

Preparation and Evaluation of Certified Reference Materials for Asian Mineral Dust

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Abstract

Asian mineral dust, which forms what is known as kosa aerosol, is transported from the desert and loess areas of interior China to Japan and even to central Pacific islands by the prevailing westerly winds. Certified Reference Materials for kosa aerosols are necessary for analytical quality control and to enable researchers to distinguish between kosa and non-kosa aerosols. Two Certified Reference Materials were made from material from the loess plateau (Gansu Province, China) and from desert surface soil of the Tengger Desert, China. The first of these is designated as China Loess (CJ-1) and the other as Simulated Asian Mineral Dust (CJ-2). Thirteen certified elemental concentration values for these materials were determined. For example, Al, Ca and Sr, which are good indicator elements for kosa aerosol, were certified as 6.01%, 5.83% and 277 $\mu\text{g/g}$ in CJ-1 and 5.88%, 5.33% and 244 $\mu\text{g/g}$, in CJ-2. It was shown experimentally that kosa aerosol can have a neutralizing effect on acid rain.

Key words : Acid rain, Asian mineral dust, Certified Reference Material, Kosa aerosol, Loess, Neutralization

1. Introduction

The troposphere contains mineral aerosols generated by wind action on arid and semi-arid areas such as the Sahara Desert in Africa, and the Taklamakan and Gobi Deserts in Asia. The mineral aerosol in the atmosphere, estimated at about 1,500 million tons in total weight, has huge effects on the global environment (Jonas *et al.*, 1996). For example, it has been suggested that this mineral aerosol has a restraining effect on global warming, and an effect on the earth's radiative budget similar to that of anthropogenic sulphates of approximately -0.75 W/m^2 (Andreae, 1996; Hansen *et al.*, 1998; Bergametti & Dulac, 1998). Asian mineral dust (known as kosa aerosol) is borne by the prevailing wind from the interior of China to Japan in spring every year (Iwasaka *et al.*, 1988; Kwon *et al.*, 1997; Mori *et al.*, 1998a), and has even been observed reaching the North American continent when conditions were right for long-range transport (Holmes *et al.*, 1996; Uematsu, 1998; Husar, 1999). The amount of kosa aerosol deposited in the East Pacific region, including Japan, is estimated at between 0.1–10 g/m^2 per annum (Tsunogai *et al.*, 1985; Uematsu *et al.*, 1985; Prospero, 1996; Liu & Zhou, 1999), and is considered to be one of the main sources of water soluble iron and phosphorus for ocean plankton growth (Duce & Tindale, 1991; Zhuang *et al.*, 1992; Kuma *et al.*, 1992). Kosa aerosol is high in calcium carbonate and, therefore, has the potential to neutralize acid rain (Hirai *et al.*, 1991; Sakamoto, 1991; Inoue *et al.*, 1998), and is a noticeable carrier/scavenger of sulphates and nitrates in the

atmosphere (Okada *et al.*, 1990; Nishikawa *et al.*, 1991a; Quan *et al.*, 1994). Thus, kosa aerosol has been monitored by a wide range of scientific disciplines, such as meteorology, atmospheric science, earth science, oceanology and environmental chemistry. Until now there have not been any reference materials available to provide quality control of chemical analytical data for mineral aerosols. This paper reports the procedures undertaken to produce the first mineral aerosol reference materials, the process by which the values were certified, and the physical and chemical characteristics of the aerosols.

2. Source and Preparation of Materials

There is a loess plateau occupying large areas of Gansu, Shanxi, Shaanxi, Ningxia Hui and Nei Menggu Provinces along the Huang He (Yellow River) in China. Aeolian dusts originating from large inland deserts have been deposited on the loess plateau, and have formed layers up to several hundred meters thick (Liu *et al.*, 1985). It is important for environmental and earth sciences to have a set of reference materials made from this fresh aeolian desert dust and from old loess soil that has accumulated over several thousand years.

2.1 China loess material (CJ-1)

The China loess material was collected in an arid area near Huining in Gansu Province. The approximate location of the collection site is shown in Fig. 1. The height of the site was about 1800 m above sea level. The site had a loess accumulation typical of the region and was about 250 m thick. Fifty kilograms of loess soil material were collected from between 1.8

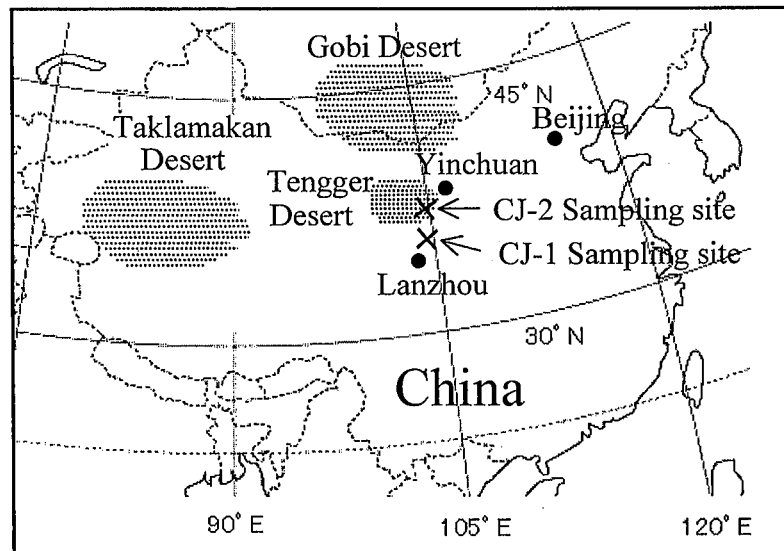


Fig. 1 Map of China showing the sampling locations for the materials used in the preparation of Certified Reference Materials CJ-1 and CJ-2

