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Celebrating the scientific forum on Water Matters: Making a Difference with Nuclear Techniques, from 20-21 September 2011 with the DDG of FAO Ms Ann Tutwiler

To Our Readers

Greetings and best wishes to you all for 2012. I hope the new year will bring you every success in achieving your personal goals and that you will have good health and renewed energy for the year ahead. In looking forward to the coming months, it is important for me to share with you some of our exciting developments in 2011.

Our most notable accomplishment was the participation of all SWMCN team members, both Laboratory and HQ, in the IAEA scientific forum entitled: Water Matters: Making a Difference with Nuclear Techniques, which took place from 20-21 September 2011 during the 55th IAEA General Conference. This forum was the initiative of IAEA Director General Mr Yukiya Amano, to promote the joint engagement of Member States and other international organizations with the IAEA in key water issues, by informing high level conference participants of the numerous and highly successful cooperative projects in IAEA Member States in the fields of agricultural water management, water resource assessment and aquatic pollution control. These are the three key pillars of water activities in the IAEA.

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The importance of agricultural water management to address food security and sustainable agriculture was highlighted in the forum session on Tackling Water Scarcity and Saving Water in Agriculture. At this session, one of the six keynote speakers, FAO's Deputy Director General for Knowledge (Ms Ann Tutwiler), highlighted the need to better manage water in both rainfed and irrigated agriculture to meet an expected 50% increase in global agriculture water requirements by 2050. This increase will be crucial if we are to cope with an additional two billion mouths to feed as a result of an increase in population growth from the current level of 7 billion to 9 billion by 2050.

Ms Tutwiler's concluding remarks highlight the important role of the Joint FAO/IAEA Division through the SWMCN Subprogramme in addressing agricultural water management in Member States:

> "*The IAEA, through its unique partnership with FAO, works with Member States to use nuclear techniques for the development of farm management practices that can cope with drought, reduce water wastage and improve agricultural water conservation for food security and production with more crops per drop in both irrigated and rainfed agriculture in Africa, Asia, Europe and Latin America*".

These remarks were also reflected in the addresses delivered by other keynote speakers from Kenya (Ms Jane Wamuongo, Assistant Director, Kenya Agricultural Research Institute), Spain (Mr Ellias Fereres, Professor, Institute of Sustainable Agriculture), China (Mr Xurong Mei, Director General, Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences), Australia (Mr Christopher Smith, Deputy Chief, CSIRO Land and Water), Thailand (Mr Royol Chitradon, Director, Hydro and Agro Informatics Institute) and Japan (Mr Maki Tsujimura, Associate Professor in Hydrology/Hydrogeology, Graduate School of Life and Environmental Sciences, University of Tsukuba). On behalf of the SWMCN team, I would like to thank all keynote speakers for their support and their valued contributions to this scientific forum, where they highlighted case studies using nuclear techniques to tackle water scarcity and save water in agriculture.

Besides the scientific water forum, a new coordinated research project (CRP) on Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-based Cropping Systems in Sub-Saharan Africa was launched last year. This exciting CRP will help to provide valuable information on the use of nuclear techniques to address key issues in soil and nutrient management in Sub-Saharan Africa. The first research coordination meeting for this CRP will be held in Vienna from 30 January to 3 February 2012.

Another new CRP, which aims to enhance crop productivity through an integrated approach using improved crop varieties and best soil-nutrient-water management practices, has also been jointly launched by the SWMCN and Plant Breeding and Genetics Subprogrammes.

The SWMCN Subprogramme has been busy planning the FAO/IAEA international symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation, which will be held in Vienna from 23-27 July 2012. Approximately 150 papers have been submitted for presentation. I do hope that you and your colleagues will be able to attend this Symposium.

In mentioning all the initiatives and successes we have accomplished in 2011 or launched for 2012, I would like to thank you, all our readers, for your continuing support. Without the dedication and commitment of all of you, the SWMCN Subprogramme and its many stakeholders worldwide would not have been able to accomplish what I have outlined above. I also want to give a big 'thank you' to all my SWMCN team members and to our consultants, Erik Busch-Petersen, Phillip Chalk and Felipe Zapata.

I wish you all a very happy and festive holiday season and a prosperous and healthy 2012.

Long Nguyen
Head
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Staff News

Mr. Leo Mayr and **Mr. Gerd Dercon** received Merit Awards in September from the Deputy Director General and the Head of the Department of Nuclear Sciences and Applications (Mr. Daud Mohamad) for their contributions to the Soil and Water Management & Crop Nutrition Subprogramme in 2010.

Ms. Peggy Macaigne joined the SWMCN Subprogramme as a consultant for 5 months on 14 November 2011. Peggy will work with Long Nguyen and Lee Heng on the use of isotopic techniques to assess organic and conventional farming towards improving crop water productivity and nitrogen use efficiency. She will also conduct a review on green economy agriculture for subsequent SWMCN programmatic planning. Welcome Peggy.

Ms. Belén Vallina Gonzalez completed her one-year internship with the SWMCN Section on 17 October 2011. During her internship, Belén coordinated the updates of the SWMCN Subprogramme website. She also assisted the SWMCN team to compile brochures for distribution to participants at the scientific forum on Water Matters. She had the opportunity to participate in a workshop about Project Design organized by the Technical Cooperation Department to improve her technical skills. We thank Belén for her inputs and wish her all the best for her future career.

Ms. Jordana Antal joined the SWMCN Section as a team assistant on 25 November 2011 and is providing administrative support to the forthcoming FAO/IAEA symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation in 2012. Prior to joining the Section, Jordana worked for the International Organisation for Migration in Vienna for over six years, assisting in the administration and organisation of conferences. She also has experience working in the IAEA Physics Section, Division of Physical and Chemical Sciences where she assisted with administrative support to several technical and research coordination meetings (RCMs) for six months in 2010. In addition, Jordana worked for three months in 2010 as an office assistant/secretary to the Director of the IAEA Division of Human Health (NAHU).

Mr. Sorivan Chhem-Kieth joined the FAO/IAEA Seibersdorf Laboratories in September 2010, as an intern in the Food and Environmental Protection Laboratory (FEPL). In August 2011, Sorivan joined the Soil and Water Management and Crop Nutrition Laboratory (SWMCNL) for 6 months. In 2010, Sorivan obtained his Bachelor degree in Biochemistry at Concordia University in the province of Quebec (Canada). It was his interest in food and agricultural sciences that brought him to the Seibersdorf Laboratories. His training with the FEPL included the use of chromatography techniques for drugs and pesticide authentication, as well as stable isotope ratio analysis for food traceability purposes. At the SWMCNL, Sorivan is currently undergoing training in the use of fallout radionuclide (FRN) based methodologies for assessing soil erosion and evaluating the efficiency of soil conservation measures in agricultural lands. Under the supervision of Mr. Lionel Mabit, Sorivan has undergone basic training in the use of FRN, including field work and soil sample collection, laboratory sample preparation, gamma spectrometry and use of FRN conversion models as well as data analyses and interpretation for two case studies in Europe (Slovenia and Spain).

Feature Articles

Non-invasive, Cosmic Ray Neutrons Approach for Area Wide Soil Moisture Measurement

L.K. Heng
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Measurement of area wide soil moisture content is needed for a variety of applications such as large scale irrigation scheduling, yield forecasting and climate change studies. In past decades, measurement of area wide soil moisture has been a challenge since most devices are for small plots within the range of 0.05 to 1 m in diameter. As a result, a large number of measurements, which can be costly and time consuming, are required. The recent development of a cosmic ray neutrons approach represents a breakthrough in addressing this challenge (Zreda et al. 2008, Shuttleworth et al. 2010). Cosmic-ray neutrons monitor the background radiation in the air above the soil, the intensity of which depends primarily on soil moisture that was found to correlate with soil hydrogen content. The cosmic ray soil moisture probe integrates soil moisture content over an area of approximately 700 m in diameter to a depth of 70 cm, covering the rooting zones of most crops. As a result it can enhance point measurement devices to yield a reliable measure of area average soil moisture. The probe is insensitive to temperature, salinity, soil mineral chemistry and is non-invasive (Desilets et al. 2010), thus allowing measurements to be carried out under undisturbed soil conditions. The cosmic ray neutron probe responds to all forms of moisture, including liquid and frozen soil water, snow, and water in or on vegetation, allowing for the assessment of the total surface moisture. The probe will enable us to provide soil moisture readings at a large number of sites with different physical characteristics, from simple and easy (flat grasslands) to complex and difficult terrain.

Photo courtesy of Dr Chris Smith, CSIRO Land and Water, Canberra

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Linking Models and Measurements of Soil Nitrogen Emissions on a Field Scale

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High production farming relies heavily on the addition of nitrogen (N) fertilisers to the soil, where microbial action brings about many chemical transformations, including the formation of a number of gases that can be emitted to the atmosphere. In this study we concentrate on nitrous oxide (N_2O), a long lived greenhouse gas with a global warming potential almost 300 times that of CO_2. It is formed as the nitrogen fertiliser is transformed to nitrate during the process of nitrification and again when denitrification occurs and the nitrate is eventually transformed to molecular nitrogen. Obviously, the emission of N_2 has no deleterious effects on the environment, but in many situations where the soil is anaerobic due to high water content it represents a significant loss of fertiliser N. Unfortunately, it is hard to measure N_2 emissions directly. They are usually estimated as remainders in mass balance experiments.

N cycle processes have been modelled extensively through such well known models as DNDC and DAYCENT, and many others. However, where models have been tested in the field, it has usually been in hindsight from data collected for other purposes and by groups not associated with the modellers. This report describes a collaborative undertaking between modellers and field scientists to devise and operate a field experiment in which modellers have stipulated priorly the data they need to validate their models of N transformation and the field scientists have tested whether and how well they can measure all the required data. To keep the experiment as simple as possible, it was conducted on bare soil after the application of urea fertiliser, perhaps the most popular N fertiliser in use, and only one model, APSIM (an Australian Agricultural Production Systems Model) was tested. The absence of plants avoided the need to account for the effects of plant transpiration on the amount and distribution of water and N in the soil profile.

The experimental field remained bare for the 2 months of the test. N_2O fluxes in the field were measured with a micrometeorological mass balance technique and some supporting measurements of background fluxes were made with static chambers. Urea was applied to a circular plot, 50 m in diameter, at a rate of 200 kg N ha^{-1} and incorporated into the top 10 cm of soil at the commencement of the test. Gas concentrations, wind speeds, soil temperatures, soil moisture content and evaporation at the centre of the plot were measured continuously for 2 months. The mass balance technique assumes that all gas emitted from the ground surface in the treated area in the prevailing wind direction is transported across the centre of the plot and so equates the rate of gas emission from the surface with the net horizontal gas flux across the plot centre. The net horizontal flux was calculated as the integral of the horizontal fluxes (the products of wind speed and concentration, measured at 5 levels up to 4.8 m) using closed path FTIR spectroscopy (Fig. 1). Evaporation rates were measured by eddy covariance. Profiles of temperature, moisture content, gas concentration and mineral N content in the soil were measured to a depth of 0.8 m. Urea treated with ^{15}N was applied to small sub-plots to estimate the total gaseous N loss. Only emissions of N_2O are considered here.

Fig. 1. Experimental setup showing 2 & 3D sonic anemometers and NH_3/NOx analyser at plot centre (left); Laying 2.5 km of air lines (centre) and FTIR spectrometer for N_2O analysis at 5 levels (right)

Soil moisture is a very important driver of N transformations. It is essential to model it correctly. In this case, modelled evaporation rates were somewhat higher than the measured rates and so the modelled soil moisture was 20 to 30% lower than measured (Fig. 2). Partly as a consequence, the modelled and measured N_2O emissions also differed (Fig. 3).

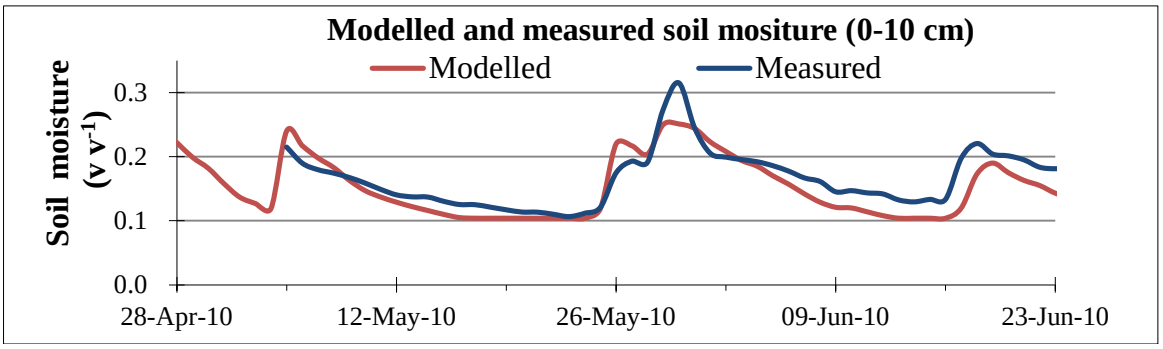

Fig. 2. Modelled and measured moisture content of the surface soil

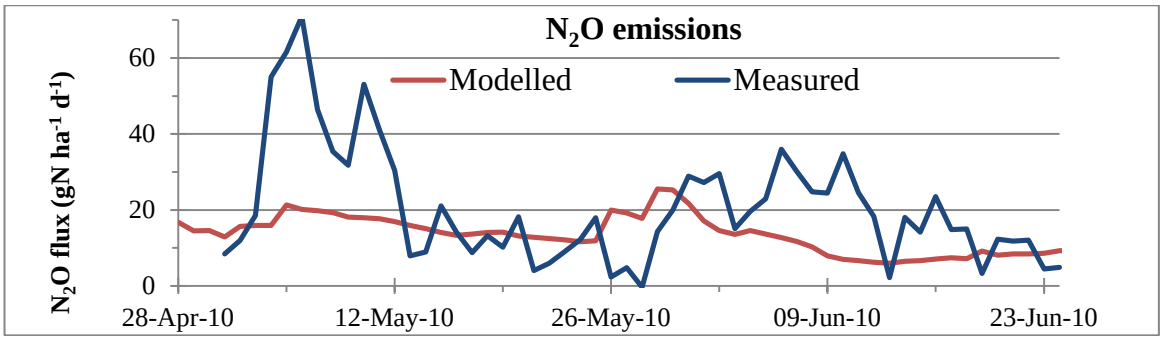

Fig. 3. Modelled and measured N_2O emissions; apart from the discrepancy at the start of the measurement period, there was generally good agreement between model and measurement

The difference between the modelled and measured N_2O emissions was small, indicating that the experimental techniques employed are sufficiently sensitive for model validation. In future, we will undertake more detailed testing of the N_2O model in our research, including production and emission of NO_x, the further development of a model of NH_3 volatilisation and extension to the far more complicated problem of N cycling in plant communities where both soil and plant processes need to be considered.

