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RESTORATION AND DAMAGES CAUSED BY THE GREAT EAST JAPAN EARTHQUAKE

USUWANIE STRAT SPOWODOWANYCH WIELKIM TRZĘSIENIEM ZIEMI WE WSCHODNIEJ JAPONII

Wielkie Trzęsienie Ziemi we Wschodniej Japonii spowodowało liczne problemy w różnych obszarach w całej Japonii. Skala zniszczeń była ogromna: sporo ludzi zostało zabitych przez gigantyczne trzęsienie ziemi i tsunami, i zaistniał znaczny spadek w dostawach prądu z powodu uszkodzeń w elektrowniach jądrowych. Wpływ na środowisko wodne, takie jak szkody w systemach kanalizacyjnych, były również ogromne, powodując problemy zdrowia publicznego zagrażające codziennemu życiu mieszkańców. Raport ten proponuje środki zaradcze wobec przyszłych trzęsień ziemi dla systemów kanalizacyjnych, ucząc się od skutków i środków stosowanych wobec katastrofy tego czasu.

The Great East Japan Earthquake caused numerous problems in various areas throughout Japan. A scale of damage was immense: quite a lot of people were killed by the gigantic earthquake and tsunami, and there were a significant drop in public power supply due to damage in nuclear power plants. Effects on water environment, such as damages on sewerage systems, were also tremendous, causing public health problems threatening residents' daily lives. This report proposes countermeasures against future earthquakes for sewerage systems, learning from the effects and measures against the disaster of this time.

1. Introduction

An earthquake of moment magnitude 9.0, the largest ever recorded in Japan, which occurred on March 11, 2011 caused tremendous building damage and human casualties mainly in Eastern Japan with its huge tremor and following tsunami waves, and was named as the Great East Japan Earthquake. Since then, restoration activities and investigation on accidents have been conducted in a wide range of fields, while discussion on aseismic measures has been actively conducted since an early stage.

Damages on sewerage systems are also enormous: Functions were suspended at wastewater treatment plants and pump stations in coastal areas due to tsunami, bringing a huge impact on water environment such as heightened public health risk caused by overflow damages at urban areas, or release of untreated wastewater to the public water body. Damage at Fukushima Daiichi Nuclear Power Station due to earthquake and tsunami also had various effects on sewerage systems.

This paper presents an overview of damages from the Great East Japan Earthquake and the impact on water environment, mainly on sewerage systems, together with countermeasures taken, to propose countermeasures against future earthquakes, considering the impact on water environment.

2. Scale of earthquake and tsunami

2.1. Scale of earthquake

On March 11, 2011 at 14:46, an earthquake of moment magnitude (Mw) 9.0, the largest ever recorded in Japan occurred off the Sanriku Coast, Eastern Japan, originating approximately 24 km depth.

Seismic motion was observed at all areas throughout the nation, as shown in Figure-1[1)]. The intensity scale used by Japan Meteorological Agency is a nine-point scale. At a seismic intensity scale of lower 6, it is difficult to stand independently. At a higher 6 or more scale, it is impossible to move without crawling. At this intensity, you are tossed about by tremor, unable to move by yourself, and sometimes blown off.

After the main quake, quite frequent afterquakes occurred: Five afterquakes of magnitude 7.0 or higher, 82 of 6.0 or higher, 506 of 5.0 or higher (as of June 11, 2011). Such tremendous earthquake damages and the negative effects on people's daily lives continued for an extended period of time.

