ISSN: 2347-4688, Vol. 05, No.(2) 2017, Pg.196-202

Current Agriculture Research Journal

An International Open Access, Peer Reviewed Journal

www.agriculturejournal.org

Effect of Lime, Compost and Microbial Inoculants on Micronutrient Removal by Mustard and Maize in Trace Metal Contaminated Soil of Jharkhand

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Abstract

A field experiment was conducted on trace metal contaminated soil at Patratu (Ramgarh) to study the effect of lime, compost, plant growth promoting rhizobacteria and arbuscular mycorrhizal fungi on micronutrient removal viz. Zn, Cu, Mn and Fe in mustard-maize cropping system. Results reveal that inoculation with Glomus mossae, Pseudomonas striata and Azotobacter chroococcum increased Zn concentration to the extent 13 to 32, 10 to 24 and 9 to 24 (%), respectively over control. Copper, manganese and iron uptake followed almost similar trend as that of Zn. Microbial inoculants with or without vermicompost increased the trace metal removal, however, vermicompost alone decreased the removal. It was observed that microbial inoculations reduced the total Zn, Cu, Mn and Fe content in soil. However, available micronutrients were significantly reduced by microbial inoculation and amendments.

Article History

Received: 2 September 2017
Accepted: 27 September 2017

Keywords:

removal of Zn, Cu, Mn, Fe, trace metal contaminated soil, mustard, maize, lime, compost, plant growth promoting rhizobacteria, arbuscular mycorrhizal fungi

Introduction

Trace metals are ubiquitous in the environment and present in small amounts in normal condition. Contamination of trace metals refers to their anthropogenic accumulation, which may or may not inflict any harm to the system or organism. Pollution is the worst example of contamination where irreversible toxicity-damage has already occurred due to buildup of the toxic substances in the system[1]. Anthropogenic sources of trace elements are a consequence of industrial development and urbanization. These sources are related to human

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To Link to this Article: http://dx.doi.org/10.12944/CARJ.5.2.07

activities such as mining and smelter activities, fossil fuel combustion, waste incineration and disposal, agricultural practices like use of fertilizers and pesticides[2]. Soil is the key component of natural ecosystems because environmental sustainability depends largely on a sustainable ecosystem. Unlike other environmental components, pollutants have long residence time in soil. Therefore, soil acts as a sink or a filter in which pollutants are accumulated rapidly but depleted slowly. Jharkhand has several coal mines. The Damodar river basin is a repository of approximately 46 per cent of the Indian coal reserves. Due to extensive coal mining and rapid growth of industries, soil and water resources have been badly contaminated. Besides mining, coal based industries like coal washeries, coke oven plant, coal fired thermal power plant, steel plants and other related industries in the region are responsible for degradation of environmental quality. Hence, the present investigation was planned to study the effect of amendments and microbial inoculants on micronutrient removal by mustard-maize cropping system in trace metal contaminated soil.

Materials and Methods

An experiment was conducted in farmer's field during rabi season in 2009-10 and kharif season in 2010 at Patratu (Ramgarh) to investigate the effect of lime, compost, plant growth promoting rhizobacteria and arbuscular mycorrhizal fungi on removal of micronutrients including Zn, Cu, Mn and Fe by mustard and maize in trace metal contaminated soil. The soil was sandy loam in texture with pH 6.08, EC 0.07 dS m^{-1}, organic carbon 2.85 g kg^{-1}, DTPA-extractable Zn 3.05, Cu 1.46, Mn 20.53 and Fe 39.62 mg kg^{-1}, Total Zn 37.75, Cu 48.32, Mn 344 and Fe 19457 mg kg^{-1}. Mustard (cv. T 59) and maize (cv. PEHM 2) were grown in sequence at the same site with 10 treatments in randomized block design with three replications. The plant samples were collected at harvest of the crop, washed with double distilled water, oven dried and digested in mixture of HNO_3:$HClO_4$ in the ratio of 9:4 at 80^0C until a transparent solution was obtained (Allen, et al., 1986). The transparent solution was diluted with double distilled water and filtered. The micronutrient content in plant parts was determined on Atomic Absorption Spectrophotometer (EICL AAS4139) by employing the appropriate hollow cathode lamp. Micronutrient status of soil after harvest of both crops was determined by extracting soil with DTPA (0.005M DTPA, 0.01M $CaCl_2$, 0.1M TEA), pH adjusted to 7.3 with the help of dilute HCl, maintaining 1:2 soil to extractant ratio and shaking for 2 hrs at 120 rpm[4].

