Managing post-disaster debris: the Japan experience

United Nations Environment Programme

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Cover image: The sole tsunami survivor in a plantation of 70,000 trees, 'Single Pine Tree' in Rikuzen Takata has become a symbol of the resilience of the Japanese people
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Layout: Matija Potocnik

Images: Unless otherwise credited, all images in this publication were taken during the UNEP International Expert Mission by the mission team members, Sendai Television Broadcasting Enterprise and the International Recovery Platform experts

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Managing post-disaster debris: the Japan experience

Report of the International Expert Mission to Japan

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Foreword

The Government of Japan and the United Nations Environment Programme (UNEP) have a long history of collaboration which dates back 40 years to UNEP's inception.

In the aftermath of the tragic events in Japan of 11 March 2011, I am pleased UNEP has been able to contribute to the post-disaster effort. It is impossible to look at images of the devastation without feeling enormous sympathy for the people of Japan's Tohoku region, who are still enduring great upheaval and disruption to their daily lives.

Due to its location, extent and intensity, the Great East Japan Earthquake has created one of the most challenging and expensive disaster debris management operations in history.

This makes Japan's clean-up efforts all the more remarkable. It has been a recovery effort around which an entire nation has rallied and approached with resolute determination. Following a UNEP International Expert Mission to the post-disaster zone, this report documents how – despite their own personal tragedies – the officials of impacted cities have made extraordinary progress in the past 12 months. Commendable emphasis has been placed on waste segregation and recycling, and some segregated materials are already being reused. However, the sheer scale of the disaster means that cleaning up the debris will take several more years.

UNEP's expert mission had two objectives: firstly to bring global experience in disaster response to the Japanese officials who are handling this massive challenge; and secondly to document and share the methods and lessons learned in Japan to help other countries be better prepared to handle debris generated by future natural disasters.

UNEP hopes to use data gathered by its expert mission to assist in developing an international methodology on estimating the volume of debris in post-disaster settings. Such a methodology would prove invaluable in terms of estimating the associated workload and cost of cleaning up after disasters.

Importantly, the expert mission is also the first step in setting up an international network of disaster-debris management specialists, so that their knowledge and experience can be combined and made available to any country dealing with a future major disaster.

I look forward to UNEP's continued collaboration with the government and people of Japan, in particular through UNEP's International Environmental Technology Centre in Osaka.

Achim Steiner
United Nations Under-Secretary-General
Executive Director
United Nations Environment Programme

Foreword

Japan experienced an unprecedented disaster in March 2011 – the Great East Japan Earthquake. Following the disaster, we received many warm messages of condolence and heartfelt support from all over the world.

Now that more than one year has passed since the disaster, Japan is on the robust path toward reconstruction. Many new "Kizuna" (bonds of friendship) were born out of this process between Japan and nations of the world, one of which is the bond created through disaster waste management.

The earthquake generated tremendous amount of debris. Prompt management of debris is an extremely important task in the process of reconstruction. The UNEP International Environmental Technology Centre (IETC), with its headquarters in Osaka, has carried out diverse activities on the dissemination of environmental technologies since its establishment in 1992, and it offers an insight into waste management.

Recently, a group of international experts, who have engaged in different disaster waste management projects, visited Japan and exchanged views with three affected prefectures as well as the Tokyo Metropolitan Government so that they could contribute to the prompt reconstruction of the affected areas.

Because of the frequent occurrence of natural disasters, building a resilient society against natural disasters is more important than ever. Japan intends to share its experiences and lessons learned from this earthquake and the reconstruction process with the international community. Japan would like to cooperate with UNEP/IETC to make this newly born Kizuna of some help to reconstruction of the affected areas and to further expand the network of Kizuna throughout the world for facilitating more resilient society.

Koichiro Gemba
Minister for Foreign Affairs, Japan

Boat swept into the centre of Ishinomaki City
by the tsunami

The event

On 11 March 2011, at 14:46 local time, a massive earthquake occurred off the Pacific coast of Japan. Its epicentre was approximately 70 km east of Japan's Oshika Penisula, while its hypocentre was 35 km underwater. With a magnitude of Mw 9.0, this was the strongest earthquake ever to hit Japan and one of the five most powerful earthquakes measured in the world since modern record keeping began in 1900.

Such was the earthquake's force that it moved the island of Honshu – Japan's mainland, or largest island – 2.4 m east, and is also believed to have shifted the earth on its axis by between 10 cm and 25 cm.

The earthquake triggered a massive tsunami which reached Japan's east coast in less than one hour. Like the earthquake, the tsunami's severity was unprecedented, both in height and reach. A number of coastal cities were completely inundated. In the northern city of Miyako, the flooding from the tsunami reached a height of 40.5 m. In some of the rivers in Sendai plane, the tsunami impacts could be felt up to 10 km upstream.

The tsunami impacted Japan's entire east coast, from Naha in Okinawa prefecture in the south to Nemuro in Hokkaido prefecture in the north. However, the most heavily impacted areas were in the three prefectures of Miyagi, Fukushima and Iwate, which lay closest to the earthquake's epicentre.

The earthquake also damaged the Daiichi Nuclear Power Plant located in the Fukushima prefecture. The reactors were shut-down automatically after the earthquake but the tsunami subsequently destroyed the emergency generators which were needed to cool the reactors. Over the following three weeks, there were explosions, containment vessels were damaged and radiation was released into the region. The Japanese authorities declared a 20 km radius around the power plant a 'no-go' zone and local residents were evacuated.

Japan is situated in a highly hazard prone area and has faced multiple natural disasters in the past. The country has developed substantial defenses against natural hazards, including:

- better engineering of buildings to withstand earthquakes;
- planning restrictions, such as coastal protection forests, physical defenses against tsunamis (solid brick or cement walls) and tsunami gates to prevent tsunamis from entering rivers;
- protection forests planted along the coast to form natural defenses against disasters;
- early warning systems;
- designated shelters and safe areas;
- community-based disaster response training, and
- robust emergency response systems.

The events at the Daiichi plant were rated at level 7 on the International Nuclear Event Scale (representing a major release of radioactive material with widespread health and environmental consequences requiring implementation of extended counter measures). The power station was closed and is not expected to reopen.

Japan is considered one of the best disaster-prepared countries in the world. Yet the triple disaster left close to 20,000 people dead or missing (in total 15,854 dead and 3,155 missing as at March 2012, according to official Japanese Government figures). Hundreds of thousands of houses and other buildings were damaged and more than 400,000 people were displaced. With damage estimated at more than USD 210 billion (¥16,800 billion), this event is not only tragic in terms of its human toll; it is the most economically devastating disaster in history.

The earthquake and ensuing Tohoku tsunami have become collectively known as the Great East Japan Earthquake. Key statistics about the event are set out in Box 1.

One year after the disaster, the environmental, economic and social costs are still unfolding. A number of communities who were uprooted from their coastal villages may never return to those areas. Some of the disaster debris which was washed into the sea may yet turn up in other countries. The final closure and decommissioning of the Daiichi reactors in Fukushima remains a challenge, as does the rehabilitation of the no-go zone around the reactor.

The disaster and Japan's response to it has been closely watched by the international community. The lessons from this disaster are expected to change the rules of the game in a number of areas, from early warning to improved safe operation of nuclear industries.

