Impacts of the Kuwait Oil Fires on the Mount Qomolangma Region[1]

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ABSTRACT

Mt. Qomolangma (also known as Mt. Everest), the world's highest mountain, is situated over the world's highest plateau, the Tibetan Plateau. Because of its height and because of its distance from industrialized areas, the environmental state of the Mt. Qomolangma region can normally be considered "undisturbed". It is interesting to investigate how this "undisturbed" state has been changing with time and whether it has been influenced by large environmentally disruptive events such as the Kuwait oil fires of 1990 and 1991 (Small, 1991). In order to do this, river water samples were collected from the Rongpu River at Rongpu Temple Station in the summers of 1992 and 1993, as was done in 1975, and aerosol samples were collected in the summer of 1992 at the same station as was done in 1980. River water samples were analyzed using atomic absorption spectroscopy (AAS) at the Chinese Academy of Sciences. Aerosol samples were analyzed using proton-induced x-ray emission (PIXE) at the University of Fudan in Shanghai. The results show that the concentrations of chemical species in the river water at Rongpu Temple Station were much higher in the summer of 1992 than they were in 1975 and 1993, and the concentrations of atmospheric chemical species were much higher in 1992 than they were in 1980. The environment of the north slope of Mt. Qomolangma was therefore heavily polluted before and / or during the summer of 1992, possibly due to the Kuwait oil fires in 1990 and 1991.

Key words: Kuwait oil fires, Mt. Qomolangma, Contamination, Large external pollution source

I. BACKGROUND AND OBJECTIVES

In the winter of 1990, black snow cover was found on the north slope of the central Himalayas. Small (1991) has pointed out that most of the fallout from the Kuwait oil fires would probably occur over Pakistan and the extreme northern India. Based on these observations, we have investigated whether the environment of the north slope of Mt. Qomolangma was influenced by the oil fires in Kuwait in 1990 and 1991. This region is located downstream of the prevailing westerlies from Kuwait during the spring, autumn and winter. In addition, the state of the environment on the north slope of Mt. Qomolangma had been observed in the spring of 1975 and 1980 allowing us to assess changes over a 10–15 year period.

Aerosol samples and river water samples from the Rongpu River were collected at Rongpu Temple Station in the summers of 1992 and 1993. Unfortunately, the aerosol samples obtained in 1993 were damaged before they could be analyzed. As shown in Fig. 1, Rongpu Temple (4950 m ASL) is located in a deep river valley having a depth of about 1500 m and a width at the bottom of about 1400 m. Rongpu Temple is on the NNW side of Mt. Qomolangma at a distance of 6.9 km from the end of the Rongpu Glacier and about 20 km

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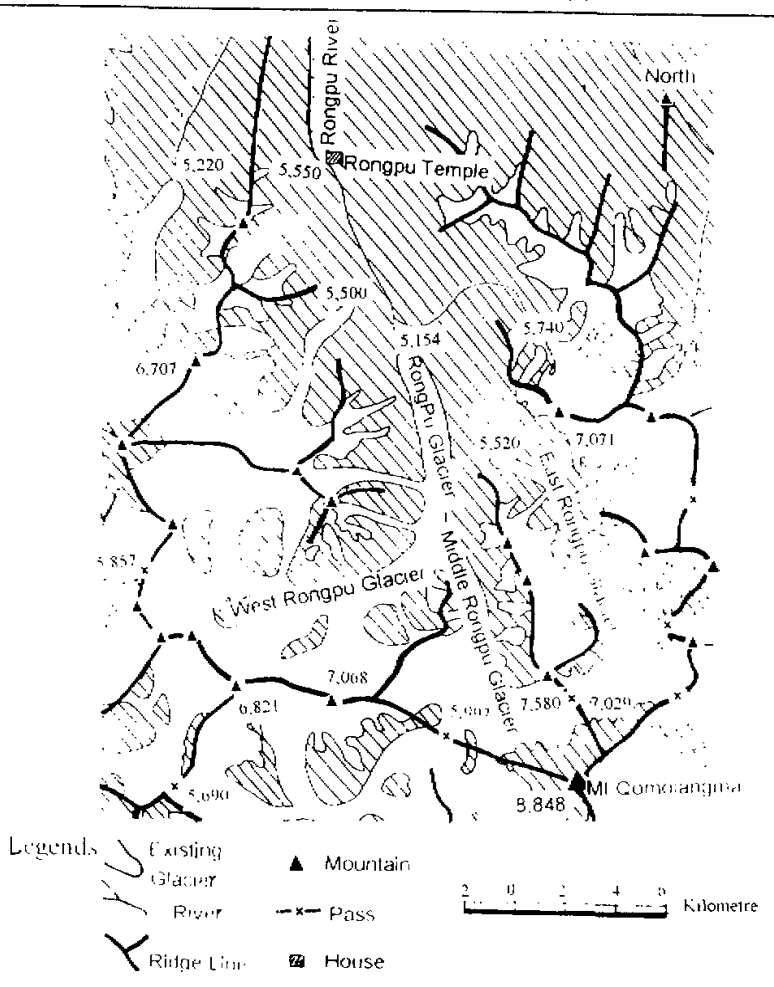

