How to win the fight against soil erosion: saving fertile land and preserving water quality with the help of nuclear techniques

By Nicole Jawerth and Miklos Gaspar

Erosion eats away at fertile land, threatening food production and farmers' income alike. The top layer of the soil, which is the first to go, is the most nutritious. Often this nutritious soil ends up in rivers and lakes where it encourages algae to grow, causing the amount of oxygen in the water to decrease. This in turn compromises water quality and harms fish populations.

Nuclear techniques can help scientists and farmers find erosion hot spots and identify the right soil conservation technique to save both farmland and fresh water sources (see The Science box on page 17). The IAEA, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), provides support to 70 countries on erosion research. This article profiles two of them: Morocco, where the focus is on saving agricultural land, and Myanmar, where they are fighting off an algae boom in the country's second largest lake.

Saving farmland in Morocco

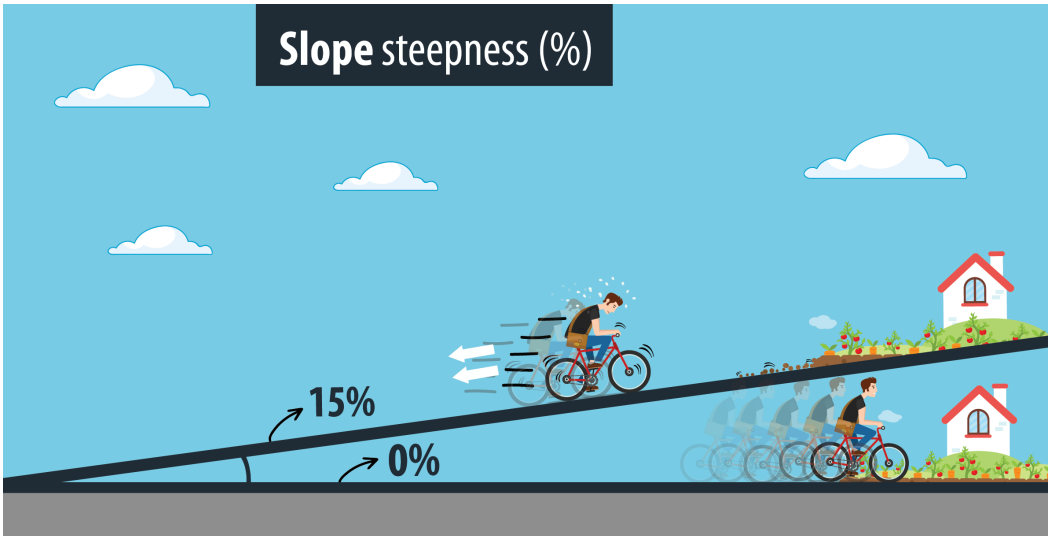
Farmer El Haj Abdeslam's son drives a tractor to help with the farm work while scientists take soil samples from the fields.
(Photo: R. Moussadek/INRA)

Farmer El Haj Abdeslam and his three helpers spent years fighting soil erosion that swept away their crops' fertile ground, taking their incomes with it.

"Year after year, soil erosion was making the quality of my land worse and that made my farm less productive," said Abdeslam, whose 5-hectare chickpea and cereal farm feeds his family of seven and is his sole source of income. "Since the scientists helped me conserve my soil, my farm has been producing 20 to 30% more with less input, and my income has gone up."

The scientists used fallout radionuclides and compound-specific stable isotope techniques (see The Science box on page 17) to pinpoint erosion-prone areas and evaluate the effectiveness of various conservation methods. The technique was introduced in response to Morocco's more than 100 million tonnes of soil losses each year.

"Once we knew where the erosion hotspots were, we tested several soil-conservation methods using nuclear techniques to see how we could improve the situation. We adapted and combined different conservation methods



On a 15% slope, the soil has to withstand a much greater source of gravity.
(Graphic: F. Nassif/IAEA)

already in use worldwide to see what worked best under Morocco's environmental and agricultural conditions," said Moncef Benmansour, Head of the Division of Water, Soil and Climate at the National Centre for Nuclear Energy, Science and Techniques (CNESTEN).

Over 40% of Morocco's total land area suffers from soil erosion owing to deforestation, overgrazing by animals and poor planting techniques. This is compounded by harsh climate conditions such as long periods of drought and short periods of intense rain. The steep ridges carved into the country's landscape make the situation worse for the land and the farmers.

Abdeslam's farm, for example, is on a sharp 10–15% slope. This means, the soil can be more easily washed away by rainfall, especially the fertile top soil (see infographic).

The new conservation method combines growing cereal crops using no-till land management with growing fruit trees and shrub strips. No-till helps to leave the soil undisturbed instead of the digging or stirring of the soil associated with tilling. The roots and leftover parts such as stems and leaves from the selected plants improve the soil structure and overall soil health, which helps hold the soil in place on steep hills.

