Combating Soil Erosion-Caused Land Degradation in the Asia and the Pacific Region

At the turn of the 20th century, the rapidly growing populations of most countries in the Asia and the Pacific region and the consequent need for greater food production, have imposed increased pressures on land and water resources leading to intensive land use/management over extensive tracts of land. All these changes, combined with burgeoning urban, industrial and transport infrastructures have resulted in widespread degradation of land and water quality through accelerated soil erosion and increased sedimentation, flooding and pollution of downstream water bodies. Furthermore, severe soil erosion and sedimentation problems have been worsened in the region due to improper land use and poor farming practices.

Deforestation and intensive cultivation on steep land led to severe soil erosion in the tropical uplands of Thailand

Soil erosion degrades soil, reduces land productivity, and hence adversely affects overall environmental sustainability. There is a direct contribution from these impacts to food insecurity and to increased malnutrition. The chain of consequences does not end there because malnutrition often results in higher levels of poverty, which may then be a factor for rural migration and social unrest, all of which lead to poor economic development. Implementation of effective soil conservation practices has the potential to contribute substantially to mitigating these problems.

Collection of samples for the assessment of reservoir sedimentation rates in an arid environment in South East Australia using fallout radionuclide techniques

Measuring soil erosion is a key element in designing effective soil conservation strategies. Reliable quantitative data on the actual rates of soil erosion are required so that a more comprehensive assessment of the magnitude of its effects can be conducted. These data can be used for better understanding of the main factors involved in soil erosion/sedimentation and validating new soil erosion/sedimentation prediction models. In addition this information provides a basis for developing scientifically-sound land use policies and selecting effective soil conservation measures and land management strategies, including assessment of their economic and environmental impacts.

Soil erosion research is capital- and labour-intensive as well as time-consuming. Well-designed experiments using standardized methodologies have to be performed to ensure that the data obtained are comparable and representative of the study areas. Existing classical techniques such as erosion plots and surveying methods for monitoring soil erosion are capable of meeting some of these requirements but they have a number of crucial limitations in terms of the representativeness of the data obtained, their spatial resolution, and the potential to provide information on the long-term rates of soil erosion and associated spatial patterns over extended areas, as well as the costs involved. There has been a quest for alternative soil erosion assessment techniques to complement the existing methods and to meet new requirements that have arisen because of the introduction and application of distributed numerical models, the Geographical Information Systems (GIS) and geo-statistics. As a result, attention has been directed to the use of fallout radionuclide techniques and these have proved to be very effective in conducting such measurements.

The RCA Member States, recognizing the benefits of using these nuclear techniques to address soil erosion and related issues, decided to develop the required capabilities through two RCA projects implemented under the IAEA Technical Cooperation programme. These RCA Projects were focused on developing sustainable land and water management strategies for reducing soil erosion and improving soil and water quality in the region. These projects used the latest nuclear-based techniques, namely fallout radionuclides (FRNs). Under the first regional project, implemented from 2001 to 2005, the national teams in participating RCA Member States gained the capacity to conduct soil erosion measurements using the caesium-137 (^{137}Cs) technique. Under the second regional project, implemented from 2005 to 2009, more advanced radioisotopic techniques involving the combined application of caesium-137 (^{137}Cs) with other radionuclides such as lead-210 (^{210}Pb) and beryllium-7 (^{7}Be) were introduced. These techniques were used to investigate soil erosion/redistribution over a range of time scales (from less than one month to up to one hundred years), and to establish the relationship between soil redistribution and soil and water quality.

A major challenge for each participating Member State was the need to form a multi-disciplinary and often inter-institutional team of researchers with complementary skills and expertise in soil erosion research (soil science, soil geography, hydrology, land care/husbandry, agronomy, ecology, soil conservation, etc.) as well as nuclear sciences. In addition basic infrastructure/equipment to perform the required field and laboratory work had to be available. The IAEA assisted developing Member States, as required, in the establishment and strengthening of their human and institutional capacities as these were essential requirements for the successful and effective application of the FRN techniques in soil erosion studies. Laboratory quality control assurance and relevant expert services on the use of FRN techniques were provided for the participating Member States to improve their national capacities.

