Bull. Environ. Contam. Toxicol. (1998) 60:892-897

Bulletin of Environmental Contamination and Toxicology

# Metal Levels in Rain Water from Kobe City in Japan

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Received: 16 January 1998/Accepted: 31 March 1998

With regard to the resulting pollution of ram water, atmospheric contaminants are the generic term for solid, fluid, or gaseous materials in the atmosphere, which are washed out by rain or snow or deposit as sediments. Chemical analysis of rain water has been done since about 1774 ( Goettle 1978 ). Dustfall studies began about 1894, when samples were taken of snow that had extremely black appearance, as a result of dust and soot from the atmosphere ( Johnson et al. 1966 ). We have previously reported volatile chlorinated organic compound ( Adachi et al. 1994 ) and formaldehyde ( Adachi et al. 1996 ) levels in ram water from three different locations. The distances from highway ( Hanshin Highway ) are 50 meter at the A point, 1,500 meter at the B point and 2,900 meter at the C point, respectively. Since few detailed investigations have been appeared in the effects of geographical situation on air-polluted chemical components, we performed the determinations of thirteen kinds of metals in rain water and compared the respective data.

## MATERIALS AND METHODS

Six hundred nine samples of ram water were collected through five years (January, 1991 - December, 1995) at the different points as shown in Figure 1. All the rainfalls were individually collected in funnel-bottle samplers ( volume: 2000 ml ). Sampling was started from the first ram droplets fell on the ground. The collected ram water was filtered through 0.45 $\mu$ m Millipore filter and kept at 4 °C until analyzed. The distances from the highway ( Hanshin Highway ) are 50 meter at the A point, 1,500 meter at the B point and 2,900 meter at the C point, respectively. The C point stands 300 meter above the sea-level. Concentrations of $Ca^{2+}$, $Mg^{2+}$, $K^{+}$, $Na^{+}$, Fe, Total Mn, $Al^{3+}$, $Pb^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Ni^{2+}$, $Cd^{2+}$ and Total Cr in water samples were assayed by a flameless atomic absorption

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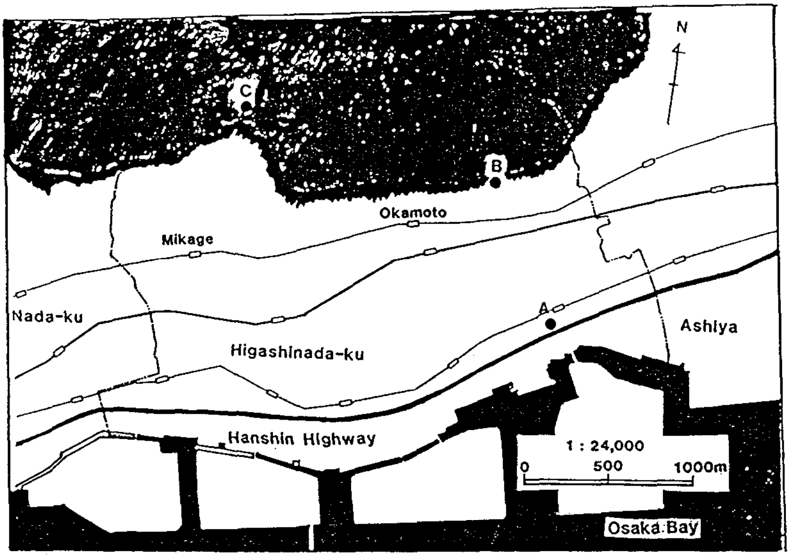

Figure 1. Sampling points of rain water

Table 1. Operating conditions of atomic absorption spectrophotometry

Apparatus : Shimadzu AA-620 + GFA-1
Special bandwidth : 0.19 nm
Expantion : x 1
Gas mode and flow rate : 2-Ar, 1.51 / min
Injection volume : 10 ~ 25 μ l

spectrophotometric method. Operating conditions were shown in Table 1.The rain water samples were subjected to atomic absorption spectrophotometer with or without dilution by deionized distilled water. Satistical analysis was performed by the Student’s T-test.