Results and Discussion

Micronutrient Removal by Mustard and Maize

Removal of Zn, Cu, Mn and Fe by mustard, maize and mustard-maize system as presented in table 1 and 2. Inoculation of Glomus mossae resulted in significantly higher removal of Zn by mustard stover (114g ha^{-1}), grain (44g ha^{-1}), mustard (158g ha^{-1}) and maize straw (397g ha^{-1}). However, Zn removal by maize grain (181g ha^{-1}), maize (570 g

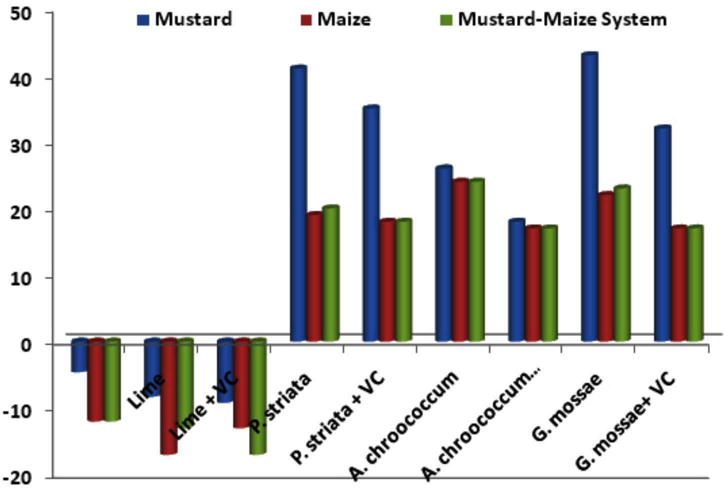

Fig. 1: Effect of treatments on per cent increase or decrease in Zn uptake

ha^{-1}) and mustard-maize system (584g ha^{-1}) was observed with Azotobacter chroococcum inoculation. The differences observed among three microbial inoculants were not significant. Application of vermicompost alone or in combination with lime and microbial inoculants resulted in reduction of Zn uptake. However, significant reduction in Zn removal by crops was observed when lime was applied either alone or in combination with vermicompost. Per cent increase or decrease in Zn removal by crops is presented in fig.1 The extent of decrease in Zn uptake by vermicompost, lime and their combination was 5 to 12, 8 to 17 and 9 to 17 per cent over control. However, increase in Zn uptake from 22 to 43, 19 to 41 and 24 to 26 per cent as compared to control was observed under G. mossae, P. striata and A. chroococcum inoculation. Copper uptake followed almost similar trend as that of Zn. Cu uptake by mustard stover + grain (34g ha^{-1}) and maize straw (207g ha^{-1}) was higher under G. mossae inoculation while Cu uptake by maize straw + grain (230g ha^{-1}) and mustard-maize system (233g ha^{-1}) was higher under A. chroococcum inoculation. Reduction in Cu removal by crops with vermicompost, lime and their combination was noticed (9 to 17 per cent over control). It was also observed that when vermicompost was applied with microbial inoculants this resulted in decreased Cu uptake as compared

Table 1: Effect of lime, compost, PGPR and AMF on Zn, Cu, Mn and Fe uptake (g ha^{-1}) by mustard and maize