and 2.5 m depth in the Malan loess horizon. The material was greyish yellow colour and had a particle size range of about 0.01–0.04 mm. The Malan loess horizon had a susceptibility value of 30–40 SI and could therefore be distinguished from the upper surface soil which had higher susceptibility values (60–120 SI) (Ren *et al.*, 1996). After rough sieving through a 16 mesh sieve to remove large particles, plants roots etc. at the collection site, the secondary material was transported to the National Research Center for Environmental Analysis and Measurement in Beijing where further sieving using a 100 mesh sieve was conducted. Forty kilograms of tertiary material was obtained by this means. The material was then homogenized using a V blender for four hours, and it is this latter material that was the source of CJ-1.

After homogenization, the material was separated into 15 g portions and sealed into 2,000 brown glass bottles. All bottles containing the loess material were then sterilized by exposure to cobalt 60 irradiation.

2.2 Simulated Asian mineral dust material (CJ-2)

Twenty-five metric tons of desert surface sand (0–6 cm depth) were collected from the southeast part of the Tengger desert in the Ningxia Hui autonomous region of China. The approximate location of the collection site is also shown in Fig. 1. The sampling site was located near Shapotou village (40°N and 116°E). The landscape of the sampling site consisted of big sand dunes and a thick layer of porous pale yellow sand. At the collection site, 800 kg of primary material were obtained by 60 mesh rough sieving. Further sieving through a 250 mesh sieve produced 33 kg of secondary

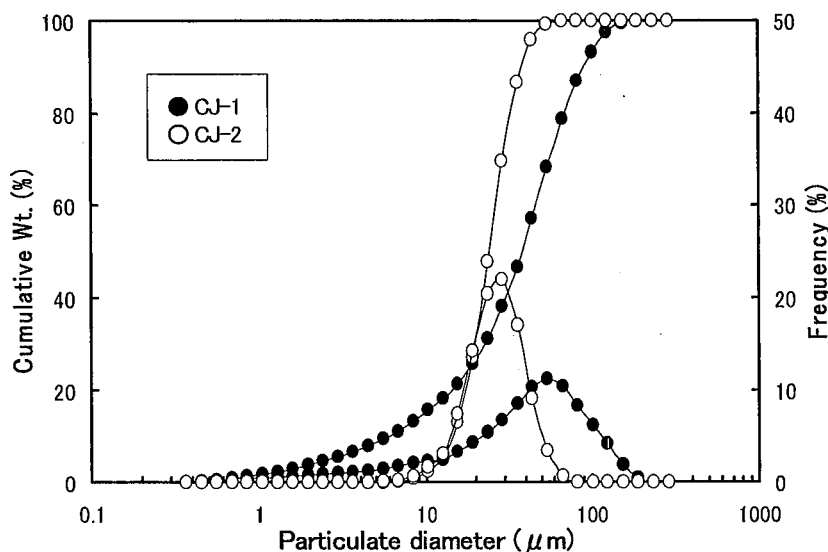


Fig. 2 Particulate size distributions of CJ-1 and CJ-2 measured by a laser scattering particle-size distribution analyser (SALD-2100, Shimadzu Co.) after ultrasonic dispersion for 1 minute in ultra-pure water.

Table 1 Summary of mean elemental values from inter-laboratory analysis of China Loess (CJ-1)

	(Unit: $\mu\text{g/g}$)								ICP/AES (Acid Digestion)			ICP/AES (Alkali Fusion)			AA	NAA	AFS	XRF				PIXE	IC	Combustion Method	CHN	Gravimetric Method
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 1	No. 2	No. 3				No. 1	No. 2	No. 3	No. 4								
Na	13600	13400	13400	13200	13300				13400	13100	12300	13000	13400				13500	12900		15100	13830					
Mg	16000	15500	16000	15900	15900		15400	15700	15300	15500	16200	16700				15700	15400	15200	15600	15300						
Al	60500	60400	60400	59800	60300			60300	59400	60400		64500				61100	59900	60700	63800							
Si								276000	279000	278000						279000	271000	280000	277000	256000					278000	
P	720	617	620	615				640		830						700	608	633								
S																(480)						243				
K	19900	19500	19400	19200	19400			19500	20300	17200	18500	18800			19200	19200	20000	21300	19700							
Ca	60000	57900	59000	58200	59000		60100	57700	57600	57600		55500			58600	59100	58500	76400	57800							
Sc	9.57	9.52		10.2									11.0		(13)											
Ti		3110	3500		3460			3600	3380	3740		3870			3600	3650	3630	3740								
V	80.9	71.2	75	76.9	82.3	79.5	74.7						75.7		81	71.0										
Cr	49.1	55.2	59	60.5	58.2		52.1	62			56.3	64.1			67			(59)								
Mn	659	606	630	643	654			639	628	697		666			(650)	611	600	699								
Fe	29800	29200	29800	28900	29700		28700	29200	28900	29700	27900	28800			29600	29900	29700	31800								
Co	(12)	(12)	14		15.3						11.9	11.7														
Ni	29.8	29.6	30	31.9	32.8						22.4				32	32.1		(36)								
Cu	21.5	21.3	20	19.9	19.9	18.4	20.2				25.8				23	22.6		(21)								
Zn	59.8	59.7	59	56.7	57.9			60			54.4	74.2			58	61.8		(68)								
As						11.4						10.6	9.6	(7)	12.4											
Rb												88.2			93	92										
Sr	284	271	277	283	274		276	280				281			268	276		321								
Y		16.3		18.9											27	25.4										
Ba	518	492	520	511			486	506				496			472	(491)										
Pb	(31)	15.4		20.1		18.4					18.4				(10)	19.8		(31)								
T-C																								1.75		
CO ₃ -C																								1.26		
T-N																								(<0.01)		