## RESULTS AND DISCUSSION

Figure 2 shows variation of yearly cumulative amounts of rainfall collected from the three locations. The respective amounts of rainfall were close to each other. Table 2 shows the assayed values of metals in sample waters from the three points. The concentrations of $Pb^{2+}$, $Cu^{2+}$ and $Ni^{2+}$ at the B point were significantly higher than those of the A and C point, respectively ( $p<0.01$ ) . Figure 3 shows the yearly cumulative amounts of these elements in rain water collected from the three points. When the values were compared to each other, the amounts of $Ni^{2+}$ from the B point were approximately 2 and 3 times higher than those from the A and C points, respectively. We have previously reported that significant correlations were observed between the $NO_3^-$ and $Ni^{2+}$ levels in the rain water obtained from the A and B points ( Adachi et al. 1992 ). Since these ions are usually included in motor vehicle exhausts, it was concluded that both A and B points were influenced by the air pollution due to motor vehicles ( Adachi et al. 1992 ). Moreover, we suggested that the assayed values of $Ni^{2+}$ in rain water can be used as one of indicators for air pollution by motor vehicle exhausts. As shown in Figure 3, the amounts of $Pb^{2+}$ and $Cu^{2+}$ at the B point am higher than those at the A and C point. These two elements may be derived from industrial production in this area. The A point is closer than the B point to the highway and factory. The results showed that the amounts of $Pb^{2+}$, $Cu^{2+}$ and $Ni^{2+}$ at the B point are higher than those at the A point, suggesting that the aerosol particles containing these metals are not diffusable across the mountains and accumulate near the mountainside, i. e., the B point. Figure 4 shows the specific gravity of the metals assayed. Those of $Pb^{2+}$, $Cu^{2+}$ , $Ni^{2+}$ and $Cd^{2+}$ is larger than eight. The amounts of three elements except $Cd^{2+}$ at the B point are higher than those at the A and C points. The reason why there was no significant difference among the $Cd^{2+}$ concentrations obtained from the three different points may be very low level of this element. These results suggest that the specific gravity of the metals may has an important effect on its diffusion rate. Kennedy et al.( 1982 ) reported that the predominant factor affecting deposition of airborne particulates is the size of the particle and the motion of particles is related to their size, density and shape. Figure 5 shows the total metals in the three rain collections (μ equivalent /1). When the these values were compared, that of B point was highest. These results suggest that a geographical situation affects the concentration of chemical components in rain water, because the pollutants at the B point may stay for a long time without diffusion by a wall made by Rokko mountain situated at the back of the B point.

Table 2. Assayed values of metals in rain water at A, B and C from January of 1989 to December of 1993

| Substance | A | | B | | C | |
|---|---|---|---|---|---|---|
| | Min. - Max. | M±SD | Min. - Max. | M±SD | Min. - Max | M±SD |
| $Ca^{2+}$ (mg/l) | 0.14-8.52 | 0.83±0.83 | 0.01-3.64 | 0.77±0.78 | 0.03-10.5 | 0.73±0.26 |
| $Mg^{2+}$ (mg/l) | 0.01-1.39 | 0.14±0.28 | 0.02-0.61 | 0.10±0.0 | 0.01-0. 22 | 0.10±0.04 |
| $K^{2+}$ (mg/l) | 0.02-0.80 | 0.49±0.23 | 0.01-0.44 | 0.30±0.18 | 0.02-1.18 | 0.60±0.72 |
| $Na^{+}$ (mg/l) | 0.04-11.81 | 0.45±0.34 | 0.03-10.60 | 0.60±0.53 | 0.03-1.35 | 0.38±0.30 |
| $Fe^{2+}$+$Fe^{3+}$(mg/l) | 0.01-0.80 | 0.16±0.13 | 0.01-1.21 | 0.11±0.19 | 0.01-0.33 | 0.13±0.08 |
| Total Mn(mg/l) | 0.01-0.05 | 0.01±0.01 | 0.01-0.04 | 0.01±0.005 | 0.001-0.04 | 0.009±0.007 |
| $Al^{3+}$ (mg/l) | 0.01-4.00 | 0.17±0.26 | 0.01-1.16 | 0.13±0.15 | 0.01-1.20 | 0.20±0.34 |
| $Pb^{2+}$ (mg/l) | 0.01-0.19 | 0.06±0.03 | 0.01-0.27 | 0.16±0.03* | 0.01-0.24 | 0.07±0.02 |
| $Cu^{2+}$(mg/l) | 0.38-2.42 | 1.07±0.48 | 0.56-2.48 | 1.58±0.48* | 0.33-2.41 | 0.97±0.48 |
| $Ni^{2+}$ (mg/l) | 0.01-4.63 | 0.49±0.58 | 0.07-4.56 | 1.36±0.77* | 0.01-1.99 | 0.39±0.12 |
| $Zn^{2+}$ (mg/l) | 0.24-0.71 | 0.40±0.11 | 0.25-0.71 | 0.45±0.1 | 0.23-0.59 | 0.41±0.12 |
| $Cd^{2+}$ (μg/l) | 0.01-0.46 | 0.13±0.13 | 0.01-0.40 | 0.21±0.16 | 0.01-0.46 | 0.11±0.09 |
| Total Cr(μg/l) | 0.01-3.00 | 0.08±0.16 | 0.01-3.00 | 0.07±0.14 | 0.01-2.00 | 0.04±0.06 |

*Significantly higher than the respective data of A and C, $p<0.01$.