Box 1. Great East Japan Earthquake: vital statistics

Epicentre:	38° 19' 19.2" N, 142° 22' 8.4" E
Earthquake magnitude:	Mw 9.0 [1]
Peak acceleration:	3 g
Aftershocks:	1,235
Casualities:	15,854 deaths [2] 3,155 missing 26,992 injures
Building damage:	129,225 (fully collapsed) [2] 254,204 (half collapsed) 691,77 (partially damaged)
Economic damage estimate:	USD 210 billion (¥16,800 billion) [3]

Sources: 1) US Geological Survey 2) National Police Agency, Japan 3) The Economist

This report focuses on the enormity of the post-disaster debris challenge and documents the response by the people of Japan and key learnings one year after the event.

More than 400,000 people were displaced following the triple disaster

Such was the scale of destruction, a number of communities may never fully recover

Mixed debris
in Minami Sanriku

The debris challenge

All natural disasters – whether they involve earthquakes, tsunamis, floods, landslides or other natural hazards – result in disaster debris. Increasingly, the management of debris generated by natural disasters is becoming a major expenditure in the immediate aftermath and longer-term recovery effort. For example, the cost of handling the disaster debris following Hurricane Katrina exceeded USD 4 billion (¥321.7 billion) in a post-disaster recovery effort which lasted more than three years.

The debris generated by tsunamis is often more complicated to handle than other types of debris. This is due to a number of factors, including:

1. Tsunamis tend to move a substantial amount of debris from its original location, making the task of identifying and recovering the material by its owners extremely difficult;

Professor Toshiaki Yoshioka

Tohoku University, Sendai, and member of Japan's Task Force on Disaster Debris Management

"Due to a shortage of land, waste management in Japan is a challenge even during normal periods. The generation of large quantities of disaster debris thus makes the entire operation extremely challenging, both technically and financially."

The disaster generated an unprecedented volume of debris which will take several years to clean up

2. Tsunami waves mix up materials from everything in their path, causing various kinds of debris – from hazardous to non hazardous, biodegradable and recyclable to non-recyclable waste – to be combined into piles. This can cause entire mounds of debris to deteriorate rapidly, making recovery and recycling more difficult;
3. The debris is washed with salt water increasing corrosion and degradation in the short term and making downstream processing, such as incineration and biodegradation, more difficult;
4. Massive quantities of debris will often be carried back into the sea along with the return waves, whereby the heavy materials will be deposited in the coastal area and lighter materials will tend to float out to sea where they can remain for months or even years, causing hazards to marine life as well as affecting the shipping and fishing industries; and
5. Tsunami waves can also carry large volumes of marine sediments inland. Depending on the quality of the sediment and where it has been deposited, this may also need to be handled as disaster debris.

Tohoku tsunami

Due to its location, extent and intensity, the Tohoku tsunami has created one of the most challenging disaster debris management operations. It encompassed all of the characteristics mentioned above. Anything standing in its way – from boats to trees to concrete bridges, tsunami gates, trains, automobiles, houses, supermarkets and schools – was swept up and moved, often by several hundred metres or more, and converted in an instant into disaster waste.

Large quantities of sediments, often up to 20 percent of the total debris estimate for an impacted city, were deposited on the land and an unknown quantity of debris was carried back into the ocean.

Along the Tohoku coast, as cities were decimated or even wiped out, landscapes and seascapes were strewn with debris of an order of magnitude and nature that nobody could have prepared for. In the city of Ishinomaki, the tsunami produced an estimated 6.15 million tons of debris which was equivalent to 103 years of solid waste production in that city in normal circumstances. The situation in other cities was similar, although variable in scale.

While the challenge caused by the tsunami debris was both massive and complex, it was also urgent. As tsunamis often carry victims along with the debris, it is important that the piles of debris are inspected for any human remains. Initially, debris had to be moved into the streets so that both rescue workers and communities could gain access to the affected areas.

At the same time, survivors of a tsunami also need to be given an option to look through the debris to recover any items of practical or personal value (such as documents, albums and toys). However, once this is done, the debris needs to be moved as quickly as possible to prevent it from degrading at the site and to facilitate emotional and practical recovery. It is important for the emotional well-being of the communities who remain in the location to see that the remnants of the destructive event are removed from the location as soon as possible. Reconstruction can only begin once the debris has been removed.

Table 1. Waste volumes in selected impacted cities

Prefecture	Local Government	Amount of waste (tons)	Prefecture	Local Government	Amount of waste (tons)	Prefecture	Local Government	Amount of waste (tons)
Iwate	Hirono	15,000	Miyagi	Sendai	1,352,000	Fukushima	Iwaki	880,000
	Kuji	96,000		Ishinomaki	6,163,000		Soma	217,000
	Noda	140,000		Shiogama	251,000		Minami Soma	640,000
	Fudai	19,000		Kesen-Numa	1,367,000		Shinchi	167,000
	Tanohata	86,000		Natori	636,000		Hirono	25,000
	Iwaizumi	42,000		Tagajyo	550,000		Naraha	58,000
	Miyako	751,000		Iwanuma	520,000		Tomioka	49,000
	Yamada	399,000		Higashi-Matsushima	1,657,000		Ohkuma	37,000
	Ohtsuchi	709,000		Watari	1,267,000		Futaba	60,000
	Kamaishi	762,000		Yamamoto	533,000		Namie	147,000
	Ofunato	752,000		Matsushima	43,000			
	Rikuzen	1,016,000		Shichigahama	333,000			
				Rifu	15,000			
				Onagawa	444,000			
				Minami Sanriku	56,000			
	Total	**4,755,000**		**Total**	**15,691,000**		**Total**	**2,280,000**

Source: Sendai City Waste Management Guidelines for Great East Japan Earthquake, Environmental Bureau, City of Sendai, January 2012

The use of heavy mechanization was a key feature of the response effort

The Japanese Government's response

While the disaster debris management challenge was both daunting and urgent, for Japanese Government agencies, from the municipal to national level, this was one of multiple issues that had to be addressed in the wake of the Great East Japan Earthquake. The enormity of the challenge was most acute at the municipal level where the harsh reality was that in many cases the officials who would normally have been responsible for waste management were either killed or traumatized by the loss of family or friends or the destruction of property. The emotional mindset of the officials who remained and had to face the deconstruction of entire cities can only be imagined by those who were not present.

Japan has three tiers of government: national, prefecture and municipal. According to the law, waste management issues are dealt with at the municipal level with technical and financial support from the relevant prefecture government. While arguably more emotionally detached, officials at the national level also had serious challenges to overcome. It was evident from the scale of the destruction that the local and prefecture governments in the affected areas would be unable to respond to the disaster on their own. Thus, human, technical and financial resources had to be found at a time when the disaster caused a massive blow to Japan's economy. With every municipality needing technical support, the resources of national ministries were stretched to the limit. Meanwhile, the unfolding crisis at the Daiichi Nuclear Power Plant, with its global implications, also demanded the attention of officials in the national government.

