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Effect of Air Pollution Chemical Components on the Acidity of Rain Water in Japan

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Acid rain has recently become a serious environmental problem in Japan. The observation of acid rain by the O.E.C.D. project "Long Range Transport of Air pollutants" have shown that acid rain is widespread in Europe (Marsh 1978). Acidification of many lakes in the northeast areas of the United States and Canada has impacted fish life (Hultberg et al.1982). Acid rain is regarded as the results of air pollution mainly derived from SO_2 and NO_x, which are hydrolyzed and/or oxidized to H_2SO_4 and HNO_3, respectively (Mcnaughton 1981, Galloway et al.1981). Marsh(1978) reported that the acidity of rain is governed by the overall charge balance equation of the ions in solution. Krupa et al. (1976) stated that no correlation could be found between the concentrations of SO_4^{2-}, NO_3^- and Cl^- and the observed change in pH of rain water. Therefore, there is no general theory for the acidity of rain water. Since few detailed investigations have been appeared in the effects of various kinds of air-polluted chemical components on acidity of rain water, we performed the determinations of pH, electric conductivity (EC) and cationic and anionic ions in rain water collected from industrial and residential areas in the southern part of Hyogo prefecture in Japan and compared the respective data.

MATERIALS AND METHODS

Sixty two samples of rain water were collected through a year (from January in 1986 - to December in 1986) from two different locations: Kobe and Tsuchiyama. The two locations, situated in the southern part of Hyogo prefecture in Japan, were chosen as representatives of residential and industrial areas, respectively. During this period there were thirty one times of rain-

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falls. All the rainfalls were individually collected in funnel-bottle samplers (volume: 2000ml) and the collected rain water was kept at 4°C until analyzed. The concentrations of SO_4^{2-}, NO_3^-, NO_2^-, Cl^- and NH_4^+ in rain water were assayed by colorimetric methods, while those of Na^+, K^+, Mg^{2+} and Ca^{2+} were determined by an atomic absorption spectrophotometric method.

RESULTS AND DISCUSSION

Figure 1 shows variations of the amounts of rainfall and pH in rain water collected from the two locations. In almost all cases, the pH value of the rain water collected from the industrial area was higher than those from the residential area. The respective amounts of rainfall were closed to each other except in 1 May and 29 August 1986. Table 1 shows the assayed values of pH, EC and the ion concentrations in the rain water. The average concentration of SO_4^{2-} regarded as the most probable concomitant to acid rain in industrial area was 5.1 mg/l, which was significantly higher than those in the residential area(2.5 mg/l). On the other hand, the mean value of pH in the rain water of industrial area was 6.3, which was a little higher than that in those of residential area (5.8) but not significant. This is a discrepancy, because air pollution in industrial area is generally more heavy than that in residential area and therefore everybody can imagine the formers may be more acidic than the latters. In order to clarify the discrepancy, we assayed all the ions in the rain water. The results showed that the concentrations of cations (NH_4^+, Ca^{2+}, Na^+ and Mg^{2+}) in the rain water of industrial area were significantly higher than those in the residential area (Table 1). Figure 2 shows the comparison between the levels of anions and cations in the two rain water collections(µequivalent/l). The total cations levels in the rain water collected from the industrial area are about 2 times higher than those from the residential area. The results suggested that these cations neutralized the acidic anions(SO_4^{2-} and NO_3^-). Marsh(1978) commented that usually SO_4^{2-} and NO_3^- are dominantly contributing to acidity of rain water, while NH_4^+ is neutralization of acid. Sullivan et al.(1988) reported that the acidity of rain water depends on the balance between anions and cations levels in the water. The higher concentration of these cations in the formers might be derived from dust and ash from many factories in the industrial area. Our results suggest that these cations may act an important role to neutralize acidic anions.

