Science of the Total Environment 644 (2018) 830–834

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Editorial

# Human impacts on soil

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GRAPHICAL ABSTRACT


ARTICLE INFO

*Article history:*
Received 28 June 2018
Accepted 30 June 2018
Available online xxxx

## 1. Background

World population ranged from 1 billion in 1820 to 7 billion in 2012 (CIA, 2017), and it is expected to reach 10 billion by 2056. With an exponential population growth, the need for food, clean water, energy and biofuels has been rising substantially. In 2030, the population supply will require an increase in food production and clean water supply by 50% and 30%, respectively. This increase will induce a tremendous pressure on soil and water resources (UN, 2017).

Soil supports all the earth system, including hydrological and geochemical processes, and provides several ecosystem services (ES) (e.g. Pereira et al., 2018a). Soil affords 90% of all food, feed and fibre production, and it provides raw material for several human activities (EEA, 2017). It provides numerous regulation services, such as water storage and purification (Rakshit et al., 2017), climate change regulation, since it is the second global carbon sink (Paleari, 2017), and nutrient cycling. Soil supports biodiversity and comprises the largest number of species (Brevik et al., 2016).

The intensified use of ES provided by soils and unsustainable human activities have resulted in land degradation, and this trend is expected to continue (Paleari, 2017). According to Rakshit et al. (2017), 33% of

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https://doi.org/10.1016/j.scitotenv.2018.06.391

the global land area is degraded. In 2008, there were approximately 1.38 billion hectares of arable land worldwide (FAO, 2010) and up to 5 million hectares are lost every year because of degradation (Jónsson et al., 2016). Soil degradation affects more than 1.5 billion people in 110 countries, 90% of which live in low-income countries (Nellemann et al., 2009).

Soil degradation may assume different forms, such as physical, chemical and biological degradation, and leads to several environmental, social and economic problems, such as desertification and loss of biodiversity (e.g. Rakshit et al., 2017). In the EU, for example, 1) artificial surfaces increased 8.8% between 1990 and 2006, and approximately half of these surfaces are sealed (Stolte et al., 2016); 2) soil erosion by water is 1.6 times greater than soil formation rate (Panagos et al., 2015); 3) 342 thousand contaminated sites identified and 2.5 million are potentially contaminated (Panagos et al., 2013). Nowadays, more than 700 emerging pollutants (synthetic or naturally occurring chemicals or microorganisms), their metabolites and transformation products, are present in the European environment (Dulio et al., 2018).

The European Commission identified several soil threats: 1) erosion; 2) decline in organic matter (OM); 3) soil contamination; 4) soil sealing; 5) soil compaction; 6) decline in soil biodiversity; 7) salinization; 8) floods and 9) landslides (European Commission, 2006). These threats are a consequence of human activities such as urbanization, intensive agriculture and disturbances in forest environments, identified as major causes of degradation (Jónsson et al., 2016; Ferreira et al., 2018a).

Soils often react slowly to changes in land use (e.g. urbanization), land-use intensity (e.g. monoculture agricultural practices) and management (Bünemanna et al., 2018). Thus, it is more difficult to detect changes in soil health and quality before non-reversible damages have occurred comparing with water and air resources (Nortcliff, 2002). Since soil is a non-renewable resource at the human time-scale (Rakshit et al., 2017), major concerns have been rising over the last decades as a consequence of increasing urbanization and agriculture intensification. Most of the strategies recently adopted by the EU in different environmental policy areas highlight that soil preservation is a prerequisite to accomplish some of the Sustainable Development Goals (Keesstra et al., 2016; Paleari, 2017). Soils are relevant to fulfill, particularly, food security (goal 2: zero hunger), water security (goal 6: clean water and sanitation), lives and livelihoods (goal 11: sustainable cities and communities) and healthy ecosystems (goal 15: life on land) (UN, 2015). The need to ensure a sustainable use of soils and protect their functions have been expressed by the European Commission, through the Seventh Environment Action Programme (EP and Council, 2002) and the Proposal for a Directive to establish a framework for the protection of soil (EC, 2006). The United Nations has declared the period of 2015–2024 as International Decade of Soils to enforce the importance of soil as a resource (Rakshit et al., 2017).

