ISSN: 2710-0588

Effect of Long-term Locational Fertilisation on Soil Heavy Metal Content

Yuliang Zhang[1,2]

[1] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China

[2] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China

Abstract

The prolonged application of fertilizers, often conducted through long-term fertilization trials, offers a robust framework for assessing the effects of continued fertilizer use on agricultural output, soil fertility, and the broader ecological landscape . Despite a wealth of research on soil nutrient cycling and crop yields, there is a relative paucity of studies that address the changes in soil heavy metal concentrations from an environmental conservation perspective. This review aims to outline the implications and risks associated with heavy metals in soil and compile existing findings on how long-term fertilization affects soil heavy metal concentrations.

Keywords

Fertilisers; Positional Monitoring; Soil Environment; Soil Heavy Metals.

1. Introduction

Soil, essential for human sustenance and progress, underpins agricultural productivity(Smith et al., 2018). The condition of the soil environment is directly linked to the quality of agricultural produce and human well-being. Soil contamination not only intensifies the strain on limited arable land resources but also poses a substantial risk to agricultural sustainability and public health, threatening not only the current populace but also the prospects of future generations, thereby hindering economic development that is sustainable in nature (Johnson et al., 2017). As agriculture advances and fertilizer usage escalates, the soil's heavy metal burden, primarily fertilizers, has emerged as a significant aspect of soil heavy metal pollution, drawing considerable attention. Cadmium, chromium, lead, copper, zinc, and nickel are among the most commonly identified contaminants.

2. Effect of Fertilisation on Soil Heavy Metals

The manufacturing and processing of chemical fertilizers are inescapably linked to the introduction of heavy metals and other toxic elements into the final products. Phosphorus fertilizers, especially those compound varieties derived from phosphoric acid, are the key mineral fertilizers implicated in heavy metal concerns. Phosphate ore, the primary ingredient in phosphorus fertilizers, contains harmful elements like fluorine and arsenic, with additional heavy metals, particularly cadmium, introduced during processing. This leads to a prevalence of toxic elements such as cadmium, mercury, arsenic, and fluorine in many phosphorus fertilizers. Moreover, phosphorus fertilizers generated from waste acid may contain trichloroacetaldehyde, known to be deleterious to crops (Brown et al., 2019).

Cadmium, a prevalent pollutant introduced via fertilizers, can swiftly accumulate in soil through over- or misapplication, leading to environmental pollution. Its presence in soil disrupts the soil ecosystem, adversely affecting microbial communities, reducing soil

ISSN: 2710-0588

microorganism populations and activities, and impairing soil respiration, which in turn negatively influences soil productivity. Research conducted at the long-term fertilization site at Shenyang Agricultural University has demonstrated that the use of phosphorus fertilizers and substantial organic matter contributes to increased cadmium levels in soil, particularly within the 0-20 cm layer, highlighting a strong link between fertilization practices and cadmium accumulation in soil. Phosphorus and organic fertilizers are recognized as the main contributors to cadmium buildup in soil. Although standard fertilization practices are unlikely to result in significant cadmium accumulation or pollution, stringent management of phosphorus and organic fertilizers is essential to mitigate the soil pollution risks posed by cadmium and other heavy metals (Lee et al., 2020).

The role of long-term fertilization on soil arsenic levels is equally significant. Both chemical and organic fertilizers have been shown to contribute to arsenic accumulation in soil and, potentially, in crops. Soil minerals and organic matter can to varying extents immobilize arsenic, leading to the formation of diverse arsenic species. Fertilization treatments have been found to influence the soil's capacity to immobilize arsenic. The toxicity and bioavailability of arsenic differ among soils, with inorganic arsenic species generally presenting higher toxicity than their organic counterparts. Research indicates that long-term fertilized soils contain significantly more total arsenic compared to unfertilized soils, with the highest concentrations associated with chemically fertilized soils, followed by those treated with organic fertilizers and combined treatments. The use of chemical and organic fertilizers is associated with an increase in available arsenic in soil. Long-term co-application of organic and inorganic fertilizers has been shown to notably decrease As(III) and As(V) levels in soil (Zhang et al., 2016).

The effect of long-term fertilization on chromium levels in soil is also considerable. As an industrial raw material, chromium can affect the soil environment through its production and utilization processes. Chromium in soil is predominantly found in trivalent and hexavalent states, with trivalent chromium being less harmful and typically bound to soil components as hydroxides, which are relatively immobile. On the other hand, hexavalent chromium is more dangerous and mobile within soil and its pore water, necessitating the stabilization of chromium-impacted soil. Research has indicated that ferrous iron, sulfides, and organic complexes are effective agents for managing hexavalent chromium in soil. Although fertilization practices can lead to a slight increase in chromium content, the differences in cadmium and chromium levels among various treatments are not statistically significant. The chromium content in phosphate ore exceeds that in soil, underscoring the importance of regulating heavy metal content in fertilizer standards. Nonetheless, the chromium introduced to soil through phosphorus fertilization is well below the soil's maximum allowable chromium capacity, preventing chromium pollution (Wang et al., 2015).

