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Effect of Atmospheric Depositionon Cadmium Accumulation in Soils: A Review

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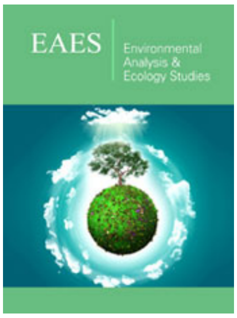

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Abstract

Atmospheric depositions are the main sources of soil Cadmium(Cd) in mine lot and other industrial location, Cd accumulated in soils could have direct and indirect impacts on crops, lead to health risks as consequences. According to studies, Cd flux of atmospheric deposition showed a clear feature of spatio-temporal variation, such as its in mining area > industrial area > suburb > rural area; rainy season > dry season, dry deposition was winter spring > summer autumn; The studies also displayed much higher Cd accumulation rate in soils as affected by coal combustion, road traffic, and soil particles as well. We should pay more attention on atmospheric deposition and soil quality monitoring in the future, for Cd pollution control and environment management.

Keywords: Atmospheric deposition; Soil; Cd; Spatio-temporal variation; Accumulation rate

Introduction

Cadmium is known to be both extremely toxic and ubiquitous in natural environments. It occurs in almost all soils, surface waters and plants, and it is readily mobilized by human activities such as mining. Ingestion of even trace quantities of cadmium can influence not only the physiology and health of individual organisms, but also the demographics and the distribution of species [1]. Atmospheric deposition is one of the main sources of soil Cd in mine lot and other industrial location. Cd was non degradable and would accumulate after sedimentation, causing secondary pollution to soil, plants and water [2]. Studies results showed that Cd in atmospheric deposition mainly came from artificial sources, such as smelting, fossil fuel combustion and road traffic, while the contribution of natural sources such as soil dust and volcanic activity was relatively small [3,4]. We need to know more information about the sediment flux of Cd from different source, and the accumulation rate in soils affected by natural and anthropogenic factors.

Variation of Cd Flux from Different Source of Atmospheric Deposition

Spatial variation of Cd in atmospheric deposition

Heavy metal deposition fluxes are important indicator for atmospheric deposition assessment and are mainly affected by local air quality, terrain characteristics and long-distance transportation of air [5]. Generally speaking, the atmospheric deposition of Cd in southwest, central, southern and Northern China was higher than that in Northwest and Northeast China, Inner Mongolia and Qinghai Tibet, which was reflected in different degrees of industrial economic development [6]. Even in the same area, the atmospheric deposition of Cd was still very different, and the deposition in industrial developed areas was always much larger than that in rural areas [7,8]. It could be seen from Table 1 that the atmospheric deposition flux of Cd shows spatial variation, and the overall level of different regions follows the order: mining area > industrial area > suburb > rural area.

Seasonal variation of Cd in atmospheric deposition

The seasonal variation of atmospheric deposition may be caused by the difference of seasonal precipitation, and may also be caused by the burning of waste gas, traffic density and seasonal variation of different land use patterns [9]. Sharma's study on atmospheric deposition in Varanasi, India, found that the ratio of Cd deposition in summer and winter was higher than that in autumn [10]. Precipitation changes significantly affected atmospheric deposition of heavy metals, which may lead to higher deposition in rainy season than in dry season [11]. However, the research on dry settlement showed that the Cd content in dry deposition was higher in winter and spring than in summer and autumn, and higher in heating period than in non-heating period [2]. For example, the seasonal variation of atmospheric dry deposition flux in Qingdao was the highest in winter, followed by spring. Beijing was the highest in spring, followed by winter [7].

Distribution of Cd from different source of atmospheric deposition

In recent years, great progress has been made in source apportionment of heavy metals in atmospheric deposition. Chemical mass balance (CMB), principal component analysis (PCA), enrichment factor (EF), factor analysis (FA) and multiple linear regression (MLR) have been proposed. Cui Xingtao et al. [12] conducted correlation and principal component analysis on heavy metal elements in atmospheric deposition in Shijiazhuang City, and concluded that the main sources of Cd in atmospheric deposition were coal combustion and road traffic [12]. Through the principal component analysis of heavy metals in dry and wet deposition in Chengdu Economic Zone, Tang Qifeng et al. [13] concluded that the main sources of Cd were metallurgy and chemical production [13]. Mijic et al. [14] used the UNMIX receptor model to analyze the sources of heavy metals in atmospheric deposition in the capital of Serbia, and concluded that Cd mainly came from road traffic and industrial production. By comprehensive analysis, cadmium in the atmosphere was mainly from road traffic, fossil fuel combustion and smelting [15,16].