Learning together the principles of the Fallout Radionuclide techniques for measuring soil erosion and determining the effectiveness of soil conservation measures during the IAEA/RCA Regional Training Workshop in China (Beijing, 2005)

Collection of bulk core soil samples for fallout radionuclide analysis to assess soil erosion and sedimentation rates under different land uses in the Philippines

These RCA's regional projects have made an important scientific and technical contribution to the protection of land and water resources and environmental sustainability in the region. The national teams from the participating Member States have obtained a wealth of valuable information on soil erosion rates in agricultural landscapes and assessed the effectiveness of soil conservation measures through the use of nuclear and related techniques in a wide range of environments of the region.

Combination of soil conservation measures at Yan'an site in the Loess Plateau, China

The techniques are now becoming recognized as essentials tools in land care/management programs, and the number of organizations adopting this nuclear technology continues to grow through the implementation of land development projects. Specifically, FRN capacities of a high technical level have been established in China. As an example, effective soil conservation measures identified by this regional project at Yan'an site (80,000 ha) in the Loess Plateau, China, have substantially reduced soil erosion and project data were used by the Ministry of Soil and Water Resources, China, to establish water quality maps.

Based on the results of this assessment, recommendations were made to the land management practitioners on how to improve their soil conservation policies as well as how to restore land productivity across the region.

Nuclear technology: Fallout Radionuclides (FRNs) as tracers in soil erosion studies

In soil erosion and sedimentation investigations, work has been focused on the use of a particular group of environmental radionuclides, namely fallout radionuclides, which include caesium-137 (^{137}Cs), excess lead-210 ($^{210}Pb_{ex}$), and beryllium-7 (^{7}Be). These radionuclide techniques, in combination with classical methods, are very effective tools to complement and meet new methodological requirements in the assessment of soil erosion and the evaluation of the efficiency of soil conservation practices.

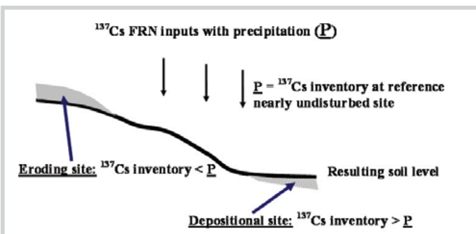

Diagram illustrating the application of the ^{137}Cs method to study soil erosion and deposition within a landscape

The basic principles for the application of these FRNs in soil erosion and sedimentation studies are similar. The fallout input of these natural (^{7}Be and ^{210}Pb) and artificial (^{137}Cs) radionuclides from the atmosphere to the land surface occurs through wet (rainfall) and dry (wind) deposition. It is assumed to be spatially uniform, at least over a relatively small area. Once these radionuclides are deposited, they are rapidly and strongly adsorbed by fine soil particles (clay and humus) and accumulate at or near the soil surface. Documenting the subsequent redistribution of the FRN tracers, as they move across the landscape in association with soil or sediment particles, primarily through physical processes, affords a very effective tool for measuring erosion and deposition by water, wind and tillage within agricultural landscapes. The resultant soil redistribution data (soil and sedimentation rates and patterns) represent an integrated measurement of all effects leading to soil redistribution and occurring during the period extending from the time of the main input from the atmosphere to the time of sampling. When using several radionuclides, soil redistribution data over different time scales (from less than one month with ^{7}Be to up to fifty and one hundred years with ^{137}Cs and $^{210}Pb_{ex}$ respectively) can be obtained using a single sampling campaign, thereby avoiding the time-consuming and costly installations and procedures commonly required by the non-nuclear methods to monitor study sites over extended periods of time.

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