Despite these extraordinary circumstances, it is to the credit of Japan's Ministry of the Environment that they quickly identified dealing with the debris as a major post-disaster challenge and formed a Task Force on Disaster Debris Management. This consisted of more than 100 experts from government agencies, research institutions, academia and industry. Individual technical experts from various offices within the ministry were deployed to back-up and strengthen those prefecture

Chihori Kikuchi

Coordinator, Japan International Cooperation Centre

"As a victim of this disaster, I have been glad and honoured to see the progress with recovery efforts in the affected areas for myself. I hope our experiences will be of value to other countries in the future."

and municipality offices which were trying to address the disaster debris. On 16 May 2011, just two months after the event, the Ministry of the Environment came with clear guidance notes for the municipalities on how to deal with the disaster debris.

The ministry's guidelines laid out the key activities to be undertaken in each municipality to deal with the disaster debris. This ensured there was consistency in the overall approach to the clean-up, segregation, offsite transportation and final disposal of debris. The guidelines emphasized the importance of maximizing recycling opportunities. They also requested local governments to ensure efficiency in contract management and the maximization of local employment in disaster debris management.

Recognizing that many municipalities would be unable to handle the volumes of disaster debris without assistance, the guidelines promoted collaboration between municipalities at the prefecture level, as well as

Guidance notes provided by Japan's Ministry of the Environment advised municipalities on segregating debris cross-jurisdictional involvement between prefectures. The guidelines also set an ambitious schedule to achieve initial clean-up, segregation and final disposal of disaster debris, with the management of disaster debris to be completed by the end of 2014 – or three years after the tsunami.

The guidelines also recommended increased subsidies to local municipalities to help them deal with disaster debris and requested the issuance of bonds by the municipalities to bridge any funding shortfalls.

The disaster waste guidelines from the ministry, together with the technical experts deployed in the field, essentially formed the foundation for the post-disaster debris management operation. The guidelines were then implemented by the municipalities, often with the support of the prefecture governments. There was greater involvement by prefecture governments in cases where the municipalities had limited local capacity or where the local resources were totally overwhelmed by the scale of the disaster.

Table 2. Recommended approaches to disaster debris management

Sl #	Debris category	Suggested approach
1	**Combustible waste**	After shredding, use for cement calcination process and power generation wherever possible
2	**Waste wood**	Expose the wood to rain to wash out the salt to meet user requirements Mainly use for making multi-purpose wooden boards and as fuel for boilers and power generation Copper chrome arsenate (CCA) treated wood should be incinerated at waste treatment facilities
3	**Non-combustible waste**	Separate from combustible waste and dispose of at landfill sites
4	**Scrap metal**	Should be recycled after separating ferrous and non-ferrous metals whenever possible
5	**Waste concrete**	Should be separated into asphalts, concrete, stone and other materials Should preferably be used as materials for reconstruction in the impacted areas
6	**Home appliances and automobiles**	Items should be separated to the extent possible (televisions, air-conditioners, washing machines, dryer and refrigerators) Should be managed under relevant Designated Home Appliances Recycling Act 1998 Automobiles should be delivered to collection companies for recycling pursuant to the End-of-Life Vehicle Recycling law 2002
7	**Watercraft**	Ships should be dismantled after removing fuel and batteries Scrap metal should be recycled Waste plastic and wood must be incinerated and used for power generation, to the extent possible Parts of vessels containing asbestos should be disposed of according to the specified procedures for asbestos-contaminated waste
8	**Hazardous wastes**	Waste containing asbestos, polychlorinated biphenyls (PCBs) and other hazardous substances should be separated from other waste, treated as a discreet category of specially-controlled waste, and disposed of according to its properties
9	**Tsunami sediments**	Materials containing toxic substances (i.e. heavy metals), perishable combustible materials and sediments containing oil should be used as raw materials of cement or subjected to incineration for landfill Other materials with similar properties to water botton sand should be segregated from foreign matter and used as backfill in ground subsidence areas, recycled into civil engineering materials or placed into the ocean
10	**Waste at post-fire sites**	At sites affected by fires, ash should be segregated from scrap metal and waste concrete Ash, along with tsunami sediments mixed with ash, should be molten or disposed of in landfills at final disposal sites, deemed suitable based on the detected dioxin levels

Source: Guidelines (Master Plan) for Disaster Waste Management after the Great East Japan Earthquake, Ministry of the Environment, May 2011

Members of the UNEP mission team are briefed during a visit to Ishinomaki

UNEP's International Expert Mission

The ongoing post-disaster debris management operation in Japan is the largest in recent history. In light of this, the Ministry of Foreign Affairs felt there was an opportunity to exchange experiences between international and Japanese experts in disaster waste management.

Following the earthquake and tsunami in March 2011, the UNEP's Executive Director, Achim Steiner, wrote to Japan's Prime Minister, His Excellency Naoto Kan, expressing condolences and offering UNEP's expertise and availability to assist in any way. In May 2011, UNEP participated in a visit to the tsunami-impacted region arranged by the Asia Disaster Reduction Centre at the behest of the foreign affairs ministry.

The International Environmental Technology Centre of UNEP is based in Japan and waste management is among its core areas of expertise. UNEP's Post-Conflict and Disaster Management Branch, based in Geneva, has extensive experience in post-crisis environmental assessment and clean up efforts. For example, UNEP was involved in post-disaster debris management following the 2004 South-East Asian Tsunami, the 2005 Pakistan earthquake, Cyclone Nargis in Myanmar and the Wenchuan Earthquake in China in 2008, as well as the 2010 earthquake in Haiti.

The United Nations Environment Programme (UNEP) was therefore invited by the foreign affairs ministry to facilitate an experience sharing mission. The government's request to UNEP had three distinct elements:

1. Facilitating a mission of experts with post-disaster debris management expertise from around the world to visit selected municipalities dealing with the task of post-tsunami debris management;

Muralee Thummarukudy
Chief, UNEP Disaster Risk Reduction
Mission leader

"The ongoing disaster debris management in Japan is the world's single largest waste management operation, surpassing Hurricane Katrina. It is therefore appropriate that such a process is informed by the international experiences and that we document lessons from this operation for use elsewhere."

2. Preparing a documentary on the visit for information, dissemination and training purposes internationally; and
3. Participating in various events organized by the Government of Japan on post-disaster recovery to present the expert mission's findings.

