Num.7-2016-Art.6 | Quantification of soil losses due to erosion, pollution and urbanization

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Soil deterioration includes both natural and man-made events, the latter usually known as "soil degradation". This process causes a lowering of the actual or potential capacity of soil to give rise to products or services. Hereafter only events of anthropic origin are dealt with. Soil is a complex ecosystem formed by four phases: skeleton, gases, water and biophase. The latter gives the soil the trait of a living organism, as it is formed by a variety of microbes, micro- and meso-fauna.

The microbial community represents a relevant component by weight: one hectare of land of 25 cm depth, weighing 3,000 t with 1.5 % organic matter (the majority of European agricultural soils are below 2% o.m.), contains up to 3 t of microbes, i.e. 109 microbial cells belonging to up 2,000 different taxa. In other words, one gram of soil is a huge biochemical library producing a variety of genetic instructions, present on the earth for 4 billion years. In one gram of soil there is enough DNA for 1,598 km. The microbes in bulk soil and around the roots (i.e. the rhizosphere) are almost never alone, rather they are present in micro-colonies or micro-aggregates, never mono-specific, rather in microbial multi-specific consortia. These play the following roles in ecosystems: (a) maintain active biogeochemical cycles, (b) interact tightly or loosely with plant root canopy, ensuring plant nutrition and plant health, (c) maintain soil functional biodiversity, i.e. the capacity to perform the physiological functions irrespective of their taxon.

If an environmental stress (e.g. anoxia, pesticides) causes the inhibition or slowdown of one component of a functional group (e.g. ammonia oxidizers or lignocellulose degraders), another component, belonging to a different taxon, will replace the functions of the former and the overall biogeochemical function (e.g. ammonia oxidation or lignocellulose turnover) will go on. However, the limiting factor of the above soil functional biodiversity is the content of organic matter, namely ca. 1.75 % or organic carbon corresponding to ca 3.5% organic matter. Below this threshold the environmental stress (pH variations, inorganic fertilizations, pesticides, anoxia etc.) compromising one or more functions cannot be compensated, unless significant, biologically active, organic matter is delivered to restore its o.m. content to above 3.5%.

The fundamental role of biodiversity for the maintenance of our quality of life on the Earth is highlighted by the United Nations: “Biodiversity, including the number, abundance, and composition of genotypes, populations, species, functional types, communities, and landscape units, strongly influences the provision of ecosystem services and therefore human well-being”. Anthropogenic soil losses have been recognized for more than four decades (Fig.1).

Fig 1. An example of soil erosion affecting an agricultural hilly soil.
Photo: Tim McCabe, NRCS NRCSWA84007
http://whyfiles.org/2011/soil-key-to-solving-the-food-crisi

s/

Early in the 70’s the OECD and EEC affiliated member States already warned that “Loss of productive soil is one of the most pressing and difficult problems facing the future of mankind “. Annual losses through erosion were 0.3% of total areas in the emerging Countries and 30% of ploughing layer was affected by degradation in USA in the last 200 years, along with yield decreases and subsequent need for higher energy inputs in agriculture. As much as 40 years ago, due to increases in salinity and alkalization, 200-300.000 ha/y were lost in industrialized countries, while 0.3% of irrigated land was lost in developing countries. Because of urbanization 0.1-0.8% of soil was lost annually in OECD Countries (1 million ha just in the USA).

Twenty years later, the European Environmental Agency listed as soils affected by degradation (in million ha): 115 due to erosion, 42 due to wind, 85 due to acidification, 180 due to pesticide pollution, 170 due to nitrates and phosphates pollution, 33 for compaction, 3.2 for organic matter loss, 3.8 for salinization, 0.8 for waterlogging/anoxia.

A few years later, aiming at contrasting progressive soil losses, the European Commission officially listed the following causes: erosion, pollution (localized and diffuse), salinization/alkalization, decrease of organic matter content (today 84% of agricultural soils in EU are below the threshold of 3.5%), cementification and overbuilding, flooding, compaction, and loss of soil biodiversity (Tab.1).

In Ecuador, 48 % of its soils is affected by soil erosion, and 7 stations have been installed since the 80’s (in the Interandean basin, slopes of the cordillera, coastal and agroforestry regions) for monitoring purposes (Fig 2, 3)..

Fig 2. Soil erosion in Ecuador

The major role in soil degradation is exerted by agriculture (inappropriate management, intensive practices, higher specialization and monoculture, insufficient or excessive usage of fertilizers/pesticides, compaction due to overgrazing, unbalanced decline of organic matter, loss of biodiversity).

Household activities can cause soil erosion through deforestation (for household heating and cooking), excessive silage, and timber overcutting. All (bio)industrial activities (power, heat, mining, waste recycling, infrastructures etc.) cause soil pollution, salinization, and/or cementification.

Urbanization causes land losses for residential purposes, tourism infrastructure and transport chains cause soil cementification and pollution, landslides and flooding, and habitat fragmentation. In the EU a map (PESERA Map, Pan-European Soil Erosion Risk Assessment) has been developed, identifying the annual soil losses between 1 and 50 t per ha: Italy is in pole position (often losses are 20-50 t x ha), along with the Pyrenees region and Greece, although a lower rate of soil degradation is a diffuse event in EU. In Countries where there is a low soil formation speed, any annual soil loss higher than 1 t per ha must be seen as irreversible in a 50-100 year span without recovery measures.

Annual direct and indirect costs of soil losses in EU are impressive (billion euros): 7.3 due to erosion, 3.4-5.6 due to organic matter decline, 0.15-032 due to salinization, 0.01-06 due to landslides, and 0.2 due to pollution. There is another relevant consequence of the carbon dynamics at geo-climatic level: C sequestration and C sinks might help in contrasting GHG emission in the atmosphere. Considering 1 ha of agricultural land at 33.5 cm depth, with a density of 1.4 t/ m3 , the soil mass will be ca. 4.700 t; if this soil contains 1% organic matter, i.e.47 t, there will be ca. 25 t of C sequestered in the soil, particularly in the humic fraction (degradable in about 100 years).

About 200,000 Hectares of forests are harvested each year in Ecuador to serve the demand of local and international markets, while only about 5000 Hectares are replanted.

But if the organic matter is brought back to 4% (i.e. above the threshold for maintaining the soil functional biodiversity, as it was for most agricultural soils a century ago) we will have 100 t of C sequestered in soil. At the global level, it should be made clear that carbon sequestered in plants is 650 Gt, in the atmosphere is 750 Gt, but in soil it accounts for 1500 Gt. It is highly possible that in the next 30 years only soils will be able to immobilize significant amounts of carbon and therefore reduce the actual levels of CO2.

Alternative strategies require more than 30 years to capture amounts of CO2 relevant to counteract climatic changes. Maybe this is the reason why we have begun talking about “regenerative agriculture” and “regenerative soils” as an approach of true eco-sustainable agriculture at the global level. This would certainly help in implementing the year 2015 as the International Soil Year, according to the Resolution of the 38th General Assembly of United Nations on December 2nd 2013, following the Resolutions of FAO n. 4/2013 e n. 5/2013 adopted on June 22nd 2013.

Fig 3. Erosion in Ecuador.
Fuente:

http://ecuadorianrivers.org/projects/