Particulars	Control	Vermi-compost	Lime		P. striata		A. chroococcum		G. mossae		S Em	CD (P =0.05)	CV
			Alone	+ VC	Alone	+ VC	Alone	+ VC	Alone	+ VC	±		%
					Zinc								
Mustard Stover	75	70	67	67	113	108	99	91	114	104	5.1	15.2	11.3
Mustard Grain	36	35	34	33	42	40	39	39	43	41	0.4	1.3	12.3
Total	110	105	101	100	155	148	139	130	158	146	5.1	15.2	13.9
Maize Straw	324	269	264	261	391	374	389	361	397	360	7.7	22.9	10.4
Maize Grain	135	136	119	139	158	169	181	176	164	178	2.1	6.2	9.9
Total	460	404	383	399	549	543	570	537	561	538	8.4	24.9	11.4
					Copper								
Mustard Stover	15.4	13.6	13.1	14	23.1	22.1	21.2	20.6	23.6	22.6	1.12	3.33	8.6
Mustard Grain	6.6	5.5	5.3	5.4	8.9	7.6	8.9	7.5	9.9	7.7	0.15	0.45	9.7
Total	30	19	18	19	32	30	29	28	34	30	1.2	3.5	10.4
Maize Straw	158	137	141	142	196	181	205	183	207	185	3.4	10.2	10.9
Maize Grain	17.6	17.8	15.5	17.6	21.2	21.9	25.2	23.3	22.6	22.9	0.39	1.15	8.8
Total	175	155	156	160	217	203	230	207	230	208	3.5	10.3	11.2
					Manganese								
Mustard Stover	71	74	72	80	113	106	101	102	120	110	5.9	17.4	9.1
Mustard Grain	72	71	69	68	87	82	83	80	92	84	0.9	2.7	10.3
Total	144	145	140	149	200	188	184	182	212	194	6.1	18	10.8
Maize Straw	328	279	287	292	427	377	433	378	445	378	5	14.9	7.4
Maize Grain	12.1	11.7	10.3	11.9	15.6	15.3	17.8	15.8	15.9	16.1	0.25	0.74	7.5
Total	340	290	298	304	443	392	451	394	461	394	5	14.9	8.3
					Iron								
Mustard Stover	712	737	730	767	1042	988	955	964	1005	981	49.2	146.2	9
Mustard Grain	546	525	514	512	732	647	693	636	741	666	3.9	11.5	11
Total	1258	1262	1244	1279	1774	1636	1648	1600	1745	1646	51.2	152.1	11.4
Maize Straw	1572	1519	1551	1550	1772	1731	1763	1717	1826	1696	13.7	40.7	11.2
Maize Grain	98	95	84	95	121	126	140	129	127	132	2	5.9	10.7
Total	1670	1614	1635	1645	1893	1858	1903	1846	1953	1828	14.2	42.2	12.3

to microbial inoculants alone (Fig. 2). Similar trend in Mn and Fe uptake by mustard-maize cropping system was noticed. Glomus mossae inoculation resulted in significantly higher Mn removal by mustard (212g ha^{-1}), maize (461g ha^{-1}) and mustard-maize system (673g ha^{-1}). However, Mn removal by crops with G. mossae, P. striata and A. chroococcum inoculation were statistically at par. Vermicompost application alone or with microbial inoculants and lime decreased the Mn removal to some extent. Higher Fe uptake by mustard was recorded with P. striata, while G. mossae recorded the high Fe uptake by maize and mustard-maize system. Reduction in Fe uptake was also observed with vermicompost, lime and their combination. Increase in micronutrient removal by plant growth promoting rhizobacteria (Pseudomonas striata and Azotobacter chroococcum) might be due to their ability to produce siderophores that chelate cations and make available to the plant root. Leung[5.] (2000) reported the increased Zn and Cu uptake by Pseudomonas pseudoalcaligenes. Gamalero[6]. (2004) found that Pseudomonas fluorescence increased the micronutrient removal by tomato and cucumber in heavy metal contaminated soil. Jeffries[7]. (2003) reported that arbuscular mycorrhizal fungi (Glomus mossae) form a unique structure called abuscules vesicules that help plant to capture nutrients from soil. Significant increase in Zn content in clover roots without affecting the shoot concentration by mixed population of AMF was reported by Tonin[10]. Weng,[9] observed increased accumulation of Zn and Cu by Elsholiza splendens inoculated with AMF.

Reduction in micronutrient removal particularly Zn and Cu with vermicompost and lime might be due to their adsorption. Similar results were observed by Pierzynski and Schwab[10], Bolan,[11] and Rattan,[1].

Table 2: Effect of lime, compost, PGPR and AMF on total Zn, Cu, Mn and Fe removal (g ha^{-1}) by mustard and maize.