Legacy Phosphorus in Agricultural Watersheds: Implications for Restoration and Management of Wetlands and Aquatic Systems

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Phosphorus is added to watersheds in various forms, including fertilizers, nonhazardous wastes (animal manures and biosolids) and nutrient enriched waters. Globally, approximately 14 million metric tons of phosphorus is added as fertilizer to agricultural watersheds. The approximate ratio of nitrogen to phosphorus fertilizer application at the global level is 5.8 (Mullins et al., 2005).

Historically, organic wastes such as animal manure were applied to agronomic crops and pastures on the basis of their nitrogen availability, which has resulted in excessive application of phosphorus. The nitrogen to phosphorus ratio of manure is less than 2. As a result, many agricultural watersheds receiving land application of wastes and fertilizers have accumulated phosphorus in excess amounts. However, as soils in agricultural watersheds become saturated or overloaded with phosphorus, a significant portion of stored phosphorus can be released and transported with water during runoff events into adjacent water bodies such as wetlands, streams, shallow lakes and other aquatic systems (Carpenter et al., 1998; Foley et al., 2005). Wetlands, riparian zones and water conservation areas in agricultural watersheds serve as sinks, sources and transformers of nutrients and other chemical contaminants, and as such, they can have a significant impact on water quality, nutrient retention and ecosystem productivity. Here we briefly present a case study of water quality issues in the Lake Okeechobee Basin (LOB), FL, USA and its impact on an adjacent lake. In the LOB, wetlands cover about 16% of the land area, and about 60% of the wetlands are within the four priority basins (Fig. 1. area shown in red). These sub-basins have historically contributed a majority of the phosphorus load to the lake, which is often cited as being a result of nutrient loss from agricultural practices. Most of the four priority basins are dominated by agriculture (64%), with about 48% of agricultural land being used for improved grazing pasture, 7% for dairy farming and 6% used as unimproved/rangeland. Within the four priority basins 18% of the land area is wetland.

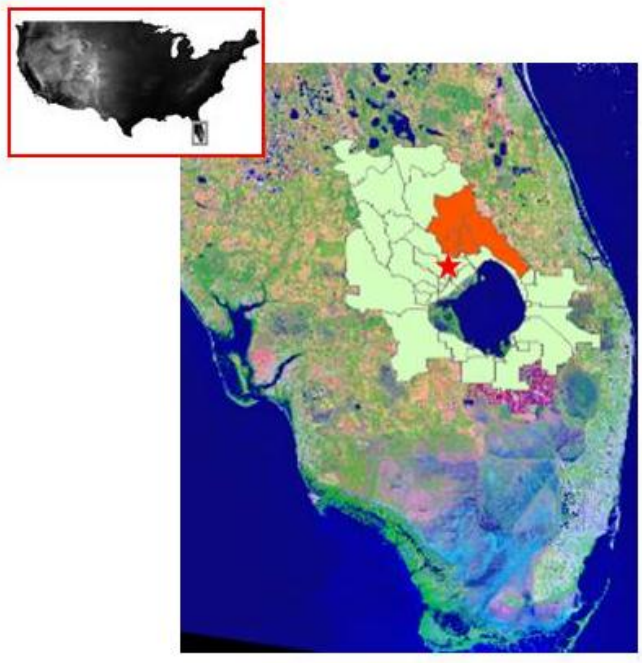

Fig. 1. A map showing the Lake Okeechobee Basin (LOB) in south Florida

Total phosphorus loading from the LOB is approximately 500 metric tons (mt) per year. Intensive phosphorus management strategies are needed to reduce loads from the LOB and to meet the current total maximum daily load (TMDL) target of 140 mt by the year 2015. Legacy phosphorus in the LOB is one of the major sources of P to the lake. Improved land use management practices in uplands can reduce overall phosphorus load to receiving water bodies. Based on the phosphorus storage in surface soils, Reddy et al. (2011) estimated the potential lag time to recovery resulting from the legacy phosphorus currently stored throughout the drainage basin. Based on the chemical fractionation of soil phosphorus, they estimated that approximately 35% of total phosphorus in soils is non-reactive and is not biologically

available. The remaining 65% may be available for release at different times. The current phosphorus release rate from the LOB to Lake Okeechobee is estimated as ~500 mt of phosphorus per year (based on a 30 year phosphorus loading average). Reddy et al. (2011) estimated a 22 year lag time if 10% of the reactive phosphorus is assumed to be available for release to the downstream receiving basin. The lag time is in the order of 55 years if 25% of the reactive P pool is available for release. In other words, legacy P in the LOB would support the current 500 mt P per year load to the lake for the next 22 to 55 years, even if all other sources of P were curtailed.

The concept of a safe soil phosphorus storage capacity (SPSC) developed for upland soils (Nair and Harris, 2004), has now been extended to wetland soils to evaluate the behaviour of inorganic phosphorus in soils, where P retention is largely related to iron and aluminium. This concept serves as an indicator to determine the legacy phosphorus effects on water quality. The SPSC, based on a threshold phosphorus saturation ratio (PSR, a ratio of extractable phosphorus to extractable iron plus aluminium; Nair et al. (2004)), provides a direct estimate of the amount of P a soil can sorb before exceeding a threshold soil equilibrium concentration, i.e., before the soil becomes an environmental risk. Soil phosphorus sorption is primarily related to iron and aluminium concentrations, with organic matter playing a minimal role in P retention in wetland soils up to the threshold PSR value, i.e., until SPSC becomes zero. When SPSC becomes negative, phosphorus release from a wetland soil is probably affected by the organic matter in the soil. Additional phosphorous retention in wetlands may occur through biological assimilation of phosphorus and storage in recalcitrant organic compounds. An evaluation of the relationship of SPSC and water-extractable P for eight beef ranches in the LOB, differentially impacted by manure, showed that SPSC is an appropriate and promising soil index (Fig. 2).

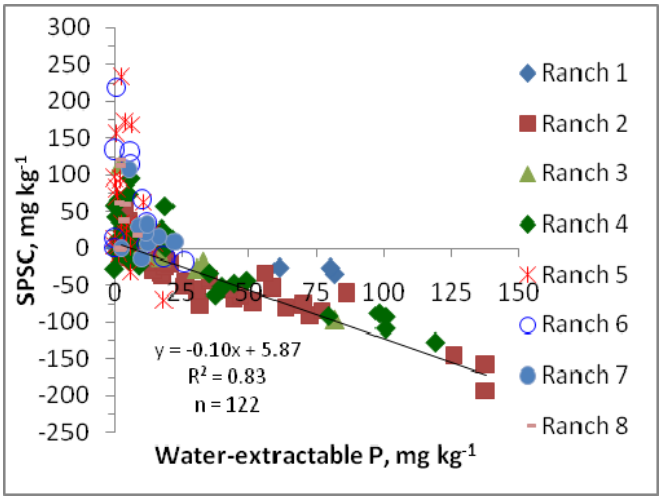

Fig. 2. Relationship between soil phosphorus storage capacity and water extractable phosphorus in wetland soils

The impact of legacy phosphorus is seen in many watersheds used intensively for agricultural activities where phosphorus applications have exceeded the assimilative capacity of soils and ultimately caused eutrophication of adjacent aquatic systems in the drainage basin.

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Redistribution of Carbon and Nitrogen through Irrigation in Intensively Cultivated Tropical Mountainous Watersheds

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This study aimed to trace and quantify organic carbon and total nitrogen fluxes related to suspended material in irrigation water in the uplands of northwest Vietnam. In the study area, a reservoir acts as a sink for sediments from the surrounding mountains, feeding irrigation channels to irrigate lowland paddy systems (Fig. 1). A flow separation model identified the flow components of overland flow, water release from the reservoir to the irrigation channel, direct precipitation into the channel, irrigation discharge to paddy fields and discharge leaving the sub-watershed. A mixed effects model was used to assess the C and N loads of each flow component. Irrigation water had an average baseline concentration of 29 ± 4.4 mg L^{-1} inorganic C, 4.7 ± 1.2 mg L^{-1} organic C and 3.9 ± 1.6 mg L^{-1} total N. Once soils were rewetted and overland flow was induced, organic C and total N concentrations changed rapidly due to increasing sediment loads in the irrigation water. Summarizing all monitored events, overland flow was estimated to transport about 63 kg organic C ha^{-1} and 8.5 kg N ha^{-1} from surrounding upland fields to the irrigation channel. The drainage of various non-point sources towards the irrigation channel was supported by the variation in the estimated organic C/total N ratios of the overland flow, which fluctuated between 2 and 7. Nevertheless, the majority of the nutrient loads (up to 93–99%) were derived from the reservoir, which served as a sediment buffer trap. Due to the overall high nutrient and sediment content of the reservoir water used for irrigation, a significant proportion of nutrients were continuously transported to the paddy fields in the lowlands throughout the rice cropping season. The cumulative amount of organic C and total N load entering paddy fields with the irrigation water between May and September was estimated at 0.8 and 0.7 Mg ha^{-1}, respectively. Therefore deposition of C and N through irrigation is an important contributor in maintaining soil fertility, and a process which should be taken into account in the soil fertility management of these paddy rice systems.

Fig. 1. Redistribution of carbon and nitrogen through irrigation in rice paddy systems of north-west Vietnam.

Nitrate leaching under vegetable fields above a shallow aquifer in Slovenia[1]

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The Challenge

Shallow aquifers can be prone to nitrate pollution, especially in rural, high rainfall zones under intensive vegetable production, as well as in areas with urban and industrial pollution. Due to its mobility in the soil, nitrate is the most problematic pollutant in intensive agricultural production areas. The risk of nitrate leaching is closely related to the excessive application of organic and inorganic nitrogen (N) fertilizers and can occur at and after harvest, as well as during the crop cycle, because of excessive irrigation or heavy precipitation. The impact of agriculture on groundwater quality can be minimized through improved nitrogen and water management (irrigation) practices, which should be evaluated with regard to their production, polluting effects and cost effectiveness.

Most of the Slovenian highly fertile arable lands occur on plains in the shallow groundwater recharge zones, and are used for intensive fresh vegetable production, an important source of income generation for the farmers. These shallow alluvial aquifers are, however, one of the country's most important sources of drinking water. This leads to a conflict of interest between drinking water resource protection and agricultural production. The common farming practice in Slovenia is to broadcast fertilizer applications which often results in extensive nitrate leaching. Thus nitrate management in agriculture is a contentious issue, as adequate nitrogen fertilization is required to ensure reasonable crop yields, yet excessive N fertilization can lead to groundwater pollution.

The Project

Through an IAEA technical cooperation project SLO 5002 Protecting Groundwater and Soil Pollutants using Nuclear Techniques, various irrigation, nitrogen and cropping system management strategies for the production of vegetables with a shorter growing period were assessed at a benchmark site in Slovenia during the years 2006 and 2007. Four irrigation and fertilization treatments were applied: (1) 50% drip irrigation of plant water requirements ET_{crop} and the farmer's practice of fertilization (broadcasting), (2) fertilization and 100% drip irrigation (fertigation), (3) the farmer's practice of irrigation (sprinkler irrigation using water stored in plastic tanks) and fertilization, and (4) control (the farmer's practice of irrigation but no fertilization). An equivalent of 80, 80 and 200 kg ha^{-1} of nitrogen (N), 50, 50 and 80 kg ha^{-1} of phosphorous (P) and 120, 120 and 300 kg ha^{-1} of potassium (K) was added for iceberg lettuce, endive and cabbage, respectively. Nitrogen (N) labeled fertilizer (^{15}N) was applied to trace the movement of the applied N fertilizer. The soil of the study area was a sandy loam classified as gleyic Fluvisol and endogleyic Fluvisol according to the World Reference Base for Soil Resources (2006).

Soil water balance was calculated on a daily basis for the whole experimental field according to the following soil water balance equation:

$$\Delta W = P + I + U - R - I_c - ET - D \quad (1)$$

where ΔW is the daily change in soil water storage in the soil profile (0–100 cm), P the daily rainfall, I irrigation, U upward movement of water through capillary rise, R surface runoff, Ic intercepted water on the leaves of crops, ET the daily evapotranspiration and D is the deep drainage below the effective root zone (all in mm). Taking into account the specific situation of the experimental field, quantities R and Ic were assumed to be negligible, whereas U and D could be then obtained from the following simplified equation:

$$D - U = P + I - ET - \Delta W \quad (2)$$

When $D - U > 0$, deep percolation occurred from the soil profile, whereas the negative sign indicates capillary rise from the lower soil layers to the rooting zone. Soil water measurements were conducted continuously with a Trase® time domain reflectometer (TDR), Soil Moisture, USA, at depths of 10, 30, 50, 70 and 100 cm. Soil water content was meas-

[1] Extracts from Agriculture, Ecosystems and Environment 144: 167-174 (2011)

ured in the 50% drip irrigation plot, fertigation plot and on the borderline between farmer's practice and control, both treatments having the same irrigation practice (Fig. 1). Soil water storage W (mm) was calculated from TDR soil water content measurements (vol%) over the entire depth of the soil layer (cm). Daily reference ET data was calculated using the Penman–Monteith method, and potential crop evapotranspiration (ETcrop) was estimated using the crop coefficient for iceberg lettuce, endive and cabbage (Allen et al., 1998).

