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Culture and horticulture: Protecting soil quality in urban gardening

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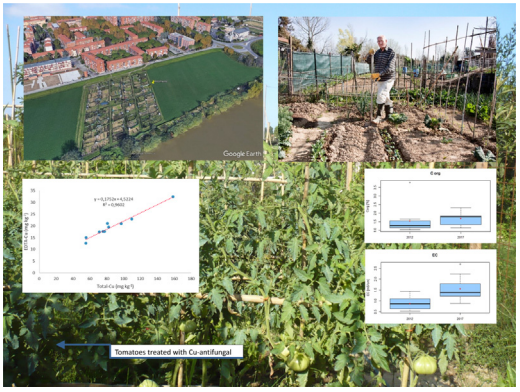
HIGHLIGHTS

- Urban cultivation for food production was investigated for soil quality.
- We surveyed the changes in soil properties of ten allotments after five years.
- The gardeners' identikit revealed their cultural background, and horticultural practices.
- Electrical conductivity, organic carbon and copper increased unevenly.
- Awareness of sustainable practices can contribute to protecting urban soil quality.

GRAPHICAL ABSTRACT



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ABSTRACT

Urban cultivation for food production is of growing importance. The quality of urban soil can be improved by tillage and the incorporation of organic matter, or can be degraded by chemical treatments. Urban gardeners have a role in this process, through the selection of various cultivation techniques. Our study focuses on an allotment area in the town of Pisa (Italy), which since 1995 has been run as a municipal vegetable garden by the residents. We analysed the soil and compared the data with those collected five years previously, to verify the possible changes in soil properties and fertility. We also interviewed the gardeners regarding their backgrounds, motivations and cultivation practices. We looked for possible changes in the soil quality attributable to the cultivation techniques. We found that the allotment holders influenced the soil quality through the cultivation techniques. Organic carbon, electrical conductivity and the content of copper increased unevenly in relation to the gardeners' cultivation practices. At the same time the study highlights that the urban gardeners were not completely aware of how to protect and enhance the fertility and the quality of urban soil. We believe that town councils should be responsible for providing correct information to the allotment holders and thus prevent the possible misuse of urban soil to grow food, as this can affect everyone's health.

1. Introduction

Urban food production has become a major topic in environmental and social sciences (Egerer et al., 2018). On the one hand the cultivation of food in urban areas can increase food security (Lal, 2017) and access

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to nutritious food, which is lacking for the poor in urban society (Gerster-Bentaya, 2013). On the other, because of urban pollution, the safety of consuming food grown in cities is a concern. Studies have investigated the contamination of vegetables grown in cities, due to soil pollution, mainly trace metals, as they are persistent and accumulate in the soil (Alloway, 2004; Hough et al., 2004; Béchet et al., 2016). The past land use (industrial, agricultural, military) can contribute to the pollution of urban soils (Hursthouse and Leitao, 2016). The translocation of metals from soil to edible parts of vegetables is negligible if the soil properties, such as pH, organic matter, texture, do not allow the mobility of metals (Sipter et al., 2008; Weeks et al., 2007; Bretzel and Calderisi, 2011). As the major sources of trace metals in cities are traffic and industries, the contamination of home-grown vegetables comes directly from the atmosphere (Amato-Lourenco et al., 2017). To tackle the pollution of home-grown vegetables, guidelines have been proposed in a recent COST action (Bell et al., 2016) indicating a series of management techniques, such as the isolation of the allotment area from atmospheric sources of pollution (i.e. traffic), the careful cleaning of produce, and cultivation in raised beds. These guidelines are intended for the widest public access, thus they can be downloaded for free from the web (Urban Allotment Gardens in European Cities - Future, Challenges and Lessons Learned, http://www.urbanallotments.eu/fact-sheets.html).

Planners regard urban farming, vegetable gardens, and rooftop agriculture as new forms of urban greening, thus involving citizens and improving the liveability of cities (Tappert et al., 2018). Nevertheless, at an institutional level, urban agriculture is not taken into consideration, as it does not produce an income; which results in poor services, and no training for technicians and gardeners. Moreover, municipalities tend to allocate neglected land to urban allotments that does not have much fruitful potential (Gerster-Bentaya, 2013). This often means that the physical and chemical quality of the soil is lacking. However, the role of urban farmers or gardeners is fundamental, as they can contribute to improving the quality of the soil if they are aware of the cultivation techniques required (Edmondson et al., 2014). Conversely, they can accelerate the degradation process, if they try to compensate for the lack of nutrients by the overuse of chemicals (Bretzel et al., 2016), at the same time posing a threat to their health. In any case "examining variability within local soil management systems is crucial to understanding anthropogenic impacts on soil dynamics" (Engel-Di Mauro, 2003).