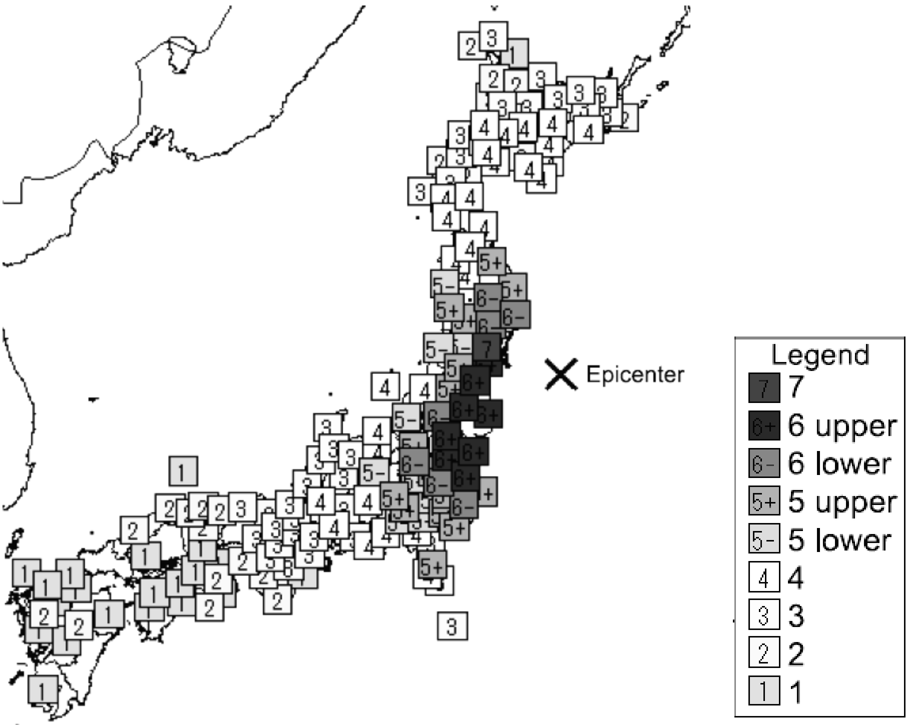

Fig. 1. Distribution of Seismic Intensity by the Japan Meteorological Agency

Rys. 1. Podział natężenia sejsmicznego przez Japońską Agencję Meteorologiczną

2.2. Scale of tsunami

During the Great East Japan Earthquake, tsunami waves were observed at various coastal areas of Japan, including off the Pacific coast of the Tohoku Region, in addition to seismic motion. As shown in Figure-2[1)], extremely high tsunami waves were observed at various places on the Pacific coast, mainly on the Pacific coast of Eastern Japan, such as the maximum height of 9.3 m or more at Soma City, Fukushima Prefecture, and 8.6 m or more at Ayukawa, Ishinomaki City, Miyagi Prefecture. This tsunami brought devastating damages to various places along the Pacific coast.

Immersion due to tsunami occurred in an extensive range of coastal areas, from Aomori Prefecture to Chiba Prefecture. The immersion area was 561 km^2 in total, among which that of Miyagi Prefecture is the largest at 327 km^2, due to its topographic characteristics of having a wide plain field in coastal areas.