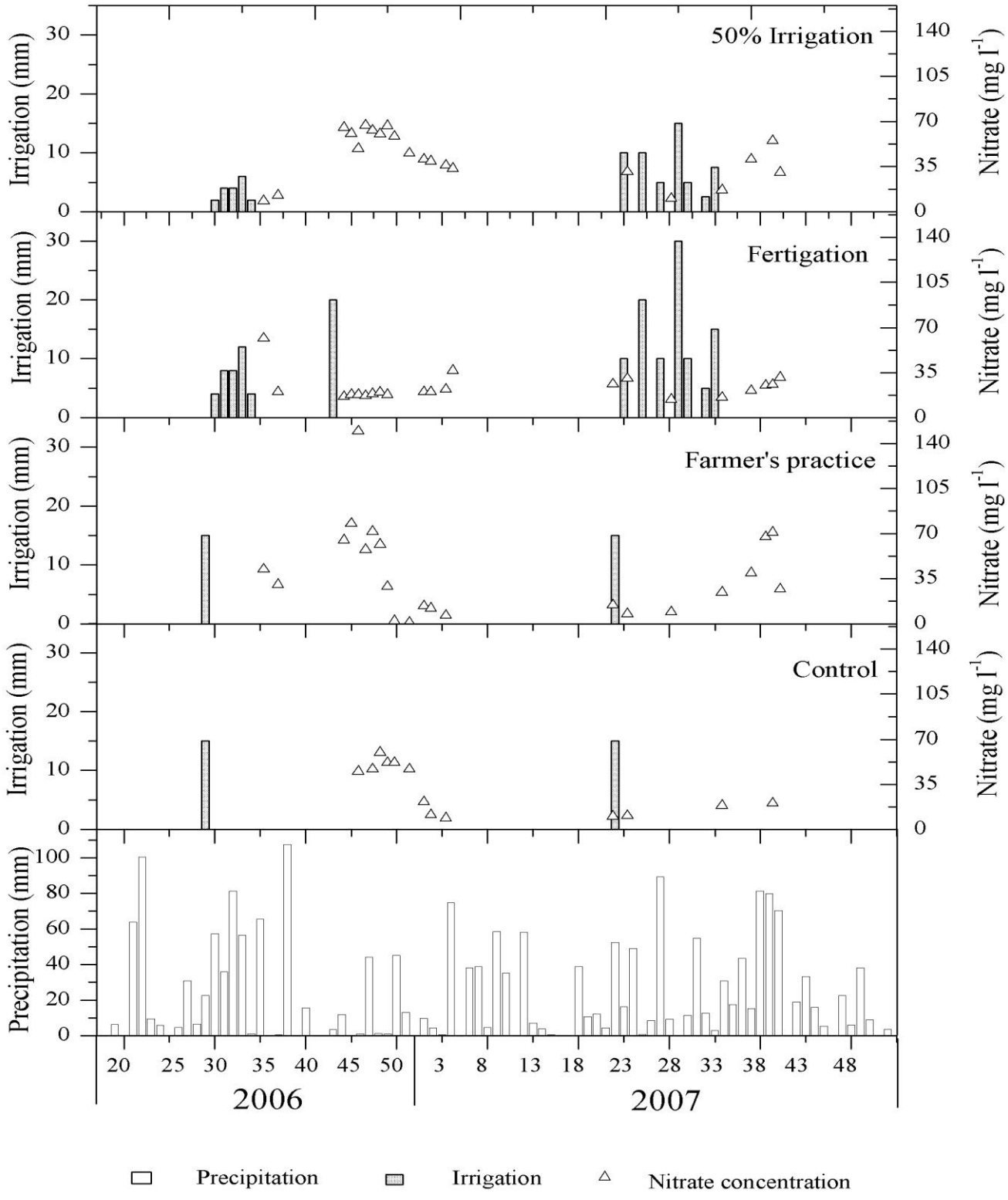

Fig.1. Nitrate concentration (mg L^{-1}) in soil water collected with suction cups from June 2006 till December 2007 in Sneberje for 50% irrigation, fertigation, farmer's practice and control, and weekly precipitation (mm). (Second Y axis scale range for nitrate concentration in soil water ranges from 0 to 175 mg L^{-1}, marking numbers are adapted for clear print.)

Soil water was sampled weekly with soil moisture suction cups at a depth of 50 cm, and the samples were analyzed for nitrate N concentration, soluble and total N using ISO/DIN 14255 (1999) and ISO 13878 (1998) standard methods. The nitrate concentration results are expressed in mg L^{-1} of nitrate N. For N isotope analysis, nitrate was isolated from the soil water as ammonium sulphate using the microdiffusion method. The isotopic composition of the samples was determined using a continuous flow isotope ratio mass spectrometer Europa 20–20 with an ANCA-SL preparation module (PDZ Europa Ltd., U.K.)

Conclusions and Perspectives

The project addressed different irrigation and nitrogen system management strategies to reduce nitrate leaching while sustaining yields in farmer managed vegetable fields located over a shallow aquifer at a benchmark site in Sneberje, Slovenia.

From the food security aspect, the farmer's practice resulted in the highest yield for both lettuce (2006) and cabbage (2007), although fertigation provided the most optimal water management. The yield of endive (2006) did not differ among the treatments due to unfavourable weather conditions for the open air field experiment. From the environmental aspect, there were no statistically significant differences in nitrate concentrations in soil water among treatments; however the fertigation and control treatment had the lowest ^{15}N atom% excess, indicating the lowest N leaching deriving directly from added fertilizer. Also, the lowest estimated N losses (kg ha^{-1}) were under the fertigation treatment, the highest were calculated for the farmer's practice treatment.

Fertigation, as an environmentally friendly practice, should therefore be considered for vegetable production on or close to groundwater protection zones, even with lower yield remuneration for enhanced practical application. The ^{15}N technique was useful to identify which technologies present a higher or smaller potential threat for nitrate leaching, as well as for the design of cost effective and environmentally friendly N fertilizer management for intensive vegetable production in vulnerable areas. The results confirm that fertigation and improved irrigation scheduling can be an effective way of minimizing nitrate leaching, and should be considered for vegetable production in or close to groundwater protection zones.

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Land-use and Erosion Source Discrimination of Soil and Carbon Sources to the Logan and Albert rivers in Australia using Compound Specific Isotope Analysis

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The compound specific isotope analysis (CSIA) technique has been used to identify the sources of soil erosion contributing sediment to the Logan-Albert catchment (Fig. 1). Soil samples were collected in January 2010 and used to assess the ability of the CSIA technique to discriminate probable sources of soil erosion. Fatty acid and bulk carbon isotope signature ($\delta^{13}C$) were measured. This study has built on a previous sediment tracing study undertaken in 2008 using fallout radionuclides and major/minor element geochemistry. It was found that surface soils from forest, pasture and cultivated land uses are well discriminated using CSIA. Furthermore, sub-surface soil sources associated with channel bank erosion and exposed subsoils (gullies and hillslope scalds) occurring specifically in the mid-western Logan catchment could also be discriminated. The CSIA and bulk carbon $\delta^{13}C$ data were used in the IsoSource mixing model to estimate the erosion sources of sediment collected during the January 2008 flood. The results of this analysis were compared with results obtained using other sediment tracers. For the lower Logan River, the CSIA tracing results are consistent with fallout and element geochemistry tracing, with channel bank erosion being confirmed as the major sediment source. However, the significant contribution to Logan River sediment of exposed subsoils originating on hillslopes and drainage lines from the mid-western region of the Logan catchment has also been confirmed by CSIA. This erosion source was not quantified by catchment modelling. In the Albert River catchment about 50% of soil comes from forest land use, although more than half of this soil comes from sub-surface sources. These results have demonstrated that the CSIA technique has the potential to significantly enhance the ability of CSIRO Land and Water sediment tracing studies to determine the extent that different land uses are contributing eroded soil to rivers, thus providing a check on catchment model predictions and/or a calibration of model parameters. In particular, sources of surface soil erosion in agricultural regions can now be distinguished from pristine forest hillslopes. Likewise, sub-surface soil sources such as river bank and gully erosion may also be distinguished.

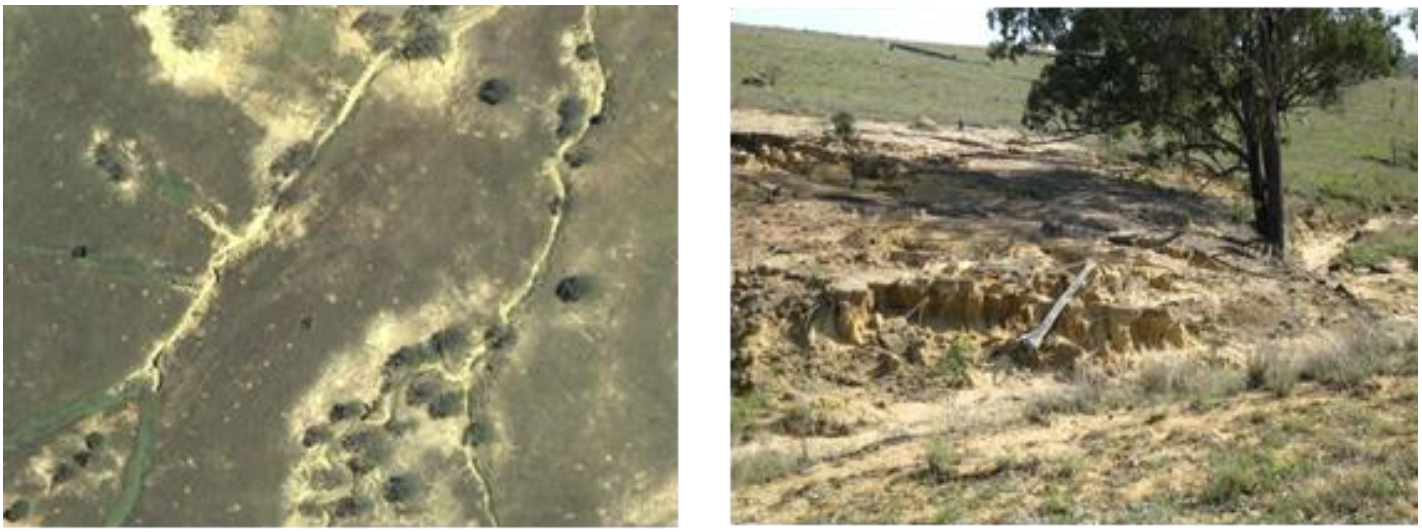


Fig. 1. Hot spots of land degradation in the Logan-Albert catchment (eastern Australia)
http://www.clw.csiro.au/publications/science/2011/sr02-11.pdf

Technical Cooperation Projects

Operational Projects and Technical Officers responsible for implementation

Project Number	Title	Technical Officer
AFG5003	Sustainable Increase in Crop Production in Afghanistan	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
ANG5005	Effect of Biofertilizer and Inorganic Fertilizer Uses on the Growth and Yield of Maize and Bean in Ferralitic Soils of Huambo	Adu-Gyamfi, Joseph Jackson
BEN5005	Improving Maize and Yam-Based Cropping Systems and Soil Fertility	Adu-Gyamfi, Joseph Jackson
BKF5007	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
ECU5026	Improving the Efficiency of Irrigation in the Rio Chota Sub-Basin	Sakadevan, Karuppan
ERI5004	Improving Crop Productivity and Combating Desertification	Adu-Gyamfi, Joseph Jackson/ Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
HAI5003	Enhancing Crop Productivity through the Application of Isotope Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Food and Environmental Protection Section
INS5037	Applying Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
IRQ5017	Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
IVC5031	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	Adu-Gyamfi, Joseph Jackson
KEN5030	Assessing Nutrient and Moisture Use in Major Cropping Systems	Heng, Lee Kheng
MAG5015	Optimization of Phosphate Fertilization of Ferralsols (classically deeply weathered red or yellow soils found in humid east Madagascar) in the Highland Areas of Madagascar	Nguyen, Minh-Long / Dercon, Gerd
MAR5017	Investigating the N Dynamics in the Crop-Soil System of a Multiple Cropping System to Optimize Fertilizer Use	Nguyen, Minh-Long
MLI5022	Assessment of Erosion and Sedimentation in the Niger Watershed with the Use of Radioisotopes, Phase-1	Mabit, Lionel
MOZ5003	Sustaining the Management of Soil Fertility	Dercon, Gerd
NAM5009	Using Mutation Breeding and Integrated Soil Plant Management Techniques to Develop Sustainable, High Yielding and Drought Resistant Crops	Heng, Lee Kheng in collaboration with Plant Breeding and Genetics Section
NER5014	Improving the Productivity of Cowpea/Finger Millet Based Cropping Systems	Sakadevan, Karuppan in collaboration with Plant Breeding and Genetics
NIC8012	Applying Nuclear Techniques for the Development of a Management Plan for the Watershed of the Great Lakes	Dercon, Gerd
QAT5002	Developing Biosaline Agriculture in Salt-affected Areas in Qatar	Nguyen, Minh-Long in collaboration with Plant Breeding and Genetics Section
RAF5058	Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies	Heng, Lee Kheng

