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1 **Hazard Posed by Metals and As in PM_{2.5} in Air of Five Megacities in the**
2 **Beijing-Tianjin-Hebei Region of China during APEC**

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18

19 **Abstract**

20 Airborne fine particulate matter (PM_{2.5}) from five megacities including Beijing,
21 Tianjin, Shijiazhuang, Baoding, and Jinan were collected during November 2014 and
22 compared with similar periods in 2012 and 2013. The November 2014 period
23 coincided with the Asia Pacific Economic Cooperation (APEC) Leaders meeting
24 during which measures to control pollution of the air were introduced.
25 Concentrations of eleven elements in PM_{2.5} were quantified by ICP-MS after
26 microwave-assisted digestion. Potential effects of five toxic trace metals including
27 Mn, Ni, Cu, Zn, Pb and the metalloid As on health were assessed. In 2014,
28 concentrations of PM_{2.5} were significantly less than during the same period in 2012
29 and 2013. Mean concentrations of 6 elements ranked in decreasing order: Zn>Pb>
30 Cu≈Mn>As>Ni and spatial concentrations ranked in decreasing order: Shijiazhuang
31 >Baoding>Tianjin>Jinan>Beijing. Risks of the five metals and the metalloid As to
32 health of humans were small, except for Mn in Shijiazhuang. Risks to health posed
33 by other elements were less during the period of study. Risks posed by the five metals
34 and As in Beijing were greater to varying degrees after the APEC meeting. Risks to
35 health of humans during the APEC were overall lesser than the same period in 2012
36 and 2013, mostly due to lesser emissions due to the short-term control measures.

37

38 **Keywords:** Human Health; Risk assessment; APEC; Asia; Air Pollution

39 **1. Introduction**

40 Beijing is the political, economic and cultural center of China. Rapid
41 economic development, urbanization and industrialization of the
42 Beijing-Tianjin-Hebei region during recent decades have been linked with poor air
43 quality. Pollution of air includes particulate matter, dust-haze, photochemical smog,
44 and concentrations of metals potentially adverse to human health (Chan and Yao,
45 2008; Zhang et al., 2013; Zhao et al., 2013). Airborne fine particulate matter (PM
46 with aerodynamic diameter $<2.5 \mu\text{m}$, $\text{PM}_{2.5}$) has been considered a particularly
47 harmful air pollutant, which brings a challenges to China (Chan and Yao, 2008; Hu et
48 al., 2010). Concentrations of metals in air in China have been well documented with
49 potentially toxic concentrations of metals or metalloids such as As, found in urban
50 regions present in aerosols related to anthropogenic processes (Fang et al., 2010; Wei
51 and Yang, 2010). The International Agency for Research on Cancer (IARC) has
52 classified arsenic (As) and arsenicals, cadmium (Cd) and cadmium compounds,
53 hexavalent chromium (Cr) and nickel (Ni) compounds as “carcinogenic to humans”
54 (Group 1); inorganic lead (Pb) compounds as “probably carcinogenic to humans”
55 (Group 2A). Several other metals and As were classified as “possibly carcinogenic
56 to humans” (Group 2B) (IARC, 2006). Concentrations of metals can be enriched in
57 aerosols especially in and on surfaces of particulates, such as $\text{PM}_{2.5}$, which can
58 penetrate the human respiratory system and can be associated with cardio-pulmonary
59 diseases. Metals, once inhaled, can also be distributed to organs, such as liver and
60 kidney, where they can cause other adverse effects on health. Thus, exposure to

61 elevated concentrations of metals in respired air represents a serious concern for
62 human health (Duan and Tan, 2013).

63 Research on airborne particulate contaminants has tended to focus on their
64 physical properties (Duan et al., 2003; Feng et al., 2005; Novák et al., 2013; Okuda et
65 al., 2008; Qu et al., 2012; Sun et al., 2004; Xu et al., 2005; Zhang et al., 2014) but,
66 there have been few assessments of risks posed by metals carried in PM_{2.5} in polluted
67 air events in China (Li et al., 2015).

68 The 22nd annual Asia Pacific Economic Cooperation (APEC) Leaders Meeting
69 was convened in Beijing in November, 2014. To ensure good quality of ambient air
70 during the meeting, many of the primary combustion sources of PM_{2.5} were controlled
71 (MEP, 2014a, b, c). Cessation of many combustion activities over this period
72 provided an excellent opportunity to assess changes in air quality when compared to
73 the same period in previous years when no control occurred. This information could
74 be used to calibrate changes in quality of the air related to remedial actions and serve
75 as a guide for future corrective actions.

76 The objectives of this study were, first to determine concentrations of five metals:
77 Nickel (Ni), lead (Pb), zinc (Zn), copper (Cu) and manganese (Mn) and the metalloid
78 arsenic (As) present in PM_{2.5} from five megacities including Beijing (20 million
79 people), Tianjin (14 million people), Shijiazhuang (10 million people), Baoding, and
80 Jinan in the Jing-Jin-Ji region and surrounding areas during the APEC meeting.
81 Second, to assess risks to health of humans posed by metals associated with PM_{2.5}
82 during this period. Third, to compare concentrations with those during the same

83 period in 2012 and 2013 when no controls were imposed.

84 **2. Materials and Methods**

85 *2.1 Sample collection*

86 A total of 55 samples of PM_{2.5} were collected in Beijing, Tianjin, Shijiazhuang,
87 Baoding and Jinan, during the period November 2 - 20, 2014 (Figure 1). Samples
88 were collected from the local Atmospheric Boundary-layer Observation Stations,
89 which were located along roadways in commercial-residential areas. There are no
90 high buildings or factories in the vicinity, and no “special” sources of contamination
91 at these sample sites but included exposure to natural patterns of wind. Devices for
92 sampling particulate matter were situated on flat roofs 10~20 m above the ground.

