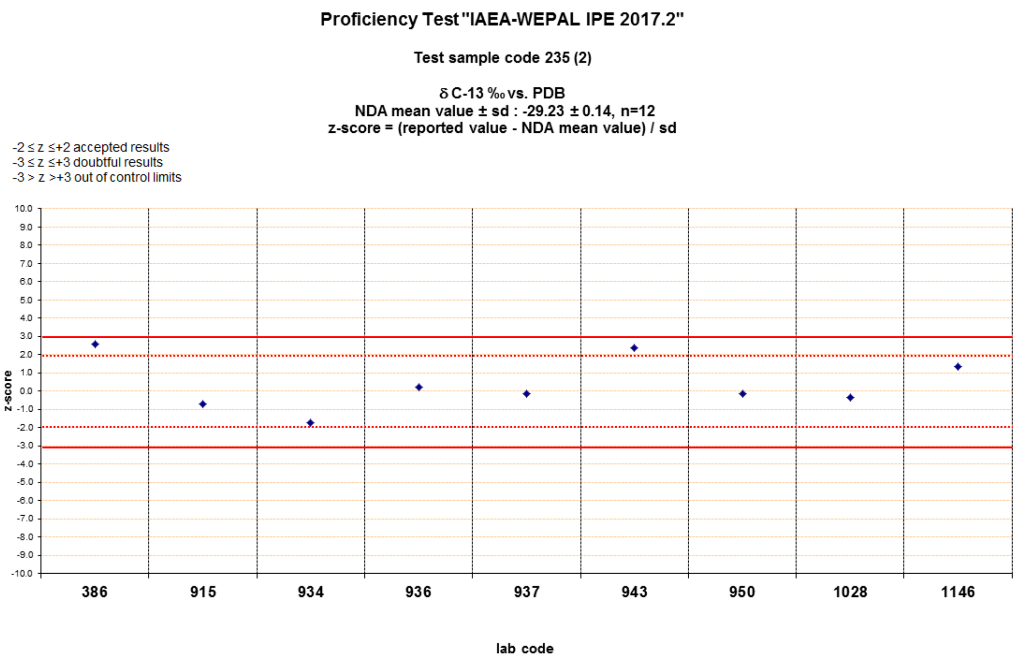

Figure 2. Z-score evaluation of the ^{13}C analysis

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Websites and Links

- Soil and Water Management and Crop Nutrition Section:
  http://www-naweb.iaea.org/nafa/swmn/index.html
- Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture:
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  http://www.fao.org/ag/portal/ag-home/en/
- FAO Land & Water: http://www.fao.org/land-water/en/ 1
- New communication materials outlining successes in the area of nuclear techniques:
  http://www-naweb.iaea.org/nafa/resources-nafa/IAEA-success-Stories-3.pdf
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