Treatments		Zn	Cu	Mn	Fe
Control		471	178	483	2928
Vermicompost		415	157	435	2876
Lime	Alone	393	158	438	2879
	With VC	409	162	453	2924
Pseudomonas	Alone	565	220	643	3667
striata	With VC	558	206	580	3493
Azotobacter	Alone	584	233	635	3551
chroococcum	With VC	550	209	576	3446
Glomus	Alone	577	233	673	3698
mossae	With VC	553	211	588	3475
S Em		8.5	3.5	9	56.4
CD (P = 0.05)		25.4	10.4	26.8	167.5
CV %		12.7	12.6	9.9	13.3

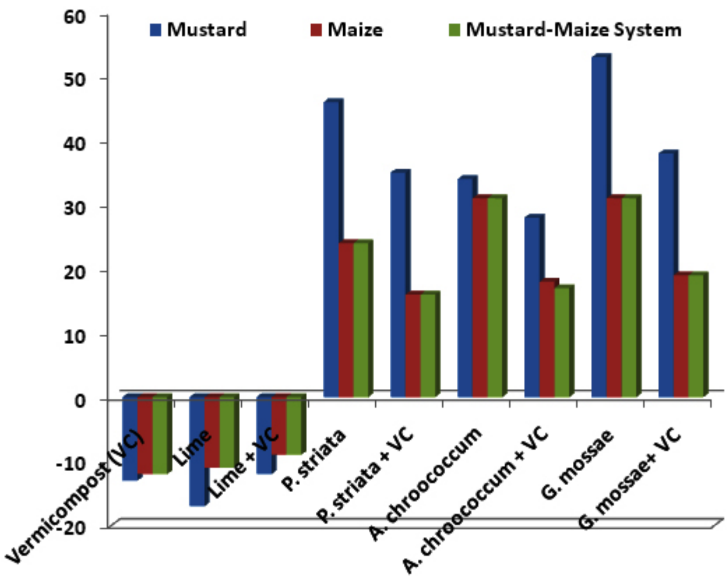

Fig. 2: Effect of treatments on per cent increase or decrease in Cu uptake

Micronutrient status of Soil after Harvest of Mustard and Maize

Results presented in table 3 indicate total and available micronutrients of soil after harvest of mustard and maize. It was observed that microbial inoculations reduced the total Zn in soil to the extent of 8 to 15 per cent as compared to control. The lowest total Zn after harvest of mustard (30.17 mg kg^{-1}) and maize (23.42 mg kg^{-1}) was found with Glomus mossae inoculation which was at par with other two microbial inoculants. However, DTPA-Zn was significantly reduced by microbial inoculation and amendments. The extent of reduction was 17 to 49 per cent over control for microbial inoculants and the corresponding value was 17 to 24 per cent for amendments (Fig. 4.19). Total Cu, Mn and Fe followed similar trend of reduction in content by microbial inoculations and the extent was 6 to 21, 3 to 18 and 2 to 5 per cent, respectively over control. Glomus mossae was the most efficient strain in reducing the total content; however, no significant influence of amendments on total metal content was noticed after harvest of both crops. Application of vermicompost, lime, lime + vermicompost and microbial inoculations resulted in significant reduction in DTPA-Cu, Mn and Fe after harvest of crops and the extent was 16 to 43, 19 to 36 and 18 to 27 per cent for microbial inoculations and 16 to 22, 12 to 22 and 14 to17 for amendments. It was noticed that microbial inoculation along with vermicompost resulted in further reduction of DTPA extractable micronutrients in soil. Pseudomonas striata and Azotobacter chroococcum have ability to produce siderophores which chelate cations and make available to the plant roots. This might be the possible reason for increased micronutrient uptake by crops, resulting in reduced total and available content in soil. The results are in conformity with Leung, *et al.* (2000) and Gamalero, *et al.* (2004). Formation of abuscules vesicules by Glomus mossae, that help plant to capture nutrients from soil might had increased the micronutrient uptake thereby reduction in content (Jeffries, *et al.,* 2003, Wu, *et al.,* 2004 and Weng, *et al.,* 2004). Reduction in available micronutrient