RLA5051	Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems (ARCAL C)	Dercon, Gerd and IAEA Environment Laboratories
RLA5052	Improving Soil Fertility and Crop Management for Sustainable Food Security and Enhanced Income of Resource-Poor Farmers (ARCAL CI)	Sakadevan, Karuppan
RLA5053	Implementing a Diagnosis System to Assess the Impact of Pesticide Contamination in Food and Environmental Compartments at a Catchment Scale in the Latin American and Caribbean (LAC) Region (ARCAL CII)	Dercon, Gerd in collaboration with Food and Environmental Protection Section
SAU5003	Improving Fertilization under Saline Conditions for Sustainable Crop Production	Nguyen, Minh-Long in collaboration with Plant Breeding and Genetics Section
SEN5030	Integrated Approach to Develop Sustainable Agriculture in Senegal	Dercon, Gerd in collaboration with Plant Breeding and Genetics Section
SIL5008	Contribution of Nitrogen Fixing Legumes to Soil Fertility in Rice-based Cropping Systems	Adu-Gyamfi, Joseph Jackson
SIL5012	Managing Irrigation Water for a Dry Season Sorghum/Legume Intercropping System for Income Generation and Soil Health	Adu-Gyamfi, Joseph Jackson
SRL5040	Study on Nitrogen Balance in Coconut-Based Agroforestry Systems Using Nitrogen-15 Isotope Dilution Technique	Adu-Gyamfi, Joseph Jackson
SUD5030	Increasing Productivity of Selected Crops Using Nuclear Related Techniques	Adu-Gyamfi, Joseph Jackson in collaboration with Plant Breeding and Genetics Section
TAD5005	Developing Soil Conservation Strategies for Improved Soil Health	Dercon, Gerd
ZAM5026	Improving Crop Varieties Through Use of Nuclear Techniques	Heng, Lee Kheng in collaboration with Plant Breeding and Genetics Section
ZIM5014	Developing and Promoting Strategies for Improved Crop Production	Heng, Lee Kheng

Forthcoming Events Announcement

FAO/IAEA Events

International Conference on Managing Soils for Food Security and Climate Change Adaptation and Mitigation

23-27 July 2012
Vienna, Austria

The registration for this conference and the deadline for the submission of extended synopses, forms A and B was extended until 31 December 2011 (all forms can be obtained from the website listed below).

The topics to be discussed at the conference are as follows:

1. Managing soils for increased productivity and on-farm and area-wide ecosystem service efficiency;
2. Managing nutrient resources for increased efficiency;
    a. External input management
    b. Internal recycling of crop residues and agricultural wastes
3. Preserving and protecting soil resources;
    a. Assessment and control of soil degradation, on-farm and off-farm soil and nutrient losses
    b. Remediation and restoration of degraded soils in agricultural landscapes
4. Managing soils for climate change adaptation;
5. Managing soils for climate change mitigation;
    a. Enhancing soil carbon stocks (C sequestration)
    b. Reducing greenhouse gas emissions
6. Applications of isotopic tracers to measure soil organic matter, nutrient and water dynamics in agro-ecosystems (identifying sources and sinks and quantifying fluxes), including agroforestry, conservation agriculture, integrated cropping-livestock enterprises and food-biofuel production systems;
7. Advances in the development of nuclear-based instrumental and analytical techniques for application in soil management research.

For more details, visit http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=41176.

The programme combines plenary lectures, keynote speakers and poster sessions.

Non-FAO/IAEA Events

- International Conference on Plant Growth, Nutrition & Environment Interactions
  Date: 18-21 February, 2012; Place: Vienna, Austria
  Website: http://www.vipca.at/Documents/VIPCA-INFO.pdf

- 8th International Soil Science Congress on Land Degradation and Challenges in Sustainable Soil Management

  Date: 15-17 May, 2012; Place: Izmir, Turkey
  Website: http://soilcongress.ege.edu.tr

- 7th International Symposium on Mineral Nutrition of fruit crops
  Date: 19-25 May, 2012; Place: Chanthaburi, Thailand
  Website: http://www.mnutrition7.kmitl.ac.th

- BALWOIS 2012 — Fifth International Scientific Conference on Water, Climate and Environment
  Date 28 May - 2 June, 2012; Place: Ohrid, Macedonia
  Website: http://www.balwois.com/2012

- IsoPhos2012 Conference on Development of Isotopic Tracers for a Better Understanding of the Phosphorus Cycle
  Date 24 – 29 June, 2012; Place: Centro Stefano Franscini, Monte Verità, Ascona, Switzerland
  Website: http://www.isophos2012.ethz.ch/

- New Horizon 17th International Nitrogen Workshop
  Date: 26-29 June, 2012; Place: Wexford Opera House, Ireland
  Website: http://www.nitrogenworkshop.com/

- EUROSOIL 2012 on Soil Science for the Benefit of Mankind and Environment
  Date: 2-6 July, 2012; Place: Bari, Italy
  Website: http://www.eurosoil2012.eu/

- 13th International Conference on Wetland Systems for Water Pollution Control
  Date 25 - 29 November, 2012; Place: Murdoch University, Perth, WA, Australia
  Website: http://www.promaco.com.au/events/wetlandsystems2012.html

- 5th Joint ASSSI and NZSSS Soil Science Conference
  Date: 2-7 December, 2012; Place: Hobart, Tasmania, Australia
  Website: http://www.soilscience2012.com/

Past Events

Duty Travel

Kenya: Filming and interviewing for TC projects: RAF/5/058 (Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies), and KEN/5/030 (Assessing Nutrient and Moisture Use in Major Cropping Systems), for presentation at the IAEA scientific forum on Water Matters: Tackling Water Scarcity and Saving Water in Agriculture, 30 May-3 June 2011

Technical Officer: Lee Heng

Lee Heng travelled to Nairobi and other parts of Kenya with IAEA's Media and Outreach Section (Ms. Louise Potterton and Mr. Petr Pavlicek) to provide support to both the media team and the Kenyan counterparts for developing videos and audio films to be presented at the 3rd session of the IAEA scientific forum on Water Matters: Tackling Water Scarcity and Saving Water in Agriculture (20-21 September 2011).

The trip involved interviewing key personnel (Directors of KARI; counterparts of both projects) and key players involved in the two projects. Films were also taken at various experimental sites involved in the studies, e.g. the KARI Experimental Station, where the drip irrigation experiment was conducted, and the Katumani Research Centre in Marchako where we interviewed the Centre's Director Dr. Charles Karluki, who told us of the worsening situation in terms of rainfall availability for growing crops. At Katumani, the successful experiment on pigeonpeas was demonstrated, showing incorporation of crop residues to improve water storage of soil. We also interviewed farmers whose crops had failed and listened to their concerns relating to water scarcity. We visited a small pond, where villagers collect the dirty water for drinking, cooking and their animals, thus the water was insufficient for growing crops.

In addition, we visited a farmer in Kajiado who owns a borehole and irrigates his crops using flood irrigation. Due to the inefficiency of this irrigation method, the farmer spends about Ksh 3200 (US $35) per month on fuel for pumping.

A trip was also made to Namanga, a border town with the United Republic of Tanzania in the Rift Valley area where there is a large concentration of Maasai people. We interviewed Mr. David Mathenge from the Green Belt Movement (GBM), who manages projects on water scarcity in the southern part of Kenya, together with the African Medical and Research Foundation (AMREF). Both organizations are helping Maasai people to improve their livelihoods and one of the activities is to teach them to grow vegetable crops using small scale drip irrigation. Traditionally the Maasai have been nomadic cattle herders but due to climate change and water scarcity, the men now have to go further with their animals in search of pasture and water, leaving their families without food for months. By growing crops using small scale drip irrigation the women

and children have food to live on during this period, at the same time allowing them to diversify their diet and improve their health and nutrition. GMB and AMREF approached KARI, which works closely with IAEA, for assistance with small scale drip irrigation and irrigation scheduling technology.

Two videos were produced from the Kenya trips; they can be downloaded at:
http://www.youtube.com/watch?v=v1c8M5sFUJU
http://www.youtube.com/watch?v=vbaTz8TO55E

Brazil: Training course on the use of isotopic techniques to study carbon and nitrogen dynamics and modelling to improve soil fertility and crop productivity, 20-22 June 2011

Technical Officer: Karuppan Sakadevan

The training course was conducted at the Centro de Energia Nuclear na Agricultura (CENA), Universidade de São Paulo, Piracicaba, Brazil. The training programme was aimed at improving the skills, knowledge and technical competence of scientific and technical personnel on the use of isotopic techniques to study soil organic carbon, and the use of numerical modelling to assess soil organic carbon dynamics. Sixteen scientific and technical personnel from 10 Latin American countries (Argentina, Bolivia, Brazil, Chile, Cuba, Dominican Republic, Haiti, Mexico, Nicaragua and Paraguay) participated in the training. This training will help to improve local capacity building in soil, crop and fertilizer management in the region to ensure that future project activities relating to soil fertility, crop nutrition and crop production planning will be more effective.

The following topics were covered in the training programme: (1) introduction to soil organic carbon and nitrogen, and their contribution to soil health and fertility, (2) factors affecting fluxes of carbon and nitrogen in soil-plant systems, (3) soil and plant sampling in the field, and laboratory analysis, (4) practical training on soil organic matter modelling with case studies and (5) interpretation and reporting of data obtained from field measurements and modelling.

The speakers at the training course included: Karuppan Sakadevan, Takashi Muraoka (CENA, Universidade de São Paulo, Piracicaba, Brazil), Hector Causarano (Universidad Nacional de Asunción, Paraguay), Carlos Cerri (Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Brazil) and Plinio De Camargo (Laboratório de Isotopos Estavei, Centro de Energia Nuclear na Agricultura, Universidade de São Paulo, Brazil).

Training course participants on a field visit to a sugarcane farm in Brazil

Italy: Technical Meeting on Preparedness and Response to Nuclear and Radiological Emergencies affecting Food and Agriculture, 14-18 November 2011

Technical Officer: Gerd Dercon

FAO organized a technical meeting on preparedness and responses to nuclear and radiological emergencies affecting food and agriculture, including the application of agricultural countermeasures and remediation strategies in response to such events. The meeting included invited experts who advised the organization on how to meet its obligations under international conventions and agreements, in particular to assist FAO Member States to prepare for and respond to nuclear and radiological emergencies affecting food, agriculture, fisheries and forestry.

The meeting was held at FAO Headquarters in Rome.

Japan: IAEA's International Expert Mission on Remediation Issues, 7-14 October 2011

Technical Officer: Gerd Dercon

An International Expert Mission was sent to Japan to advise the country on the development of its remediation plans following the nuclear accident at the Fukushima Daiichi Nuclear Power Plant. The mission, requested by the Japanese Government, involved twelve experts from several countries and IAEA/FAO experts. The Joint FAO/IAEA Division supported this mission in the field of food and agriculture, among others through the Soil and Water Management & Crop Nutrition Section.

The mission team met with Japan's relevant Government Offices, Ministries and Agencies involved in the effort to develop strategies and plans to implement countermeasures for remediating the areas affected by the consequences of the nuclear accident.

At several locations in Fukushima, the team visited model remediation projects, including two sites in the village of Iitate, where agricultural remediation technologies are applied and verified. At all of these demonstration sites, experts are evaluating the efficiency of a number of methods and technologies that can be used in remediation strategies.

For more information, please visit http://www.iaea.org/newscenter/news/2011/missiononremediation.html

Peru: Regional TC project RLA/5/051 on Using Environmental Radionuclides as indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems, 22-26 August 2011

Technical Officer: Gerd Dercon

Mr Gerd Dercon visited the Instituto Peruano de Energía Nuclear (IPEN), Lima, the main project counterpart from Peru in RLA/5/051, which aims to enhance soil conservation in the region to ensure sustainable agricultural production and reduce the on- and off-site impacts of land degradation. Mr. Dercon reviewed the progress of project implementation, assessed the results to date and assisted in preparing the work plan through working group sessions and plenaries. He also presented case studies on experiences of community based soil conservation strategies across the globe and how science and development can be linked.

The following summary outlines the progress of the project to date:
1) A total of 36 scientists and technicians from universities and governmental organizations were trained in: a) use of Fallout Radionuclides (FRN) for estimating soil erosion and assessing the effectiveness of soil conservation measures, b) use of models to convert FRN data for the assessment of soil redistribution and tools for analysis and data visualization, c) basic geostatistics applied to FRN data and d) gamma ray spectroscopy.
2) Networking and south-south cooperation through twinning missions enabled interaction, discussion, support and interchange with the respective groups. It also initiated a cross-institutional collaboration between regional and national research institutions involved in nuclear applications, agricultural and environmental management, soil protection and policy making.
3) Partnerships were developed with UN agencies (e.g. UNEP in Cuba), private sectors (e.g. the forestry sector in Chile, farmers in Argentina) and other research centres (e.g. Universidad Fluminense de Brazil).
4) Analytical capacity of good quality is currently available in 8 out of 14 countries (not including El Salvador and Nicaragua, which will soon have the required analytical capacity). Analytical capability (gamma ray spectroscopy) in Argentina and Chile (under Government cost sharing) was developed.
5) Pilot investigations are being carried out in the study areas in the respective Member States. Technical results of the project should be transformed into strategies that will be useful for decision and policy making to mitigate specific environmental impacts. The results will be incorporated into an on-line decision support system under Part 2 of the project in 2012-2013.

Italy: Final meeting on FAO's AquaCrop model development and the publication of the new Irrigation and Drainage Paper No. 33, 28-30 August 2011

Technical Officer: Lee Heng

Lee Heng attended the final meeting of the FAO's AquaCrop core group in FAO, Rome in August this year. The meeting was held to discuss the details of the publication of FAO's new Irrigation and Drainage Paper No. 33 on Yield Response to Water. All chapters of the publication are in their final stage of publication, with the AquaCrop model forming part of this publication. A list of AquaCrop applications and guidelines for local adjustment and model calibration will be provided to guide users. Beside herbaceous crops, the publication will also include yield response to water for fruit trees and vines. In future, the model could be linked with GIS and other spatial platforms. The meeting also discussed further model development, producing training material and future training workshops.

