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SHORT COMMUNICATION

Did Arsenic Contamination in the Inagawa River Occur in Geogenic Relation to the Great Hanshin (Kobe) Earthquake of 1995?

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Arsenic contamination in river and ground water was investigated in the Inagawa area of Kansai district, Japan, from August to October, 1995. Arsenic has been continually detected at a level about 2 times higher than the environmental standard in the two tributaries of the Inagawa River, i.e. the Kimo and the Shio Rivers. The arsenic contamination was probably caused by the topographical change after the Great Hanshin Earthquake.

Keywords: Arsenic; environmental standard; river; ground water; earthquake

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INTRODUCTION

Arsenic above the environmental standard (0.01 mg l^{-1}) was detected in the Inagawa River, Japan (Fig. 1), during the regular screening test of its water by the administration on 8 February 1995, about three weeks after the great Hanshin

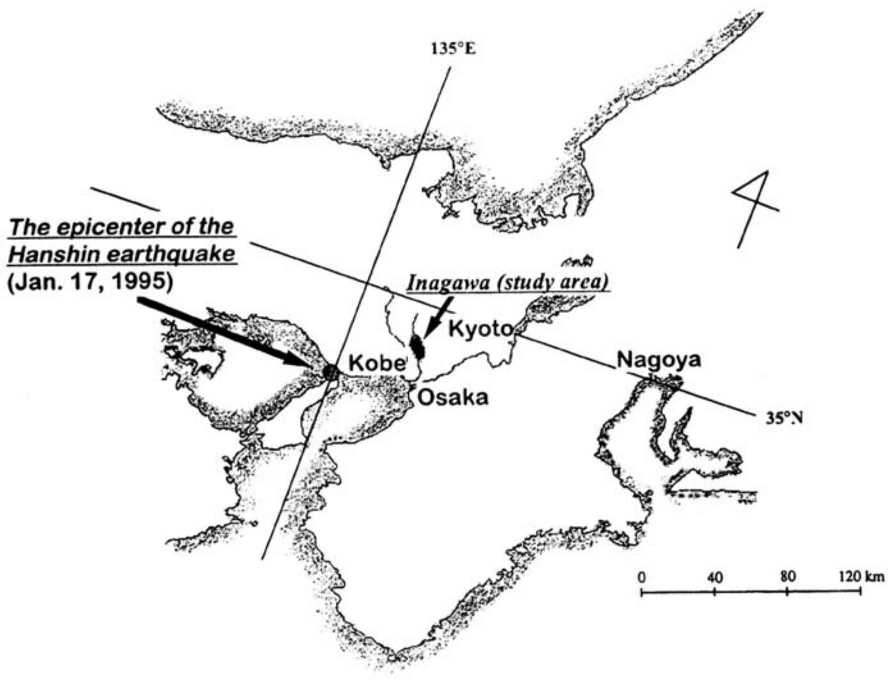

Figure 1 Location map showing the Inagawa area and the epicenter of the great Hanshin earthquake.

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(Kobe) earthquake. According to the official announcement on 17 March 1995, the administrators inspected the concentration of arsenic at 54 points on the river, in addition to its regular monitoring spots, and found that arsenic concentration in the water was extraordinarily higher than the environmental standard at 24 points.

The Inagawa area is located about 35 km northeast from the epicenter of the Hanshin earthquake of 17 January 1995. Earthquake tremors with slight vibrations frequently occurred in the area before and after the great Hanshin earthquake. The possible relation between the Hanshin earthquake and the Inagawa tremors is under geophysical investigation by various research groups.

