Asian Journal of Chemistry; Vol. 24, No. 6 (2012), 2811-2812

ASIAN JOURNAL OF CHEMISTRY

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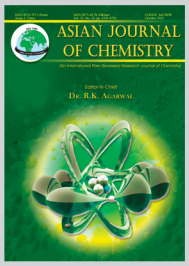

NOTE

Effects of Organic Fertilizer on the Contents and Distribution of Heavy Metals in Spinach

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(*Received*: 31 January 2011; *Accepted*: 22 January 2012) AJC-11004

Organic fertilizer is the important source of heavy metals in vegetables. Organic fertilizer could change the availability of heavy metal in soil and concentration of heavy metals in vegetables. Eight kinds of heavy metals were determined in different organs of spinach applied different amounts of organic fertilizer to investigate the effects of organic fertilizer made from animal manure on the concentration of heavy metals in vegetables. The results showed that the organic fertilizer application can increase the contents of some heavy metals in stem and leaf of spinach, such as Cu, Zn and Se, but all heavy metals had no significant difference in stem and leaf of spinach. Root of spinach contained more Cr, Cd, Pb, Fe and Mn than stem and leaf of spinach. But application of organic fertilizer decreased the contents of heavy metals Cr, Cd, Pb, Fe and Mn, which is different from previous studies. The difference may be due to different organic fertilizer and different vegetable.

Key Words: Organic fertilizer, Heavy metals, Spinach, Root, Stem and leaf.

Serious environmental problems caused by heavy metals are attracting increasing attention because many diseases about heavy metals show increasing trend, such as diseases relative to the cardiovascular system, blood system, endocrine system, immune system,reproductive system as well as nerve system[1]. Jiang *et al.*[2] showed that the animal manures contained much heavy metals because additives are added in feeds during intensive farming, especially Cu, Zn, Pb and Cd and total Zn concentration in 7.8 % and total Cd concentration in 5.2 % of soil samples applied pig manures exceeded the Chinese Soil Environment Quality Standard III, which means they have been heavily polluted. Zhao *et al.*[3] reported that organic fertilizer could change the availability of heavy metal in soil and concentration of heavy metals in vegetables and Wang *et al.*[4] liying also concluded that the source of many kinds of heavy metals is organic fertilzier made of livestock and birds litter, such as Fe, Cu, Zn and Cr.

To investigate the effects of organic fertilizer made from animal manure on the concentration of heavy metals in vegetables, eight kinds of heavy metals were determined in different organs of spinach applied different amounts of fertilizer by ICP-MS, which is an advanced and popular test technology[5,6].

Treatment NC: No organic input, 82 Kg N /ha (Urea); Treatment NC + W1 (Farmers commonly used treatment): 82 Kg N ha^{-1} (Urea) and 45 ton pig manure ha^{-1}; treatment NC + W2: 82 Kg N ha^{-1} (Urea) and 22.5 ton pig manure ha^{-1}; all treatments were applied the same amount of P fertilizer and K fertilizer, 220 kg K_2O ha^{-1} (potassium sulfate), 200 kg P_2O_5 ha^{-1} (superphosphate). And potassium sulfate was applied two times, basal fertilizer 120 kg K_2O ha^{-1} and top dressing 100 kg K_2O ha^{-1}, superphosphate was applied only as basal fertilzier.

The contents of eight kinds of heavy metals in swine manure applied in this experiment are shown in Table-1.

TABLE-1
CONTENT OF HEAVY METALS IN SWINE MANURE

Elements	Content in Swine manure
Cr	8.16
Cu	623.3
Zn	1488.97
Se	1.46
Cd	0.33
Pb	4.39
Fe	7515.04
Mn	691.35

Detecting method of heavy metals

Sample preparation: Weigh appropriate amount of sample in quartz cup for digestion, add HNO_3 (BVIII level)

1.5 mL and H_2O_2 (BVIII level) 0.5 mL and digested in microwave digestion oven. Digestion procedures: 150 ºC for 15 min, power: 500 W; 200 ºC for 20 min, power: 800 W; 100 ºC for 10 min, power: 400 W; cooling, sample solution were transferred to 10 mL volumetric flask, constant volume. Diluted according to element content, awaiting determination.

ICP-MS instrument conditions: ICP-MS model: ELAN DRCII, Manufacturer: PE company of USA.

Parameters referred to Rui *et al.* method[7] with minor modifications: Parameters of ICP: RF power: 1100 W, cooling gas flow: 15.00 L/min, supplemental gas flow: 1.80 L/min, carried gas flow: 0.95 L/min.

Parameters of MS: vaccum of analysis room, 5.89×10^{-6} Tor r, impulse voltage: 1400V.

Parameters of detecting: Resolution (10 % peak height): 0.6-0.8 amu, retention period: 50 ms, three times of replication, peak measurement points: 1, 20 times of circle, period of analysis: 30 s, sample size: 1 mL/min

Instrument stability: Short-term stability (0.5 h), RSD < 3 %; long-term stability: (2 h) RSD < 4 %. The linear correlation coefficient of elements detected: $r > 0.999$.

The instrument drift was calibrated by internal standard elements of Re. The mass numbers of elements detected were showed in Table-2.

TABLE-2
MASS OF ELEMENTS DETECTED

Elements	Mass
Cr	51.9
Cu	62.9
Zn	65.9
Se	81.9
Cd	110.9
Pb	208
Mn	54.9
Fe	55.9

Content of heavy metals in stem and leaf: Results showed that the organic fertilizer application can increase the contents of some heavy metals in stem and leaf of spinach, such as Cu, Zn and Se, but all heavy metals had no significant difference in stem and leaf of spinach applied organic manure from that of CK (Table-3).

Content of heavy metals in root: Root of spinach contained more Cr, Cd, Pb, Fe and Mn than stem and leaf of spinach (Table-4). But application of organic fertilizer decreased the contents of heavy metals Cr, Cd, Pb, Fe and Mn, which is different from previous studies[8]. The causes resulted into the above difference may be due to different organic fertilizer and different vegetable.

TABLE-3
CONTENT OF HEAVY METALS IN STEM AND LEAF OF SPINACH

Elements	NC	NC + W1	NC + W2
Cr	1.41	1.28	1.87
Cu	13.72	14.76	17.69
Zn	54.46	55.23	61.28
Se	0.04	0.06	0.05
Cd	1.06	0.58	0.68
Pb	1.78	1.31	1.39
Fe	657.85	642.67	861.22
Mn	45.58	35.65	41.83

TABLE-4
CONTENT OF HEAVY METALS IN ROOT OF SPINACH

Elements	NC	NC + W1	NC + W2
Cr	15.24	12.98	10.24
Cu	13.72	13.10	12.76
Zn	59.94	55.35	54.40
Se	0.09	0.09	0.09
Cd	1.21	0.83	1.09
Pb	2.24	1.81	1.75
Fe	1928.49	1481.09	1600.34
Mn	97.19	84.87	82.97

ACKNOWLEDGEMENTS

The project was supported by the Key National Natural Science Foundation of China (No. 41130526).

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