Fig. 1. Sampling location on the north slope of Mt. Qomolangma.

from the foot of Mt. Qomolangma. The source of water in the Rongpu River is mostly from melting ice and snow from the region of the Rongpu Glacier.

II. DATA COLLECTION AND ANALYSIS

Aerosol samples were obtained between April 25 and May 8, 1980 and between July 29 and August 5, 1992 using an eight-stage impactor. The eight stages, numbered from 0 to 7, corresponded to aerodynamic diameters > 16 μm, 16–8 μm, 8–4 μm, 4–2 μm, 2–1 μm, 1 μm, 0.5 μm, 0.5–0.25 μm and < 0.25 μm, respectively. The flow rate was about 11 min^{-1}. The impactor was located 2 m above the ground on the upwind side of the Rongpu Temple Station. Table 1 lists the collection periods for the aerosol samples.

Aerosol samples collected in 1980 and 1992 were analyzed at the same laboratory at the University of Fudan using proton-induced x-ray emission (PIXE) to obtain the elemental composition of the individual particles. PIXE provides a sensitivity of 0.1–1.0 ppm and a

precision of ± 20%.

River water was collected from the Rongpu River at the Rongpu Temple Station in April 1975 and in July 1992 and 1993 using standard methods. For each period, the water samples were analyzed at the same laboratory in the Chinese Academy of Sciences using atomic absorption spectroscopy (AAS) to obtain elemental concentrations. The relative standard deviation and detection limits for each element are shown in Table 2.

Table 1. Aerosol Sampling Periods

Sample number	Start time GMT	End time GMT
1	0220 April 25, 1980	0220 April 26, 1980
2	0700 April 26, 1980	0700 April 28, 1980
3	0830 April 28, 1980	0830 April 30, 1980
4	0930 April 30, 1980	0930 May 2, 1980
5	1100 May 2,1980	1100 May 4, 1980
6	1200 May 4, 1980	0100 May 8, 1980
7	1245 July 29, 1992	0200 July 30, 1992
8	0240 July 30, 1992	0430 Aug 1, 1992
9	0500 Aug 1,1992	0920 Aug 2, 1992
10	0940 Aug 2, 1992	1030 Aug 5, 1992

Table 2. Standard Deviations and Detection Limits for the AAS Analysis of River Water

Years	1992				1993			
Elements	D.L ($\mu g/l$)	Mean ($\mu g/l$)	S.D ($\mu g/l$)	R.S.D %	D.L ($\mu g/l$)	Mean ($\mu g/l$)	S.D ($\mu g/l$)	R.S.D %
Cu	0.1	3.4	0.96	28	0.1	0.85	0.11	13
As	1	3.8	0.66	17	1	3.2	0.73	23
Pb	0.05	8.15	1.07	13	0.05	4.4	0.33	7.4
Zn	0.02	34.3	2.00	5.8	0.02	0.70	0.11	16
Cd	0.005	0.13	0.04	31	0.005	0.02	0.00	0.00
Fe	0.2	10215	609.56	6.0	0.2	1695	15	0.9
Al	0.2	7828	410.96	5.3	0.2	2214	15	0.7
Cr	0.01	12.25	1.48	12	0.01	1.43	0.38	27
Cs	0.03	15.0	1.00	6.7	0.03	0.36	0.06	17
K	0.02	12525	573.73	4.6	0.02	1110	26	2.3
V	2	19.3	0.43	2.6	2	<2	–	–
Sc	2	<20	–	–	2	<2	–	–
Ca	0.18	20250	1373.86	6.8	0.18	23600	162.84	0.69
Mg	4.7	4735	193.83	4.1	4.7	1830	12.1	0.66

D.L.: Detection Limits M: Mean

S.D.: Standard Deviation R.S.D.: Relative S.D.