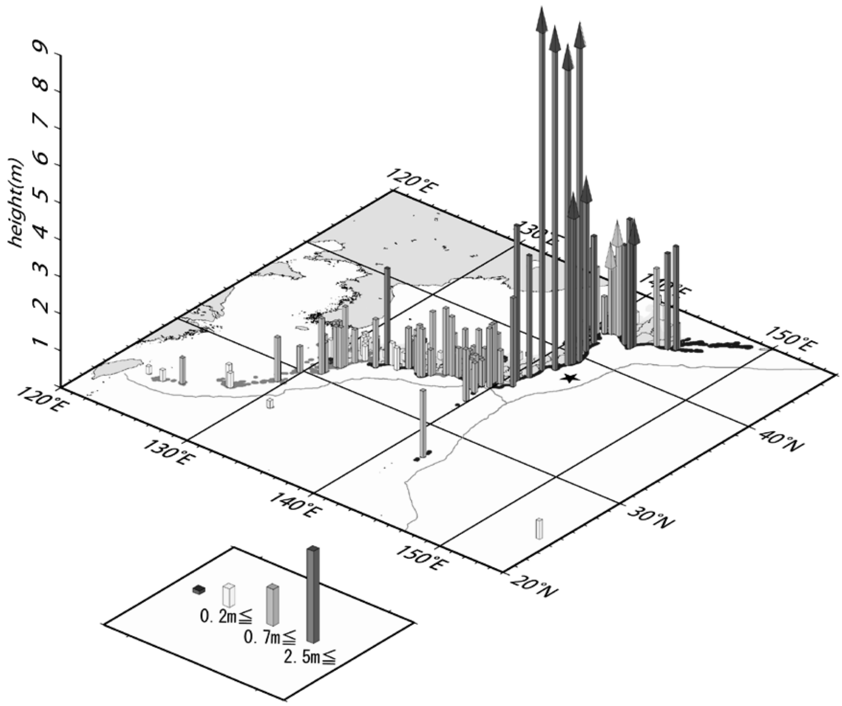

Fig. 2. Heights of tsunami observed at tsunami observation facilities

Rys. 2 Wysokości tsunami zaobserwowane w ośrodkach obserwacji tsunami

3. Overview of damages

According to the report on damage situation by the Great East Japan Earthquake (including the main quake and afterquakes) as of June 9, 2011[1)], the number of deaths is 15,401: it is the first time in Japan that the number of total victims (dead and missing people) exceeds 10,000 due to natural disaster since the end of the World War II. The number of destroyed buildings is 112,409, which includes a large number of houses swept away by tsunami waves, especially those in coastal areas in Iwate, Miyagi and Fukushima Prefectures.

3.1. Overview of damages in lifeline systems

Lifeline systems were also tremendously damaged. A massive power outage occurred, where 4.48 million households in the Tohoku region[2)] and 4.05 million households in the Kanto region[3)] were lacking electrical power. As a result, power saving and preparation for power outage became a social issue since brownout was implemented due to suspended operation at Fukushima Daiichi Nuclear Power Station. Suspension of city gas or water supply, that of landlines and mobile phone lines, etc. also occurred frequently, mainly in coastal areas. The total damage in lifeline systems (water, gas, electricity, communications, etc.) is assumed to be approximately 1.3 trillion yen[4)].

3.2. Overview of damages at sewerage systems

Sewerage systems also suffered enormous damages, far exceeding those by past earthquakes: The length of damaged pipelines totaled 642 km[5)] and 48 treatment plants were suspended[5)]. As shown in Figure-3, damages were different by region. Damages in treatment plants, etc. by tsunami were prominent in coastal areas of the Tohoku region, while there are a lot of damages in an extensive range of pipelines caused by liquefaction at shore areas in the Kanto region.

To conduct adequate temporary restoration for damaged sewerage facilities or full-fledged restoration to prevent disaster in the future, "the Technological Review Committee on Countermeasures against Earthquake and Tsunami for Sewerage Facilities" was established one month after the earthquake, which consists of academic experts, persons in the Ministry of Land, Infrastructure, Transport and Tourism, local governments, and related parties.

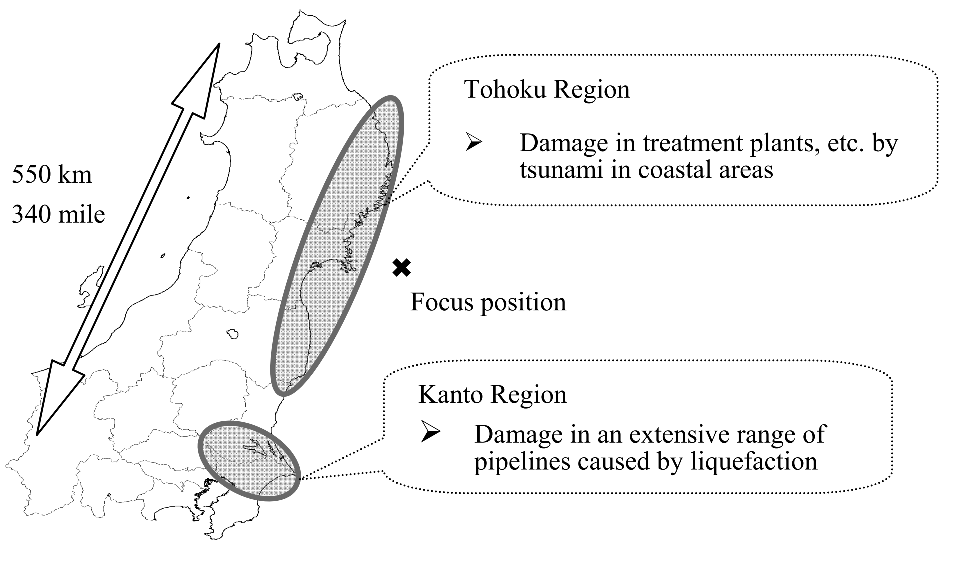

Fig. 3. Characteristics of damages in sewerage systems by region

Rys. 3 Charakterystyka zniszczeń w systemach kanalizacyjnych wg regionów

4. Effects on water environment

Sewerage service was suspended in various areas, due to suspended functions at treatment plants, pump stations, or pipelines, or lacking electrical power.