(): semi-quantitative value, T-C: total carbon, CO₃-C: carbonate carbon, T-N: total nitrogen

ICP/AES: Inductively Coupled Plasma Spectrometry, AA: Atomic Absorption Spectrometry, NAA: Neutron Activation Analysis, AFS: Atomic Fluorescence Spectrometry,

XRF: X-ray Fluorescence Spectrometry, PIXE: Proton Induced X-ray Emission Analysis, IC: Ion Chromatography, CHN: Elemental Analyzer

Table 2 Summary of mean elemental values from inter-laboratory analysis of Simulated Asian Mineral Dust (CJ-2)

(Unit: $\mu\text{g/g}$)

	ICP/AES (Acid Digestion)								ICP/AES (Alkali Fusion)			AA	NAA	AFS	XRF				PIXE	IC	Combustion Method	CHN	Gravimetric Method	
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 1	No. 2	No. 3				No. 1	No. 2	No. 3	No. 4						
Na	13800	13700	13900	13600	14100				14000	13700	12800	13600	13700		14200			16300	14000					
Mg	15800	15800	16000	15700	16400			15700	15800	15700	15800	16800	15300		15700	15900	15700	14800	15100					
Al	57300	58500	57900	59000	59400				58600	58100	58800		60000		59400	59900	58500	59200						
Si									277000	282000	281000				280000	283000	280000	279000	265000					280000
P	970	902	870	879				942	920		961				(850)	958	933							
S															(1100)	(1300)				640				
K	17000	16400	16900	16600	17300				17000	17600	15400	16800	15600		17000	17100	17400	17600	17000					
Ca	53100	51300	53100	52500	54800			54400	52400	52800	52800		54600		54000	54400	53600	66000	51700					
Sc	9.16	10.4		10.2									11.4		15									
Ti		4150	4310		4390				4700	4380	4850		4510		4740	4660	4800	4490						
V	78.1	74.7	75	73.9	84	81.7							69.8		80	75.6								
Cr	62.1	68.9	64	62.8	66		74.8		85			67.6	82.3		79			(79)						
Mn	646	623	634	633	675				638	639	697	824	633		630	627	633	661						
Fe	29700	29800	30300	29000	31100			29700	30100	29700	30900	28200	29900		30600	30200	30500	30900						
Co	(12)	(11)	15		16.7							12.9	11.4											
Ni	33.3	34.4	33	34.2	36.8							28.4			34	32.2		(34)						
Cu	28.5	27.4	27	27.9	27.6	24.3		27.5				29.7			29	28.1		(24)						
Zn	79.1	79	78	75.6	78.9				80			75	85.8		84	82.9		(79)						
As						9.4							11.5	9.9		12.8								
Rb													72.8		81	78.8								
Sr	244	240	243	243	248		254		250				301		233	239		280						
Y		20.9		22.5											42	35								
Ba	471	468	478	462			476		471				457		451	470								
Pb	(29)	25.3		24.4		20.8						16.4			13	27.4		(47)						
T-C																							2.37	
CO ₃ -C																							1.01	
T-N																							(0.04)	

(): semi-quantitative value, T-C: total carbon, CO₃-C: carbonate carbon, T-N: total nitrogen

ICP/AES: Inductively Coupled Plasma Spectrometry, AA: Atomic Absorption Spectrometry, NAA: Neutron Activation Analysis, AFS: Atomic Fluorescence Spectrometry,

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material. This secondary material was transported to the Institute of Desert Research, Chinese Academy of Sciences, Lanzhou, and by employing a 2 m/s breeze in the Institute's wind tunnel, a fine particulate dust which blew into the settling box 16 m from the tunnel entrance was collected.

In this operation the conditions of the wind tunnel were theoretically designed to produce conditions for collecting fine particles close in size to those of loess particulates (less than 0.03 mm diameter) (Quan *et al.*, 1996). Approximately 4 kg of tertiary material were obtained by this means. There was a change of colour of the material with each of the above steps; the original sand was pale yellow, the secondary material was a dark yellow, and the tertiary material was similar to the colour of loess (grayish-yellow). This material was transported to the National Research Center for Environmental Analysis and Measurement. After homogenization for four hours using a V-blender, 2 g of the material was sealed into each of 1,800 brown glass bottles. All bottles and the materials contained therein were then sterilized by exposure to cobalt 60 irradiation.