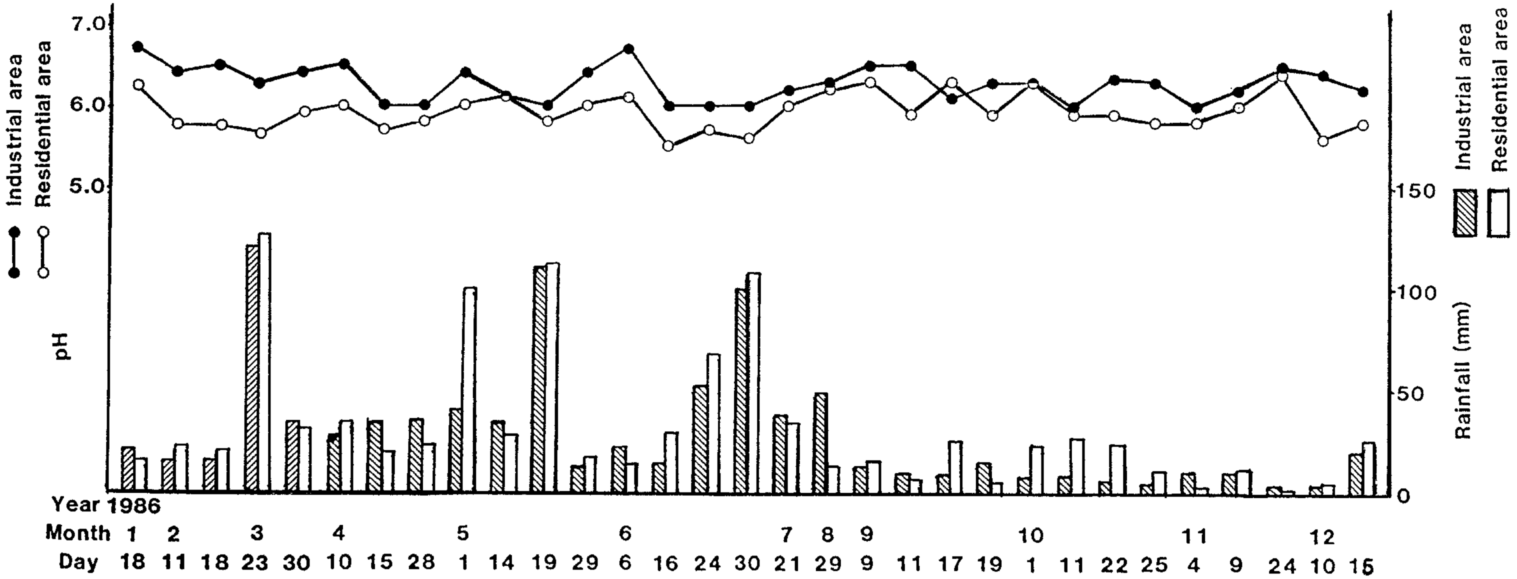

Figure 1. Variation of the amounts of rainfall and pH in rain water collected from the two locations in the southern part of Hyogo prefecture

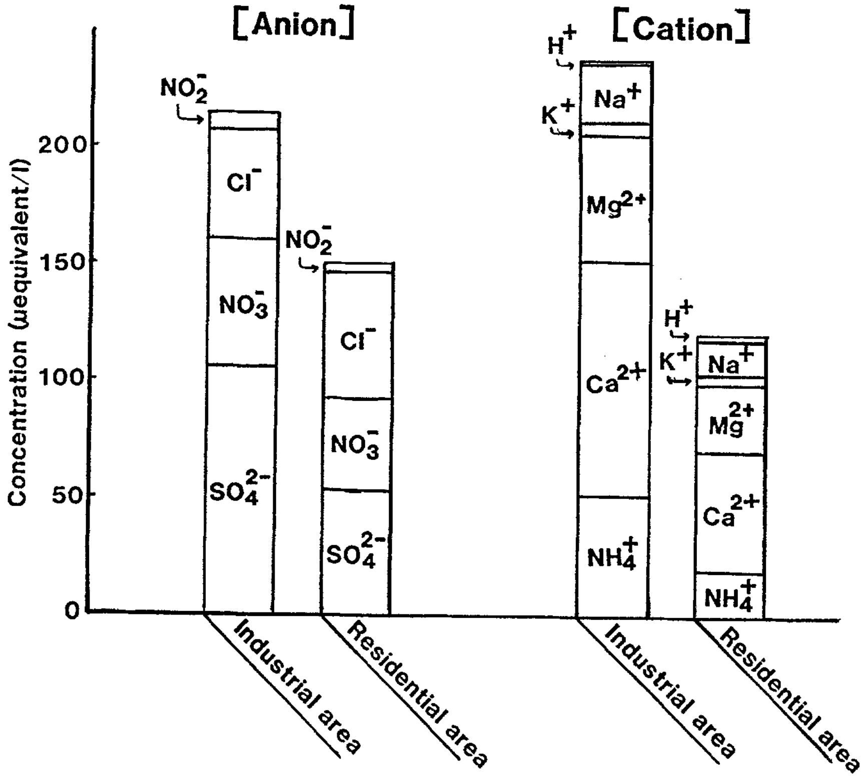

Figure 2. Comparision of between the levels of anions and cations in rain water collected from locations in the southern part of Hyogo prefecture

Table 1. Assayed Values of pH, EC and Ions in Rain Water at the Southern Part of Hyogo Prefecture

Substance	Industrial area		Residential area	
	Min.-Max.	M±SD	Min.-Max.	M±SD
pH	6.0-6.7	6.3±0.2	5.5-6.4	5.8±0.2
EC (μ℧/cm)	11.3-89.0	34.1±21.8	14.9-186.0	46.2±38.4
SO_4^{2-} (mg/l)	0.23-22.10	5.1±6.1★	0.02-9.00	2.5±1.8
NO_3^- (mg/l)	0.92-8.71	3.4±2.1	0.5-14.2	2.5±2.1
NO_2^- (mg/l)	0.07-1.16	0.30±0.29	0.01-0.53	0.19±0.15
Cl^- (mg/l)	0.2-6.2	1.6±1.5	0.6-5.8	1.9±1.5
NH_4^+ (mg/l)	0.11-7.89	0.89±1.51★	0.05-3.72	0.34±0.70
Ca^{2+} (mg/l)	0.20-10.03	2.32±3.50★	0.13-10.52	1.02±2.05
K^+ (mg/l)	0.04-1.79	0.25±0.35	0.03-0.55	0.15±0.13
Na^+ (mg/l)	0.01-2.77	0.57±0.76★	0.01-1.00	0.30±0.25
Mg^{2+} (mg/l)	0.02-0.93	0.63±1.01★	0.02-0.81	0.35±0.30

★ Significantly different from the respective data of Industrial area, $p < 0.05$.

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