93

94 *Figure 1 near here*

95

96 Samples of PM_{2.5} were collected daily by use of “middle-flow”, impact
97 particulate samplers (Wuhan Tianhong TH-150A) with $\phi 90$ mm quartz filter
98 membrane. The rate of airflow during sampling was 100 L/min. Quartz filters were
99 preheated in a muffle furnace at 600 °C for 3 h to remove volatile components before
100 being used for sampling. Before use, filter membranes were placed into a
101 temperature and humidity controlled chamber for 24~48 h at 15~30 °C, with relative
102 humidity of 45%~55% until it achieved a constant weight. An electronic balance
103 with accuracy of 0.01 mg (Mettler Toledo Inc., Switzerland) was used to weigh the
104 membranes before and after sampling. After collection and determination of mass of

105 particulates, samples were sealed and kept in a refrigerator at 4 °C until analysis.

106 Two filed blanks were performed at each site.

107 *2.2 Sample analysis*

108 One-fourth of each filter was extracted with HNO₃-HCl in a microwave digestion
109 system (CEM Co. Ltd., U.S.A) for 15 min at 200 °C (HJ 657-2013) (MEP, 2013).

110 The 10 metals including Al, Fe, Zn, Mn, Ni, Cu, Se, Pb, Ba and V and the metalloid
111 As were quantified by use of inductively coupled plasma mass spectrometry (ICP-MS)
112 (Agilent Technology Co. Ltd., U.S.A) (Zhang et al., 2014.).

113 *2.3 QA/QC*

114 Acids and other chemicals used in this study were of highest-purity. Two field
115 blanks and one laboratory blank were prepared and analyzed. Concentrations of
116 metals and As in the blanks were generally less than 5% of those in samples. Four
117 internal standard elements were used to compensate for matrix suppression and drift
118 of sensitivity of the ICP-MS. Concentrations of metals and As were calculated by
119 use of a five-point, external calibration curve with linearity as determined by
120 coefficients of determination (R^2) of greater than 0.999. A standard was run after
121 every 10 samples to monitor stability of the ICP-MS. The relative standard
122 deviations (RSDs) of concentrations of elements were typically less than 5%.
123 Precision and bias were less than 10%.

124 *2.4 Health risk assessment*

125 The model used in this study to assess risk to humans was that recommended by
126 the United States Environmental Protection Agency (US EPA). Concentrations of

127 five metals (Ni, Pb, Zn, Cu Mn) or As were introduced into the model based on the
128 data collected during the APEC 2014 meeting as well as the same period in 2012 and
129 2013. Exposure concentrations for trace metals in 2012 and 2013 were from the
130 national air quality monitoring program. The main route of exposure was considered
131 to be the human respiratory system into lungs. The risks induced by digestive tract,
132 dermal absorption and others were ignored since their calculated risks would be less
133 than the actual exposure. Assessments of risks to health of the five metals and As
134 were calculated separately for men, women or children. Suitable exposure
135 parameters were introduced into the model used to assess risks to health were based
136 on characteristics of the population of China. As and Ni are recognized carcinogens,
137 while Pb, Zn, Cu and Mn were non-carcinogens (Dong et al., 2014).

138 Risk was predicted based on the assumption of lifetime exposure to the levels of
139 pollutants measured in this study. Lifetime average daily dose (LADD) was used to
140 express exposure to carcinogens, while Incremental life time Cancer Risk (ILCR) was
141 used to express the risk of carcinogens (Equation 1; USEPA, 1989). This would
142 result in predicted risks that were greater than that incurred for the period of exposure,
143 but could be used to make comparisons among periods.

$$144 \quad ILCR = LADD \times SF = \frac{c \times IR \times EF \times ED}{BW \times AT} \times SF \quad (1)$$

145 The ILCR predicts incidence of cancer, as the probability of patients with additional
146 cancers, relative to the background rate. If the ILCR was between $10^{-6} \sim 10^{-4}$ (1 per
147 10,000 to 1 per 1,000,000 additional cancers), indicated it posed *de minimis* risk of
148 cancer (Ma and Singhirunnusorn, 2012). The cancer slope factor (SF) [mg·(kg

149 $\text{bm}\cdot\text{d}^{-1}]^{-1}$ indicated maximum probability of cancer due to exposure to each metal or
150 As. The values examined here were mean daily exposures or doses (ADD;
151 $\text{mg}\cdot(\text{kg}\cdot\text{d})^{-1}$), life, mean, daily exposure doses (LADD; $\text{mg}\cdot(\text{kg}\cdot\text{d})^{-1}$), the
152 concentration of heavy metal (C; $\text{mg}\cdot\text{m}^{-3}$), respiratory rate (IR; $\text{m}^3\cdot\text{d}^{-1}$), exposure
153 frequency (EF; $\text{d}\cdot\text{a}^{-1}$), exposure duration (ED; a), body mass (BM; kg), average
154 exposure time (AT; d). The ADD was used to express exposures to non-carcinogens.
155 The Hazard Quotient (HQ) was used as the measure of hazard posed by
156 non-carcinogens. The non-carcinogen hazard posed by single pollutants was
157 calculated (Equation 2; USEPA, 1989).

$$HQ = \frac{ADD}{RfD} = \frac{c \times IR \times EF \times ED}{BW \times AT \times RfD} \quad (2)$$

159 Where: ADD= Average Daily Dose of non-carcinogen [$\text{mg}\cdot(\text{kg}\cdot\text{d})^{-1}$] and RfD=
160 Reference Dose [$\text{mg}\cdot(\text{kg}\cdot\text{d})^{-1}$] associated with a particular level of effect. If HQ was
161 less than 1.0, hazard associated with the RfD would not be exceeded and hazard was
162 considered to be *de minimis*, whereas values of $HQ > 1$ the hazard posed by the
163 non-carcinogen would be of concern.

164 2.5 Exposure parameters

165 Exposure parameters used in the current study were selected based on China's
166 population characteristics (Dong et al., 2014; Wang et al., 2009). Exposure to metals
167 in air was assessed by predicting inhalation and subsequent exposure to the
168 respiratory system (Table 1). The SF and RfD were those suggested by USEPA's
169 Integrated Risk Information System (IRIS) (Table 2) (USEPA, 1999).