Suspension of sewerage service led to the secondary damage including overflow of wastewater from manholes, etc. and release of untreated wastewater to the public water body, all of which may affect water environment. Therefore, here we present the survey results on the secondary damage and countermeasures against it at disaster-stricken areas.

4.1. Damages by overflow and countermeasures

Overflow of untreated wastewater in urban areas is a problem to be most strictly avoided, because it carries a high risk of contact with residents, causing contagious diseases. In the earthquake last year, however, there were overflows in some disaster-stricken areas.

Under the lack of electricity, countermeasures against overflow include water pumping from overflowed manholes or treatment plants without electrical power using temporary pumps, and an emergent release of water after simple treatment using disinfectant. Thanks to these measures, there are few cases of contagious diseases which are concerned most and the overflow problem was solved within a month after the disaster, as shown in Figure-4[6].

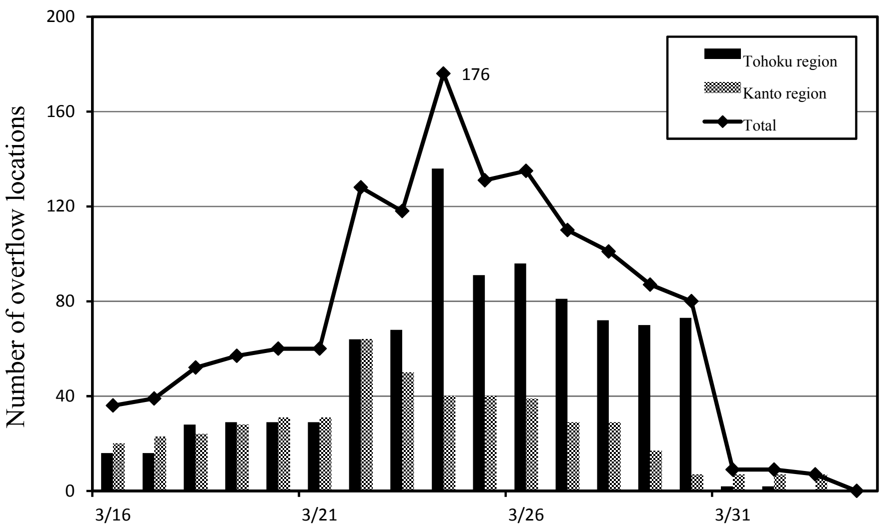

Fig. 4. The number of overflow locations from manholes

4.2. Release to public water body and implementation status

Immediately after functions at treatment plants were suspended, outfall to pipelines was blocked, temporary release with a simple treatment were considered, and construction of a simple treatment plant used for such release with sedimentation/disinfectant processes at treatment plants started at an early stage.

For example, at the Ishinomaki East Purification Center in Miyagi Prefecture whose treatment facilities suffered tremendous damages, wastewater inflow were pumped up with a temporary pump, and temporary release were conducted after wastewater underwent a simple sedimentation at the primary sedimentation tank, disinfected at the chlorine mixing tank. Figure-5 shows the effluent water quality (PH, BOD, SS) for six months after the disaster, while Table-1 presents target values in temporary emission standards at Ishinomaki East Purification Center set by Miyagi Prefecture.

All values meet the target value by effluent water quality standards. Moreover, the values from the water quality monitoring survey[7)] at the public water body in disaster-stricken areas implemented by the Ministry of the Environment were lower than the environmental standards related to protection of human health.