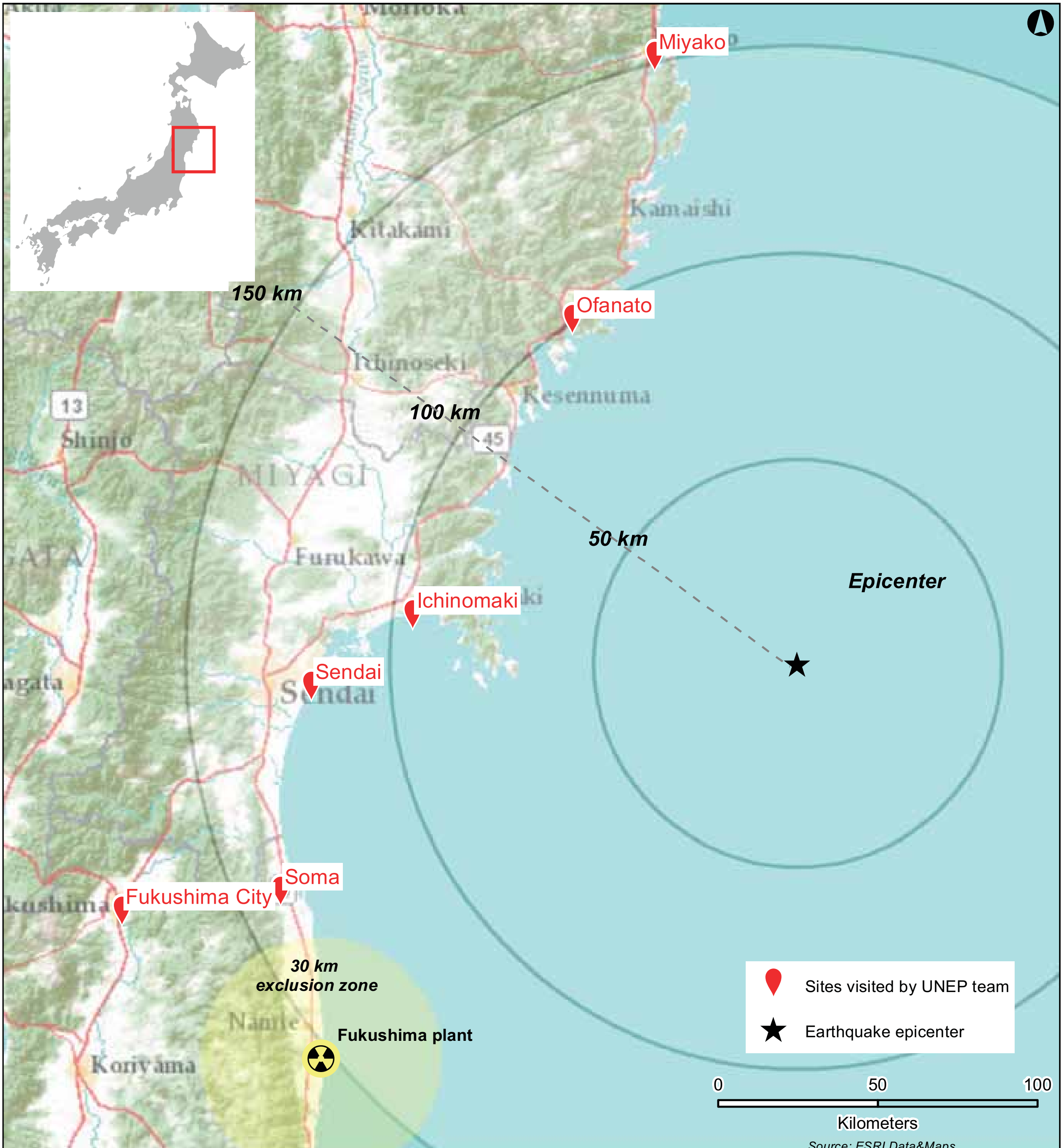
Mission team

UNEP formed an international team of senior experts from the USA, France, the United Kingdom, Germany, Switzerland and St Lucia. They were joined by a member of Japan's Task Force on Debris Management and UNEP officials. Details of mission team and their areas of expertise are presented in Table 3.

Table 3. Participants in the International Expert Mission

Expert	Designation	Main expertise	Experience in post-crisis settings
Muralee Thummarukudy	(Mission Team Leader) Chief of Disaster Risk Reduction, Post-Conflict and Disaster Management Branch, UNEP, Switzerland	Post-disaster response, strategic planning of debris management, environmental assessment, financing, contracting, disaster risk reduction	Cyclone Nargis, Wenchuan Earthquake, Haiti earthquake, Thailand floods, oil spills
Surya Chandak	(Mission coordinator) Senior Programme Officer, International Environmental Technology Centre, UNEP, Japan	Waste-to-energy, cleaner production	South-East Asian Tsunami of 2004
Professor Toshiaki Yoshioka	Professor, Tohoku University, Sendai, Japan	Environmental impact assessment, waste management	Great East Japan Earthquake and tsunami, 2011
Ronnie Crossland	Associate Director of Disaster Preparedness, US Environmental Protection Agency, USA	Contingency planning for waste management, onsite assessment, clean-up, debris management	United States (many disasters including hurricanes Katrina, Gustave, Ike and Rita), Deepwater Horizon oil spill
Thorsten Kallnischkies	Independent consultant to the UN, The World Bank and the Government of Germany	Management of landfills, industrial waste management, landfill design and operation, contracting for waste management	Includes post-crisis response in Ukraine, Dominican Republic, Mexico, Lebanon, Nigeria
Yves Barthelemy	Head of Geomatics Department, Paris Est University, Ecole Superieure Ingenieurs, France	Disaster waste estimation, siting of new landfills, environmental assessment of landfills, use of geographic information system (GIS) for waste management and tracking	Post-crisis response in Myanmar, Lebanon, Iraq, Rwanda, Congo, Ecuador, Tanzania
Mike Cowing	Independent consultant to the UN and The World Bank	Waste segregation and recycling, landfill design and operation, healthcare waste management	Includes post-crisis response in China, the Caribbean (post hurricane), Haiti (post earthquake), Russia, Indonesia, Sri Lanka
David Smith	Director, LilQuest Waste Assessment and Handling Company, United Kingdom	Assessment and clean-up of hazardous wastes, asbestos	Post-crisis response in Indonesia, China, Lebanon, Nigeria and the United Kingdom
Mario Burger	Head, Physics, Speiz Laboratory, Switzerland	Environmental monitoring, radiation assessment	Includes post-crisis response in Iraq, Kuwait, Serbia, Nigeria

Map 1. The sites visited during the UNEP International Expert Mission, conducted from 27 February-5 March 2011



Mission activities

UNEP's international expert mission was conducted in two phases. During the preparatory phase, the team of experts collected all relevant background information about the Great East Japan Earthquake and tsunami, including satellite images and government documents. A preliminary visit was undertaken by UNEP officials to some of the selected municipalities to scope the main mission and examine logistics.

Phase two was the mission itself which involved detailed coordination with government authorities at all levels. Five municipalities were chosen to provide sufficient geographic diversity and to expose the experts to the different scale and nature of disaster debris problems faced by the municipalities, as well as the range of solutions being tested. The impacted cities visited during the expert mission were:

- Sendai City
- Miyako City
- Ofunato City
- Ishinomaki City
- Soma City

In addition, a recycling facility in Tokyo where the disaster debris is being received was also visited.

The activities of the mission team at each site included the following:

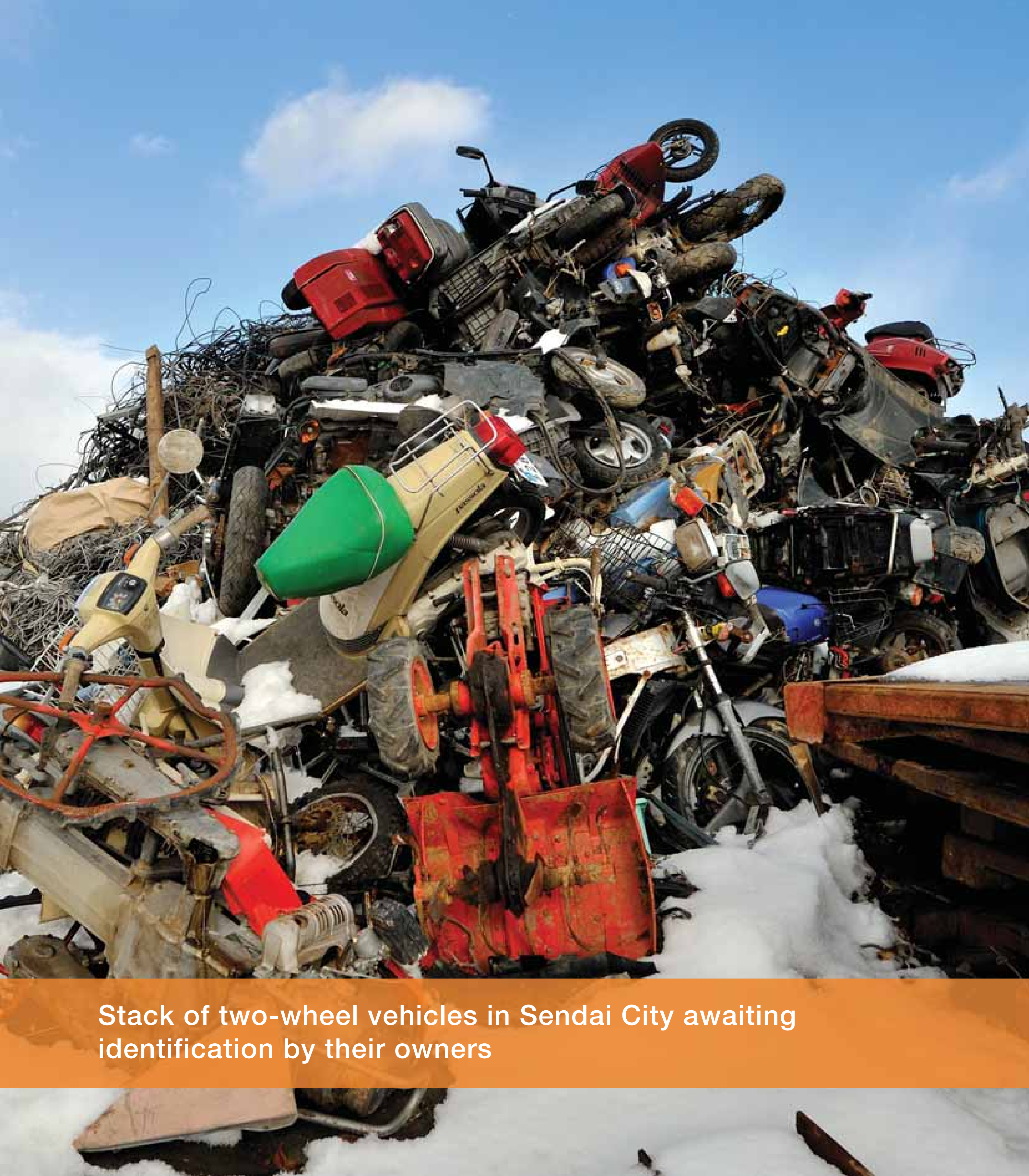
- A meeting with the city officials dealing with debris management;
- A visit to the storage areas as well as any treatment, recycling, re-use and disposal facilities, making observations and notes, and exchanging ideas with technicians on the ground; and
- A close-out meeting with experts and city officials were experiences were exchanged in a structured manner.

Yukiko Fujimura
Freelance journalist

"Having reported on the disaster when it occurred, it was meaningful for me to cover the UNEP Expert Mission one year later and see the changes and ongoing challenges at familiar places and to know how local municipalities are dealing with them."

The mission team was accompanied by a film crew and photographer from the Sendai Broadcasting Corporation who were contracted by UNEP to document the entire mission. The team also met briefly with Japan's Minister of Foreign Affairs, The Honourable Koichiro Gemba, and gave him feedback about the mission's observations. The mission concluded with a press conference at the Japan National Press Club in Tokyo as well as a briefing in Osaka where experts from various national and international organizations were invited to discuss the mission team's preliminary observations. It was not part of the scope of UNEP's mission to visit the Daiichi power plant or its exclusion zone, nor to examine the Japanese Government's plans to dispose of radiation-contaminated debris.

Initial meeting for the UNEP International Expert Mission in Sendai



Stack of two-wheel vehicles in Sendai City awaiting identification by their owners

Sendai City

Situated 87 km west of the earthquake's epicentre, the first tsunami wave struck the Sendai coast at 15:30. As of March 2012, there were 704 people confirmed dead and 26 missing out of the city's total population of more than one million people. Estimates from Sendai municipal authorities indicate the disaster produced 1.35 million tons of debris and some 1.3 million tons of tsunami sediment in Sendai alone. Close to 246,628 houses were damaged. Other vital statistics about the city of Sendai with reference to the tsunami are presented in Table 4.

The management of tsunami debris is ongoing in Sendai. Almost all loose debris from the impacted areas has been collected and moved to interim and final storage locations. Three new incinerators, with a combined capacity of processing 480 t/day of debris, were commissioned within four months of the disaster and are now fully operational. The municipality has commenced shipping damaged automobiles from a central storage area for final processing.

Sendai had a number of advantages compared to other municipalities in terms of disaster debris handling. To begin with, Sendai had a contingency plan for disaster debris management. Even though the scale of the disaster far outstripped the scope of the city's contingency plan, having such a document in place enabled the municipal authorities to quickly adapt it to the new situation.

Being a large municipality, Sendai also had an established environment department which could deal with many of the technical challenges posed by the disaster. The presence of Tohoku University in Sendai further enabled the municipality to access technical expertise to supplement their existing staff.

The municipality prepared waste management guidelines with the basic objective to "remove all disaster waste within a year and to dispose of all waste within three years", as well as seeking to rebuild the local economy by utilizing local businesses. What is interesting about the *Sendai Disaster Waste Management Guidelines for the Great East Japan Earthquake* is that in addition to the collection and handling of disaster debris, they also provide guidance on other important, related aspects such as:

- Maintaining hygienic environmental conditions and prompt restoration of the livelihoods of citizens, which includes a contingency plan to restore the daily waste collection and disposal service as soon as possible;
- Environmental safety and work security, which includes ensuring that the debris management does not create additional health or safety hazards, including traffic congestion; and
- Specifications about maximizing local business opportunities (for e.g. all vehicles to be hired were prescribed to be only from the Sendai municipality).

Sendai's three principal disaster debris management sites are located on the coast: Gamo, Arahama and Ido. They are being managed by private contractors under the supervision of the Sendai Municipality. The UNEP mission team was given an overview of the three facilities, and visited one of the locations, at Arahama.

Table 4. Tsunami-related facts and statistics for Sendai City

Parameter	Value
Location	Sendai City
Prefecture	Miyagi
Population at the time of the event	1,0456,000
Estimated quantity of tsunami debris	1.35 million tons
Number of automobiles damaged	9,700
Number of storage facilities established	3
Total incineration capacity	480 t/day
Waste exported outside	10,000 tons
Estimated cost of debris management	USD 1.15 billion (¥92.5 billion)
Ongoing monitoring	Radiation and asbestos
Health and safety incidents related to debris management	None recorded

Source: Sendai City Municipal Government, 2012

At the site visited, the mission team found that good health and safety arrangements were in place, including fencing, visitor registration, personal protective equipment arrangements for staff and visitors, and good traffic management.

Waste was segregated into various piles, consistent with the national guidelines. The results of daily radiation monitoring were displayed outside the facility.

The pile heights were of medium scale compared to those in other impacted cities, and therefore Sendai was not experiencing an accumulation of methane gas and spontaneous combustion was reported in some of the other municipalities visited.