Switzerland: WHO Final Review Meeting of the International Expert Panel, 13-14 October 2011

Technical Officer: Lionel Mabit

Lionel Mabit represented the Joint FAO/IAEA Division at this meeting.

The purpose of the meeting, hosted at the World Health Organisation (WHO) headquarters and conducted by the International Expert Panel, was to review and discuss the results of the Fukushima nuclear power plant accident initial dose assessment. Topics included: (i) general review of the assessment: scenarios applied inside and outside Japan; studied population, age groups; applied assumptions; evaluated exposure pathways, (ii) approaches used, data considered, methods, tools, and review of results for each of the exposure pathways considered, (iii) comparisons between human monitoring and assessments based on measurements, (iv) review of the estimation of total exposure (all exposure pathways) inside and outside Japan, (v) discussions of the consistency, completeness, gaps, and uncertainties and (vi) presentation of the results, report format and outline.

The final report of the WHO International Expert Panel entitled Initial Evaluation of Radiation Exposure from the Nuclear Accident after the 2011 Great East-Japan Earthquake and Tsunami will be published in 2012.

The Second Coordination Meeting (6-9 December 2011) and the 4th training course (10-13 December 2011) for the Regional TC project RAF5058 on Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies, will be held in Quatre-Bornes, Mauritius.

Technical Officer: Lee Heng

The meeting was to evaluate the progress made in each of the 19 participating countries, reformulate work plans and streamline protocols to achieve the objectives of the project which are to enhance the productivity of high value crops and income generation with small scale irrigation technologies. The development of a guideline and practical recommendations on the water and nutrient requirements under small scale irrigation technologies was discussed. So far, irrigation scheduling for various high value crops (capsicum, cucumber, potato, tomato etc.) using small scale irrigation has been determined and a socio-economic survey was also carried out as part of the study. Project participants from the following countries attended this meeting: Algeria, Benin, Botswana, Cameroon, Ethiopia, Ghana, Kenya, Mali, Mauritius, Morocco, Nigeria, Sudan, Uganda, United Republic of Tanzania, Zambia and Zimbabwe.

The regional training course was held in the same venue in Mauritius as the coordination meeting and the purpose of the training course was to provide training on the use of isotopic and conventional methods for improving water use efficiency. Training included comparative methods of improving irrigation water use and calculating crop water use efficiency using FAO's AquaCrop model to validate yield performance under this project.

FAO/IAEA Events

Final Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) on Selection and Evaluation of Food (Cereal and Legume) Crop Genotypes Tolerant to Low Nitrogen and Phosphorus Soils Through the Use of Isotopic and Nuclear related Techniques (D1.50.10), 14–18 November 2011, Vienna, Austria

Scientific Secretaries: Joseph Adu-Gyamfi and Gerd Dercon

The purpose of this final research coordination meeting, which is the culmination of the five year CRP, is to provide an opportunity for participants to highlight research achievements, summarize results and to prepare conclusions and final recommendations for publication of the IAEA-TECDOC. Participants from sixteen countries (nine research contract holders, one technical contract holder and six agreement holders) participated in this RCM. The contributions to the IAEA technical document submitted by the participants were reviewed and discussed during the meeting. The main outputs and the possible impacts of their results will help farmers improve crop productivity in harsh environments through integrated crop, soil and nutrient management practices.

Visitors

- Dr Vesna Zupanc of the Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Slovenia, visited the SWMCN Laboratory in Seibersdorf on 7th October 2011 to present a short seminar and to discuss the dataset of stable isotopes (^{13}C and ^{15}N)

analysed from a joint field experiment with the SWMCN Laboratory team carried out in East Slovenia.

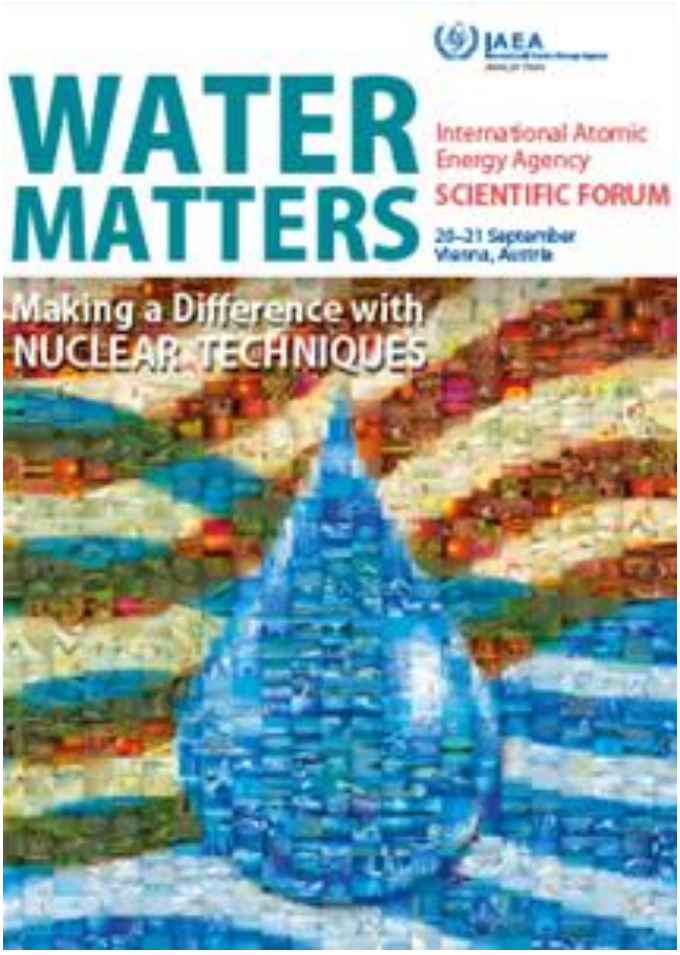
- Ms. Ann Tutwiler, FAO-DDG and Mr. Robert J. Samors visited the FAO/IAEA Agriculture and Biotechnology laboratories in Seibersdorf, including the SWMCNL, on 19th September 2011 to familiarize themselves with on-going activities.

- Dr. Gerardo van Helsema, from the Irrigation and Water Engineering Group, Centre for Water and Climate, Wageningen University, the Netherlands, visited the SWMCN Section on 21st September to discuss research opportunities relating to agricultural water management and possible joint projects on conservation agriculture. During his visit, Dr. van Helsema attended the scientific forum on water matters.

- Mr. Vincent Isaya Sijali, irrigation specialist from Kenya Agricultural Research Institute (KARI), counterpart in KEN/5/030 (Assessing Nutrient and Moisture Use in Major Cropping Systems) and RAF/5/058 (Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies), and Mr David Mathenge from the Green Belt Movement in Nairobi, visited the SWMCN Section from 19-23 September as part of the team participating in the scientific forum, where their work relating to the introduction of a drip irrigation system for the Maasai community was presented.

- Mr. Tom Denmead, from the CSIRO Division of Land and Water, currently also Principal Fellow at the University of Melbourne, visited the SWMCN Section from 26-29 September, to discuss possible work on linking the Inverse Lagrangian dispersion analysis to the isotopic estimation of soil evaporation and plant transpiration. Tom has 56 years' experience in CSIRO Divisions of Plant industry, Environmental Mechanics, and Land and Water. Although retired, Tom still collaborates with various universities and state agencies in projects to determine emissions of sulphur gases from soils, greenhouse gases from crops and animal production systems, nitrogen losses from fertilisers and grazing, and is also involved in a project extending the studies of nitrogen and carbon dynamics from the laboratory to the field scale.

IAEA scientific forum on Water Matters: Making a Difference with Nuclear Techniques



The IAEA's scientific forum, which took place on 20-21 September 2011, focused on the theme: Water Matters: Making a Difference with Nuclear Techniques. The Forum was held in conjunction with the 55th annual General Conference.

During the Opening Session of the IAEA scientific forum, the inaugural address was given by IAEA Director General Mr Yukiya Amano, followed by invited speakers, including Mr Steven Chu, the Secretary of Energy, United States of America.

The SWMCN Subprogramme was involved in the 3rd session of the Forum, on Tackling Water Scarcity and Saving Water in Agriculture. The speakers for this session were:

- Ms. Jane Wamuongo, Assistant Director, Kenya Agricultural Research Institute (KARI), Kenya
- Ms. Ann Tutwiler, Deputy Director General, Food and Agricultural Organization (FAO)
- Mr. Ellias Fereres, Professor, Institute of Sustainable Agriculture, Spain
- Mr. Xurong Mei, Director General, Institute of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Sciences, China

- Mr. Christopher Smith, Deputy Chief, CSIRO Land and Water, Australia
- Mr. Royol Chitradon, Director, Hydro and Agro Informatics Institute, Thailand
- Mr. Maki Tsujimura, Associate Professor in Hydrology/Hydrogeology, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan.

During the water forum, a vacuum distillation setup for extracting plant and soil samples for isotopic analysis to identify the sources of water for improving water use efficiency was displayed. In addition, a drip irrigation prototype mimicking the operation in the field was also shown.

The FAO DDG Ms. Ann Tutwiler giving her presentation at the 3rd session of the Water Forum (top) and Mr Leo Mayr, a staff member at SWMCNL explaining to visitors at the display corner (bottom)

Sixteen impact reports from both CRP and TC projects were developed and distributed during the forum. These reports include:

- Algeria: "An integrated land-water management approach enables farmers to cope with soil water salinity in Algeria"
- Bangladesh: "Using saline water in salt affected soils to enhance food productivity and farmer incomes in Bangladesh"
- Chile: "Improving water quality through better soil management in Chilean vineyard plantations" and "Improving water quality in forested catchments in south-central Chile"
- China: "Improving water productivity and agricultural sustainability in Northern China"
- Ghana: "Saving scarce water and improving farmer livelihoods in peri-urban areas of Ghana through better irrigation"
- Kenya: "Improving agricultural water management through low-cost small-scale irrigation technologies" and "Enhanced utilization of scarce water improves soil fertility and crop yields in Kenyan drylands"
- Libya: "Improving agricultural water and fertiliser management in Libya"
- Mali: "Utilising crops to access scarce water enhances crop yields and farmer livelihoods in Mali"
- Qatar: "Blending of saline groundwater with treated sewage water offers bright future for saline soils in Qatar"
- Tajikistan: "Improving agricultural water management in Tajikistan: an essential tool in soil conservation and sustainable farmer livelihoods"
- Turkey: "Improving water and fertiliser use efficiency in potato production: the Turkish way"
- United Republic of Tanzania: "Drip irrigation offers high tea yields for small-scale plantation farmers in Tanzania"
- Vietnam: "Coping with water scarcity in Vietnamese highlands" and "Improving water quality through better soil management in Vietnamese mountainous uplands"

In the week preceding the Forum and in conjunction with this event, the SWMCN subprogramme organized a display of promotional material to illustrate the work of the Section, including photographs from Member State field projects, a live display of the vacuum distillation method, a drip irrigation prototype, a demonstration of root development in large transparent plastic tubes and an interactive map on the percentage of irrigated land in each country. This display was staged in the rotunda of the Vienna International Centre (VIC). The event attracted the interest and attention of both VIC staff and visitors.

Coordinated Research Projects (CRPs)

Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions: a Role for Isotopic Techniques (D1.20.09)

Technical Officers: Lee Heng and Minh-Long Nguyen

This CRP has entered its final phase, and the last contract renewal has been evaluated. The final research coordination meeting will be from 23-27 July 2012, to coincide with the International Conference on Managing Soils for Food Security and Climate Change Adaptation and Mitigation (23-26 July 2012). All participants in the project were able to use one method or another to separate soil evaporation (E) and transpiration (T) through a combination of isotopic techniques and soil water balance methods. FAO's AquaCrop model was used to verify the results obtained. The study in Vietnam showed that E and T of coffee at the bean development stage varied according to different management practices: traditional furrow irrigation practice: T = 83%, E = 17%, drip irrigation without mulch: T = 85%, E = 15% and drip irrigation with mulch: T = 90%, E = 10%, with an improvement of WUE of 25% under the drip and mulching practice. In China, evaporation accounts for about 48% of the total water loss in winter wheat fields, however during the last month of the season, it increases to 88% of the total water loss. The isotope mass balance of soil water approach is being used in the Malawi study, while the conventional soil water balance coupled with isotopic and modelling approaches is being employed in other countries.

The overall objective of this CRP is to improve the water productivity of crops (production per unit of water input) under water limiting conditions, and the specific objectives are as follows: (i) to quantify and develop a means to manage soil evaporative losses to maximise the beneficial use of water through improving the transpiration component of evapotranspiration; (ii) to quantify and develop a means of improving the amount of biomass produced per unit of transpiration; and (iii) to devise irrigation and related management techniques to enhance the yield component of biomass production (Harvest Index). This CRP has a total of twelve participants comprising seven research contractors from China (2 participants), Morocco, Pakistan, Turkey, Vietnam and Zambia and five agreement holders (Mr Peter Cepuder, Universitat fur Bodenkultur, Vienna; Mr Elias Fereres, IAS-CSIC and University of Cordoba, Spain; Mr Theodore Hsiao, UC Davis; Mr David Williams, University of Wyoming-Laramie, USA and Mr Shamie Zingore, International Plant Nutrition Institute, Nairobi, Kenya).

Strategic Placement and Area-Wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security (D1.20.10)

Technical Officers: Karuppan Sakadevan and Lee Heng

The overall objective of this CRP is to assess and enhance services provided by water conservation zones (farm ponds, wetlands and riparian buffer zones) to optimize water and nutrient storage, biomass production and food security within agricultural catchments. The specific objectives of the project are: (1) to optimize water storage in water conservation zones for downstream irrigation use, (2) to regulate nutrient cycling in water conservation zones to improve bio-fuel crops and fuel wood production and downstream water quality and (3) to optimize the use of water conservation zones for crop production.

