Human activities boosted global soil erosion already 4,000 years ago

October 29 2019

Erosion caused by agriculture is a major cause of land degradation. Credit: Rick Bohn / United States Fish and Wildlife Service (USFWS)

Soil erosion reduces the productivity of ecosystems, it changes nutrient cycles and it thus directly impacts climate and society. A team of

researchers recorded temporal changes of soil erosion by analyzing sediment deposits in more than 600 lakes worldwide. The scientists found that the accumulation of lake sediments increased significantly on a global scale around 4,000 years ago. At the same time, tree cover decreased as shown by pollen records, which is a clear indicator of deforestation. The study suggests that human practices and land use-change have intensified soil erosion long before industrialization.

Soils are the foundation for almost all biological processes on the Earth's land surface. On millennial time scales, their weathering and erosion is controlled mainly by climatic and tectonic impacts. In the short term and at smaller local scales, anthropogenic activities are the main drivers of soil erosion. It remained unclear, however, if soil erosion caused by humans has an impact on the global scale as well.

To address this question, a team of international scientists led by French geoscientist Jean-Philippe Jenny from Max Planck Institute for Biogeochemistry, Jena, Germany, and CARRTEL Limnology Center, Thonon-les-Bains, France, looked back in time regarding soil erosion. They investigated drill cores of sediments from 632 lakes worldwide, which had been collected by pollen scientists during the last decades. "Lake sediments are considered natural archives of erosion activities. All fluxes and processes removing soil, rock and dissolved materials result in chronological sediment layers that are accumulated and preserved at the bottom of the lakes", says Dr. Jenny.

Using 14C radiocarbon measurements, the scientists dated the age of lake sediment layers and the sediment accumulation rates. "Surprisingly, 35% of the 632 lakes analyzed showed an increasing sediment accumulation approximately 4,000 years ago", says Dr. Nuno Carvalhais, group leader at Max Planck Institute for Biogeochemistry and supervisor of the study.

When searching for potential causes of this increased sedimentation, the researchers analyzed pollen fossils recorded in the databases, in order to reconstruct land cover changes in the lake watersheds. "We were exited to find that increased sediment accumulation 4,000 years ago coincided with a reduction of arboreal pollen derived from trees," says Dr. Jenny. "The tree pollen decrease reflects land-cover changes, in particular land clearances, e.g., for agriculture and settlement, that in turn are likely to lead to soil degradation and erosion."

Further statistical analyses supported the notion that land cover change was the main driver of globally accelerated sediment accumulation in lakes, which is the proxy for soil erosion.

Looking closer at their data, the researchers also found other exiting connections: On a regional level, changes in sediment accumulation seem to correlate with historical socio-economic developments during human settlements. For example, the increase of soil erosion started later in North America than in Europe. This increase likely corresponds to the delayed introduction of European agricultural practices in North America following colonization. On the contrary, the decrease of soil erosion in 23% of sites is likely associated with increased water use and river management practices, especially in the Roman and Chinese empires 3,000 years ago.

Collectively, this study suggests that the change in tree abundance in lake catchments has long been the leading factor driving soil erosion. Furthermore, anthropogenic deforestation explains the accelerated soil erosion during the last four millenia. "Well before the more recent and abrupt influences by greenhouse gas emissions, human activities must have influenced the global environment already 4,000 years ago," says Dr. Jenny, who led the research project at Max Planck Institute for Biogeochemistry as a fellow funded by the AXA research foundation.

More information: Jean-Philippe Jenny et al. Human and climate global-scale imprint on sediment transfer during the Holocene, *Proceedings of the National Academy of Sciences* (2019). DOI: 10.1073/pnas.1908179116

Provided by Max Planck Society