Compared to major disaster sites elsewhere in the world, the mission team concluded that the amount of hazardous waste generated in Sendai did not appear to be significant, probably as the areas impacted were more residential than industrial. However, the hazardous materials that had been collected here were being kept in the open, sometimes simply under tarpaulins.

The mission team felt the management of hazardous waste at this site could be improved, preferably by moving it to an offsite location with more secure containment and roofing which would ensure the safety of the materials as well as the health of staff working on-site. The storage of automobiles, and in particular two-wheelers, could also be improved as they were stacked without first removing the fuel.

Pile of tyres at Arahama

In some cases, potentially hazardous materials were kept in the open

A shipment of mixed tsunami debris
leaves Miyako for Tokyo

Miyako City

Miyako is a small municipality located 150 km north-west of the 2011 earthquake's epicenter. The city had a population of 40,769 at the time of the event. The first tsunami wave arrived at 15:26 on 11 March. A total of 526 people have since been confirmed dead, with 114 missing. Some 4,859 houses were damaged. The total volume of post-disaster debris is estimated at 574,900 tons. See also Table 5.

The expert mission observed that almost all loose debris from the impacted area had been collected and moved to a final storage location. The material had been sorted into major separate categories such as wood, automobiles, housing appliances, traditional beds (tatami), fishing nets and building debris, consistent with the national guidelines. The pile heights were of medium scale compared to those in other impacted cities, and the city was not experiencing an accumulation of methane gas and spontaneous combustion as was reported in some of the other municipalities visited.

Being a fishing village, there was a notably large mound of fishing nets. As the nets had become fully entangled, separating them for disposal was not practical. The fishing nets are mostly made out of nylon which is not biodegradable and although their storage had not caused a safety hazard to date, officials were hopeful of finding a suitable solution. (This was a common issue in a number of other coastal municipalities where fishing or oyster farming was a dominant economic activity).

Table 5. Tsunami-related facts and statistics for Miyako City

Parameter	Value
Location	Miyako City
Prefecture	Iwate
Population at the time of the event	40,769
Estimated quantity of tsunami debris	574,000 tons
Number of automobiles damaged	3,000
Number of storage facilities established	1
Total incineration capacity	90-95 t/day
Waste exported outside	1,900 tons
Estimated cost of debris management	USD 120 million (¥9.653 million)
Ongoing monitoring	Radiation and asbestos
Health and safety incidents related to debris management	None recorded

Source: Miyako City Municipal Government, 2012

David Smith
Hazardous waste expert

"There had been no decline in the health and safety standards and typically this is not the case. In many other situations, due to the emergency nature of the operation, the health and safety standards are relaxed, exposing workers to unnecessary danger."

A large pile of mixed debris was still being manually segregated at a new sorting plant. An incinerator with a capacity of 90-95 t/day is being established. Miyako City is also exporting disaster debris to Tokyo.

Being a small municipality, Miyako officials have had significant technical and financial constraints in dealing with disaster debris. The municipality is being supported by Iwate prefecture officials on technical and administrative matters regarding debris management. The municipality has ensured that local employment is maximized and approximately 100 local people are currently employed at the Miyako site involved in various stages of disaster debris management.

At the storage, sorting and disposal site visited, there were good health and safety arrangements in place, including fencing, visitor logging, personal protective arrangements for staff and visitors and good traffic management. The results of daily radiation monitoring were displayed outside the facility.

Disposing of fishing nets has been a major issue in many coastal communities

Ofunato City

Ofunato is a small municipality located 100 km north-west of the earthquake's epicentre. It had a population of 40,769 at the time of the event. The first tsunami wave arrived in the city of Ofunato at 14:54 – within eight minutes of the earthquake. As of March 2012, there were 340 people confirmed dead and 84 still missing.

According to official figures from the municipal government, the earthquake and tsunami damaged 5,387 houses and the event generated an estimated 756,000 tons of debris. See also Table 6.

The mission team observed that almost all loose debris from the impacted area had been collected but was not yet fully consolidated at one location. The debris was segregated into many different piles according to the guidelines of the national government. Fishing nets were a major issue here also with no known plan for their disposal.

A dedicated site for storing hazardous materials had not been damaged by the tsunami. As its roof and concrete floor were in tact, a range of waste – from pesticides to PCB containing transformers – was being stored there with good safety signage.

Table 6. Tsunami-related facts and statistics for Ofunato City

Parameter	Value
Location	Ofunato City
Prefecture	Iwate
Population at the time of the event	40,769
Estimated quantity of tsunami debris	756,000 tons
Number of automobiles damaged	4,777
Number of storage facilities established	20
Total incineration capacity	1,000 t/day
Waste exported outside	None
Estimated cost of debris management	USD 5.15 million (¥414 million)
Ongoing monitoring	Radiation and asbestos
Health and safety incidents related to debris management	None recorded

Source: Ofunato City Municipal Government, 2012

Mario Burger
Spiez Laboratory

"There was systematic monitoring of environmental components in and around the waste management centres, which was also made available to the public. This is one practice which could be followed elsewhere."

Ofunato City is home to a major cement industry, the Taiheiyo Cement Corporation. Its facility was flooded and partly damaged by the tsunami. However, the cement plant was rapidly put back into operation and one of its kilns was converted into an incineration plant. Consequently, the facility is able to process around 1,000 t/day of combustible tsunami debris. The cement plant has also set up a de-salting plant to wash the tsunami debris so that it can be used as fuel for cement generation, maximizing the economic value of utilization.

At the main storage and handling site visited, there were good health and safety arrangements in place, including fencing, visitor logging, personal protective arrangements for staff and visitors and good traffic management. Daily radiation checks were being done and the results were made publicly available.

An incinerator under construction in Ishinomaki is due to be the largest in Japan

Ishinomaki City

Ishinomaki is a medium-sized municipality located 95 km west of the earthquake's epicentre. Predominantly a fishing centre, it had a population of 162,822 at the time of the event. The first tsunami wave arrived in Ishinomaki at 15:26. The tsunami left the city and its residents completely devastated. As of March 2012, there were 3,280 people confirmed dead and 595 missing. An estimated 6.16 million tons of debris was generated with some 53,742 buildings damaged.

While all of the urban areas along the Tohoku coast were overwhelmed by the amount of tsunami debris, the situation was most grave in the city of Ishinomaki, which suffered the most casualties, the greatest destruction of houses and the highest volume of debris of all the municipalities.

It was estimated that the debris produced on 11 March 2011 was equivalent to the volume of waste which would usually have been generated by the city over a 103-year period. The local capacities – technically, administratively and financially – were totally overwhelmed by the destruction and scale of the challenge. See also Table 7.

Table 7. Tsunami-related facts and statistics for Ishinomaki City

Parameter	Value
Location	Ishinomaki City
Prefecture	Miyagi
Population at the time of the event	162,822
Estimated quantity of tsunami debris	6.16 million tons
Number of automobiles damaged	21,038
Number of storage facilities established	23
Total incineration capacity	1,500 t/day
Waste exported outside	None
Estimated cost of debris management	USD 262.5 million (¥21,115.5 million)
Ongoing monitoring	Radiation and asbestos
Health and safety incidents related to debris management	Roll-over of vehicles

Source: Ishinomaki City Municipal Government, 2012

Matthew Gubb
Director, UNEP International Environmental Technology Centre

"Japan has been able quickly to apply technology solutions to the tsunami debris, for example, constructing the country's largest incineration facility and installing waste sorting equipment at an impressive speed."