3. Results and Discussion

3.1 Homogeneity tests for CJ-1 and CJ-2

In order to check the homogeneity of each bottle of CJ-1 and CJ-2, 30 bottles of each were randomly selected and analysed in the following manner: 100 mg of material was taken from each bottle, and decomposed in a mixture of nitric, perchloric and hydrofluoric acids. The digested samples were then analysed for Fe, K, Mn, and Cu by atomic absorption spectrometry at the National Research Center for Environmental Analysis and Measurement, China. The relative standard deviation (RSD, %) of the determined concentrations of each element were: Fe, 1.1%; K, 1.8%; Mn, 1.5%; and Cu, 3.0% for CJ-1, and Fe, 1.6%; K, 2.2%; Mn, 1.7%; and Cu, 3.9% for CJ-2. These relative standard deviations were within the expected variation range for the instrumental conditions. In addition, there was no significant variation between bottles in a one-way analysis of variance (ANOVA test). The results of an investigation of the moisture content of 10 bottles chosen at random gave 0.7% moisture (RSD, 4%) for CJ-1 and 0.8% moisture (RSD, 12%) for CJ-2. The distributions of particulate diameters of the contents of three bottles of each material chosen at random are shown in Fig. 2. The averages of the median diameters (mode diameters) of CJ-1 and CJ-2 were 38.1 (48.8) μm and 24.1 (26.1) μm , respectively. Dispersions of the median diameters were found to be within 1 μm (CJ-1) and 0.5 μm (CJ-2). After the homogeneity test, randomly selected bottles of CJ-1 and CJ-2 were shipped to co-operating laboratories for chemical analysis.

3.2 Interlaboratory analyses

Batches of 3–10 bottles of both CJ-1 and CJ-2 were distributed to co-operating laboratories, with a request for triplicate analysis of their contents. Analytical data were obtained by 23 different analytical

methods from a total of 14 institutes (6 organisations from China, 5 from Japan, 1 from the UK, 1 from New Zealand and 1 from the USA). The mean and standard deviation from each analytical method were calculated, Tables 1 and 2 show mean values of reported data from each laboratory. For those elements where the reported data exceeded 5% of the relative standard deviation, the values were considered to be semi quantitative. The Committee of Certified Reference Materials of the National Research Center for Environmental Analysis and Measurement of China evaluated all data using the statistical method recommended by ISO guide 35, and decided to give certified values according to the following criteria:

a) All data reported by any individual laboratory using any method was regarded as being equal and were evaluated without weighting.

b) A Grubbs test was carried out on each mean value in Tables 1 and 2 to exclude outliers.

c) Using data which were not excluded by the Grubbs test, the overall mean values and standard deviations were determined, and the elements were classified into three categories depending on the values of the relative standard deviations (RSDs).

c-1) Elements with 2 x RSD values that exceeded 10% were excluded.

c-2) Elements with 2 x RSD values of 5–10% were not certified, but were reported as information values only.

c-3) Only those elements with 2 x RSD values of less than 5% were certified as to the overall mean value. The uncertainty range of certified mean values should be considered as two times the standard deviation. However, to be certified, elemental concentration data had to be produced by more than two different analytical methods.

d) Even if elements did not satisfy the above conditions, they were adopted as information values if the Committee judged that the analytical methods associated with the errors and uncertainty made it appropriate to do so.

After following steps a)–d), the certified and information values for CJ-1 and CJ-2 as determined by the Committee for Certified Reference Materials were as shown in Table 3. In the Table, the concentrations of Ti and P were adopted as information values under the conditions listed in c) above. Because Sc is important as an indicator element of the earth's crust, the Committee decided to adopt the results of its analysis as an information value under the conditions listed in d) above although twice the RSD% values for CJ-1 and CJ-2 were over 10% and there were few analytical data.

3.3 Additional geochemical information on CJ-1 and CJ-2

Patterns of the mineral composition of CJ-1 and CJ-2 were obtained by X-ray diffraction analysis, and are shown in Fig. 3 and 4. The patterns for CJ-1 and CJ-2 are very similar, and show that both consist of quartz, feldspar, calcite, clay minerals (chlorite, mica, etc.). The calcite mineral in the kosa aerosol is particularly important when considering investigations into

Table 3 Certified and information values of constituent elements

CJ-1(China Loess)			CJ-2(Simulated Asian Mineral Dust)		
Element	Certified value and uncertainty	Method used	Element	Certified value and uncertainty	Method used
Na	1.33±0.06 (%)	a,b,c,d,f	Na	1.38±0.08 (%)	a,b,c,d,f
Mg	1.57±0.06	a,b,c,e,f	Mg	1.57±0.06	a,c,d,f
Al	6.01±0.17	a,c	Al	5.88±0.16	a,c,d,e
Si	27.7±0.6	a,c,g	Si	28.0±0.4	a,c,g
K	1.94±0.10	a,b,c,d,f	K	1.70±0.08	a,b,c,e,f
Ca	5.83±0.23	a,c,d,f	Ca	5.33±0.22	a,c,d,f
Ti	(0.36)	a,c,d,e	Ti	(0.46)	a,c,d,e
Fe	2.94±0.09	a,c,d	Fe	3.02±0.12	a,c,d,e
P	(640) (μg/g)	a,c	P	(930) (μg/g)	a,c
Sc	(11)	d	Sc	(11)	d
Mn	633±44	a,c,d	Mn	638±31	a,c,d,e
Ni	31±3	a,c	Ni	34±3	a,c
Cu	21±3	a,c	Cu	28±2	a,b,c
Zn	59±5	a,b,c	Zn	79±6	a,b,c
Sr	277±11	a,c,d	Sr	244±12	a,c
Ba	504±27	a,d	Ba	469±14	a,c,d

Note: Non-certified values are given in parentheses as information values.