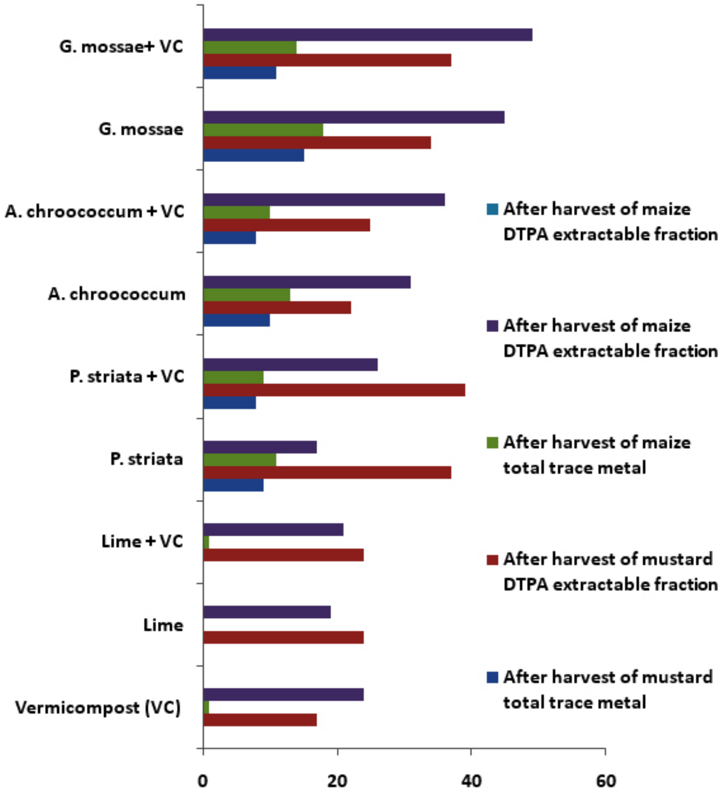

Fig. 3: Per cent reduction in zinc content after harvest of crops

content by amendments might be due to their adsorption, complexation or precipitation. Similar results were observed by Pierzynski and Schwab[10], Bolan,[11] and Rattan,[1].

Conclusion

On the basis of present investigation it can be concluded that microbial inoculation resulted in increased micronutrients removal by mustard, maize

Table 3: Effect of treatments on micronutrient status (mg kg^{-1}) of soil after harvest of mustard and maize

Treatments	Mustard		Maize	
	Without VC	With VC	Without VC	With VC
		Zn		
Control (RDF)	35.42 (2.57)	35.33 (2.14)	28.67 (2.14)	28.50 (1.62)
Lime	35.42 (1.96)	35.42 (1.96)	28.58 (1.74)	28.50 (1.69)
P. striata	32.25 (1.63)	32.75 (1.57)	25.50 (1.77)	26.00 (1.58)
A. chroococcum	31.75 (2.01)	32.58 (1.93)	25.00 (1.48)	25.83 (1.37)
G. mossae	30.17 (1.69)	31.42 (1.63)	23.42 (1.18)	24.67 (1.10)
SEm±	0.32 (0.09)		0.36 (0.09)	
CD (P=0.05)	0.95 (0.27)		1.08 (0.26)	
CV %	9.59 (11.23)		12.25 (12.01)	
		Cu		
Control (RDF)	46.58 (1.60)	46.17 (1.25)	39.25 (1.41)	38.67 (1.18)
Lime	46.25 (1.29)	46.17 (1.24)	38.75 (1.17)	38.67 (1.17)
P. striata	40.58 (1.10)	43.17 (1.07)	33.08 (1.14)	35.67 (1.11)
A. chroococcum	41.50 (1.19)	43.83 (1.17)	34.00 (1.19)	36.33 (1.13)
G. mossae	38.33 (0.95)	41.92 (0.92)	30.83 (0.93)	34.42 (0.89)
SEm±	0.38 (0.03)		0.43 (0.03)	
CD (P=0.05)	1.12 (0.09)		1.26 (0.09)	
CV %	9.90 (4.67)		12.28 (5.09)	
		Mn		
Control (RDF)	325 (20.11)	320 (17.43)	307 (19.16)	304 (15.35)
Lime	321 (17.76)	323 (17.60)	305 (15.01)	306 (15.23)
P. striata	297 (15.55)	301 (16.16)	278 (13.90)	281 (14.64)
A. chroococcum	296 (16.01)	315 (16.28)	282 (14.34)	284 (14.83)
G. mossae	292 (15.05)	297 (15.88)	252 (12.17)	273 (12.59)
SEm±	1.36 (0.31)		1.40 (0.22)	
CD (P=0.05)	4.05 (0.91)		4.15 (0.66)	
CV %	13.44 (12.97)		14.28 (10.08)	
		Fe		
Control (RDF)	19130 (40.39)	19040 (34.73)	18525 (36.48)	18442 (30.90)
Lime	19057 (34.15)	19062 (34.67)	18463 (30.32)	18477 (30.51)
P. striata	18738 (32.61)	18790 (33.61)	18142 (28.45)	18222 (29.45)
A. chroococcum	18547 (32.31)	18603 (33.11)	17952 (28.15)	18023 (28.95)
G. mossae	18258 (30.79)	18312 (32.00)	17647 (26.63)	17727 (27.63)
SEm±	10.12 (0.42)		11.10 (0.40)	
CD (P=0.05)	30.07 (1.24)		32.99 (1.18)	
CV %	12.80 (12.39)		14.27 (12.61)	

*Data in parenthesis indicate DTPA-extractable values and system. However, amendments (vermicompost, lime and their combination) reduced the removal by the crops. Reduction in total micronutrients content in soil after harvest of crops was recorded with microbial inoculation. However, DTPA extractable micronutrients decreased with addition of amendments as well as inoculation of microbes.