The debris management effort in Ishinomaki is being handled jointly by the municipality and the Miyagi prefecture. Experts from the federal Ministry of the Environment have also been posted there to provide technical backstopping as needed.

To the credit of local officials, in just 12 months almost all loose debris from the impacted area has been collected and moved to interim storage locations. The material has been segregated into categories such as wood, automobiles, housing appliances, traditional beds (tatami) and building debris. There is a large storage yard containing fresh timber collected from a protection forest which was overrun by the tsunami.

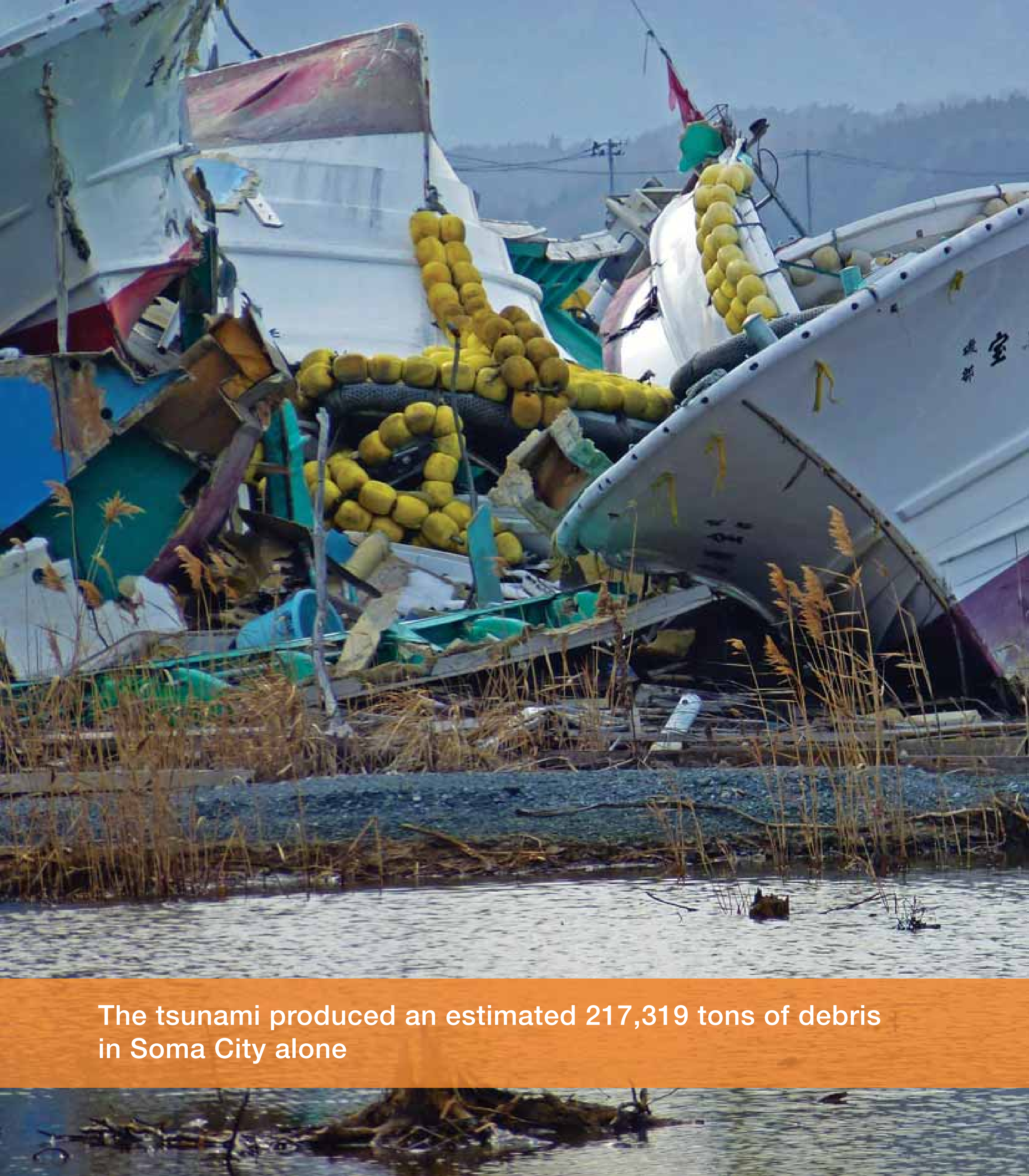
Ishinomaki officials are considering all possible avenues for disaster debris management to overcome the huge challenge posed. The sheer volume of debris remains a significant hurdle for local officials. Spontaneous fires had occurred in some of the mixed waste piles. While passive venting systems have been put in place, fire hazard remains a threat which will become acute in the summer.

An incineration facility, the biggest in Japan (with a processing capacity of 1,500 t/day) consisting of multiple incinerator modules, is being set up and is expected to be operational by August 2012. The municipality has received agreement from the national government to use part of the disaster debris and the incinerator ash for land reclamation within the Ishinomaki port. Once the local paper mill damaged in the earthquake is operating again, it is likely that large quantities of the raw wood will be sent there for use after salt levels in the wood have dropped to acceptable levels.

At the incineration facility visited, there were good health and safety arrangements in place, including fencing, visitor registration, personal protective equipment arrangements for the staff and visitors.

The destruction of coastal forests by the tsunami created piles of timber which are now used for a range of purposes

Fast-paced construction at Ishinomaki



The tsunami produced an estimated 217,319 tons of debris in Soma City alone

Soma City

Soma City is the smallest of the municipalities visited by UNEP's expert team and is primarily a fishing and farming centre. Its population at the time of the disaster was 38,042 people. It is located in the Fukushima prefecture, 134 km south west of the earthquake's epicentre. The first tsunami wave arrived in Soma at 15:53. As of March 2011, there were 458 people confirmed dead.

The municipal government estimates that some 4,141 houses were damaged and that the tsunami produced some 217,319 tons of debris. Other vital statistics about Soma City with reference to the tsunami is presented in Table 8.

As the city is located in Fukushima prefecture, the staff have been working under severe constraints as there has been strong resistance both locally and nationally to the treatment and disposal of debris given concerns over possible radiation contamination. As a consequence, Soma is lagging behind the other cities visited by the UNEP expert mission in terms of progress with establishing facilities for waste treatment and the volume of debris handled. At the time of the expert mission, the segregation of debris was still at an early stage, with the transfer of debris to a storage facility mostly complete.

Table 8. Tsunami-related facts and statistics for Soma City

Parameter	Value
Location	Soma City
Prefecture	Fukushima
Population at the time of the event	38,042
Estimated quantity of tsunami debris	217,319 tons
Number of automobiles damaged	650
Number of storage facilities established	1
Total incineration capacity	None
Waste exported outside	None
Estimated cost of debris management	USD 120 million (¥9.653 million)
Ongoing monitoring	Radiation and asbestos
Health and safety incidents related to debris management	None

Source: Soma City Municipal Government, 2012

Kazuko Uwasu

Programme Assistant, UNEP International Environmental Technology Centre

"As a Japanese national, accompanying the International Expert Mission gave me an opportunity to see first-hand the scale of the challenge. I was proud of the way officials at local municipalities have been handling this challenge, in spite of personal tragedies and shock."