People's reasons for cultivating allotments have changed through time and space, mainly in relation to historical and economic situations. Allotments became more important during war periods when they were mainly cultivated as a source of food, as happened in England and Wales (Thorpe Report, 1967). After the 1970s in northern Europe there was a revival in the cultivation of allotments, as social aspects primarily motivated most plot holders (Acton, 2011). Although there has been recent interest in Mediterranean Europe (Italy, Spain Greece), citizens of these countries have in fact cultivated vegetable gardens in cities for centuries. For example, in the Middle Ages, outside and inside the city walls of Pisa, many vegetable gardens flourished (Fischer, 1998), while during the long and drawn-out sieges, in cities across Europe the cultivation of food was the only way to avoid death from hunger. Today in low-income countries, often in the southern regions of the world, urban agriculture contributes to reducing poverty and improving food security (Mkwambisi et al., 2011; Poulsen et al., 2015). However, urban agriculture today is multi-faceted, involving socio-environmental justice (Tornaghi, 2017) and the fulfilment of ecosystem services (Langemeyer et al., 2016; Breuste and Artmann, 2014).

Although many papers have studied the soils of urban allotment, and others have studied the gardeners' profiles, very few have interviewed the gardeners in relation to the impact of the management practices on the modifications of the soil properties (Engel-di Mauro, 2003; Egerer et al., 2018; Tresch et al., 2018).

Our aim was thus to verify whether the motivation for gardening, which depends on a social, economic and cultural background of the garden holders, affects the soil quality. For example, in a previous work (Bretzel et al., 2016) we found that inappropriate anti-fungi treatments resulted in an excess of copper in the soil. In the present work, we studied an allotment area in the town of Pisa (Italy), which had been investigated five years previously (Bretzel et al., 2016). The initial holders were retired people, factory workers, living in the neighbourhood. Recently new social groups including young people and immigrants have requested an allotment. Thus, 2012 as the starting time (Bretzel et al., 2016), after five years (i.e. in 2017) the cultivation choices should have shown their effect on the soil properties, and reveal to what extent changes have occurred.

The aim of our study was to evaluate to what extent and how human actions can affect the quality of allotment soil. We thus compared the properties of the allotment soil in two different periods, 2012 and 2017, in relation to the management techniques, as revealed by interviews with the allotment holders.

2. Materials and methods

2.1. Site description

The study area is located in Pisa, Italy (90,000 inhabitants). The climate is warm and temperate, the average annual air temperature is 14.3 °C and the average annual rainfall is 900 mm. The allotment area is situated in a very populated district built in the 1960s, in the east of the town near the river Arno. The area is located in the floodplain of the river Arno, sloping 1 m in a south-north and east-west direction. It was managed for field crop production until 1995, when the municipal vegetable gardens were set up. Now the area is divided into 72 allotments, each of which is about 90 m^2, and located far from the main roads, isolated from the effects of traffic by distance and a river embankment. Ten allotments, the same ones that were selected and sampled in 2012 (Bretzel et al., 2016), were sampled to analyse the soil characteristics after five years of cultivation.

2.2. Soil analysis

Soil sampling was carried out in the tilled layer (0–20 cm depth) and each sample consisted of three sub-samples. Soil was air-dried at room temperature (20°) until constant weight, and sieved with 2 mm mesh. Texture, pH (H_2O), cation exchange capacity (CEC), organic carbon (C_{org}), total nitrogen (N_{tot}) and electrical conductivity (EC) were determined in triplicate on the 0–2 mm fraction by means of standard methods (ASA-SSSA, 1996). The concentrations of total and mobile lead (Pb), copper (Cu), nickel (Ni), chromium (Cr), zinc (Zn), cadmium (Cd) and potassium (K) were determined using ICP-OES spectrometry (Liberty Axial Varian, Turin, Italy) after acid attack (EPA 3051A). The potential mobility of soil metals and their possible translocation in plant tissues were investigated with a Sequential Extraction Procedure (SEP) (Petruzzelli et al., 2015). The first step of the SEP is with H_2O, which extracts the metal fraction free in the circulating solution of soil; the second step is with KNO_3, which is able to break the electrostatic bonds, and the third step is with EDTA, a strong organic extractant, which simulates the action of root exudates capable of breaking the covalent bonds with soil surfaces.

2.3. The survey

The survey was conducted with questionnaires presented to the allotment holders in the form of interviews conducted by the authors, in order to instantly clarify any possible doubt regarding the questions. All the sampled allotment holders were interviewed. The aims of the questionnaires were to define the typology of people, reveal the cultivation techniques and gardeners' awareness of them, and then to highlight the connections between the management choices and the soil properties possibly affected by the cultivation style. The questions were closed-ended. A first set of questions were related to personal