170

171

172 *Table 1 near here*

173

174

175 *Table 2 near here*

176

177 To ensure air quality during the November 2014 APEC meeting, the government
178 of China adopted several, long-term, permanent mitigation measures including
179 shutting down some coal-fired power plants, renovation of obsolete boilers burning
180 the equivalent of 5400 tons of coal to more efficient systems; Removing 391,000
181 older motor vehicles from highways, and closing of 300 polluting enterprises as well
182 as other measures to control some of the primary sources of air pollutants, which were
183 completed by the end of October 2014. In addition, during the APEC, use of cars
184 was restricted by implementation of the odd and even number rule and temporary
185 suspension of operations of some key industrial enterprises, large-scale infrastructure
186 construction that were known periodic sources of particulates. In addition, overall
187 activities and transportation were reduced by large portions of people taking vacation.
188 All these measures sharply reduced the concentration of PM_{2.5} during APEC (MEP,
189 2014d).

190 **3. Results and discussion**

191 *3.1 Averaged daily concentrations of PM_{2.5}*

192 Mean, daily concentrations of PM_{2.5} during the APEC varied among the five

193 megacities (Figure 2) and on each day of the APEC meeting. Two maxima were
194 observed simultaneously in five cities during haze episodes that occurred on
195 November 4 and 9 2014. The greatest concentration of $236 \mu\text{g PM}_{2.5} \text{ m}^{-3}$ was
196 observed in Beijing on November 4, while a concentration of $225 \mu\text{g PM}_{2.5} \text{ m}^{-3}$ was
197 observed in Tianjin on November 9 2014. After the haze episodes, mean, daily
198 concentrations of $\text{PM}_{2.5}$ in the five cities was less than $45 \mu\text{g m}^{-3}$ respectively between
199 November 6 ~ 7 and 11 ~ 12 which were less than the National air quality standard
200 (MEP, 2012).

201

202 *Figure 2 near here*

203

204 In November 2014, when measures were introduced to minimize emissions
205 during the APEC, concentrations of $\text{PM}_{2.5}$ in Beijing were 20.8% and 33.1% less than
206 they were during the same period in November 2012 and 2013, respectively (Figure
207 3). Similarly, in Tianjin and Shijiazhuang, mean, daily concentrations of $\text{PM}_{2.5}$ were,
208 16.4 and 48.7% and 5.0 and 57.7% less, respectively. Reductions in $\text{PM}_{2.5}$ between
209 2014 and 2012 and 2013 were most significant in Shijiazhuang.

210 During the period of the APEC meeting in November, 2014, mean, daily
211 concentrations of $\text{PM}_{2.5}$ were slightly greater than the National air quality standard of
212 $75 \mu\text{g m}^{-3}$ (MEP, 2012). Concentrations of $\text{PM}_{2.5}$ among five megacities were
213 ranked: Baoding > Tianjin > Shijiazhuang > Jinan > Beijing during the APEC.
214 Concentrations of $\text{PM}_{2.5}$ showed that a spatial trend existed with Shijiazhuang >

215 Jinan > Beijing.

216

217 *Figure 3 near here*

218

219 Meteorological conditions during APEC were characterized by a more stable
220 atmosphere conducive to the accumulation of pollutants during the period November
221 2-6, which mainly due to northwest of North China controlled by a Mongolia high
222 pressure cell, the Yangtze River Delta region to the Korean peninsula generated a
223 weak high pressure system, meanwhile with Mongolia high pressure and a
224 northeast-west trough of low pressure, a saddle-shaped field system, that covered
225 Inner Mongolia and parts of North China, developed. From November 5 to 6, a
226 high-pressure continental atmospheric air mass developed and advanced eastward.
227 This cell, which generated a cold wave system covering the Beijing-Tianjin-Hebei
228 region resulted in dispersion of air pollutants. During the period of November 8 to 10,
229 there was always a weak high pressure over the region, which resulted in relatively
230 weak northerly winds originating northwest of Beijing. Also during this period in
231 the eastern part of North China a static, stability weather pattern developed that
232 allowed pollutants to accumulate in the atmosphere. Finally during the period of
233 November 15 to 21, after the APEC, there was an obvious static, pressure field
234 present in North China which did not allow for effective dispersion of pollutants.

235 *3.2 Metal concentrations in PM_{2.5}*

236 It was expected that with lesser concentrations of PM_{2.5} during the APEC

237 meeting concentrations of metals would also be less. This lesser concentration in
238 airborne metal pollution was clearly seen in Beijing (Fig. 4) and Tianjin (Fig. 5) but to
239 a limited extent in Shijiazhuang (Fig. 6). Of the metals associated with particulates,
240 the greatest concentrations were for Al, Fe, Zn and Pb which ranged from 10^2 to 10^3
241 ng m^{-3} with lesser concentrations of Cu, Ba, Mn, As and Se, concentrations of which
242 ranged from 10 to 10^2 ng m^{-3} . Concentrations of Ni and V, which ranged from 1 to
243 10 ng m^{-3} were the least observed. Overall the cities were ranked in decreasing order
244 of pollution of air by metals: Baoding > Tianjin > Shijiazhuang > Jinan > Beijing, and
245 in order of years of decreasing pollution: 2013 > 2012 > 2014.

246

247 *Figure 4 near here*

248 *Figure 5 near here*

249 *Figure 6 near here*

250

251 Mean concentrations of five metals and As ranked in decreasing order were: Zn >
252 Pb > Cu \approx Mn > As > Ni. The concentration of Zn was greatest with a range of
253 $0.174\sim 0.554 \mu\text{g m}^{-3}$ and maximum of $3.76 \mu\text{g m}^{-3}$ in $\text{PM}_{2.5}$ from Shijiazhuang. The
254 concentration of Ni was least with a range of $0.0002\sim 0.008 \mu\text{g m}^{-3}$, but was less than
255 the LOD in Jinan and Tianjin. Concentrations of metals and As, ranked in
256 decreasing order was: Shijiazhuang > Baoding > Tianjin > Jinan > Beijing. However,
257 differences among cities were small.