The methods used in the certification were:

- a; Inductively Coupled Plasma Spectrometry (ICP/AES)
- b; Atomic Absorption Spectrometry (AAS)
- c; X-ray Fluorescence Spectrometry (XRF)
- d; Neutron Activation Analysis (NAA)
- e; Proton Induced X-ray Emission Analysis (PIXE)
- f; Ion Chromatography (IC)
- g; Gravimetric Analysis

chemical reactions with acidic substances in the atmosphere (Mori *et al.*, 1998b). Carbonate-carbon (mainly in the form of calcite) was at a concentration of 1.3% in CJ-1 and 1.0% in CJ-2, with the stable isotope ratios ($\delta^{13}\text{C}$ values) of -0.9% and -2.6% respectively (information values). The strontium isotope ratio ($^{87}\text{Sr}/^{86}\text{Sr}$) of atmospheric aerosols has been recognized as one of the best indicators for kosa aerosols, because the Sr ratios of the Chinese loess samples are reported 0.715 ± 0.001 (Yokoo, 2000) higher than those around 0.705 ± 0.001 of various Japanese igneous rocks (Nakano & Tanaka, 1997). The Sr ratios of CJ-1 and CJ-2 were also informed 0.7145 and 0.7148, respectively.

3.4 Similarity of CJ-2 to several kosa aerosol samples collected in Japan

Table 4 shows a comparison between the elemental ratios in CJ-2 and those reported for kosa aerosol samples. Concentrations are expressed as ratios relative to Al, the most abundant element of the earth's crust. The most significant feature of the kosa aerosol is that the Ca concentration is very high compared to those of various Japanese soils. Therefore the reported values of Ca/Al for kosa aerosol are within the range of 0.7–1.5. There are no significant differences in the elemental ratio between CJ-2 and kosa aerosol,

confirming that CJ-2 is an appropriate reference material for kosa aerosol. It is to be expected that CJ-2 will be of great value in monitoring kosa aerosol, and also for laboratory experiments in atmospheric environmental chemistry.

3.5 Experimental application of the neutralization effect of CJ-2 on acid precipitation

Kosa aerosols have a neutralization effect on acid rain as shown in Fig. 5. Typically, at a time when there is no kosa aerosol in the atmosphere, rain has a lower pH value when it first starts to fall than when it has been falling for some time. In contrast, rain which washes out a kosa aerosol exhibits a pH value of more than pH 5.6 (the critical point for acid rain) at the beginning of precipitation and the pH shows a tendency to decrease as the rain continues to fall. An experiment on the neutralization effect of kosa aerosols was performed by using CJ-2 and precipitation (pH 5.0) collected in Tsukuba, Japan. It has been estimated that about 1–5 g/m²/year of kosa aerosol material are deposited onto the Japanese landmass (Nishikawa *et al.*, 1991c). As the frequency of kosa events in Japan is about 5 per year, it can be estimated that the amount of kosa aerosol deposited will be about 1 g/m².