"We have now reduced soil loss in the Tangier-Tétouan region by 40% and by around 60% in the Casablanca-Settat region," Benmansour said. "The Ministry of Agriculture and the High Commission for Water and Forests and the Fight against Desertification are using the project results and methods to expand soil-conservation efforts to more farmers throughout the country."

Scientists taking a soil sample during the study of erosion hot spots, using nuclear techniques.
(Photo: INRA)

Preserving Myanmar's Inle Lake

The water quality of beautiful Inle Lake in central Myanmar is under threat as a result of erosion on the neighbouring hillsides.
(Photo: M. Gaspar/IAEA)

Tens of thousands of people depend on Inle Lake in central Myanmar for their drinking water and livelihood, but erosion on neighbouring hillsides is causing soil accumulation in the lake, threatening its water quality and fragile ecosystem. A study using nuclear techniques has identified the exact sources of the soil erosion in the valley of the Kalaw river that feeds the lake, which has seen a lot of deforestation in the last few decades. This study has enabled local forestry officials to target their conservation efforts in the areas most susceptible to erosion.

Conservation methods and the use of the new data to educate local people about the consequences of illegal logging and the increased use of the lake as a floating vegetable garden will help save Inle, said U Sein Tun, park warden at the Forest Department in Nyaungshwe, the biggest town on the lake.

The erosion site in the Kalaw watershed. Much of the soil missing from the hillside ended up in Inle Lake.
(Photo: M. Gaspar/IAEA)

The erosion research, which was completed in 2017, was carried out by Myanmar's Forest Research Institute and supported by the IAEA, in cooperation with the FAO. The project was partly funded through the Peaceful Uses Initiative.

The research uses two nuclear techniques to characterize how the soil accumulates and moves as well as to identify its origin and areas prone to soil degradation (see The Science box). The results revealed how, in the Kalaw watershed, each hectare of land that lost its forest cover 15 years ago has also lost 26 tonnes of soil every year since, said Cho Cho Win, the research officer who headed the study. For land that was deforested and cultivated 40 years ago, the soil loss has been 40 tonnes per hectare per year. "By contrast,

on comparable areas where the forest cover was left intact, there has been no erosion whatsoever," she said.

Significant soil losses on the upper slopes and soil accumulation at lower locations, closer to the lake, were noted. This indicates that significant sediment discharges into the lake continue to occur, Cho Win said.

Reversing the environmental degradation of Inle Lake brought about by soil erosion is a key objective not only of the local forestry office but also of the regional Government of Shan State, Sein Tun said. Chief Minister of Shan State Government, Linn Htut, has agreed to head the commission that is tasked with improving the condition of the lake. "The research by Ms Cho Cho Win is an important contribution to our efforts," Tun said.

These efforts will also help to protect the lake's diverse and unique habitat, which was internationally recognized in 2015 when the United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the lake a World Biosphere Reserve. "This title gives us additional responsibilities: the lake is part not only of our heritage, but also of world heritage now," Tun said.

Erosion researcher Cho Cho Win and a local forestry official looking at erosion sites around Inle Lake. (Photo: M. Gaspar/IAEA)

THE SCIENCE

Fallout radionuclides and the compound-specific stable isotope technique

Fallout radionuclides (FRNs) are present in the atmosphere and are deposited on the soil surface through rain.

They bind with soil particles and are concentrated mainly in the top soil layer. They are strongly fixed to soil particles and are not taken up by plants. During erosion and deposition processes, they move with the soil particles and can be used to trace soil redistribution over large areas and extended periods of time. When the top soil layer is eroded, the concentration of FRNs goes down, which scientists can track and measure using gamma spectrometry. Their analysis can help identify changes in soil-redistribution patterns and rates in large catchment areas. They can also evaluate the efficiency of soil-conservation measures in controlling soil erosion. The three commonly used fallout radionuclides for soil erosion tracking are caesium-137, lead-210 and beryllium-7, with caesium-137 being the most common.

Compound-specific stable isotope techniques involve measuring stable isotopes like carbon-13 found in specific, soil-bound organic compounds such as fatty acids. The fatty acids originate from plant roots, animal waste and other remains found in natural ecosystems, which break down and become part of the soil's organic matter. These compounds have unique stable isotope signatures, almost like fingerprints. As the composition of carbon-13 is unique for each compound, a carbon-13 analysis reveals the origin of the eroded soil. By linking carbon-13 fingerprints of land use to the sediment in deposition zones, the technique is useful in determining the sources of eroded soil and in identifying areas prone to soil degradation, enabling authorities to prioritize soil conservation in areas most prone to erosion.