III. RESULTS

1. The results in Table 3 show that, for the 15 elements measured in the water samples, the concentrations of 13 of them were much higher in the summer of 1992 than in the spring

Table 3. Elemental Concentrations (μ g / ml) in Rongpu River Water and Their Ratios

Elements	April–May, 1975	July–Aug, 1992	Ratio 92 / 75	July 1993	Ratio 93 / 92
V	*0.00186[1]*	*0.0193[4]*	*10.38*	*< 0.002[6]*	*0.10*
Cs	0.0017[1]	0.015[4]	8.82	0.00036[6]	0.02
Cr	0.0018[1]	0.0123[4]	6.83	0.0014[6]	0.11
Pb	0.0024[1]	0.0082[4]	3.42	0.0044[6]	0.54
Cu	0.0012[1]	0.0034[4]	2.83	0.0008[6]	0.24
As	0.0061[1]	0.0038[4]	0.62	0.0032[6]	0.84
Cd	0.00009[1]	0.00013[4]	1.44	0.00003[6]	0.23
Sc	0.000173[1]	< 0.002[4]	< 11.56	< 0.002[6]	1.00
Fe	0.7000[1]	10.2[4]	14.57	1.695[6]	0.17
Al	*1.04[1]*	*7.83[4]*	*7.53*	*2.214[6]*	*0.28*
K	2.03[1]	12.6[4]	6.21	1.110[6]	0.09
Zn	0.0063[1]	0.0343[4]	5.44	0.007[6]	0.20
Mg	3.47[1]	4.74[4]	1.37	1.83[6]	0.39
Ca	18.7[1]	20.3[4]	1.09	23.6[6]	1.16

1) The numbers in the brockets are number of samples.

Table 4. Atmospheric Elemental Concentrations (units of 0.001 μ g / m^3) on the north slope of Mt. Qomolangma (4950 m ASL)

Elements	April–May, 1980	July–Aug, 1992	Ratio
Sc	0.3[6]	3.3[4]	11.00
Cu	0.4[6]	2.2[4]	5.50
Ni	0.2[6]	0.9[4]	4.50
Pb	5.3[6]	12.4[4]	2.34
Fe	349.2[6]	635.3[4]	1.82
Cl	106.1[6]	182.5[4]	1.72
Mn	6.6[6]	10.9[4]	1.65
Zn	4.0[6]	6.1[4]	1.53
V	1.6[6]	2.4[4]	1.50
P	141.3[6]	197.6[4]	1.40
Ti	42.4[6]	57.1[4]	1.35
Ca	892.5[6]	1106.7[4]	1.24
Cr	1.8[6]	2.1[4]	1.17
Si	3571.2[6]	3182.7[4]	0.89
K	658.2[6]	313.4[4]	0.48
S	435.9[6]	151.1[4]	0.35

1) They are total concentrations from the 8 grades.

2) The numbers in the brackets are numbers of samples.

of 1975. The exception is As. In Table 4, the concentrations of 13 of the 16 elements measured in the atmosphere were higher in the summer of 1992 than in the spring of 1980. Here the exceptions were Si, K and S. For the water samples, the concentrations of Fe, V and Cs are about 10 times higher in the summer of 1992 than in the spring of 1975; the ratios are about 5 for Cr, Al, K and Zn and about 3 for Pb and Cu. For the aerosol samples, the concentration

of Sc is about 11 times higher in the summer of 1992 than in the spring of 1980; the ratios are 2–6 for Cu, Ni and Pb. For the remaining elements, the concentrations in the summer of 1992 are 10–80% higher than in the spring of 1980.

2. As shown in Table 3, the elemental concentrations in river water were much lower in the summer of 1993 than in the summer of 1992. For example, the concentrations of Cs and K in 1993 were 0.02–0.09 times those in 1992. For the other elements, the concentrations in 1993 were 0.10–0.84 times those in 1992.

IV. DISCUSSION AND CONCLUSIONS

1. From the results in Table 3, it can be seen that there was much greater contamination of the water in the Rongpu River on the north slope of Mt. Qomolangma in the summer of 1992 than in the spring of 1975 and summer of 1993. This indicates that the water may have been affected by some large external pollution source before and / or during the summer of 1992.

2. A large amount of smoke was produced by the oil well fires in the Persian Gulf during August 1990 and November 1991 (Cahalan,1992). Parungo (1992) reported that the aerosol chemical composition of the smoke from the Kuwait oil fires included the elements Mg, Al, Si, S, Cl, K, Ca, Ti, Cr, Fe, Ni, Zn and Cu. Zheng (1987) found a similar set of elements to be present in crude oil in seven oil wells in China (Table 5). It is well–known (Ye and Gao, 1979) that there are strong prevailing westerlies in the troposphere between 25°N and 30°N during the spring, fall and winter. Since the Mt. Qomolangma region is located on the highest plateau in the world and is directly downwind of the Persian Gulf during spring, fall and winter, it is quite plausible that the smoke from the Kuwait oil well fires affected the environment of the region.