Eight research contract holders from China, Estonia, Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia and Uganda, two technical contractors from the UK (University of Birmingham) and the USA (University of Florida) and agreement holders from the USA (University of Rhode Island) and France (Institut de recherche pour le Developpement) are involved in the project. Since the second RCM, which was held from 10-14 May 2010, all research contract holders have continuously collected field data on ^{15}N, ^{18}O and ^{2}H from water and plants in wetlands, farm ponds and riparian buffer zones to identify sources of water and N use efficiency in the biomass. This data has been included in the CRP's mid term review. It is planned to convert the two technical contract holders to agreement holders.

This CRP is now in its fourth year and the mid-term review was completed in November 2011 when continuation of the CRP for another two years was approved. The CRP is expected to be completed by the end of 2013 and the third RCM will be held in Vienna in July 2012 to coincide with the FAO/IAEA's international conference on Managing Soils for Food Security and Climate Change Adaptation and Mitigation. All participants in this CRP will be presenting either an oral or poster paper at the Conference.

Key outputs:

- Baseline data on soil physical and chemical characteristics, topography, land use and the location of water conservation zones (wetlands, farm ponds and riparian buffer zones) in agricultural catchments were collected for Sanjiang Plains (Northeast China), Porijogi catchment (Estonia), the Ab-Bandons (Northern Iran), Ha-Matela catchment (Lesotho), Ekiti Valley (Nigeria), Glavacioc River Basin (Romania),

Manafwa catchment (Uganda), and Kamech catchment (Tunisia).

- ^{18}O, ^{2}H and other hydrochemical measurements of water samples collected from water conservation zones, streams, runoff water from farmlands, rainfall, unsaturated zones, and other hydrological data have been used to construct water flow paths and conceptual models to identify sources of water for water conservation zones. Field studies measuring water inflow, storage and outflow and nutrient concentrations in water and biomass have been carried out for water conservation zones. Additional data will be collected and the information will be used to construct water and nutrient budgets for water conservation zones.
- Information on the isotopic signatures of ^{18}O, ^{2}H and ^{15}N for water samples, and total N, nitrate-N and ammonium-N for soil, water and plants samples were collected from field sites, water conservation zones, rivers and rainfall in China, Tunisia, Iran, Uganda, Romania and Estonia. This information was used to understand the biogeochemical mechanisms of N transformation in these systems.

Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion (D1.20.11)

Technical Officers: Long Nguyen and Gerd Dercon

The overall objective is to develop integrated isotopic approaches to identify hot spots or critical areas of land degradation in agricultural catchments for effective soil conservation measures (precision conservation). Specific research objectives are: (i) to develop the combined use of fallout radionuclide (FRN) techniques with conventional techniques and spatial analysis to establish soil redistribution patterns and rates over several temporal scales on an area-wide basis (catchment), (ii) to develop and validate protocols for the application of compound specific stable isotope (CSSI) techniques to identify and apportion the amount of source soils (land degraded areas) from main land uses/management (cropland, grassland and forestland) in the catchment, (iii) to integrate nuclear based approaches with other non-nuclear techniques through modelling and other tools to establish comprehensive soil redistribution studies on an area-wide basis and (iv) to create a basis for developing decision support tools to implement precision conservation and contribute to sustainable land management.

This CRP, which was formulated on the basis of the recommendation from a Consultants Meeting held at IAEA Headquarters, Vienna, 5-7 November 2007, is in its third year. The first RCM was held at IAEA headquarters in Vienna from 8 to 12 June 2009. The second RCM was held at the National Centre for Atomic Energy, and Nuclear Sciences and Applications (Centre national de l'énergie, des sciences et des techniques nucléaires (CNESTEN) in Rabat, Morocco, from 27 September to 1 October 2010. A Mid-Term Review of the CRP was successfully carried out in November 2011.

Eight research contract holders from Chile, China, Morocco, Poland, the Russian Federation, Syrian Arab Republic and Vietnam, four technical contract holders from China (Chinese Academy of Agricultural Sciences), Germany (University of Hohenheim), United Kingdom (University of Exeter) and Belgium (University of Ghent), and four agreement holders from Australia (CSIRO), Canada (University of Manitoba), New Zealand (National Institute of Water & Atmospheric Research) and the United Kingdom (University of Plymouth) attended the meeting.

The third RCM will be held at IAEA Headquarters in Vienna from July 23-27, 2012 at the same time as the FAO/IAEA International Conference on “Managing Soils for Food Security and Climate Change Adaptation and Mitigation”.

Key outputs:

- The following approaches to up-scale soil redistribution patterns were explored and tested in this CRP:
- The use of representative geographic units as a basis for extrapolation (e.g. Morocco, Canada),
- Spatial sampling programmes aimed at maximising the information return from a limited number of samples (transects, grids, random spatial sampling), as undertaken in the Syrian Arab Republic, China, Morocco, Chile and Canada,
- Paired catchment approaches to compare soil redistribution in neighbouring catchments with properties of similar size and landscape characteristics (e.g. topography and soil type) but different land use or management (e.g. Chile) and
- The use of nested sub-catchments to determine the effect of scale (from river sub-catchment to catchment and from catchment to basin) on soil redistribution (Poland).

The following tests represent encouraging first steps in the development of effective extrapolation and up-scaling procedures:

- CSSIs were shown to be a useful technique to identify and apportion hot spots of land degradation/erosion (by linking biomarkers of land use to the sediment in deposition zones).
- A harmonized protocol for the application of CSSI techniques to identify critical areas of land degradation at the catchment scale in a range of environments and land use systems was developed. This protocol was sent to the CRP participants in October 2010 for further validation under different agroecological conditions.

- The link of FRNs (Cs-137, Be-7 and Pb-210) with CSSIs (e.g. fatty acids) also improved the ability to distinguish sediment sources (Australia).
- Integrating the use of FRNs such as Pb-210 and CSSIs (New Zealand) showed how land use history over the last hundred years can be reconstructed. CSSIs of different depth layers in a sediment core can identify land use changes associated with changes in sediment accumulation rates (defined by Pb-210).

Selection and Evaluation of Food (Cereal and Legume) Crop Genotypes Tolerant to Low Nitrogen and Phosphorus Soils Through the Use of Isotopic and Nuclear Related Techniques (D1.50.10)

Technical Officers: Joseph Adu-Gyamfi and Gerd Dercon

This CRP is in its final phase and the final RCM was held from 14-18 November 2011 at IAEA headquarters in Vienna. The first RCM was held at IAEA headquarters in Vienna from 16-20 October 2006. The second RCM was held in Morelia, Mexico from 21-25 April 2008. The third RCM was held in Maputo, Mozambique from 23-27 August 2010. The project has a total of sixteen participants with nine research contract holders (Burkina Faso, Brazil, Cameroon, China, Cuba, Ghana, Malaysia, Mexico, and Mozambique), six agreement holders (Australia, Benin, Germany, Kenya, Nigeria, and France) and one technical contractor (USA).

The overall objective of this CRP is to develop integrated crop, soil and nutrient management practices to increase crop production in marginal lands by identifying and promoting the development of food crop genotypes (cereal and legume) with enhanced nitrogen (N) and phosphorus (P) use efficiency and greater productivity. The main conclusions from the meeting were:

- Seedling screening tools demonstrated significant genotypic variation for root traits. These included root length, angle, number of axial roots and branching as well as root hair parameters (length and density).
- Cultivars identified with some of these traits proved superior for uptake of P and N under conditions of nutrient stress.
- In a number of cases cultivars with superior growth, nutrient acquisition and efficiency obtained good yields of grain under conditions of nutrient stress.
- In some cases positive agro-ecological outcomes were identified that are related to the performance of cultivars selected for favorable root traits.
- Nuclear tools, specifically the use of ^{15}N and ^{32}P as tracers proved valuable in studies that sought physiological explanations for superior genotype performance.
- The genotypes identified in a number of cases provide valuable resources for plant breeding programmes aimed at enhancing P and N use efficiency in crops.
- A number of the participants and other members of their research teams gained valuable and unique training within the CRP.

The CRP has created a database on how cereal and legume crops can acquire N and P in low nutrient soils. This database will be further expanded and interpreted using multivariate analysis. Manuscripts for the IAEA-TECDOC of this CRP submitted by participants during the final RCM were reviewed.

Integrated Soil, Water and Nutrient Management in Conservation Agriculture (D1.50.09)

Technical Officer: Gerd Dercon

This CRP is now officially closed

NEW CRP:

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

Technical Officers: Long Nguyen and Gerd Dercon

The objective of this new CRP is to investigate the effects of soil management and agronomic practices in mulch based farming systems on soil fertility, ecosystem service efficiency, agricultural productivity, and on climate change and variability in cropping or integrated crop-livestock systems in the moist and dry savannahs of Sub-Saharan Africa (SSA). The goal is to improve the livelihoods of low socio-economic farmers and rural communities in a region that is dominated by a savannah ecosystem in its natural state. In mulch based farming systems, it is critical to adopt soil management practices that could potentially increase soil organic matter content (carbon sequestration) and maximize the efficiency of utilization of soil nutrients (synthetic and organic fertilizers) and water storage for crop growth. Soil organic matter improves soil fertility, stabilizes soil aggregates, increases soil water holding capacity to absorb and hold more water for crop growth and, more importantly, provides carbon as an energy source for the soil fauna and flora, which in turn enhances the soil's chemical and physical properties.
The use of the stable isotopic techniques (C-13 and N-15) at enriched or natural abundance levels will facilitate in-depth analyses and understanding of the basic soil biological-physical processes, including soil carbon and nutrient cycling in mulch based systems. The CRP will provide a

platform for the extrapolation of the recommended soil management practices to all agro-ecological regions of SSA because of the selection of benchmark sites in diverse and representative environmental conditions.

Specifically, the CRP seeks to resolve four key issues relating to soil quality and nutrient management for sustainable food production in mulch based cropping systems in sub-Saharan Africa:

- To improve soil fertility and soil health by promoting carbon sequestration through the replacement of exported nutrients (especially N, but also P and S to a lesser extent) and by applying the principles of conservation agriculture;
- To increase productivity in integrated crop-livestock systems across different spatial scales in the moist and dry savannahs of SSA;
- To increase on-farm and area wide ecosystem service efficiency (e.g. nutrient, water, labour and energy use efficiency);
- To assess economic feasibility and conduct impact assessment of mulch-based farming systems in SSA.

The expected duration of the CRP is five years (2012-2016). This CRP, which was formulated on the basis of the recommendations of a consultants meeting held at IAEA headquarters, Vienna, 5-8 July 2010, will commence in January 2012. The first Research Coordination Meeting is planned for February 2012 in Vienna, Austria. The project has fifteen participants, with seven research contract holders from Benin, Kenya, Madagascar, Mauritius, Mozambique, Pakistan and Zimbabwe, three technical contract holders from China, the Czech Republic and the United Kingdom and five agreement holders from Austria, Belgium, Kenya, New Zealand and USA.

Activities of the Soil and Water Management and Crop Nutrition Laboratory, Seibersdorf

Test of compound-specific stable isotope (CSSI) technique to investigate sediment provenance in a small Austrian watershed

Max Gibbs[1] and Lionel Mabit[2]

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Soil erosion is a threat to the sustainable production of food crops through the loss of arable land and pollution of water bodies. Climate change driven extreme weather events are predicted to increase soil degradation processes, and water erosion risk is expected to increase by about 80% in the agricultural areas of the European Union by the year 2050. For the sustainable use and management of natural resources, there is an urgent need for reliable quantitative data on the extent and actual rates of soil erosion and a better understanding of the key driving processes. Traditional monitoring and modelling techniques for soil erosion and sedimentation that can discriminate between different sources of sediment within a watershed have certain limitations in terms of validation at a sub-watershed scale, where pedogenic differences are minimal. Alternative fingerprinting techniques using fallout radionuclides (FRN) such as ^{137}Cs, ^{210}Pb and ^{7}Be can complement existing traditional methods, but these techniques are limited to providing accurate and quantitative information about the contribution of different sources of sediment from complex landscapes at the watershed scale. A new forensic stable isotope technique, using the compound specific stable isotope (CSSI) signatures of inherent organic biomarkers in the soil, can discriminate and apportion the source soil contribution from different land-uses to complement the information provided by FRN data.

The CSSI technique was developed at NIWA in New Zealand and is based on the concept of land-use, which is typically defined by the plant community growing on the land. These plant communities label the soil where they grow by exuding organic biomarkers. Although all plants produce the same biomarkers, the stable isotopic signature of those biomarkers is different for each plant species. Using the CSSI technique, the isotopic signatures of soil biomarkers from each sedimentation zone can be used to determine the proportional contribution of each soil source. Coupled with the FRN data, CSSI data allows for the quantification and determination of the original localisation of the eroded soil from each part of the landscape.

A collaborative study between the SWMCN Laboratory and NIWA aims to test and validate the CSSI technique in a small watershed in Mistelbach, 60 km north of Vienna, Austria. This agricultural area, which comprises multiple land uses (e.g. pasture, corn, sugar beet, rotational cropping of maize associated with winter wheat) has recently been investigated using FRN (i.e.^{137}Cs and ^{210}Pbex) and erosion plots (see Mabit *et al*., 2010). This previous radionuclides based study established a sedimentation rate of 4 mm a^{-1} in the lowest part of the watershed. The CSSI technique was tested in this sedimentation area using representative samples from the different land-uses of the watershed as reference material. Results from the δ^{13}C signatures of the different fatty acids (i.e. myristic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, arachidic acid, behenic acid, lignoceric acid and lignoceric acid) present in the soil samples collected from the site, were analysed with the mixing model "IsoSource" (Gibbs, 2008).