Acknowledgement

I am very much thankful to the Chairman, Department of Soil Science and Agricultural Chemistry and the Dean, Faculty of Agriculture, Birsa Agricultural University, Ranchi, Jharkhand for providing all essential support during course of present investigation.

References

1. Rattan, R.K., Datta, S.P., Chhonkar, P.K. and Singh, A.K., Heavy metal contamination through sewage irrigation in peri-urban areas of National Capital Territory of Delhi. Technical Bulletein, Divison of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi, pp. 51, 2005.
2. Adriano, D.C., Chlopecka, A., Kaplan, K.I., Clijsters, H. and Vangronsveld, J., Soil contamination and remediation: philosophy, science and technology. In: Contaminated Soils, R. Prost ed. INRA Les olloques, n085, Paris. pp. 465-504, 1995.
3. Allen, S.E., Grimshaw, H.M. and Rowland, A.P., Chemical analysis. pp. 285-344. In: P.D. More and S.B. Chapman (eds.) Methods in Plant Ecology. Blackwell Scientific Publication, Oxford, London, 1986
4. Lindsay, W.L. and Norvell, W.A., Development of DTPA test for zinc, iron, copper and magenese. *Soil Science Society of America Journal,* ***42***, 421-428, 1978
5. Leung, W.C., Wong, M.F., Chua, H., Lo, W., Yu, P.H.F. and Leung, C.K., Removal and recovery of heavy metals by bacteria isolated from activated sludge treating industrial effluents and municipal wastewater. Water Science and Technology, ***41***, 233-240, 2000.
6. Gamalero, E., Trotta, A., Massa, N., Copetta, A., Martinotti, M.G. and Berta, G., Impact of two fluorescent pseudomonands and an arbuscular mycorrhizal fungus on tomato plant growth, root architecture and P acquisition. Mycchoriza, ***14***, 185-192, 2004
7. Jeffries, P., Gianinazzi, S., Peroto, S., Turnau, K. and Barera, J. (2003). The contribution of arbuscular mycorrhizal fugi in sustainable maintenance of plant health and soil fertility. Biology and Fertility of Soil, 37, 1-16, 2003
8. Tonin, C., Vandenkoornhuyse, P., Joner, E. J., Straczek, J. and Leyval, C., Assessment of arbuscular mycorrhizal fungi diversity in the rhizosphere of Viola calaminaria and effect of these fungi on heavy metal uptake by clover. Mycorrhiza, 10, 161-168, 2001.
9. Weng, G.Y., Wu, L.H., Wang, Z.Q., Luo, Y.M., Song, J., Wang, F.Y. and Lin, Q., Enhancement of chemical and microbial materials on phytoremediation of Elsholtzia splendens on a co-contaminated soil. In: Proceedings of the fifth international conference on environmental geochemistry in the tropics, March 21–26, 2004, Haiko, Hainan, China. Nanjing, PR China: Institute Soil Science, Chinese Academy of Science, 2004.
10. Pierzynski, G.M. and Schwab, A.P., Bioavailability of zinc, cadmium and lead in a metal contaminated alluvial soil. Journal of Environmental Quality, 22, 247-254, 1993.
11. Bolan, N.S. and Duraisamy, V.P. (2003) Role of inorganic and organic soil amendments on immobilization and phytoavailability of heavy metals: A review involving specific case studies. Australian Journal of Soil Research, 41, 533-555, 2003.
12. Wu, S.C., Cheung, K.C., Luo, Y.M. and Wong, M.H., Metal accumulation by Brassica juncea sharing rhizosphere with Zea mays: effect of mycorrhizal and beneficial bacterial inoculation. In: Proceedings of the fifth international conference on environmental geochemistry in the tropics, March 21–26, 2004, Haiko, Hainan, China. Nanjing, PR China: Institute Soil Science, Chinese Academy of Science, 2004.