258 *3.3 Hazard Posed by Five Metals and As in $\text{PM}_{2.5}$*

259 Risks posed by the five metals and As in PM_{2.5} to humans, varied among
260 elements, location and life stages of humans (Figure 7). Regardless of the location
261 or age group Mn followed by As posed the greatest risks to health of humans. As
262 and Ni were the metals considered to be of greatest carcinogenic concern. As had
263 ILCR values of 10⁻⁶~10⁻⁴. These results suggested risks due to cancer was small.
264 Risks to health posed by As ranked in decreasing order of: Shijiazhuang>Jinan>
265 Baoding>Tianjin>Beijing. Risks arranged in decreasing order for life stages were:
266 adults>children. Cancer risks from Ni were less than 10⁻⁷, which is considered *de*
267 *minimis*. Hazards posed by non-carcinogenic toxicity were in decreasing order: Mn
268 >Pb>Zn>Cu. Mn exhibited potential non-carcinogenic hazard (HQ>0.1) to
269 health of humans whereas Pb, Zn and Cu exhibited lesser hazard (HQ<0.1). HQs
270 of Mn for men, women and children in Shijiazhuang, were 1.08, 0.93 and 1.19,
271 respectively. These results suggested that Mn in PM_{2.5} posed risk to the local
272 population. Manganese is a required, trace element for animals and plants, but can
273 be toxic to humans. The main route of exposure of humans to Mn is via respiration.
274 The risks posed by dietary or dermal absorption of Mn were ignored because they
275 were *de minimis* and much less than those posed by respiratory exposure. In this
276 study, inhalation was the dominating exposure route for local residents to all metals
277 and As. The main potential sources of metals and As in PM_{2.5} were anthropogenic,
278 such as metallurgy, iron and steel industrial production and emission. After
279 accumulation via the lungs, Mn could also be distributed to other tissues, including
280 liver and kidney. Overall, health risks of five metals and As for men, women and

281 children were small except for Mn in Shijiazhuang.

282

283 *Figure 7 near here*

284

285 Risks to health of five trace metals and As for men during the APEC in 2014 were
286 less than during the other years, although not dramatically so for Beijing and Tianjin
287 than the same time of year in 2012 or 2013 (Figure 8). The lesser risk to health in
288 Shijiazhuang during the APEC in 2014 was limited.

289 The ILCR for both As and Ni were less than 10^{-4} , which suggested risks of
290 additional cancers caused by these elements were small. Mn has a potential
291 non-carcinogen hazard for human health, and hazards of the other five metals were *De*
292 *minimis*. The health risks and hazards of five metals and As to men ranked as
293 2012>2013>2014 in Beijing and Tianjin, and 2012≈2013>2014 in Shijiazhuang. ,
294 Due to lesser emissions during APEC in November 2014, risks to health of humans of
295 the five metals and As were lesser than those for the same period in 2012 and 2013.

296

297 *Figure 8 near here*

298

299 Control measures imposed for the APEC November 2014 were effective at
300 lessening concentrations of $PM_{2.5}$ and associated metals, particularly for As and Ni
301 where cancer was reduced by more than a factor of 10 (Fig. 9). Reductions in hazard
302 quotients for the other metals were more modest, with the least improvement seen in

303 Shijiazhuang (Figure 9). After the APEC meeting and relaxation of control
304 measures, the presence in air particles of As posed a potential cancer risk and Mn
305 posed a potential non-cancer hazard.

306

307 *Figure 9 near here*

308

309 **4. Conclusions**

310 In November 2014, control measures were introduced to minimize emissions
311 from combustion of fossil fuels, including coal, emissions from factories and vehicle
312 exhaust during the APEC meeting. Concentrations of PM_{2.5} in Beijing were 20-33%
313 less than they were during the same period in November 2012 and 2013, whilst in
314 Tianjin and Shijiazhuang, daily, mean concentrations of PM_{2.5} were, 16 to 49% and 5
315 to 58% less, respectively. During the period, during which controls were imposed,
316 concentrations of 10 metals and As present in the PM_{2.5} from five megacities
317 including Beijing, Tianjin, Shijiazhuang, Baoding, Jinan from Jing-Jin-Ji were also
318 less. The most dramatic decreases in concentrations were observed for Fe and V.
319 Mean daily concentrations of PM_{2.5} in the five megacities were slightly greater than
320 the Chinese National Standard limit of 75 µg m⁻³, but less than the same period in
321 2013 and 2012. Health hazards or risks of five trace metals and As for men, women
322 and children were small for most locations for most metals, except for Mn in
323 Shijiazhuang. Risks posed by five trace metals and As during APEC were overall less
324 than those during the same period in 2012 and 2013. The fact that concentrations of

325 PM_{2.5} and metals were less during APEC following control measures with predicted
326 health benefits was encouraging and demonstrated that China could improve the
327 health outcomes for its urban residents with further efforts.

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337

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429

Table 1. Human exposure parameters via respiratory system intake.

Parameter ^a	Men	Women	Children
IR/m ³ ·d ⁻¹	19.02	14.17	5
BM/kg	62.7	54.4	15
EF/ d·a ⁻¹	350	350	350
ED/ a	30	30	6
AT(carcinogen)/a	70 × 365	70 × 365	70 × 365
AT(non-carcinogen)/a	30 × 365	30 × 365	6 × 365

430

Note: ^a IR refers to respiration rate; BW refers to body weight; EF refers to exposure frequency; ED refers to exposure day; AT refers to average time;

431

432

433

434

Table 2. Dose-response parameters of 5 metals and As via inhalation.