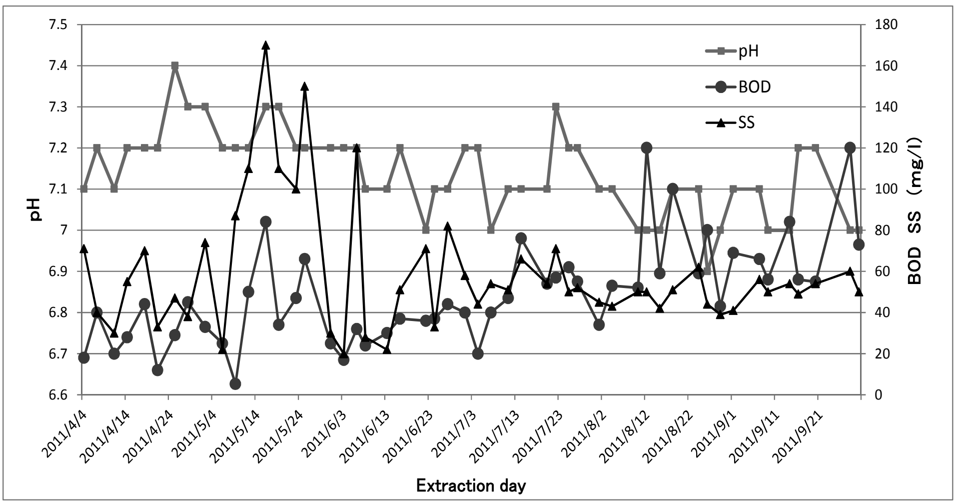

Fig. 5 Effluent water quality at Ishinomaki East Purification Center, Miyagi Prefecture

Tab. 1. Target values in temporary emission standards at Ishinomaki East Purification Center, Miyagi Prefecture

	Target values in temporary emission standards Minimum effluent standards set by the Water Pollution Prevention Act[8)]
pH	5.8 to 8.6
BOD	160 mg/l (Daily average: 120 mg/l)
SS	200 mg/l (Daily average: 150 mg/l)

5. Effects on sewerage systems from radioactive contamination

Troubles at Fukushima Daiichi Nuclear Power Station caused by the earthquake and tsunami and various actions for recovery are still the center of people's attention. These troubles also brought a huge impact on sewerage systems, in addition to nationwide power shortage.

After radioactive materials were detected from dehydrated sludge or incinerated ash of sludge at wastewater treatment plants in Eastern Japan, mainly in Fukushima Prefecture, there has been quite a lot of discussions about handling methods of radioactive materials, which still remains a most critical problem.

In "Views on Current Handling of By-products from Wastewater Treatment in Fukushima Prefecture"[9)] announced by Nuclear Emergency Response Headquarters on May 12, 2011, storage, temporary storage and landfill processes for dehydrated sludge and incinerated or melt ones were determined as follows: Sludge with the radiation dose at over 100,000 Bq/kg should be adequately stored; that with the radiation dose at 8,000 Bq/kg to 100,000 Bq/kg should be temporarily stored in an leachate-controlled type treatment plant; that with the radiation dose at 8,000 Bq/kg or under can be disposed of to landfill in the place for non-household use, or if it is confirmed that the dose is under a clearance level, sludge can be used for construction materials. For sludge with the radiation dose over 100,000 Bq/kg, we intend to continue discussion about details of handling.

6. Future tasks and activities

Temporary release of wastewater after simple treatment, including those for handling overflow, may cause accumulated load on the public water body, if it continues for an extended period, which in turn may lead to the negative effect on ambient environment. Restoration activities are continuing at treatment plants along the coastal areas in the Tohoku region even now, so it will be important to gradually improve treatment functions, while continuing monitoring of the public water body.

Moreover, it will be also desired to develop a BCP (business continuation plan) as a part of the future sewerage service, assuming the estimated damage, and aiming for early recovery of sewerage systems, since it will take a lot of time and effort to decide the way of storing, procuring and installing temporary pumps for handing overflows, as well as the effluent destination for temporary release of wastewater after simple treatment considering water usage conditions, and to negotiate with users or administrator of the water body of the release destination for necessary adjustment.

Furthermore, it is urgently needed to conduct research and development on disposal of sewerage sludge containing radioactive materials that continues in the future.

7. Conclusion

It is desired that new countermeasures be studied by drawing lessons from the disaster in areas not only the Eastern Japan, a disaster stricken area, but also in other areas to consider the effects on water environment from a large scale earthquake and tsunami to be assumed in the future.

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