## 2. Major soil threats in different land uses

### 2.1. Deforestation

Deforestation is one of the major causes of soil and land degradation. Between 1990 and 2015 forest area declined 4.1 billion hectares (FAO, 2016). This decrease is inverse to human population increase, denoting a reduction in per capita forest area. This was especially observed in the countries with low income. The forest area reduction is mainly due to the expansion of agriculture land. However, there was an increase in the total area of planted forests (FAO, 2016). The plantation of flammable monocultures (e.g. *Eucalyptus*, *Pinus*) for industrial purposes are responsible for an important decline on biodiversity and habitat loss, and increase the vulnerability to pest, diseases and wildfires, expected to be more frequent and severe in a context of climate change. Reduced biological diversity is a major cause of declining ES provide by forests (Brockerhoff et al., 2017; Farah et al., 2017; Neuer and Knoke, 2017; Shuler et al., 2017; Pereira et al., 2018b). Changes in wildfires regime are one of the most evident consequences of forest monoculture, associated with increasing severity and length of dry periods. The frequency of high severity fires, burning several hectares (megafires), is increasing as a consequence of the complex interaction between climate change, land abandonment, land use change and suppression measures (Pereira et al., 2016; Ubeda et al., 2018). Good examples of the impacts of megafires were recorded in the summer of 2017, in Portugal and California.

Although fires are a natural element of the ecosystems and affect earth's biomes since the Sillurian, fire regime was tremendously affected by human activities throughout the history. Nowadays, most of the wildfires that occur in the world are driven by criminal actions or negligence. In this case, human land management or activities influence directly or indirectly the impacts of fire on soils (Pereira et al., 2016, 2018b).

On the other hand, low severity fires, such as prescribed fires applied for landscape management, do not have or have minor negative impacts on soils and can be beneficial since they can increase temporarily soil nutrients (Shakesby et al., 2015; Alcaniz et al., 2018). High severity wildfires have direct negative impacts on soil by consuming enormous amounts of soil OM, reducing the soil cover (Pereira et al., 2018b). All these factors will contribute to soil degradation. This is especially relevant in areas where fire incidence is high, reducing the capacity of soil to recover from wildfire disturbance, with negative consequences on soil quality (Mayor et al., 2016) and vegetation recovery (Tessler et al., 2016). The impacts of high severity fires on soil degradation are complex and depend on fire history, ash properties, topography, post-fire weather, vegetation recovery and post-fire management. Post-fire management options, can mitigate or increase the impacts of wildfire. Post-fire interventions to protect the soil, such as mulching, have been well reported to reduce the negative impacts on soil degradation. On the other hand, salvage logging and site preparation have extremely negative impacts on soil, increasing substantially the disturbance produced by the fire. In many cases, the human intervention has more detrimental impacts on soil than the wildfire (Waggenbrenner et al., 2015; Pereira et al., 2018b).

### 2.2. Agriculture

Worldwide agriculture area is estimated at 4600 million ha, and from this, around 30–35% is cultivated for crops (Montanarella and Vargas, 2012). Agriculture intensification is a response to the increasing food demand and it is a cause of soil degradation, leading to temporary or persistent loss of productive capacity (Arif et al., 2018). Research mostly deals with individual degradation processes (e.g. erosion, compaction, salinization), with a lack of general overview of the full problem (Bednář and Šarapatka, 2018). The impacts of modern agriculture practices are still not well assessed, since they differ according to crops, operations, cropping sequences and soil type (e.g. Squire et al., 2015). Although physical and chemical soil degradation has been relatively well investigated, the impacts of intensive soil management on soil microbiology are not so well understood. Microbial community structure has an important role, for example, on soil organic matter dynamics and nutrient cycling (Li et al., 2018). Soil enzyme activity is a more vital contributor to soil quality than soil nutrients (Thies and Rilling, 2009).

About 24 billion tons of topsoil is lost annually on Earth (Montanarella and Vargas, 2012), covering an area of 20–50,000 $km^2$, with losses two to six times higher in Africa, Latin America and Asia than in North America and Europe (UNEP, 2012). Soil erosion in Africa provides a mean annual loss of 8.2% on yield production, and 36 million tons of cereal equivalent in south Asia. Estimated annual cost of erosion reaches US$400 billion worldwide and US$44 billion in USA (Eswaran et al., 2001).

Soil compaction in agricultural areas is a worldwide problem, as a consequence of mechanization and livestock trampling. It can cause