RfD ^b (Non-carcinogen)				SF ^c (Carcinogen)	
(mg·(kg·d) ⁻¹)				(mg·(kg·d) ⁻¹)	
Pb	Zn	Cu	Mn	As	Ni
3.50×10 ⁻³	3.00×10 ⁻¹	4.00×10 ⁻²	1.43×10 ⁻⁵	15.10	0.84

435

Note: ^b RfD refers to reference dose; ^c SF refers to slope factor;

436

437

438 **Figure captions:**

439 **Figure 1.** Areas within five megacities in the Beijing-Tianjin-Hebei Region, from
440 which samples were collected during the APEC in November 2014.

441 **Figure 2** Mean daily concentrations of PM_{2.5} in five megacities during APEC,
442 November, 2014.

443 **Figure 3** Comparison of mean daily concentration of PM_{2.5} during the non-heating
444 season in autumn 2012 to 2014.

445 **Figure 4** Concentrations of 11 elements in PM_{2.5} in Beijing during the period 2012 to
446 2014 (ng m⁻³).

447 **Figure 5** Concentrations of 11 elements in PM_{2.5} in Tianjin during 2012 to 2014 (ng
448 m⁻³).

449 **Figure 6** Concentrations of 11 elements in PM_{2.5} in Shijiazhuang during 2012 to 2014
450 (ng m⁻³).

451 **Figure 7** Risks to health of humans due to exposure to five metals and As for men,
452 women and children during the APEC.

453 **Figure 8** Comparison of risks to health posed by five metals and As for men during
454 the APEC with the same period in 2012 and 2013.

455 **Figure 9** Comparison of risks to health of humans posed by five metals and As in and
456 after the APEC in Beijing.