Distribution and Accumulation Rate of Cd in Soil from Different Source

According to a survey conducted by the Chinese Academy of Agricultural Sciences, about 35% of the Cd in farmland came from atmospheric deposition [17]. The atmospheric deposition of Cd in nine counties in Central and Eastern Guangxi accounted for 47.3% of the total input [18]. Nicholson et al. [19] investigated the sources of heavy metals in soils in England and Wales and found that about 53% of Cd came from atmospheric deposition [19]. It could be seen that atmospheric deposition is one of the important sources of soil Cd. It could be seen from Table 1 that the Cd distribution and accumulation in Soil from atmospheric deposition.

Table 1: Atmospheric deposition fluxes of Cd in different regions.

Region	Cd ($mg \cdot m^{-2} \cdot a^{-1}$)	Reference
Lead zinc mining area around port Piri, Australia.	18.25	Alphen et al. [26]
Qingguang Industrial Zone, Xiangtan, Hunan Province, China.	5.5 ~ 6.1	Cao et al. [6]
Western Shanxi Industrial Park, Shanxi Province, China.	3.07	Liang et al. [31]
Chengdu Economic Zone, Chengdu, Sichuang Province, China.	1.77	Tang et al. [13]
Suburb of Feilong County, Xiangtan, Hunan Province, China.	2.2 ~ 2.3	Cao et al. [6]
Coastal areas of eastern Zhejiang, Zhejiang Province, China.	0.75	Huang et al. [30]
Agricultural area of Changsha County, Changsha City, Hunan Province, China.	0.6 ~ 0.9	Cao et al. [6]
Beijing Plain, Beijing Municipality, China.	0.24	Cong et al. [27]
Gannan County, Heilongjiang Province, China.	0.15	Deng et al. [28]
Isfahan City, Iran.	0.04 ~ 2.08	Norouzi et al. [33]
Tokyo Bay, Central and Eastern Honshu, Japan.	0.39	Sakata et al. [34]

The regional characteristics of Cd accumulation in agricultural soils in southern China are caused by geochemical Cd background anomalies and space mining/smelting activities [20,21], followed by irrational use of sewage irrigation, chemical fertilizers, pesticides, plastic films and other agricultural inputs as well as livestock and poultry manure by-products [20]. For the high background area of castor in South China, soil dust was also the main source of Cd in atmospheric deposition [22]. The content of Cd in soil in southern China is relatively higher than that in North China, which may be related to the higher geochemical background in Southwest China [23]. For example, in Southwest China (Guizhou Plateau), the excessive accumulation of Cd in agricultural soils (average $0.659 mg \cdot kg^{-1}$) is mainly caused by natural soil forming processes such as carbonate weathering [20,24]. In the process of soil formation, calcium carbonate, the main chemical component of carbonate rocks, is dissolved and leached. Even if Cd is very low in the rock, it will gradually retain and accumulate in the topsoil, which makes the Cd element accumulate in the topsoil [25].

Conclusion

With the development of social economy and industrialization, the accumulation impact of atmospheric deposition on Soil Cd becomes serious (Table 2). The increase of Cd content in soil will cause soil pollution, which will affect the animals and plants in the ecosystem, even the human health. Therefore, it is imperative to take measures to reduce the continuous input of soil Cd by atmospheric deposition. Establishing a sound environmental monitoring mechanism strictly controls the emission of industrial production to reduce the source of Cd input to the atmosphere. Improving the removal of Cd in the deposition process blocks the deposition process of atmospheric Cd and reducing the bioavailability of Cd in soil reduces the absorption of plants and animals [26-35].

Table 2: Distribution and accumulation rate of Cd in soil.

Region	Source of Atmospheric deposition	Soil Cd ($mg{\cdot}kg^{-1}$)	Rate of Soil Cd from Atmosphere(%)	Settlement time (year)	Reference
The 34 Rural Sites in England and Wales.	local resuspension of soil particles	0.7-6.1	53	3	Nicholson et al. [19]
Lianyuan City, Hunan Province, China.	Industrial coal combustion	3.545	84.4	10	Liang et al. [17]
Central and Eastern Guangxi Province, China.	Industrial production	0.169	47.3	1	Chen et al. [18]
The Intersection of the G4 Highway and the Wuhan-Guangzhou High-speed Railway, China.	Road traffic	4.23 ± 0.32	68.9 ± 2.5	8	Feng et al. [29]
Qingguang Industrial Zone, Xiangtan, Hunan Province, China.	Industrial production	0.7	8.8	2	Cao et al. [6]
Suburb of Feilong County, Xiangtan, Hunan Province, China.	Long distance air transmission and road traffic	0.45	47.5	2	Cao et al. [6]
Agricultural Area of Changsha County, Changsha City, Hunan Province, China.	Long distance transmission of air pollution	0.43	60.9	2	Cao et al. [6]

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