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BOOK REVIEW
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Book Review: Soil Pollution: A Hidden Danger Beneath our Feet

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A Book Review on

Soil Pollution: A Hidden Reality

Natalia Rodríguez Eugenio, Michael McLaughlin, Daniel Pennock (Rome: FAO), 2018, 142 pages. ISBN: 978-92-5-130505-8, and cover page given in **Figure 1**.

In every region of the world, one can find numerous instances of the "presence in the soil of a chemical or substance out of place and/or present at a higher than normal concentration that has adverse effects on any non-targeted organism." This soil pollution is increasingly the cause of major societal concern, and policy makers at all levels are more and more recognizing that it urgently needs to be addressed. In this context, in May 2018, the Global Symposium on Soil Pollution (GSOP18) was held in the FAO headquarters in Rome, with over 500 participants from 100 different countries. The leitmotif of the symposium, "It is time to fight soil pollution: Be the solution to soil pollution," stressed the extreme urgency to protect soils. The GSOP18 presentation video (available at https://www.youtube.com/watch?v=wHcY-iFSYZM) emphasized the fact that soil contamination is a hidden danger beneath out feet. The filtering, buffering, and attenuation capacities of soils have been widely documented in many situations, but so is the fact that these capacities are finite; If and when they get exceeded, human health, as well as water- and food quality, may all become threatened.

The book by Rodríguez et al. was prepared in advance of the GSOP18 symposium and was "released" during the symposium, in order to stimulate debates. It attempts to summarize the state of the art of soil pollution, and to review the main pollutants, their sources, their effects on human health and the environment, as well as implementations of soil reclamation and management practices. Special attention is devoted to those pollutants that are present in agricultural systems and that reach humans through the food chain.

Of the 91 pages of text (supplemented by 50 pages of references), the first section, dealing with the question of "What is soil pollution?" is the longest (40 pages). It describes the basic principles of soil pollution: the differentiation of contaminant/contamination from pollutant/pollution (sometimes misused as synonyms); types of contamination (point-source and diffuse); sources of contamination (natural and anthropogenic); main soil pollutants; and the interaction of pollutants with soil constituents. Much of the chapter reiterates what is typically found in any textbook on soil contamination, but it nevertheless provides a very good (and appealingly typeset and illustrated) compilation of a wide range of contaminants emanating from different sources, including some that are not readily evident or significant, and are therefore sometimes ignored even by soil experts. Examples in this respect are the corrosion of vehicles as a source of urban contamination, military activities and war as a sizeable source of metal contamination, and the release into the environment of other hazardous substances about which relatively little research has been carried out so far. The chapter is illustrated by many examples of contamination episodes especially in Europe (which has an estimated 3 million contaminated sites!) but also worldwide.

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FIGURE 1 | Book cover of soil pollution: A hidden reality [Source: Food and Agriculture Organization of the United Nations (FAO). Reproduced with permission].

One of the high points of the first section of the book is that it provides a very good discussion of emerging pollutants (subsection 1.4.7). According to the Web of Science, more than 3,500 papers have dealt with the topic since 2010, evincing its significance in the scientific community. Regarding these pollutants, the authors point out the huge risk of reusing urban wastewater, sewage sludge, or livestock residues, such as improperly treated manure, as sources of antimicrobial substances, which are leading to the presence of antimicrobial resistant bacteria in soils (Martínez, 2008; Martinez, 2009; Rizzo et al., 2013; Kuppusamy et al., 2018). This issue is one of the major problems facing regulatory agencies and decision-makers at the moment, since it is estimated that antimicrobial resistant infections may become the leading cause of death in the world by 2050 (O'Neill, 2014). Emerging contaminants also include manmade or "engineered" nanoparticles, which cause significant concern at the moment.

Another positive aspect of the first section of the book is the inclusion of a discussion on the bioavailability, mobility and degradation (subsection 1.5.2) of the main groups of contaminants (heavy metals, radionuclides, pesticides, persistent organic pollutants, N and P). Unfortunately, since the preceding subsection on the interactions of the pollutants with soil constituents is comparatively very succinct, the text cannot analyse in depth the influence that these interactions have on the fate of pollutants in the soil environment or on the physical, chemical, and biological processes that, combined, affect the bioavailability of pollutants.

The second section ("The impacts of soil pollution on the food chain and ecosystem services") is the shortest section of the book, and describes the conditions leading to uptake by plants of different types of pollutants, and their impact on human health and soil ecosystem services (mainly related with agricultural and livestock practices). The text also focuses on the toxicological effect of the main groups of contaminants, and describes the main exposure pathways for humans. This section stresses the need for further research on the long-term impact of soil pollution on human health. Also, basic toxicological data and research on exposure pathways or on what constitutes "acceptable" doses are direly needed at this point (Landrigan et al., 2018).