Figure 1

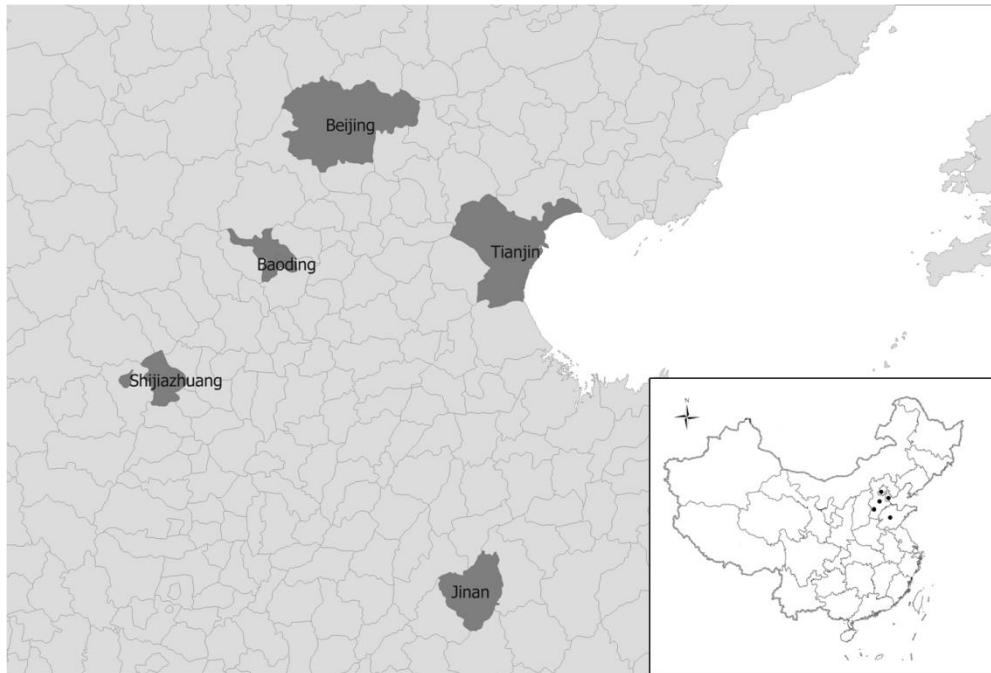


Figure 2

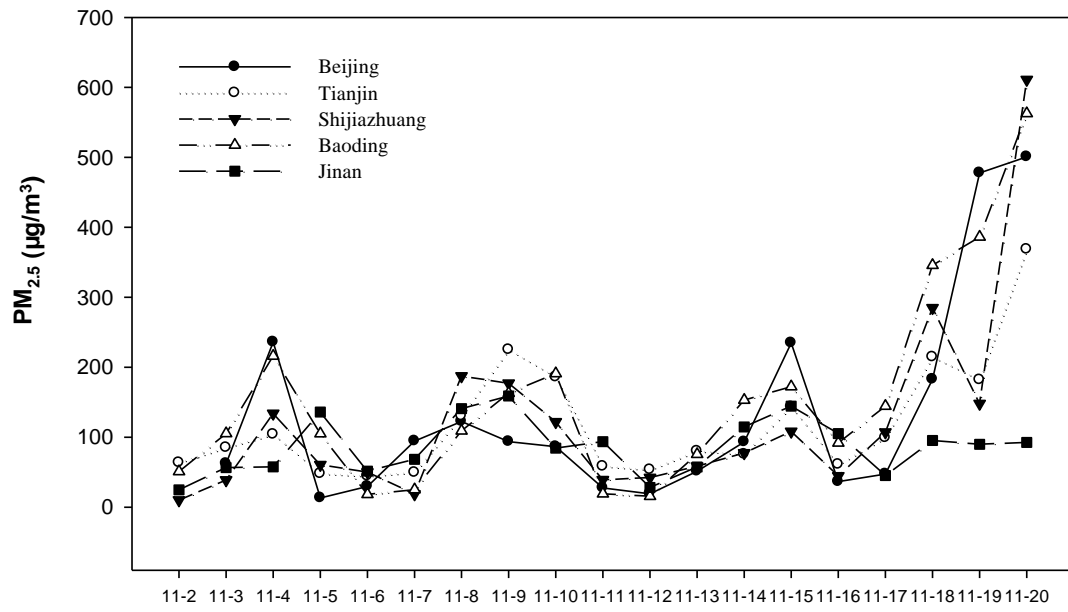


Figure 3

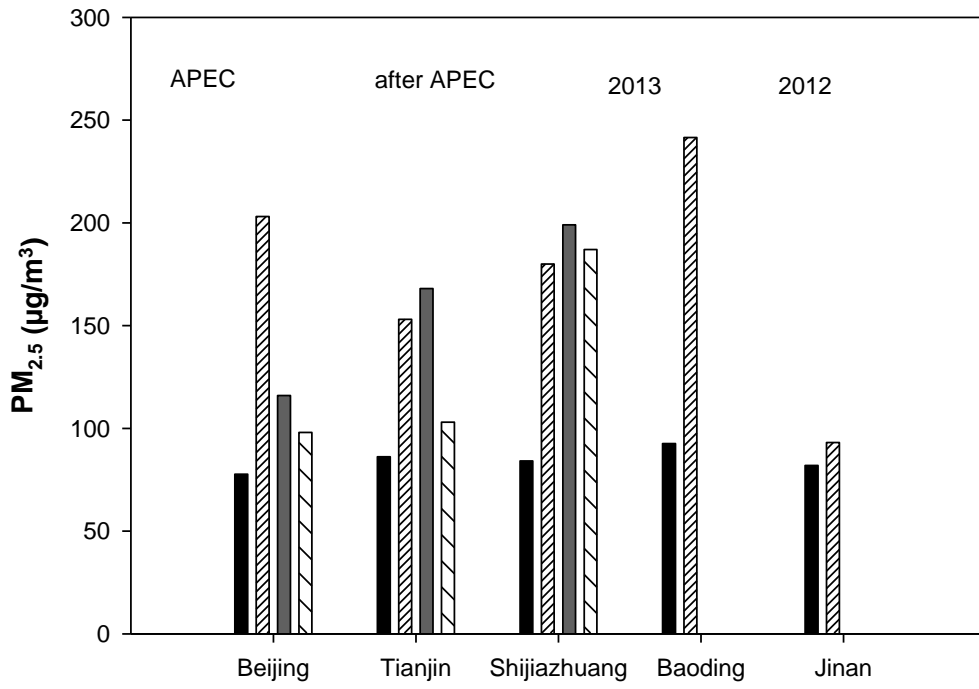