The monthly report of the Japan Meteorological

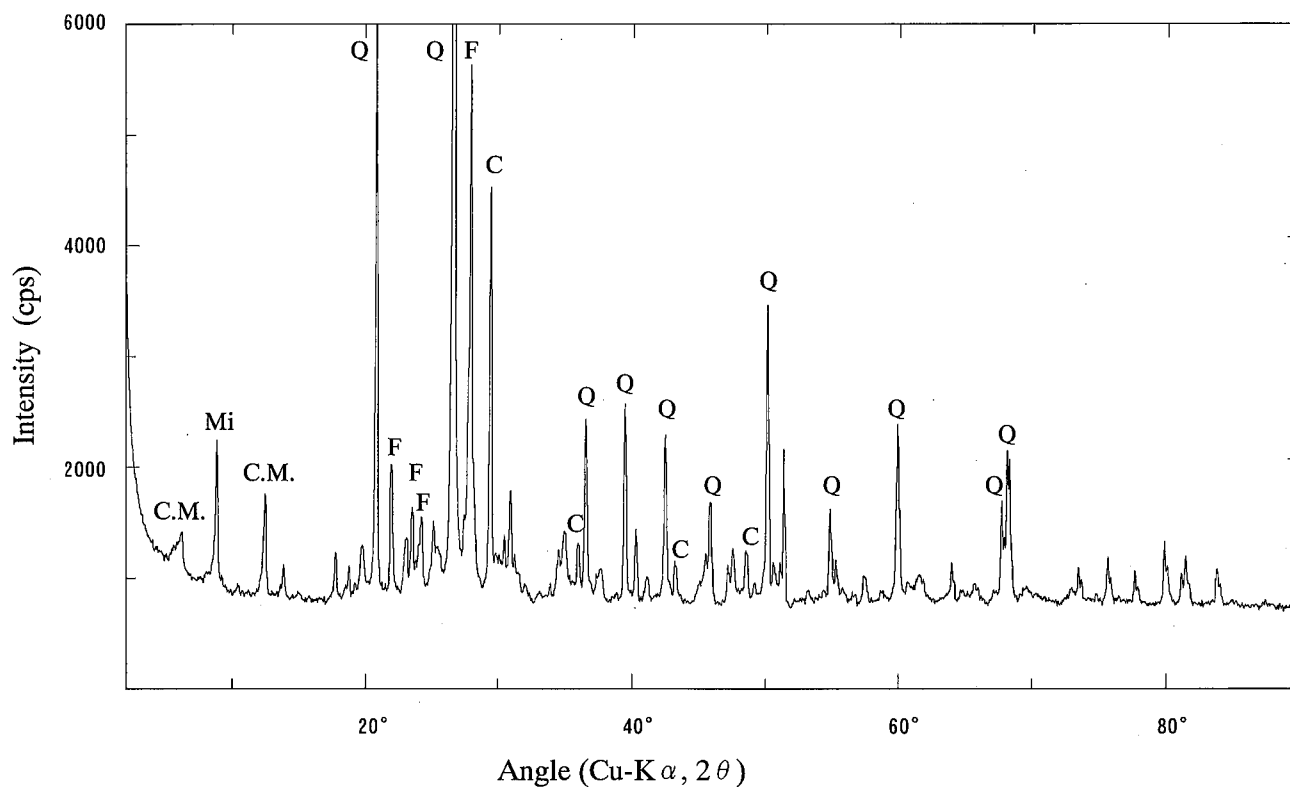


Fig. 3 X-ray diffraction pattern of China Loess (CJ-1)
C.M. : clay minerals, Mi : mica, C : calcite, F : feldspar, Q : quartz

Agency recorded that falls of less than 10 mm accounted for 62% of all precipitation in the three years 1993–1995 (total of 314 rain events) at the Aerological Observatory in Tsukuba where is near Tokyo. Kosa aerosols are almost completely scavenged during ini-

tial precipitation if it occurs as rain as in shown in Fig. 5. Therefore, if 1 g/m^2 of kosa aerosol is washed out by 2 mm of precipitation, the final concentration of kosa aerosol in the rainwater will be 0.5 mg/ml, and if it is washed out by 10 mm precipitation, the