The third section ("Management and remediation of polluted sites") describes several approaches to manage polluted sites. The text includes a discussion of the assessment of risks involved, as well as a brief review of available remediation techniques and recommended agronomic practices to reduce soil pollution and degradation. The authors argue in section 3.1 that it is mandatory to investigate the toxicity of complex mixtures of pollutants for accurate soil risk assessment. Indeed, regulations usually include a chemical-by-chemical approach, or just estimate the risk of a mixture as the cumulative risk of the individual pollutants. At this point, it is not clear at all that this simple, additive method to compute the toxicity of mixtures is ever warranted. Various authors, including some not cited in the book (Chen et al., 2015; Heys et al., 2016), have demonstrated the existence of synergistic or antagonistic effects among pollutants. Also, the authors of the book call for regulations to take bioavailability of contaminants into account, i.e., to adapt the risk assessment and the remediation efforts to the bioavailable fraction that actually causes potential risk, and not to the total concentration of pollutants in soils. This approach has already been discussed by other authors in recent years (Harmsen and Naidu, 2013; Kördel et al., 2013; Ortega-Calvo et al., 2015) and raises many questions that the brief section devoted to the issue in the book does not analyze in detail, in particular concerning the question of which one among the various existing definitions of bioavailability is most appropriate to draft suitable regulations and prioritize clean-up efforts.

The remediation of polluted sites, discussed in subsection 3.2, is an extremely broad topic. It is dealt with in just 4 pages, yet most categories of techniques are mentioned. Bio-based techniques (e.g., phyto- and bioremediation) are referred to as promising, environmentally-friendly, and less expensive or impactful than the traditional engineering-based physical methods, described elsewhere in more detail (Vangronsveld et al., 2009; Megharaj et al., 2011; Gkorezis et al., 2016). The use of organic amendments and other emerging sorbents (nanoparticles or biochar) are also cited as promising procedures to reduce the mobility of soil pollutants.

The following subsection (3.3), on agronomic practices, is one of the strengths of the book. The description of soil sustainable

management practices proposed by FAO in its Voluntary Guidelines for Sustainable Soil Management (VGSSM) (FAO, 2017) is a very good read. The text details an extensive list of practices for integrated crop, soil fertility, nutrient, pest, and weed management, as well as the selection of crops, the manipulation of soil properties and the importance of crop rotations to reduce the use of pesticides or metal uptake. The VGSSM aim to be easily accessible and readily understandable for a wide variety of stakeholders, including farmers, and the account that the book provides leaves the reader thinking that we can indeed adopt easy and simple practices to reduce soil pollution, and hinder the entry of pollutants in the food chain. A very strong point of this section is the inclusion of a description of biofertilizers, viewed by the authors of the book as an attractive eco-friendly alternative to conventional fertilizers, due to their low cost and low impact on soil quality, and their applicability in organic agriculture. On all these topics, the book provides some leads to the relevant literature, even though many more articles could have been mentioned (e.g., Vessey, 2003; Glick, 2014; Mahanty et al., 2017), in particular publications referring to the isolation of microorganisms with special capacities to enhance plant development (Weyens et al., 2009; Balseiro-Romero et al., 2017).

The fourth and last section of the book presents three case studies, in Ivory Coast, Western Siberia, and Spain, respectively. The detailed analysis of these case studies could have been a very good opportunity to illustrate concretely the various concepts, assessment methods, and reclamation strategies introduced earlier in the text, and to demonstrate how everything can be brought together to solve practical problems, but again the coverage of each case is too short for this to happen. Furthermore, only bio-based reclamation procedures (phytoremediation, bioremediation, and phytostabilization) are considered, and the multitude of physically- or chemically-based methods that could be implemented at the three sites considered are ignored.

If one looks at this book as if it were just another book on soil pollution, the overall impression that emerges from a detailed reading is that its coverage of the field is uneven, and as a result its targeted public is not readily obvious. Some subsections, describing individual pollutants, are extremely detailed and beyond the reach of many non-specialists, whereas other subsections are extremely short and not detailed enough. Such unevenness is not uncommon in the case of a multi-authored book, where the various authors write specific sections and no one edits the whole text. However, in spite of the drawbacks, one has to remember that the purpose of this book, put together ahead of, and in preparation for, the GSOP18 symposium, was to stimulate a healthy debate about the widespread pollution of soils. In that context, the book is very likely to be successful. The fact that it is in open access, downloadable at no cost from the FAO webpage (http://www.fao.org/3/I9183EN/i9183en.pdf) means that it is accessible to an extremely broad audience. At a time when many books that come off the press cost upward of $200, FAO and the authors have to be commended for putting the interest of the public ahead of their own financial well-being. As a result, their key message that soil pollution not only is a hidden reality but also constitutes a serious danger for human health is very likely to be heard loud and clear. Beyond that, by pointing out areas related to soil pollution that urgently need to be researched, the authors are helping to orient in the right direction the debate that, hopefully, will now unfold.

AUTHOR CONTRIBUTIONS

MB-R produced a first draft of the text, which she and PB subsequently revised together.

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