# MANAGEMENT OF WATER SUPPLIES AFTER A DISASTER

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## Summary

It is inevitable that various lifelines, such as water, gas, electrical power and telephones, are seriously damaged by major catastrophes. In the case of a strong earthquake, physical forces damage the water supply facilities, breaking the previously continuous supply of potable water. Accidental spills of hazardous chemicals from factories or vehicle tankers can also affect water supply system in terms of water quality. If the level of chemical contamination exceeds the manageable limit in the water supply system, it is necessary to suspend the water supply to the community.

In order to maintain a minimum supply of water to an affected community, it is necessary to know the acceptable level of short-term exposure to hazardous chemicals. The lessons learnt from the earthquake that occurred in the Hanshin area of Japan provide appropriate examples to explain the countermeasures necessary to ensure emergency water supply.

The Great Hanshin-Awaji Earthquake occurred at 5:46 a.m. on 17 January, 1995, in the southern part of Hyogo Prefecture. The number of fatalities caused by the earthquake was more than 6300 and the number of collapsed houses, both complete and partial, was more than 237 000. The earthquake had devastated infrastructure services, as well as residential and commercial buildings, railroads, and highways.

Enhanced disinfection was absolutely needed in urban areas because the distribution and service pipes were damaged everywhere. There was, therefore, a high possibility of biological contamination through the damaged pipelines. The dosage of sodium hypochlorite was increased in order to maintain free residual chlorine level at least 1.5 ppm, which was twice as much as the ordinary value at the outlet of the water purification plant. As a result, free residual chlorine in service reservoirs and at city water taps was maintained in the range 0.5 to 1.3 ppm. Also no coliform groups were detected at any of the test points.

Water shortage affected the activities of three-quarters of the emergency medical facilities. The affected citizens were annoyed by the shortage of lavatories since flush toilets could not be used. Information on the temporary water supply points was not well understood by many citizens.

Just after the Earthquake, the emergency operation center discussed whether to issue a "boil water" notice as public information through the mass media. It was very difficult to publish this notice, however, in circumstances in which heat sources such as electricity and gas were completely disrupted throughout the city. Many fires had broken out and were further spreading owing to the shortage of water for fire fighting.

In order to respond smoothly after a disaster, it is necessary to implement a nationwide mutual aid agreement. In the often very confused situation just after a disaster, it is very difficult to find the necessary material. It is therefore necessary to establish a nationwide emergency resource database, to provide information on emergency equipment.

Command lines for emergency response and restoration teams were not recognized for most of the staff in the disaster site. The persons in the disaster site were so distressed (many of them were the Earthquake victims themselves) that external technical experts working as advisers were more effective.

## 1. Introduction

It is inevitable that serious disasters damage various lifelines required to support suffering people. In the case of a strong earthquake, physical forces damage the water supply facilities which normally provide a continuous supply of potable water. The public distribution system can no longer supply sufficient quantity of water for daily activities such as domestic, social, and business purposes. Furthermore, the damage may severely affect the services that should be provided by hospitals and ambulances. Accidental spillage of hazardous chemicals from factories or road tankers can also affects water supply system in terms of water quality. If the contamination exceeds the manageable limit of the water supply system, the supply to the communities must be suspended.

Water is essential for human life as well as for various other activities, and normal consumption of water must not be allowed to pose a health risk. Water quality standards and the WHO drinking water quality guidelines are, however, established from the viewpoint of avoiding long-term chronic toxicity. Therefore, they are not intended to provide instructive guidance on short-term acceptable limits of impurities in water in an emergency situation. Ideally, no infectious microorganisms should be in drinking water, but some pollutants to a certain level can be accepted if they do not cause any health problems through short-term exposure. Considering short-term exposure to chemical substances, the Health Advisory of United States EPA provides useful information to assess the quality of water that can be supplied in an emergency.

The Great Hanshin-Awaji Earthquake occurred at 5:46 a.m. on 17 January, 1995, in the southern part of Hyogo Prefecture. The epicenter was located in Akashi Strait. The magnitude was 7.2 and the earthquake registered an intensity of 7 on the Japanese scale in Kobe. The earthquake caused horrible damage for the citizens in southern part of Hyogo Prefecture. The number of fatalities caused was more than 6300 and the number of collapsed houses, both complete and partial, was more than 237 000. The earthquake had devastated services, as well as residential and commercial buildings, railroads, and highways. Water supply was interrupted in ten cities and seven towns. Immediately after the earthquake, the whole Prefecture wrestled with the disaster under the command of the provincial Governor. The actions taken to ensure water supply on that occasion provide an appropriate reference for emergency situations in general.

