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Environmental risks for application of iron and steel slags in soils in China: A review

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ABSTRACT

Iron and steel slags are smelting wastes, mainly including blast furnace slag (BFS) and steel slag (SS) produced in the iron and steel industry. Utilization of iron and steel slags as resources for solving the problem of slag disposals has attracted much attention with increasing iron and steel smelting slags in China. Because the iron and steel slags contain calcium (Ca), magnesium (Mg), phosphorus (P), and silicon (Si), some have tried to use them as Si- and P-fertilizers, for producing Ca-Mg-P fertilizers, or as soil amendments in agriculture. However, in the iron metallurgical process, several pollutants in iron ores can inevitably transfer into iron and steel slags, resulting in the enrichment of pollutants both in BFS (mainly nickel (Ni), copper (Cu), mercury, zinc (Zn), cadmium (Cd), chromium (Cr), arsenic, lead, selenium, fluorine (F), and chlorine (Cl)) and in SS (mainly Ni, Cr, Cd, Zn, Cu, F, and Cl), in which some of pollutants (especially Cr, Ni, F, and Cl) exceed the limits of environmental quality standards for soils and groundwater. The elements of manganese, barium, and vanadium in iron and steel slags are higher than the background values of soil environment. In order to ensure soil health, food safety, and environmental quality, it is suggested that those industrial solid wastes, such as iron and steel slags, without any pretreatment for reducing harmful pollutants and with environmental safety risk, should not be allowed to use for soil remediation or conditioning directly in farmlands by solid waste disposal methods, to prevent pollutants from entering food chain and harming human health.

Key Words: blast furnace slag, environmental safety risk, heavy metal, industrial solid waste, iron and steel industry, soil pollution

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INTRODUCTION

The iron and steel industry (or ferrous slag), also known as the black metallurgical industry, is an industry with ferrous metals, iron (Fe), manganese (Mn), and chromium (Cr), as the main objects of mining, smelting, and calendaring, while the metallurgical slags of iron and steel industry refer to blast furnace slag (BFS), steel slag (SS), and ferroalloy slag produced in the smelting production (Wei, 2010), in which BFS and SS account for up to 80%–90% (thus called iron and steel slags). At present, iron and steel slags in China are mainly utilized in industrial uses: i) as paving or building materials, ii) for producing cement, and iii) to return to the smelting process as sintering materials. Some also suggested using iron and steel slags for producing fertilizer or as soil amendment agents in agricultural soils. However, these are still at the research and experimental stages (Qin *et al*., 2013). Because iron and steel slags contain some elements needed for plant growth (such as calcium (Ca), magnesium (Mg), phosphorus (P), and silicon (Si)), some tried to use them as Si-, P-, and Ca-Mg-P-fertilizers or as Si-Ca-fertilizer in agriculture, mainly in some rice-producing countries, such as Japan and Korea, where the SS was used to supplement Si in rice, while in some countries dominated by upland crops (wheat and cotton), such as in western Europe and USA, SS has been used as a lime fertilizer (Yang, 1999). During the 1960s, in China, research on SS as fertilizer, mainly as phosphate fertilizer, was carried out, but suspended due to a number of intractable problems (Yang, 1999). In recent years, some experiments were conducted in China to try to use BFS as a Si-fertilizer (Yang *et al*., 2007; Ma *et al*., 2016) and use SS as a Si-fertilizer (Li, 2011; Liang and Guo, 2016; Ma *et al*., 2016; Wei *et al*., 2018) or a SS-based Si-Ca-fertilizer (Ning, 2014; Mi, 2015; Zhang *et al*., 2017), and as a soil amendment (Deng *et al*., 2011; Liang, 2016; Zhang, 2016; Wei *et al*., 2017). However, because SS contains a certain amount of heavy metals (Zhou *et al*., 2014), its utilization in agriculture has not been officially suggested (Fan *et al*., 2017), and its potential risks of environmental safety for agricultural application are very concerned.

We reviewed the literature related to iron and steel slags (BFS and SS), mainly focused on their environmental impacts, and evaluated the risks of environmental safety for the use (disposal) of the iron and steel slags on farmland.

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