Contamination and spatial distribution of Pb, As and Cd contents in Chinese cow raw milk

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OBJECTIVE

The aim of this large scale study was to investigate the spatial variability of Pb, As, and Cd contents in raw milk within and between the 10 main milk producing areas in China.

MATERIALS & METHODS

The contents of Pb, As and Cd in 996 raw milk samples (i.e., 100 milk samples per area except for two area (n=97, n=99)) were measured by ICP-MS after microwave-assisted acid digestion. Non-parametric Kruskal-Wallis test were performed to study the differences of Pb, As and Cd between areas. Spearman correlations were calculated to assess the relationships between the studied heavy metals. Then, the spatial distribution of Pb, As, Cd was studied by ordinary kriging estimates within the studied areas. Cross-validation was used to assess the robustness of the distribution map.

RESULTS

Mean values of Pb, As and Cd were 1.75, 0.31 and 0.06 µg/L of milk, respectively. Levels of Pb in 1.20 % (12/996) of collected samples were above the maximum residue limit (MRL) imposed by the European Union (0.02 mg/kg). All samples were below the Chinese MRL (i.e., 0.05 mg/kg for Pb, 0.1 mg/kg for As). (Table 1)

High coefficient of variation were obtained within area suggesting a large variability of those metal contents in milk within regions. This shows the need to conduct a reflection about the best way to collect samples if this kind of pollution in milk want to be studied on a long period. Pb-Cd, As-Cd, Pb-As showed positive significant correlations in nine, six and five areas, respectively. Correlation values ranged between 0.20 and 0.60. However these correlations changed between areas suggesting different pollution origins. Based on the ordinary kriging estimates, Pb, As and Cd showed different spatial patterns following the studied area (figure 1-3). Based on the cross-validation, the root mean square error was not closed to the average standard error in some areas. This leads potentially to wrong predictions. The high density of sample collection may lead to this result. Further studies could implement a more appropriate sample collection in order to clarify the relationships between the contamination of raw milk by heavy metals and the herd environment.

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Table 1. Descriptive statistics of Pb, As, and Cd contents measured in raw cow milk from the 10 main milk producing areas in China (N = 996 samples).

	Pb (µg/L)			As (µg/L)			Cd (µg/L)		
	Mean ± SD	Range	Positive rate	Mean ± SD	Range	Positive rate	Mean ± SD	Range	Positive rate
A	2.11 ± 2.37	0.14-19.62	90.00%	0.27 ± 0.36	0.05-2.17	58.00%	0.09 ± 0.07	0.001-0.39	98.00%
B	1.43 ± 2.26	0.14-16.15	66.00%	0.51 ± 0.90	0.05-6.21	46.00%	0.02 ± 0.03	0.001-0.20	59.00%
C	1.60 ± 5.39	0.14-38.61	42.00%	0.33 ± 1.59	0.05-15.77	49.00%	0.07 ± 0.10	0.001-0.36	55.00%
D	2.73 ± 5.92	0.14-36.73	60.00%	0.14 ± 0.18	0.05-0.94	35.00%	0.05 ± 0.09	0.001-0.54	72.00%
E	2.96 ± 6.66	0.14-35.74	82.80%	0.34 ± 1.05	0.05-9.12	28.00%	0.04 ± 0.05	0.001-0.21	59.00%
F	1.35 ± 1.77	0.14-9.70	76.00%	0.13 ± 0.12	0.05-0.68	44.00%	0.02 ± 0.02	0.001-0.09	82.00%
G	2.01 ± 1.16	0.14-6.45	96.00%	0.17 ± 0.24	0.05-1.90	51.00%	0.05 ± 0.04	0.001-0.18	92.00%
H	1.16 ± 3.16	0.14-28.94	41.20%	0.19 ± 0.27	0.05-1.93	45.40%	0.03 ± 0.03	0.001-0.17	74.20%
I	0.46 ± 0.62	0.14-4.19	40.00%	0.18 ± 0.33	0.05-2.96	43.00%	0.03 ± 0.03	0.001-0.12	89.00%
J	1.70 ± 1.39	0.14-8.73	91.00%	0.80 ± 2.27	0.05-15.18	66.00%	0.06 ± 0.09	0.001-0.69	94.00%
Total	1.75 ± 3.73	014-38.61	68.40%	0.31 ± 1.02	0.05-15.77	46.50%	0.05 ± 0.07	0.001-0.69	77.40%

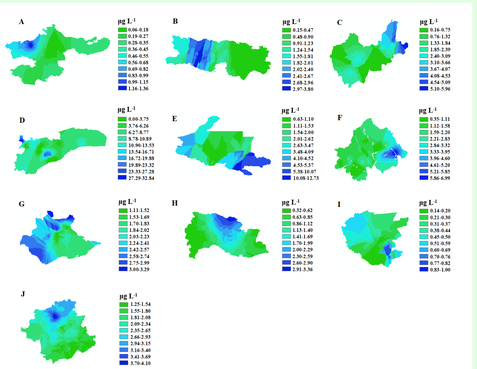

Figure 1. Spatial distribution of the lead concentrations in raw milk (µg/L) in the main milk producing areas in China.

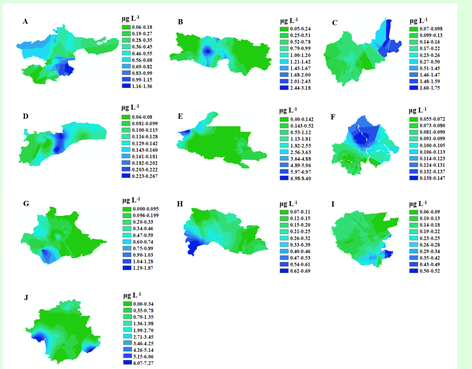

Figure 2. Spatial distribution of the arsenic concentrations in raw milk (µg/L) in the main milk producing areas in China.

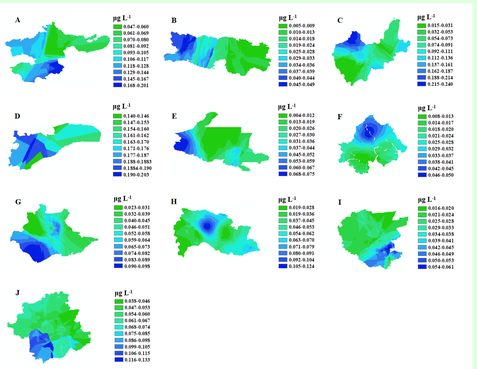

Figure 3. Spatial distribution of the cadmium concentrations in raw milk (µg/L) in the main milk producing areas in China.