Table 5. Mean Concentrations (ppm) of Chemical Elements in Crude Oil from Seven Oil Wells in China (Zheng 1987)

Fe	Ni	Ca	K	Cr	Al	Mg	Zn	V	As	Cu
7.98	7.64	6.58	6.38	5.75	2.95	2.323	1.48	0.51	0.50	0.28

Table 6. Elemental Concentrations (μ g / ml) in River and Rain Water on the North Slope of Mt. Qomolangma during the Summer of 1992

Elements	River Water[I]	Rainwater[II]	[II] / [I] (%)
V	0.0193[4]	<0.003[4]	<15.5
Cs	0.015[4]	<0.001[14]	<6.6
Cr	0.0123[4]	<0.001[14]	<8.1
Pb	0.0082[4]	0.0019[14]	23.1
Cu	0.0034[4]	0.0014[14]	44.1
As	0.0038[4]	<0.002[14]	<52.6
Cd	0.00013[4]	0.00010[14]	76.9
Sc	<0.002[4]	<0.002[14]	100
Fe	10.2[4]	0.027[14]	0.3
Mg	4.74[4]	0.027[14]	0.6
Ca	20.3[4]	0.051[14]	0.3

3. It can be seen in Table 6 that the concentrations of chemical elements in rainwater at

Rongpu Temple are much lower than those of Rongpu River water during the summer of 1992. The standard deviations and detection limits of AAS for rainwater are shown in Table 7.

Table 7. Standard Deviations and Detection Limits for the AAS Analysis of Rain Water

Elements	D.L. (μg/l)	M. (μg/l)	S.D. (μg/l)	R.S.D. (%)
V	2	<3	/	/
Cs	0.03	<1	/	/
Cr	0.01	<1	/	/
Pb	0.05	1.9	0.56	29.5
Cu	0.1	1.4	0.39	27.1
As	1	<2	/	/
Cd	0.005	0.10	0.035	35.0
Sc	2	<2	/	/
Fe	0.2	27.0	8.0	29.6
Mg	4.7	26.7	5.7	21.4
Ca	0.18	50.8	15.2	29.9

D.L.: Detection Limits; M. Mean;
S.D.: Standard Deviation; R.S.D.: Relative S.D

The proportions of the water in the Rongpu River at the Rongpu Temple Station during May and October from glacial runoff, rainwater, and groundwater are 66%, 30%, and 4%, respectively (Xie, 1975). Xie et al. (1975) have pointed out that at the end of the summer, the snowfall at 5000–6000 m ASL in the melting region of the Rongpu Glacier (Fig. 2) changes to permeating frozen ice which replenishes the glacier. This ice later melts into river water during the next summer. Therefore, approximately 66% of the Rongpu River water at the Rongpu River Station in the summer of 1992 was produced by snowfall during the end of the summer and early fall of 1991. The elemental concentrations in the river water, therefore, represent those in the snowfall during this period which was at the end of the Kuwait Oil Fires event.

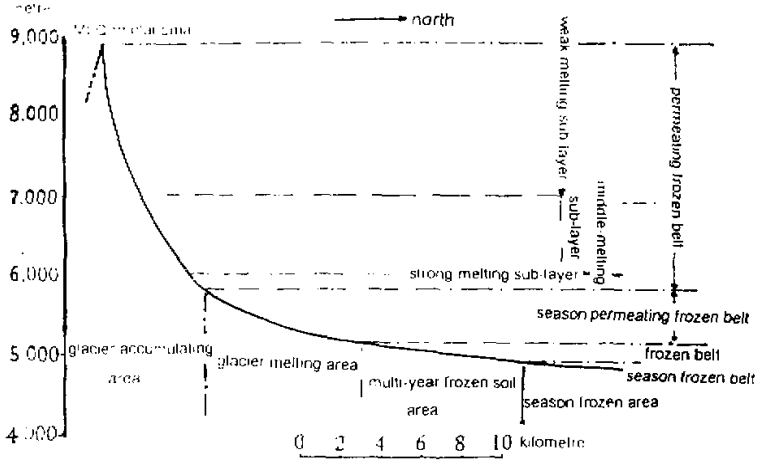

Fig. 2.Distribution of ice formation on the north slope of Mt. Qomolangma.

The elemental concentrations in Rongpu River water in the summer of 1993 mainly represent those in the snowfall during the end of the summer and early fall of the previous year and these should be similar to those in the rainfall at Rongpu Temple Station in the summer of 1992.This is verified in a comparison between the concentrations in Table 3 and 6 and explains why the concentrations in the river water were high in the summer of 1992 and low a year later.

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