## 2. Damage to water supply

### 2.1 Summary of damage

The damage to water supply caused by the earthquake is shown in Table 1. Immediately after the earthquake, interruption of water supply affected 1 265 730 households spanning ten cities and seven towns in Hyogo Prefecture. This was approximately 90% of all the households in the area, the total population of which comprised 3 495 000 residents, all of whom were dependent on the water supply network. As the damage to the water supply of one city and two towns in the southern part of Awaji Island was relatively slight, they were able to restore water services in a short period. The water supply of the rest of the area, i.e. nine cities and five towns, took much longer to restore. In Kobe, Nishinomiya, Ashiya, Amagasaki, Itami, Tsuna, Awaji, Hokutan, and Higashiura, the entire water supply network was interrupted. The cost of the damage to the water utilities in the Hyogo Prefecture amounted to more than 55 800 million yen.

| Name of city | Number of households | Length of water main (km) | Points damaged | Rate of water main damaged | Rate of service pipe damaged |
|---|---|---|---|---|---|
| | | | | (locations $km^{-1}$) | (%) |
| Kobe | 650,000 | 4002 | 1757 | 0.44 | 13.8 |
| Amagasaki | 193,300 | 847 | 130 | 0.15 | 6.9 |
| Nishinomiya | 163,800 | 966 | 1019 | 1.05 | 25.2 |
| Ashiya | 33,400 | 184 | 408 | 2.22 | 9.9 |
| Itami | 66,000 | 439 | 58 | 0.13 | 7.4 |
| Takarazuka | 73,600 | 560 | 254 | 0.45 | 17.5 |
| Kawanishi | 50,000 | 471 | 32 | 0.07 | 3.3 |
| Akashi | 111,000 | 624 | 85 | 0.14 | 11.6 |
| Miki | 24,500 | 424 | 35 | 0.08 | 1.7 |
| **Subtotal** | **1,365,600** | **8517** | **3778** | **0.44** | **13.2** |
| Tsuna | 5,600 | 90 | 64 | 0.71 | 2.3 |
| Awaji | 2,600 | 32 | 9 | 0.28 | 7.7 |
| Hokutan | 3,400 | 72 | 214 | 2.97 | 1.4 |
| lchinomiya | 3,000 | 69 | 64 | 0.93 | 35.4 |
| Hokutan | 3,200 | 52 | 13 | 0.25 | 21.9 |
| Sumoto | 14,900 | | | | |
| Goshiki | 2,900 | | | | |
| Midori | 1,800 | | | | |
| **Subtotal** | **37,400** | **315** | **364** | **5** | **12.0** |
| **Total** | **1,403,000** | **8832** | **4142** | **0.47** | **13.2** |

Table 1. Outline of water supply in Hyogo prefecture

### 2.2. Summary of damage to water supply facilities

**a. Reservoir.** The Niteko Dam in Nishinomiya almost collapsed, and the surface of Kitayama Dam also partially collapsed.

**b. Water intake facilities.** The intake in Ashiya River was buried by a landslide.

**c. Aqueduct.** In the Hanshin Water Supply Authority, the first stage aqueduct from the Yodo River was damaged, and the restoration took about one month.

**d. Water filtration plant.** In the sedimentation tank of the Inagawa water filtering plant in the Hanshin Water Supply Authority, the expansion joints loosened and water leaked out. Since the damaged joints were restored swiftly, the plant was soon back in operation.

**e. Distribution tanks.** Damage was relatively small except for the Egeyama distribution tank in Kobe.

**f. Water supply pipes.** Because so many water supply pipes were damaged simultaneously, water in the pipe ran out rapidly, and the water pressure dropped sharply. Water leakage at so many damaged points made it difficult to detect the exact locations. The damage rates of the water supply pipes were 2.22 locations $km^{-1}$ in Ashiya, 1.05 locations $km^{-1}$ in Nishinomiya, and 0.44 location $km^{-1}$ in Kobe. Extraction of mechanical joints was the main cause of the damage.

**g. Service pipe.** Service pipes were damaged in 180 000 households—equivalent to 13% of total households. But in Ashiya and Akashi, where polyethylene pipes were used under the roads, little damage was reported.

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**Biographical Sketches**

**Yasumoto Magara** is Professor of Engineering at Hokkaido University, where he has been on faculty since 1997. He was admitted to Hokkaido University in 1960 and received a degree of Bachelor of Engineering in Sanitary Engineering in 1964 and Master of Engineering in 1966. After working for the same university for four years, he moved to the National Institute of Public Health in 1970. He served as the Director of the Institute. From 1984 he worked for the Department of Sanitary Engineering, then the Department of Water Supply Engineering. He obtained a Ph.D. in Engineering from Hokkaido University in 1979 and was conferred an Honorary Doctoral Degree in Engineering from Chiangmai University in 1994. Since 1964, his research subjects have been in environmental engineering and have included advanced water purification for drinking water, control of hazardous chemicals in drinking water, planning and treatment of domestic waste including human excreta, management of ambient water quality, and mechanisms of biological wastewater treatment system performance. He has also been a member of governmental deliberation councils of several ministries and agencies including Ministry of Health and Welfare, Ministry of Education, Environmental Agency, and National Land Agency. He performs international activities with JICA (Japan International Cooperation Agency) and World Health Organization. As for academic fields, he plays a pivotal role in many associations and societies, and has been Chairman of Japan Society on Water Environment.

Professor Magara has written and edited books on analysis and assessment of drinking water. He has been the author or co-author of more than 100 research articles.

**Hiroshi Yano** is Director of the Water Quality Laboratory, Kobe Municipal Waterworks Bureau. He obtained his Master Degree in the field of biological science from Kobe University in 1969, and a Ph.D in the field of public health in 1979. His specialty is the monitoring and management of water quality in water supply systems. He has been a vice chairman of the hygiene committee of JWWA since 1996. From 1983 to 1985, he was dispatched to the Faculty of Engineering, Chiangmai University, Thailand as a JICA (Japan International Cooperation Agency) expert of environmental engineering.