The CSSI technique determined that 28% of accumulated sediments came from agricultural fields used for the cultivation of sugar beet, 68% came from the grassed talweg channelling runoff from the various agricultural fields to the deposition area, and around 4% of the sediment originated from the maize and mixed crop rotation land.

This study is the first test of this innovative nuclear based method under Austrian agro-environmental conditions and has been initiated in the frame of CRP D1.20.11 on Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion, which encourages CRP participants from Member States testing the CSSI technique to identify hot spots of land degradation. In fact, knowing where to focus sediment erosion management efforts ensures efficient soil conservation strategies to reduce soil loss and improve the sustainability of arable land.

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Combined use of fallout radionuclide (^{137}Cs) and stables isotopes (δ^{13}C, δ^{15}N) in East Slovenia: Preliminary Results

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Background information

Following a previous study in Šalamenci, east Slovenia using ^{137}Cs, ^{40}K, ^{226}Ra and ^{232}Th (Mabit *et al.*, 2010), the effect of agricultural activity on soil distribution was investigated using stable isotope readings of ^{13}C and ^{15}N. The soil composition profile of the agricultural site under investigation was compared to the undisturbed forest situated in its vicinity. This undisturbed forest selected as a reference site (see Mabit *et al.*, 2010), is dominated by oak (*Quercus robur*), hornbeam (*Carpinus betulus*), alder (*Alnus glutinosa*) and wild cherry (*Prunus avium*), and covers approximately 1.9 ha with a flat topography (slope <2%) at an average elevation of 242 meters above sea level. The agricultural field under study is cultivated under an annual crop rotation: winter wheat (2003, 2006 and 2009), winter barley and white mustard (2004 and 2007) and maize (2005 and 2008).

The aim of this additional study using stable isotopic techniques (^{13}C and ^{15}N) was to confirm the undisturbed character of the reference site established by Mabit *et al.* (2010) through the use of radioisotope based methods.

Experimental design and preliminary results

Soil profiles were collected up to a depth of 40 cm, by increments of 10 cm (i) using systematic grid sampling (40 × 30 m) in the reference site and, (ii) according to a transect sampling strategy in the agricultural field (i.e. 5 transects; 11 sampling points per transect; n = 55). The soil samples were analysed for δ^{13}C and δ^{15}N, as well as to obtain the percent composition of those two elements in the soil samples using an elemental analyser (Flash 2000, Thermo Scientific, Massachusetts, USA) coupled with an Isotope Ratio Mass Spectrometer (Isoprime, GV Instruments, Manchester, UK).

Based on the EA-IRMS analysis (Fig. 1), the total carbon content of the undisturbed soil was found to be 2.64 ±0.23% (Mean ±SE) for the topsoil (0-10 cm), displaying an exponential depth decrease to reach a minimum value of 0.32 ±0.03% at the 30-40 cm layer. The total nitrogen distribution exhibited a similar exponential trend, with levels of 0.22 ±0.02% at 0-10 cm and of 0.04% at 30-40 cm.

The agricultural soil showed a more homogenous content for both C and N, especially in the 0-30 cm range. The carbon contents (1.42 ±0.04%, 1.40 ±0.04%, 1.19 ±0.06% and 0.53 ±0.05% for 0-10, 10-20, 20-30 and 30-40 cm, respectively) are consistent with the tillage practice in the field, where the plough depth reaches around 25 cm. Again, the nitrogen contents were similar to carbon (between 0.14 ±0.01% and 0.17 ±0.01% in the 0-30 cm range and 0.07 ±0.01% at 30-40 cm). The higher overall nitrogen contents are probably the consequence of anthropogenic addition of nitrogen enriched fertilizers.

Another important observation was the vertical distribution of the C/N ratio, which is an indicator of the soil organic matter (SOM) humification rate and soil nitrogen mineralization/immobilization potential (Marchetti *et al.*, 2011). The reference site presents relatively stable values of this ratio (8.06 to 8.54). However, the agricultural site displays a constant decrease in the C/N ratio with depth from 11.84 to 7.61, respectively, at the 0-10 and 30-40 cm depth layer.

The stable isotope readings also reflected the effects of tillage practices and fertilizer application on soils. At the reference site, the general trend showed exponential variation, but the figures were more homogenous at the 0-30 cm range in the agricultural field. Due to fractionation dynamics where soil organic matter is decomposed by microorganisms, the undisturbed soil was found to be more enriched with ^{13}C and ^{15}N in the lower depths, as ^{13}C and ^{15}N enriched microbial biomass increases. In the agricultural site, tillage-caused homogenisation diminished this effect. In the undisturbed soil, the heavier ^{13}C was present in smaller proportions in the top soil, while the lower depth corresponded to more ^{13}C enriched samples (from -26.73 ±0.09‰ at 0-10 cm to -23.70 ±0.11‰ at 30-40 cm). The agricultural field presented δ^{13}C ratios between -24.34 ±0.10‰ and -24.90 ±0.08‰ at 0-30 cm depth, and a more ^{13}C enriched 30-40 cm level (-23.97 ±0.12‰). Similarly, the ^{15}N was present in a bigger proportion in the forest soils (from 2.32 ±0.18‰ at 0-10 cm to 6.63 ±0.31‰ at 30-40 cm) and the agricultural field showed high and constant δ^{15}N readings at all depths (between 6.15 ±0.11‰ and 6.78 ±0.09‰), again confirming the effects of agricultural practices.

The measured δ^{13}C and δ^{15}N levels in the undisturbed reference site was in agreement with that reported by Mabit et al. (2010) using fallout radionuclides. Further studies will focus on the spatial variation of δ^{13}C and δ^{15}N signatures within the agricultural field.

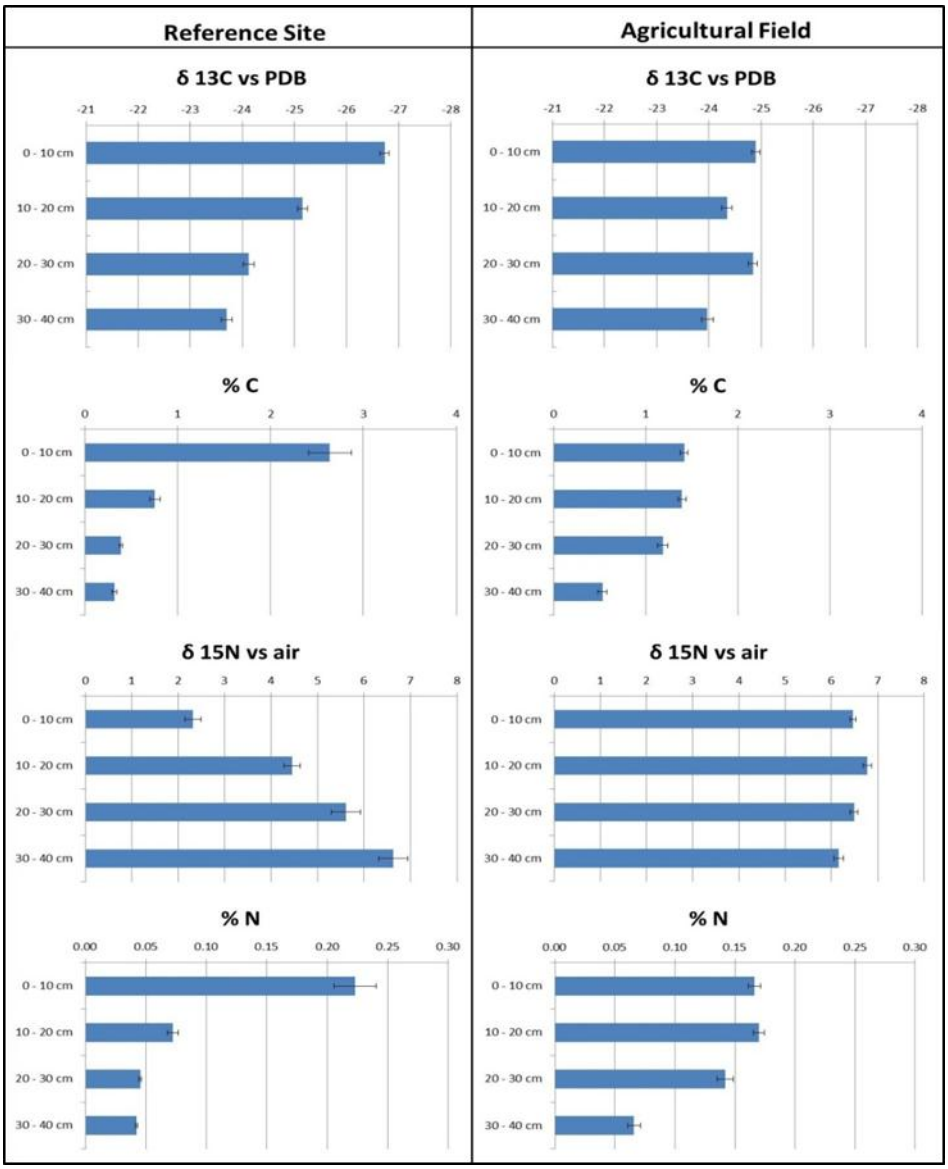

Fig. 1. Vertical isotopic distribution in the forested reference site and the agricultural field
NB: Data are presented as Mean ± SE

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Radioisotopics and physicochemical investigation to assess soil erosion affecting Spanish orchard fields

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Background information

Soil degradation is a major agro-environmental issue under Mediterranean climatic conditions. In Spain, 40% of the territory is under severe to very severe human induced land degradation, especially in the southern part of the country. While soil erosion studies in these regions have mainly been undertaken using conventional techniques such as modelling, in this preliminary study complementary nuclear techniques (naturally occurring radionuclides (NOR), such as ^{40}K, ^{226}Ra and ^{232}Th) and fallout radionuclide (^{137}Cs), were measured to establish base-

line data for future assessment of soil degradation in olive orchards.

Similar to a previous study conducted in Slovenia (Mabit *et al.*, 2010), a background assessment has been carried out for radioisotopes in an undisturbed reference site situated in the vicinity of an olive orchard in the municipality of Montefrío, south-west Spain (Fig. 2). This mountainous region covers 220 km^2 with an elevation ranging from 800 to 1600 meters above sea level and olive plantation, which represents 81% of the cultivated area.

To establish the reference radioisotopic values - where no significant net erosion or deposition had occurred - the undisturbed and flat archaeological site of *Las Peña de los Gitanos* located a few hundred meters away from the agricultural fields was selected for investigation.

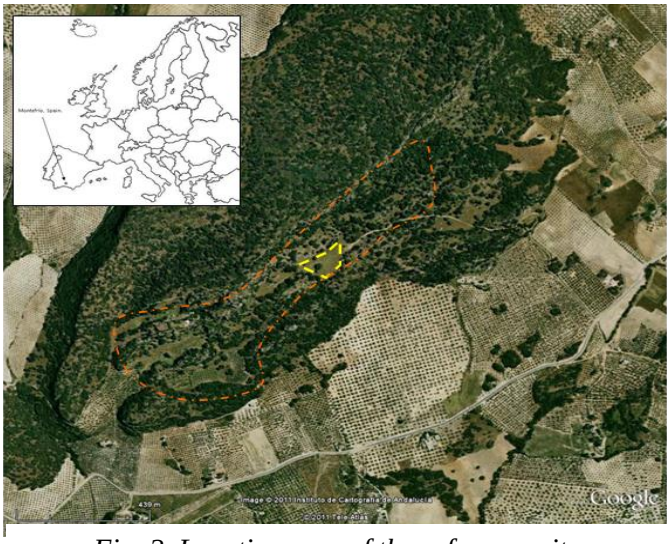

Fig. 2. Location map of the reference site

NB: The archaeological site is delimited by the red line and the sampling area by the yellow one

The two main objectives of this study were: (i) to establish the soil radiometric background (NOR and ^{137}Cs) and physicochemical information in the undisturbed area for future assessment of soil degradation and soil quality in neighbouring cultivated orchards fields, and (ii) to establish a precise reference inventory value of ^{137}Cs fallout to prepare for an investigation to apply this radiotracer method under the Spanish orchard agro-environment to assess the magnitude and extent of soil erosion under this specific type of land use.

Experimental design and results

The site chosen for the investigation was a meadow, surrounded by forest and shrubs, covering 1.5 ha. The sampling points were taken within a pair of perpendicular transects. A total of 13 soil core samples were collected at 12 different depths of 5 cm increments to a maximum depth of 60 cm depth, when possible. However, at several sampling points shallow soil development limited the collection of samples from more than 20 cm depth. A total of 89 soil samples were analysed via γ spectrometry at the SWMCN Laboratory to establish radioactivity levels and to determine the radium equivalent activity in order to compare the specific activity of matrix/material. Complementary physicochemical data were also completed, notably for SOM and texture parameters.

A recurrent problem in past studies using ^{137}Cs as a soil tracer was the inadequate attention paid to the natural variability of initial fallout. The accuracy of the background level was assessed using the following statistical test (Sutherland, 1996):

$$N = \left(\frac{t_{(\alpha,n-1)} \cdot CV}{AE}\right)^2$$

where N is the required number of samples, t is the t value at a 90% confidence level (2 tailed), CV is the coefficient of variation and AE the allowable error.

Using the mean ^{137}Cs areal activity (Bq m^{-2}) levels at each depth interval, the initial ^{137}Cs fallout was evaluated at 1925 ± 252 Bq m^{-2} with a CV of 23% and an AE of 12%.