Figure 4

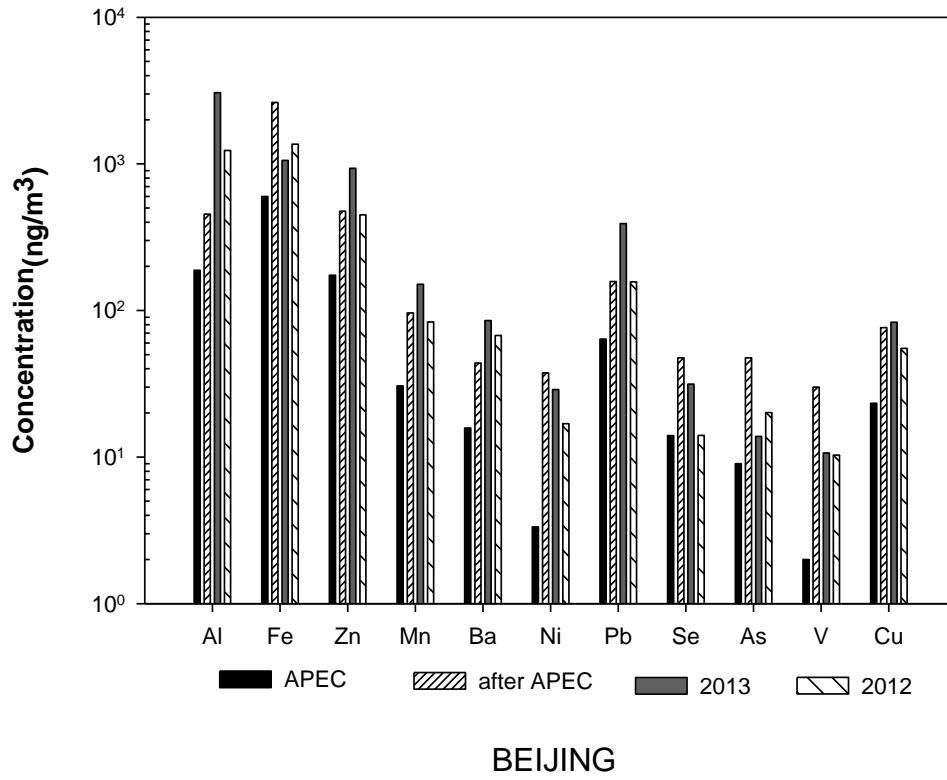


Figure 5

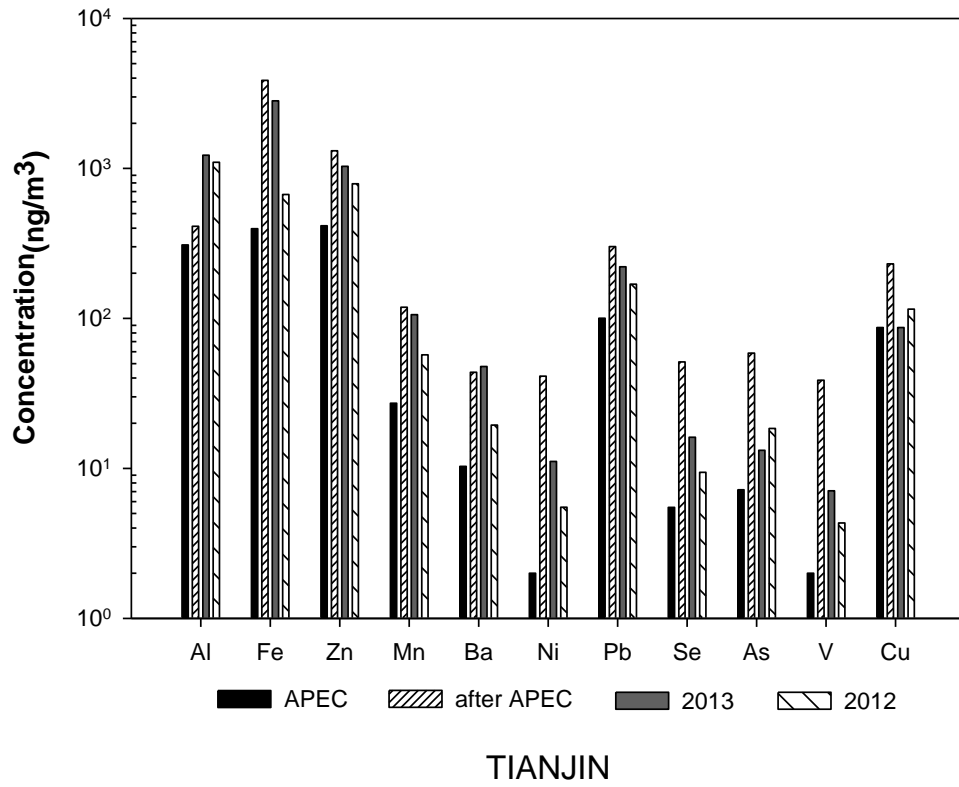


Figure 6

