

Short Communication



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공단 인근 농경지 토양 중 중금속 함량 평가

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Evaluation on Heavy Metal Contents in Agricultural Soils around Industrial Complexes in Korea

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Abstract

BACKGROUND: Agricultural soils are vulnerable from contamination of heavy metal derived from industrial waste. Monitoring on heavy metals on agricultural soils around industrial complexes and evaluation on distributional state on the concentrations of heavy metals in soil have been carried out for problem assessment on soil condition.

METHODS AND RESULTS: Soil samples of 1,200, were collected from sixty site of industrial complexes located Gyeonggi, Chungbuk, Cheonbuk, and Gyeongnam provinces. Total concentration of Cu, Pb, Zn, Ni, and As were analyzed. Heavy metal concentrations in most soil samples were below warning criteria, except 1 site of Pb, Ni, and As, separately. The comparison of mean values of

heavy metal concentrations between soils around industrial complexes and paddy soils, showed similar levels of heavy metals, except Pb. The concentrations of lots of heavy metals were distributed between from warning criteria to one fifth level of warning criteria. However, in the case of Cu and Pb, more than 30% were distributed below one twenties level of warning criteria. These results were very similar with the distribution state of heavy metals in upland soils. The concentrations of heavy metals in surface soil and subsoil were similar among the heavy metals in soils around industrial complexes.

CONCLUSION: The concentrations of heavy metals in soils around industrial complexes were distributed close to warning criteria. Long term and continuous monitoring and evaluation on heavy metals in agricultural soils are required for food safety and sustainable soil management.

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Table 1. Investigated industrial complexes

Provinces (4)	Name of industrial complexes (60)
Gyeonggi	Hakun, Yulsaeng, Mokdong, Dongducheon, Ojeong, Yangcheon, Namyeon, Yonghyeon, Jangwon, Gajang, Jangan-1, Paltan, Chupal, Pyeongtaek, Eoyeonhansan, (15)
Chungbuk	Cheomdan, Judeok, Jaecheon, Geumwang, Maengdong, Jeungpyeong-2, Sincheok, Sansu, Jincheon, Sungjae, Oksan, Balhyosikpum, Boeun, Youngdong, Okcheon (15)
Cheonbuk	Poongsan, Sinpyeong, Wanju, Gunsan-2, Okgu, Sungsan, Wangung, Gosu, Nongso, Bukmyeon, Julpo, Ansung, Janggae, Cheoncheon, Yeonjang (15)
Gyoungbuk	Youngilman-2, Gyoungsan-2, Donam, Punggak, Jangsu, Goha, Apo, Gisan, Sajyang, Bukan, Boncheon, Angang, Seokgae, Yaecheon, Hanchang (15)

서론

가 가 2017 60 (15) 가 600 (,)

재료 및 방법

가 가 60 (Table 1) 15 (1 km) 10 (0~15 cm) 가 가 (15~30 cm) 1,200 (60 , 10) 1 5 1 2 mm 가

(Min *et al.*, 2016; Kim *et al.*, 2016; Park *et al.*, 2016) (MOE 2013)

가 (CRM041-30G) 가 Table 2 (Ministry of

environment, 2014).

(Aelion *et al.*, 2009)

결과 및 고찰

가 가 Table 3 Cu, Zn Ni, As (Acosta *et al.*, 2011)

(Hu *et al.*, 2013) , Pb 1

가

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Table 2. Recovery rate of standard material (CRM041-30G)

Elements	Cu	Pb	Zn	Ni	As
Certified value(mg kg ⁻¹)	75.5	198.0	198.0	10.1	10.3
Observed value(mg kg ⁻¹)	70.6	181.6	176.8	8.7	9.4
Recovery rate (%)	93.4	91.8	89.2	86.0	91.9
Standard deviation	6.06	13.71	9.93	0.38	1.81

Table 3. Total concentration of heavy metals in soil around industrial complexes

Elements	mg kg ⁻¹				
	Cu	Pb	Zn	Ni	As
Mean	13.3	28.2	64.4	13.8	4.40
Max.	98.4	963.9	296.3	208.3	57.10
Min.	0.0	0.0	0.0	0.0	0.0
Median	11.0	16.1	60.9	11.4	3.83
95%-P	31.3	71.4	118.7	33.2	9.58
99%-P	46.0	88.0	175.1	45.1	16.21
Paddy land ¹⁾	14.9	16.7	56.8	14.0	3.68
Warning criteria ²⁾	150	200	300	100	25

¹⁾ Heavy metal in paddy land (sample number 2,070). (2015)

²⁾ Ministry of environment, 2010.

