Environ Sci Pollut Res
DOI 10.1007/s11356-015-5638-5

RESEARCH ARTICLE

Mitigation of cadmium and arsenic in rice grain by applying different silicon fertilizers in contaminated fields

Hong-Yan Wang[1,2] · Shi-Lin Wen[3] · Peng Chen[2] · Lu Zhang[3] · Kuang Cen[1] · Guo-Xin Sun[2]

Received: 11 June 2015 / Accepted: 18 October 2015

Abstract A field experiment was established to support the hypothesis that application of different silicon (Si) fertilizers can simultaneously reduce cadmium (Cd) and arsenic (As) concentration in rice grain. The "semi-finished product of Si-potash fertilizer" treatment at the high application of 9000 kg/ha (NP+S-KSi9000) significantly reduced the As concentration in rice grain by up to 20.1 %, compared with the control. Si fertilization reduces the Cd concentration in rice considerably more than the As concentration. All Si fertilizers apart from sodium metasilicate (Na_2SiO_3) exhibited a high ability to reduce Cd concentration in rice grain. The Si-calcium (CaSi) fertilizer is the most effective in the mitigation of Cd concentration in rice grain. The CaSi fertilizer applied at 9000 kg/ha (NPK+CaSi9000) and 900 kg/ha (NPK+CaSi900) reduced the Cd concentration in rice grain about 71.5 and 48.0 %, respectively, while the Si-potash fertilizer at 900 kg/ha (NP+KSi900), the semi-finished product of Si-potash fertilizer at both 900 kg/ha (NP+S-KSi900) and 9000 kg/ha (NP+S-KSi9000), and the rice straw (NPK+RS) treatments reduced the Cd concentration in rice grain about 42, 26.5, 40.7, and 23.1 %, respectively. The results of this investigation demonstrated the potential effects of Si fertilizers in reducing Cd and As concentrations in rice grain.

Keywords Field experiment · Arsenic · Cadmium · Mitigation · Silicon fertilizer · Rice grain

Responsible editor: Elena Maestri

Hong-Yan Wang and Shi-Lin Wen contributed equally to this work.

✉ Guo-Xin Sun
gxsun@rcees.ac.cn

[1] School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China

[2] State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[3] National Engineering Laboratory for Improving Quality of Arable Land, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China

Introduction

Rice (*Oryza sativa* L.) is a staple food that supports almost half of the world's population (Sun et al. 2012). Unfortunately, rice is also the major contributor to the human intake of the toxic trace elements such as cadmium (Cd) and arsenic (As) worldwide, especially in Asia (Meharg et al. 2009; Williams et al. 2009). Human exposure to As and Cd by means of daily consumption in food is a concern in many areas of China, where farming and mining coexist (Williams et al. 2009; Sun et al. 2012). Arsenic, especially inorganic form, is classified as a non-threshold class 1 human carcinogen and can cause serious health problems such as skin cancer and lung, bladder, kidney, and other diseases (Bernard and Lauwerys 1986; Ng et al. 2003; Halim et al. 2009). Cd has been linked to diseases including lung cancer, pulmonary adenocarcinomas, prostatic proliferative lesions, bone fractures, kidney dysfunction, and hypertension (Bernard and Lauwerys 1986).

Rice consumption is a major source of Cd and As for the global human population (Sun et al. 2008; Williams et al. 2009). Cd has relatively high mobility in paddy soil and can be easily absorbed into rice root using the same transport pathways as micronutrients such as Fe^{2+}, Zn^{2+}, and Ca^{2+} (Clemens 2006; Verbruggen et al. 2009; Clemens et al. 2013). Arsenic is particularly easily accumulated in rice grain compared with other cereals, because the bioavailability of As is markedly enhanced in flooded environments and the

Published online: 24 October 2015