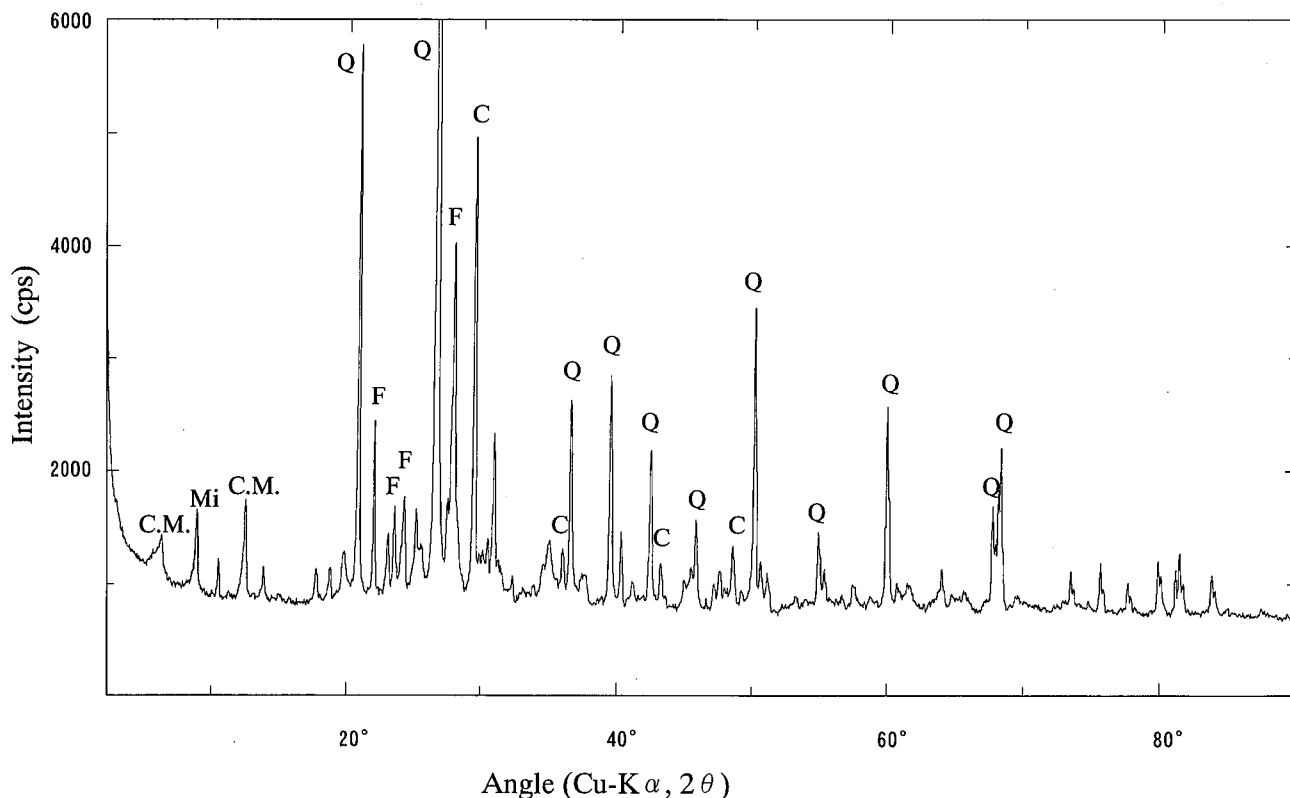


Fig. 4 X-ray diffraction pattern of Simulated Asian Mineral Dust (CJ-2)
C.M. : clay minerals, Mi : mica, C : calcite, F : feldspar, Q : quartz

Table 4 Comparison of ratios of elemental concentrations to aluminum concentration in CJ-2 and those reported for kosa aerosols.

	CJ-2	Osaka ¹⁾	Yaku shima ²⁾	Yamaguchi ³⁾	Beijing ⁴⁾
Al	1	1	1	1	1
Na	0.23	0.24	0.39	0.14	0.13
Mg	0.27		0.31	0.34	
K	0.29	0.35	0.37	0.3	0.19
Ca	0.91	0.97	0.71	1	0.96
Fe	0.51	0.55	0.52	0.64	0.44
Mn	0.011	0.017	0.014	0.02	0.014
Ni	0.00058		0.00087		0.0007
Cu	0.00048		0.0029	0.0025	0.0026
Zn	0.0013	0.016	0.0022	0.029	0.017
Sr	0.0041		0.0049	0.0064	
Ba	0.008	0.0081	0.0077		0.013

1) Mizohata *et al.* 1978; 2) Nishikawa & Kanamori, 1991b
 3) Nishikawa, 1993; 4) Sekine *et al.* 1992

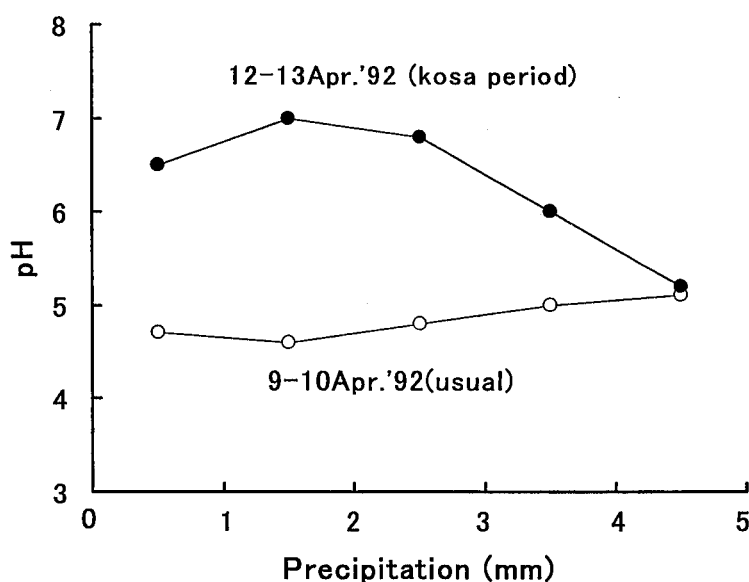


Fig. 5 The relationship of pH to amount of precipitation during a kosa period and during a period of normal atmospheric conditions. Sampling was carried out in Yamaguchi city with the collaboration of Mr. M. Itoh and Mr. T. Tanimura (Yamaguchi Prefectural Research Institute of Health). A weak kosa phenomenon was observed for a half day on 12 April 1992 in Yamaguchi Prefecture before the rainfall.

concentration will be 0.1 mg/ml. The change in pH value of the rainwater with increasing quantities of CJ-2 is shown in Fig. 6. The initial pH of the rainwater was 5.0; the addition of 0.1 mg/ml increased the pH to 6.0, and 1 mg/ml to 8.2. This pH change occurred within 1 hour of immersing the kosa in rainwater and gently shaking by hand. Figure 7 shows the changes in the concentrations of major cations and anions due resulting from the addition of 0.1 to 1 mg/ml addition of CJ-2 to the rainwater. The major cations in the solution were Ca, Mg, Na and K, and the major anions were Cl^- , NO_3^- and SO_4^{2-} in the solution. Only the Ca concentration increased markedly. Other major cations did not significantly increase in comparison with Ca. The concentrations of some

anions also increased slightly, for example the concentration of SO_4^{2-} increased from 0.031 to 0.049 mequiv./l when 1 mg/ml of CJ-2 was added to the initial precipitation. The equivalent change for NO_3^- was 0.011 to 0.012 mequiv./l, and for Cl^- 0.015 to 0.021 mequiv./l. Dissolved Ca, which must have originated in the CaCO_3 in CJ-2, was clearly the key component in controlling the pH change. Therefore, the reason that the balance between major cations and anions were gradually biased in favor of the cations according to the amount of CJ-2 added must be a consequence of the CaCO_3 . This experimental result strongly supports the idea that kosa aerosols can naturally neutralize acid rain by the same mechanism. In addition kosa aerosols, when deposited on land, might well