Furthermore, the undisturbed character of the reference site was confirmed by the vertical profiles of ^{137}Cs and NOR (Fig. 3). The radio-caesium profile highlights a typical distribution of an undisturbed soil, where the top 10 cm accounts for 75% of the total inventory and the top 20 cm for more than 90%. Concerning ^{40}K, ^{232}Th and ^{226}Ra, their relatively constant distribution within the soil layers is typical of a reference site. Their top soil layer (0-5 cm) activity was found to be above world average values but within the worldwide background activity range and determined at 508 ± 11 Bq kg^{-1} (CV=8%), 43 ± 2 Bq kg^{-1} (CV=30%) and 52 ± 3 Bq kg^{-1} (CV=21%) for ^{40}K, ^{226}Ra and ^{232}Th, respectively.

Based on the measurement of the top soil NOR content, the radium equivalent activity (Ra_{eq}) was evaluated at 153 Bq kg^{-1} and the absorbed dose rate (D) at 72 nGy h^{-1}. In this undisturbed soil, developed on a calcareous substratum, ^{232}Th represents the main natural radionuclide contribution to the D value (44%), while ^{40}K and ^{226}Ra contribute at a level of 29% and 27% respectively. The D value is about 30% higher than the global average external exposure rate from terrestrial gamma radiation, established at 57 nGy h^{-1} by UNSCEAR (2000).

The background radionuclide information (^{137}Cs and NOR) established for this undisturbed site will allow a precise assessment of the recent impact of agricultural activities on the magnitude and extent of soil degradation linked to olive tree cultivation in south-eastern Spain.

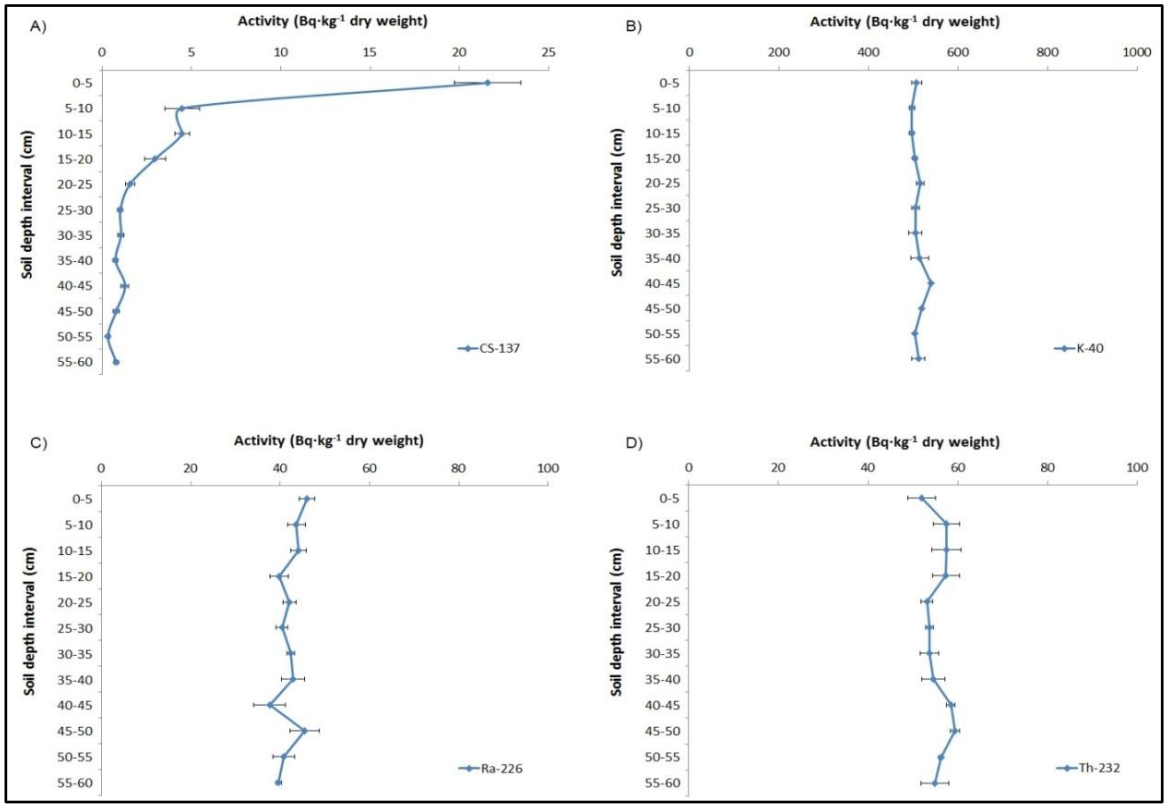

Fig. 3. Vertical distribution of mass activity for ^{137}Cs (A), ^{40}K (B), ^{226}Ra (C) and ^{232}Th (D)
NB: Data are presented as mean ± SE

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Contributions to the IAEA Water Forum on Water Matters: Making a Difference with Nuclear Techniques

Methodology to extract water from soil and plants for stable isotope ratio ($^{18}O/^{16}O$ and $^{2}H/^{1}H$) analyses by CRDS

L. Mayr, M. Aigner, J. L. Arrillaga, L. Heng, S. Linic and J. J. Adu-Gyamfi

As part of the activities supporting the IAEA scientific water forum held from 20-21 September 2011, the SWMCN Subprogramme organized a 4 day display from 12-15 September to raise awareness of the importance of using nuclear methodologies to address water scarcity and saving water in agriculture.

The SWMCN Laboratory in the FAO/IAEA laboratories at Seibersdorf exhibited a vacuum distillation technique, which has been developed to extract water from soil and plant for isotopic analysis by using cavity ring-down spectroscopy (CRDS). This technique greatly simplifies the previously employed low temperature freezing method. In the past, isotopic measurements of water in soil and plant material could only be achieved by a tedious and complicated process involving trapping by low temperature freezing and subsequent analysis by IRMS. During the exhibition, the SWMCN Laboratory demonstrated how water from soil (sand and clay) over a range of moisture levels from field capacity to permanent wilting point and plant samples could be easily extracted and analysed for ^{18}O and ^{2}H using CRDS. Accurate and reproducible results have been obtained for both sand and clay soils (with precision of the CRDS being <0.1‰ for $\delta^{18}O$ and <0.5‰ for $\delta^{2}H$), giving >99% recovery of the soil and plant water. The use of CRDS and the improved water extraction technique greatly enhanced and simplified analytical capabilities to investigate water use efficiency, something that could only be dreamt about a few years ago. Participants in the General Conference and the IAEA scientific water forum were enthusiastic about this simple technique and inquired how it could be adapted for use in Member States (Fig. 4). The methodology is currently being tested using dry ice and an immerse cooler so that it can be adapted to suit Member State facilities.

Fig. 4. A portable vacuum distillation unit on display during (left) and before (right) the IAEA water forum

The SWMCNL also developed a prototype of drip irrigation for display during the IAEA scientific water forum to demonstrate and create awareness of the effectiveness of saving water and improving water use by crops. Many participants to the forum were enthusiastic about adapting this technology with fertilizer application, commonly called fertigation (Fig. 5).

Fig. 5. DDG-NA Mr Daud Mohamad, examines the prototype of irrigation (left). A delegate to the IAEA scientific forum takes a close look at the irrigation prototype (right)

In addition, there was a display on Water Management and Root Development by Crops in Soils. Roots play important roles in capturing and utilizing soil water and nutrients for plant growth. Root development depends on soil type and moisture availability in soils. During the exhibition, root architecture and root development of maize in different soil types under different water regimes was visible in transparent glass tubes. It was demonstrated that roots, which are hidden below ground and invisible, are the key to a second green revolution for improving nutrient and water use efficiency by crops (Fig. 6).

Fig. 6. A display of the root development of maize and soybeans in plastic transparent tubes (left). A staff member of the SWMCNL explains the root development architecture of maize and soybeans to a group of visitors (right)

Analytical services conducted by the SWMCN Laboratory in 2011 (January to October)

Samples measured:

	^{15}N enriched	^{15}N nat. ab.	^{13}C nat. ab.	^{18}O,D nat. ab.	**Total**
CRP	126	137	206	4	**473**
TC	742	-	694	20	**1456**
Seibersdorf	1014	398	1687	276	**3375**
Total	**1882**	**535**	**2587**	**300**	**5304**

Measurements carried out:
(Including standards, blanks, test samples, replicates)

	^{15}N enriched	^{15}N nat. ab.	^{13}C nat. ab.	^{18}O,D nat. ab.	**Total**
CRP	204	245	348	4	**801**
TC	1101	-	1018	32	**2151**
Seibersdorf	1506	838	2745	463	**5552**
Total	**2811**	**1083**	**4111**	**499**[(1)]	**8504**

(1) 247 soil/plant samples have been processed with our new water distillation line for water extraction.

External Quality Assurance

Martina Aigner

The annual proficiency test (PT) on ^{15}N and ^{13}C isotopic abundance in plant materials jointly organized with the University of Wageningen, the Netherlands and funded by the IAEA SWMCN Laboratory, Seibersdorf, was successfully completed. The Wageningen Evaluating Programs for Analytical Laboratories (WEPAL, http://www.wepal.nl) is accredited for the inter-laboratory comparison of analysis by the Dutch Accreditation Council. Ten IAEA funded stable isotope laboratories participated in PT-round IPE 2010.2.

One ^{15}N enriched plant test sample (0.5 to 2.5 atom %, i.e. 370 to 6000 δ ‰ delta per mille) is included in the WEPAL IPE - (*International Plant-Analytical Exchange*) programme every year. A bulk plant material uniformly enriched with ^{15}N was produced by the SWMCNL and sent to WEPAL for milling, homogenization and bottling through the routine test sample production process of PTs. This ^{15}N enriched material was then sent out together with 3 other, non-enriched plant samples. Participants were invited to perform analysis offered in the WEPAL IPE scheme, which includes: ^{15}N (enriched and/or natural abundance level), total N (N-elementary), Kjeldahl-N, ^{13}C and total C (C-elementary). The participation fee for one round of PT in 2010 (round IPE2010.2) was covered by the IAEA.

Participants from ten laboratories that are registered in the PT scheme were provided with the WEPAL test sample set IPE 2010.2 consisting of the four test samples of 20 g plant material (Fig. 7). Test sample no. 3 (WEPAL material code 206) was enriched in ^{15}N and the results of this test sample are evaluated by the SWMCNL in IAEA.

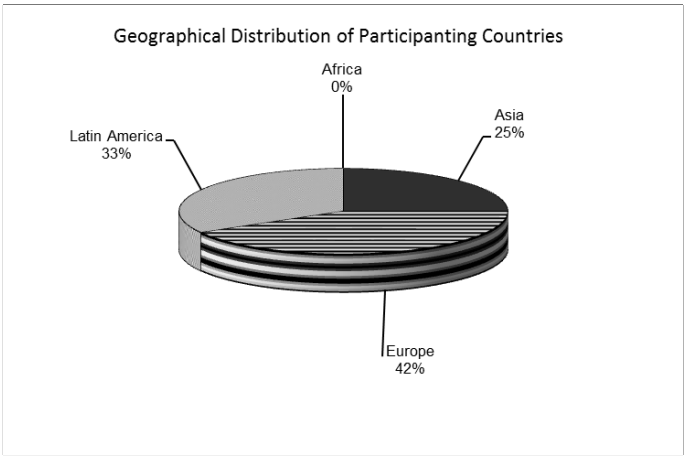

Fig. 7. Geographical distribution of IAEA participants

Seven out of ten laboratories reported acceptable ^{15}N-data and six out of seven laboratories reported ^{13}C data within the control limits. Two ^{15}N data sets were wrongly reported resulting in very high z scores.

The big advantage of comparing analytical data to those of a large and increasing number of analytical laboratories worldwide provides greater confidence in the laboratory's analytical performance and is an invaluable tool for

external quality control. It is hoped that more stable isotope laboratories will make use of this opportunity to assess their analytical performance in the future and provide evidence of the sustainable high quality of their analytical data.

Publications

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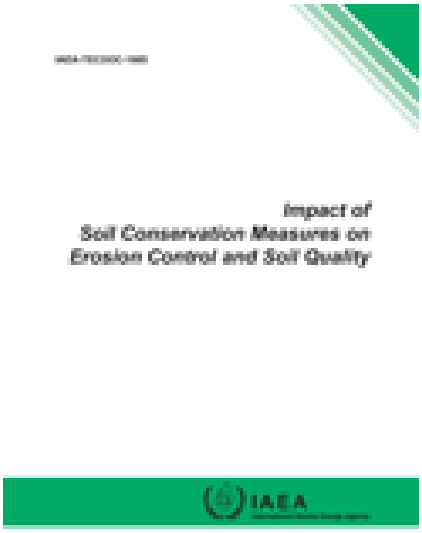
Recently Published



Impact of Soil Conservation Measures on Erosion Control and Soil Quality

IAEA-TECDOC-1665 (ISBN: 978-92-0-113410-3) 18.00 Euro;
Language: English
Date Published: 2011
Responsible Officer/Officers: Mr Gerd Dercon, NAFA

This publication summarises the lessons learnt from a FAO/IAEA coordinated research project (D1.50.08) entitled Assess the Effectiveness of Soil Conservation Measures for Sustainable Watershed Management using Fallout Radionuclides, on the impact of soil conservation measures on erosion control and soil quality over a five year period across a wide geographic area and range of environments. It demonstrates the new trends in the use of fallout radionuclide based techniques as powerful tools to assess the effectiveness of soil conservation measures. As a comprehensive reference material it will support IAEA Member States in the use of these techniques to identify practices that can enhance sustainable agriculture and minimize land degradation.

http://www-pub.iaea.org/books/IAEABooks/8612/Impact-of-Soil-Conservation-Measures-on-Erosion-Control-and-Soil-Quality

Websites

- Soil and Water Management and Crop Nutrition Section: http://www-naweb.iaea.org/nafa/swmn/index.html
- Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture: http://www-naweb.iaea.org/nafa/index.html
- FAO website: http://www.fao.org/about/en/
- FAO/AGL (Land and Water Development Division): http://www.fao.org/nr/water/landandwater_what.html

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