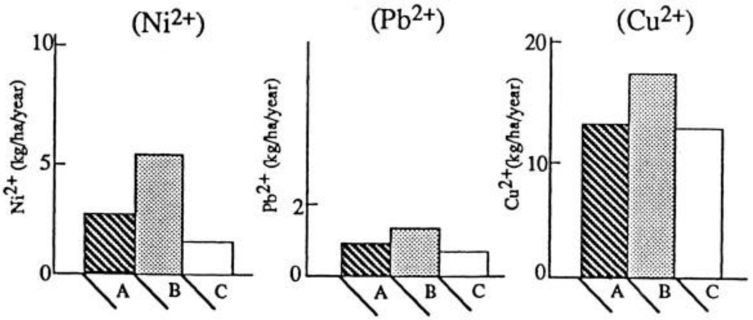

Figure 3. Yearly cumulative amounts of $Ni^{2+}$, $Pb^{2+}$ and $Cu^{2+}$ in rain water collected from the three locations

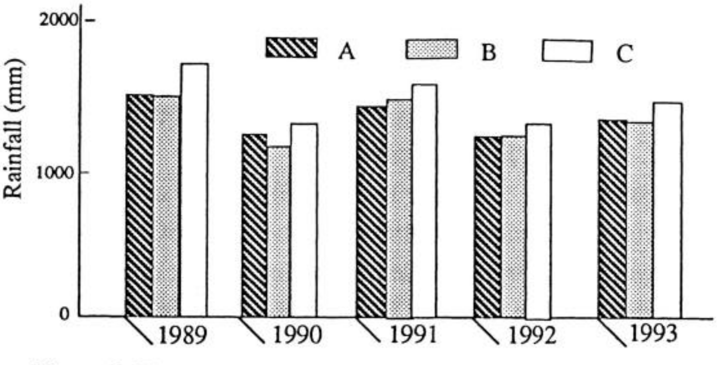

Figure 2. The amounts of rainfall collected from A, B, and C points from January of 1989 to December of 1993

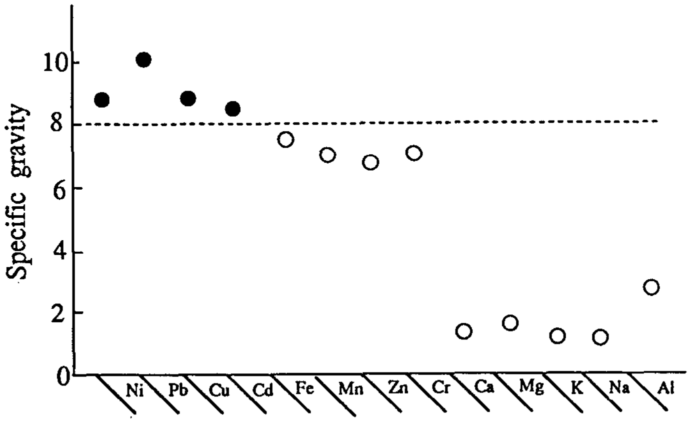

Figure 4. Specific gravity of metals

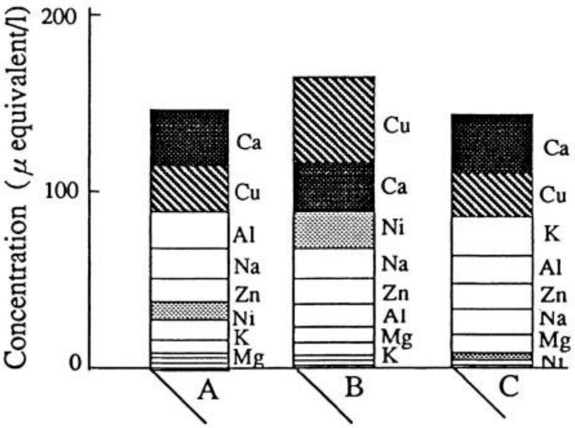

Figure 5. Comparison of metals in rain water collected from the three locations

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