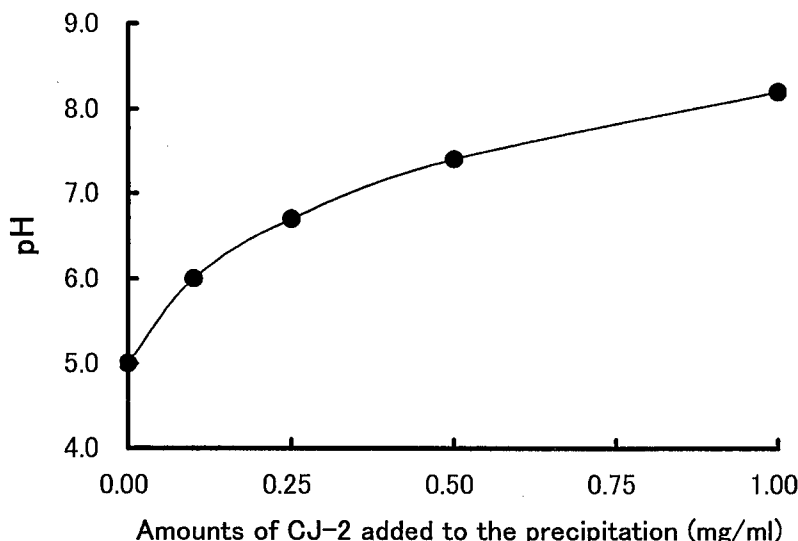


Fig. 6 The relationship between pH of collected precipitation (rainwater) and the amount of added CJ-2. The precipitation (total 11 mm) was collected on 16 March, 2000, in a 5000 ml-Teflon bottle with a 30 cm plastic funnel.

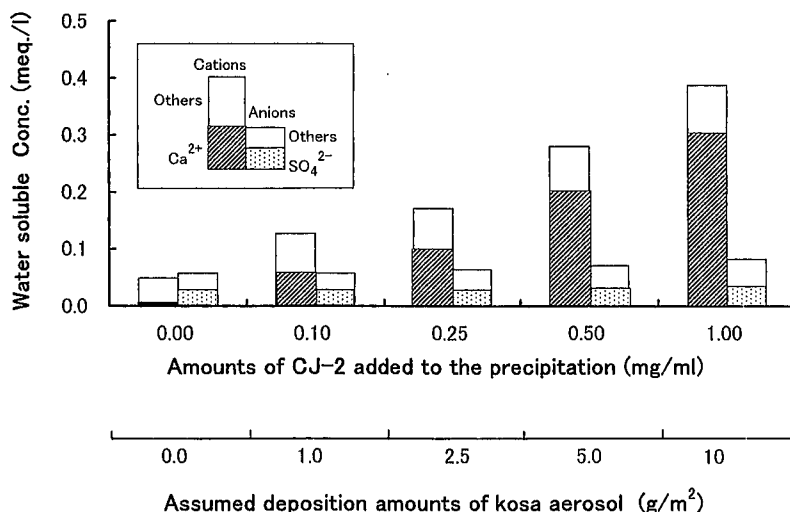


Fig. 7 Total cations and anions in collected precipitation (rainwater) after incremental quantities of CJ-2 had been added. The equivalent amount of kosa aerosol is also shown. Total cations and anions were calculated as the sum of (NH_4^+ , Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Sr^{2+}) and (Cl^- , NO_3^- , SO_4^{2-}) in the equivalent concentration, respectively. The experiment was carried out on 50 ml portions of rainwater. 1 mm of precipitation is equivalent to 1000 ml/m². It was assumed that amounts of kosa aerosol equal to 1-10 g/m² were washed out by 10 mm of precipitation.

mitigate damage to soils and plants caused by acid rain.

4. Conclusions

Certified Reference Materials for China Loess (CJ-1) and Simulated Asian Mineral Dust (CJ-2) were prepared from soil collected at a depth of 1.8-2.5 m in the Chinese loess plateau at Gansu Province, and from surface soil collected in the Tengger Desert. These are the first Certified Reference Materials of this type. Thirteen elements were certified by the Committee of Certified Reference Materials, using the 23 sets of analytical data submitted from 14 laboratories. The

chemical composition and mineral composition of these two materials were very similar. These observations strongly supported the idea that the loess plateau in China has been formed from aeolian dust transported from interior desert areas. Furthermore, the ratios of elemental concentrations to Al concentration in CJ-2 were very close to those of kosa aerosols reported in Japan. This material should therefore be useful for quality control of analytical data in the monitoring of kosa aerosols. It was shown experimentally that the pH of natural precipitation, originally at pH 5.0, was raised by the addition of CJ-2, and that this neutralization effect depended upon the concentration of Ca, derived mainly from calcite

in CJ-2. It is thus proposed that kosa aerosol can have an ameliorating effect on acid rain and can help explain the high pH of precipitation observed occasionally during kosa periods in Japan.

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Announcement

The CJ-1 and CJ-2 reference materials will be distributed from the National Research Center for Environment and Measurement, China. Please contact Dr. Quan HAO at the National Research Center for Environmental Analysis and Measurement, No.1 Yuhui Nanlu Chaoyang qu, Beijing 100029, P.R.China.

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