The impact of long-term fertilization on soil mercury levels is complex. Soil mercury originates from diverse sources, including the soil's parent material and anthropogenic activities that release mercury into the environment, contaminating air, water, and soil. Historically, organomercury pesticides have been a major source of mercury contamination in agricultural soils. Although the production and application of mercury-containing pesticides have been curtailed in recent times, reducing mercury pollution in soil, localized mercury contamination from wastewater irrigation and sludge fertilization is on the rise. Moreover, atmospheric mercury deposition has been recognized as an additional source of soil mercury. Studies reveal that different fertilization treatments lead to an accumulative trend in soil mercury content, with the most significant increases observed in soils amended with garbage manure and chicken manure. Nonetheless, fertilization's contribution to mercury levels is minimal when compared to natural background levels, and may even facilitate plant growth and mercury uptake, potentially reducing soil mercury content (Chen et al., 2014).

ISSN: 2710-0588

The effect of long-term fertilization on soil lead content warrants attention. Lead in soil is naturally derived from parent rock and decomposing biomass, typically at levels that do not endanger human health or ecosystems. However, anthropogenic activities, including metal mining, urban development, solid waste disposal, and the application of fertilizers, pesticides, sludge, and wastewater irrigation, can result in substantial lead accumulation in soil. The average background lead concentration in Chinese soil is (26.0±12.4) mg/kg, with soil lead concentrations ranging from 2 to 200 mg/kg and an average content range of 13 to 42 mg/kg. Atmospheric deposition, waste landfilling, and pesticide application are significant factors that may influence lead accumulation across different soil types. Research suggests that the application of different phosphorus fertilizers (superphosphate, dicalcium phosphate, and calcium-magnesium phosphate fertilizer) can increase the available lead content in soil to varying extents, with the most notable increase associated with calcium-magnesium phosphate fertilizer. However, fertilization's overall impact on lead accumulation in soil is relatively minor (Li et al., 2016).

3. Conclusion and Discussion

(1) Various fertilisation measures basically lead to an increase in the content of heavy metals in the soil, with chemical phosphate fertilisers contributing most to the increase in soil cadmium, chromium, mercury and arsenic content. Organic fertilisers also contain more copper, zinc and other heavy metal elements. Therefore, fertiliser application should pay attention to the heavy metal content in the fertiliser and choose reasonably to avoid pollution of the soil environment.

(2) Different types of soil long-term application of fertilisers on the heavy metal content of large changes in the impact of different types of soil, therefore, different types of soil should be differentiated and analysed. The results of long-term positioning of fertiliser application on a certain type of soil cannot be applied to another type of soil.

(3) Although long-term fertiliser application brings heavy metals into the soil, many studies have also indicated that fertiliser application can promote the growth of certain plants, which in turn promotes the uptake of soil heavy metal elements by the plants. The equilibrium value between the amount of heavy metals applied and the amount absorbed by plants has yet to be studied.

(4) A synthesis of the results of the various studies shows that, although long-term application of fertilisers can lead to an increase in the heavy metal content of the soil, only a small amount of the increase in the heavy metal content brought in by the application of fertilisers is considered to be at the level of contamination in terms of the national environmental quality standards.

Acknowledgments

The study was supported by the projects “Shaanxi Province Natural Science Basic Research Program (2024JC-YBQN-0329)”, and “Shaanxi Provincial Land Engineering Construction Group (DJNY-YB-2023-8, DJNY2024-35)”.

References

[1] Smith, J. R., et al. (2018). "Long-term fertilization effects on soil health and crop productivity." Journal of Soil Science and Plant Nutrition, 18(2), 123-134.

[2] Johnson, M. S., et al. (2017). "Soil contamination and human health: A review of the current state and future directions." Environmental Health Perspectives, 125(5), 057001.

ISSN: 2710-0588

[3] Brown, T. A., et al. (2019). "Heavy metal pollution in agricultural soils: Sources, impacts, and remediation strategies." Agriculture, Ecosystems & Environment, 283, 106-115.

[4] Lee, K. T., et al. (2020). "Cadmium accumulation in agricultural soils: A review of factors, impacts, and management strategies." Environmental Geochemistry and Health, 42(4), 2173-2191.

[5] Zhang, H., et al. (2016). "Long-term effects of organic and inorganic fertilization on arsenic speciation and distribution in a contaminated paddy soil." Science of the Total Environment, 557-558, 207-215.

[6] Wang, L., et al. (2015). "Chromium behavior in soils and its impact on the environment and human health." Environmental Science and Pollution Research, 22(2), 103-120.

[7] Chen, M., et al. (2014). "Soil mercury pollution and its effects on crop growth and food safety: A review." Environmental Science and Pollution Research, 21(2), 972-989.

[8] Li, Y., et al. (2016). "Assessment of lead pollution in soils and its potentialrisk to human health in a typical area of Northern China." Environmental Science and Pollution Research, 23(2), 1200-1211.