2,110) (Table 3) (Tariq *et al.*, 2006) 가 .
 . Cu , Ni 1.4%p . Pb, 가
 10.7%p , Ni 1.4%p . Pb, 가
 Zn As (Park *et al.*, 2016).
 68.8%p, 13.3%p, 19.6%p
 .
 Pb> As> Zn> Ni> Cu . 가
 Table 4 . (1,200 , 2,070 , 2015)
 Pb, Ni, As 가 1 1/5>, 1/10>. 1/15>, 1/20>
 ,
 가 Cu 1/5> 1/20>
 가 32% 1/10~1/15 1.3~17.0%
 가 1/5 69.3% 가
 가 Cu . Pb 가 29%
 가 , 1/20> 30.3% .
 가 Pb 가
 가 (Martley *et al.*, 2004),
 Mn, Zn Cr 가 (Vousta *et al.*, 1996) 1/20> 34.7%
 Cd, Pb, As 가 14.4~19.5% .
 (Nadal. *et al.*, 2009), Zn
 Pb, Mn, Cu, Fe (Deepali *et al.* 2010) Cr ~1/5> 89.0%

Table 4. Distribution rate of heavy metal concentrations in comparison with warning criteria in soil around industrial complexes

Soils	Elements	Distribution rate (%)						Warning Criteria
		1/20 ¹⁾ >	1/15 >	1/10 >	1/5 >	WC >	WC <	
Soil around industrial complexes (1,200)	Cu	32.4	12.3	17.0	32.7	5.6	0.0	150
	Pb	30.3	11.2	17.3	11.8	29.0	0.3	200
	Zn	2.8	0.5	7.8	38.3	50.7	0.0	300
	Ni	19.6	8.8	15.3	35.7	20.4	0.2	100
	As	12.0	3.6	11.5	39.9	32.8	0.2	25
Paddy soil	Cu	6.6	6.4	17.7	42.3	27.0	0.0	150
	Pb	34.7	14.9	19.5	16.5	14.4	0.0	200
	Zn	0.5	0.1	0.7	23.5	75.1	0.0	300
	Ni	9.6	7.9	16.6	37.3	28.6	0.0	100
	As	25.9	4.9	8.5	27.3	33.4	0.1	25

¹⁾ Concentration of heavy metal in soil/warning criteria * 100

Table 5. Comparison of heavy metal concentrations at different depths in soil around industrial complexes

Soil depth	Elements	Cu	Pb	Zn	Ni	As
		----- mg kg ⁻¹ -----				
Surface soil (0~15 cm)	Mean	14.0	28.9	66.5	13.9	4.45
	Max.	98.4	963.9	296.3	201.2	57.10
	Min.	N.D	N.D	N.D	N.D	N.D
	95%-P	31.8	71.9	122.5	33.8	9.63
Sub soil (15~30 cm)	Mean	12.7	27.4	62.3	13.6	4.36
	Max.	57.8	879.0	293.5	208.3	42.70
	Min.	N.D	N.D	N.D	N.D	N.D
	95%-P	29.4	70.8	115.5	33.1	9.45

* Soil sample numbers are 1,200 (surface and subsoil).

98.6%

. Ni As Zn

~1/5> Ni 가

56.1% 65.9%, As 72.9% 60.7%

. Zn, Ni, As

요약

cm) Table 5 (0~15 cm) (15~30 cm) 60 1,200 (, 600)

Cu 10.2%, Pb 5.4%, Zn Pb, Ni, As 가 1

6.7%, Ni 2.2%

As 2.1%

가 가

Note

(Bolan *et al.*, 2013, Kashem *et al.*, 2001).

The authors declare no conflict of interest.

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