We had begun to measure the arsenic concentration in the Inagawa River and in its tributaries

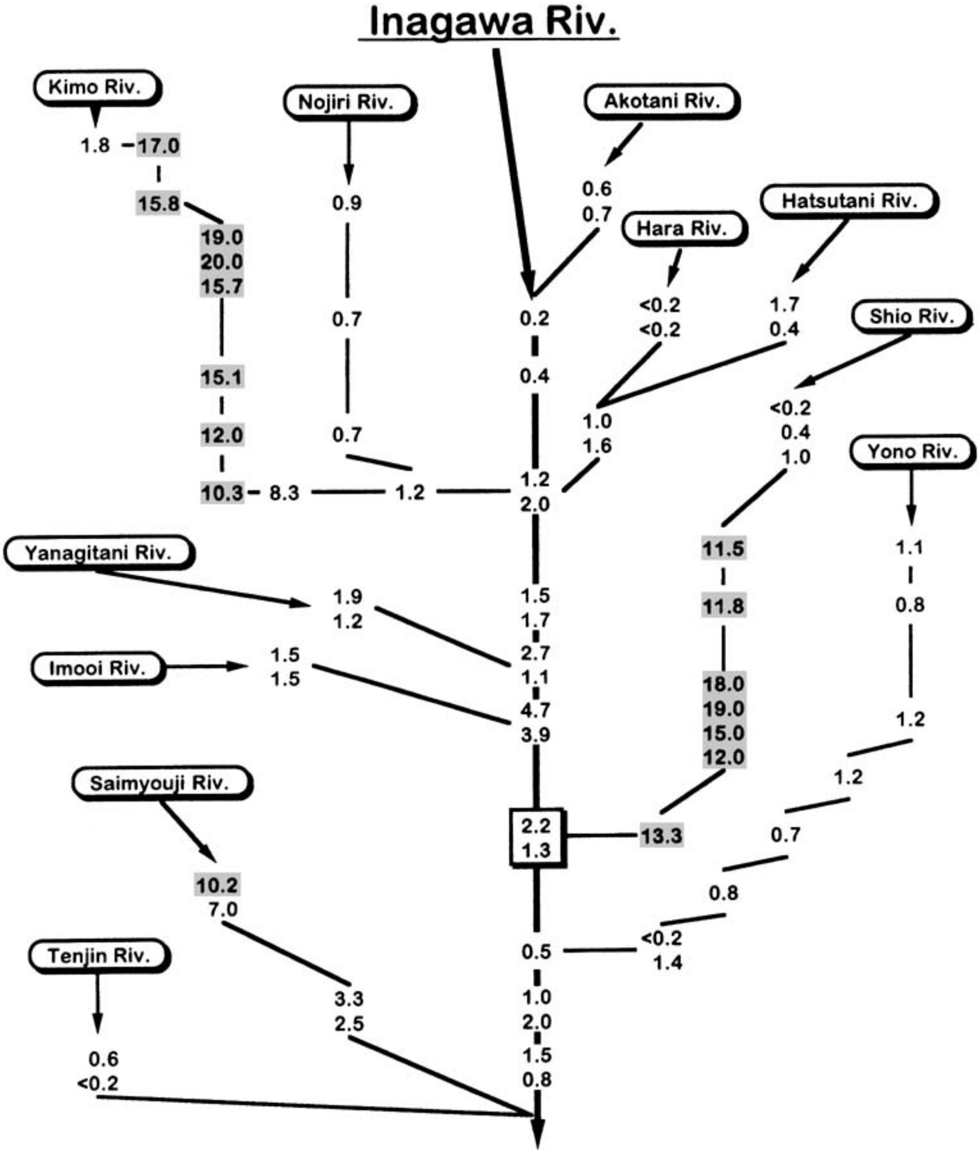

Figure 2 Arsenic concentrations (ppb) at 43 various points on the Inagawa water system. Total number of samples, 67; sampling period, 7 August–18 October 1995. Square box, Ginbashi Bridge (continuous water-monitoring station); oblong boxes, tributaries into the Inagawa River; a stippled background indicates sampling points where As concentration >10 ppb.

Table 1 Arsenic concentrations (mg kg^{-1}, dry weight) among crabs, small fish and plants in the Kimo River and the Shio River

	Crabs	Small fish	Aquatic plants
Kimo River	0.2–0.5[a] (*geothelphusa dohaani*)	1.0[b] (*Zacco temminekii*)	—
Shio River	—	4.2[c] (*Zacco temminekii*)	17.0–19.5 (*Rhizoclonium okamurai* and *Cladophora glomerata* Kutzing) 38.0–39.0 (*Egeria densa*)
Control	—	0.7 (Dried fish)	7.0 (Chopped dry kelp)