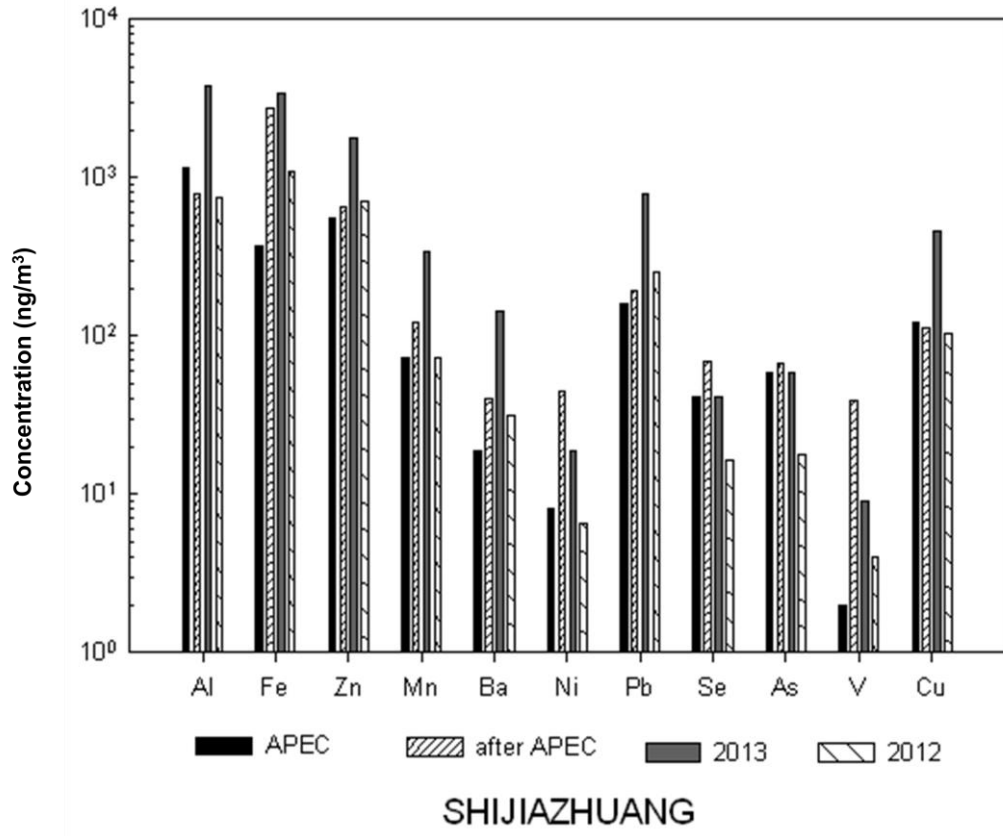


Figure 7

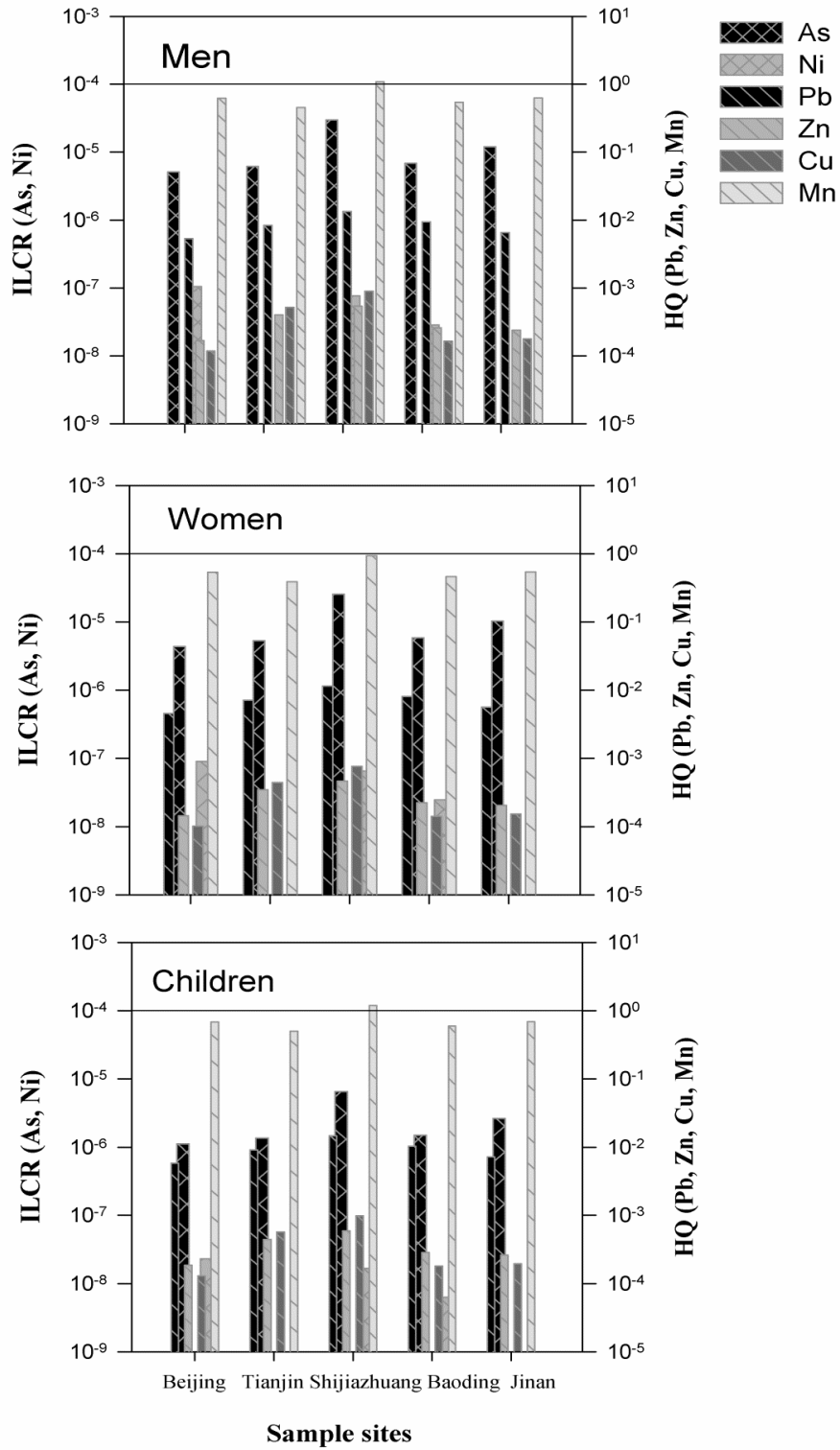


Figure 8

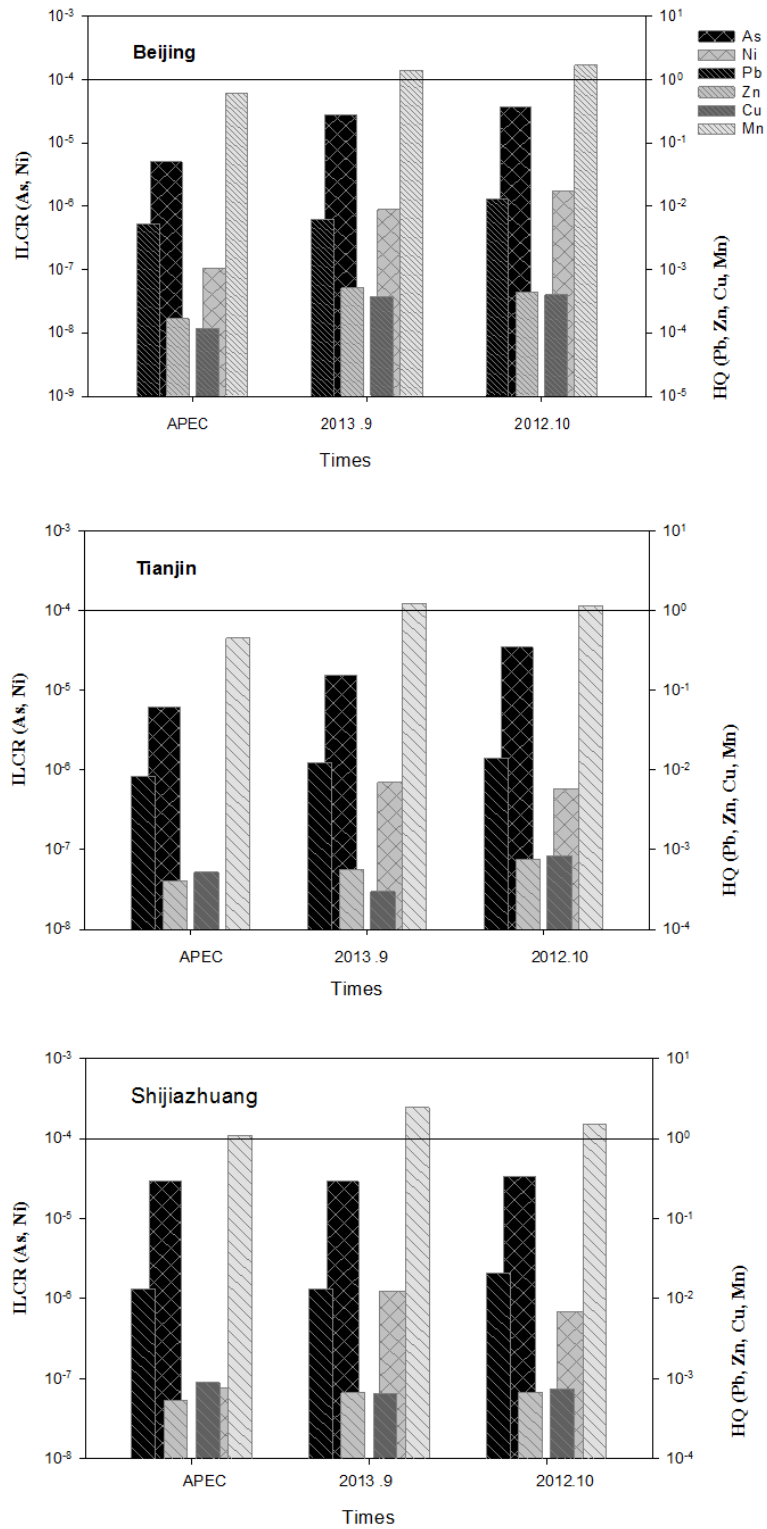


Figure 9