[a, b, c] As the animals of the two rivers were too small for determination of the arsenic individually, they were gathered together at every sampling point and analyzed. The numbers of the animals which were gathered for the analysis were: [a] 8, [b] 59, [c] 23, respectively.

in August 1995, in order to clarify the relation between earthquake occurrences and the distribution and variation of arsenic concentration in the river water. Arsenic was analyzed by electrothermal atomic absorption spectrometry (AA-860, HYD-1, -2; Nippon Jarrell–Ash, Kyoto). Arsenic was analysed by a hydride-generation method, an improved method of electrothermal atomic absorption spectrometry. The ionic metalloid form of arsenic in solution was converted to its hydride by nascent hydrogen formed by the reaction of a 10 g dm^{-3} solution of sodium tetrahydrocarbonate ($Na_2Co_3 \cdot 4H_2O$) with hydrochloric acid (specific reagents for AA analysis; Wako Pure Chemical Industries, Ltd, Osaka, Japan). The hydride generated was purged into an absorption cell attached to the atomizer part of the atomic absorption apparatus and heated electrically at 1000 °C. The atomic absorbance was measured at 193.7 nm.

The arsenic concentrations in the waters, which were sampled during the period from 7 August to 18 October 1995, are shown in Fig. 2. The detection of arsenic in the water at a level about two times higher than the environmental standard had continued in the two tributaries, i.e. the Kimo and the Shio Rivers. The concentration of arsenic along the tributary Saimyouji River showed 10.2 ppb on one day and 7.2 ppb on another day. The former value slightly exceeded the environmental standard value; however, the latter was still not low enough.

The arsenic level in the Inagawa River has been monitored monthly at the Ginbashi bridge by the Ministry of Construction, and it has always been below the environmental standard at the bridge until the Hanshin earthquake. However, the three tributaries in which arsenic was above the environmental standard in the present investigation were not monitored previously by the Ministry. As there were no data on arsenic concentrations in the three tributaries before the earthquake, we cannot know when the contamination of arsenic occurred in the tributaries.

We investigated the accumulation of arsenic in living organisms in the two tributaries. Fish, crabs and plants in water of the Kimo and the Shio Rivers were collected and their arsenic contents were determined by the silver–diethyldithiocarbamate absorbance (DDTC–Ag) method. Dried fish and chopped dry kelp, which were sold at a grocery store, were used as the control.

As shown in Table 1, the crabs (average body weight, 1.94 g) and small fish (average length and weight, 35 mm, 0.75 g) which lived in the Kimo River accumulated arsenic at 0.2–0.5 and 1.0 ppm (dry weight), respectively. The arsenic contents of the two species in the Kimo River are considered to be at a normal level, as compared with the control fish. The small fish (average length and weight, 40 mm, 0.88 g) in the Shio River, on the other hand, accumulated 4.2 ppm of arsenic, a level four times higher than that along the Kimo River. The plants in the Shio River concentrated 17.0–39.0 ppm of arsenic. The arsenic concentration of sea algae was 0.15–109 ppm (dry weight) according to Lunde,[1] and 12–86 ppm according to Phillips.[2] There are few analytical data on arsenic concentrations in freshwater flora.

It is assumed from the arsenic concentration in fish in the Kimo and the Shio Rivers that arsenic contamination started in the Kimo River at the time of the Hanshin earthquake but that, in the Shio River, an inflow of arsenic had occurred to some extent even before the Hanshin earthquake.

Mitamura *et al.* reported that groundwater in the North Osaka district contains arsenic (10–60 ppb) because of the geological characteristics.[3] The Inagawa area is located on the western side of the North Osaka district, and we found, in the present investigation, well-waters which contained 8.4–18.9 ppb of arsenic and also a location where groundwater bearing 5.2 ppb arsenic was issuing from the foot of a mountain in the area. It is assumed that the flow of groundwater was changed by displacement along active faults during the Hanshin earthquake and that arsenic-bearing groundwater was rerouted into the specific tributaries of the Inagawa water system.

We continue to monitor the arsenic and other metal ion concentrations of the surface water and the groundwater, out of concern about the Inagawa tremors which even now occur frequently in the Inagawa area.

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