Other than the storage area, the only facility which had been established was a small sorting plant to segregate the mixed debris.

At the storage, sorting and disposal site visited, the expert team observed good health and safety arrangements in place, including fencing, visitor logging, personal protective arrangements for staff and visitors and good traffic management.

Tsunami sediment remains a major issue in Soma. Unlike smaller municipalities in the north of Japan which are primarily fishing-based communities, Soma also had a strong agricultural base. As the area features coastal plains, the tsunami sediments reached more than a kilometre inland, and in some cases inundated farmlands. Due to concerns about radioactive pollution and other contamination, all the sediments are being scraped off the surface of the farmlands. However, at the time of the mission this material did not have a designated end point.

Debris from Miyako is unloaded at the Recycle Peer Company in Tokyo

Tokyo

Recognizing that the debris generated by the Great East Japan Earthquake was on such an enormous scale that the affected municipalities could not deal with it alone, the national government called upon other municipalities for support.

Tokyo is one of the municipalities which agreed to accept disaster debris and has been doing so since November 2011. The waste is being sent from Miyako and received at the Recycle Peer Company which is located in Super Ecotown on the outskirts of Tokyo. (See Map 2). The Recycle Peer Company has an installed capacity of 900 t/day and its primarily focus is on construction debris. Most of the activities in the facility are mechanized.

The debris, which is being received here are containers of mixed combustible waste. The debris is packed into containers, which are initially shipped by road, then by train and finally by road before they arrive at the processing facility. Currently they receive about 100 tons of debris per day. The waste is incinerated and the ash will be used for road construction.

Due to nationwide concern over the possibility that the disaster debris may have been contaminated by the fallout of radiological contamination from Fukushima, substantial precaution is being taken during the waste management supply chain. The container is inspected at the place of origin for its radiation levels and is shipped only if the levels are below the permitted levels.

The level of radiation is once again tested upon arrival at the Recycle Peer Company and is accepted only if the radiation levels are below permitted levels. It must be added that no shipment had to be stopped or rejected due to radiation concerns since the work started.

The government is also taking considerable effort to reassure the public about the safety of the shipments. The radiation readings taken in Miyako before the shipment leaves the city is uploaded onto the website of Tokyo municipality and is available before the shipment arrives. Public meetings were held in the community to explain all of the precautions being taken.

In spite of the above, there is significant public concern and resistance to the idea of waste shipment in Japan. While the UNEP expert team felt that all due diligence precautions were being taken by the government in ensuring that such shipments were safe, the team also felt that shipping the disaster debris hundreds of kilometres by road in small containers may not be the most appropriate method to deal with such debris, environmentally or economically.

In addition, the quantities being shipped are insignificant compared to the scale of the debris remaining at the impacted areas. While there may be strong rationale from a national perspective to facilitate such inter-municipality waste transfer, a more practical, environmentally friendly and cost effective approach may be to augment the disaster debris handling capacity in the coastline.

Map 2. The route for transporting mixed combustible waste from Miyako to Tokyo for final treatment and disposal

An example of the environmental monitoring results displayed publicly outside debris processing centres

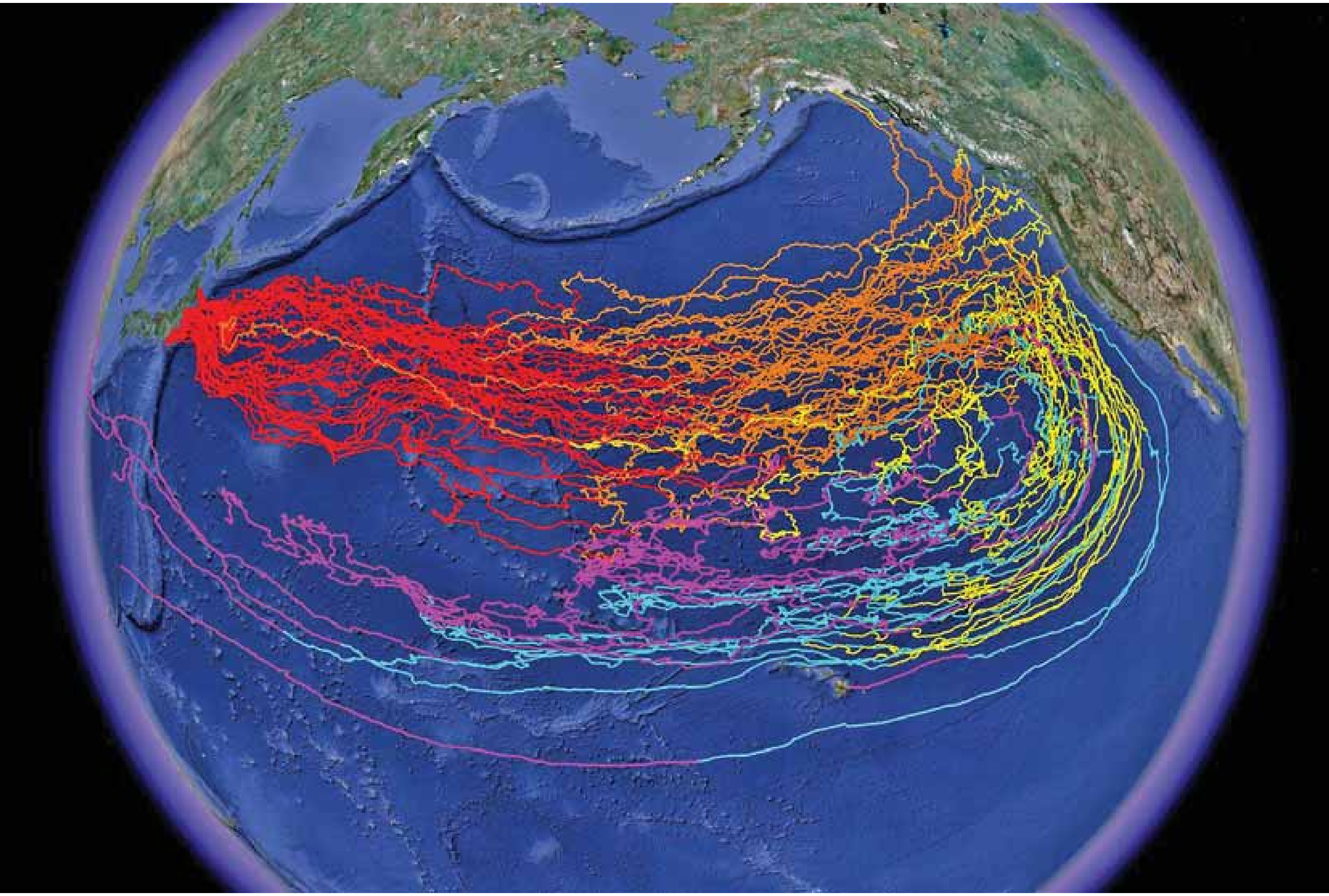


Image courtesy of Google Earth

Year 1 – Red
Year 2 – Orange
Year 3 – Yellow
Year 4 – Blue
Year 5 – Violet

The US National Oceanic and Atmospheric Administration simulation of the possible circulation in the Pacific Ocean of debris generated by the Great East Japan Earthquake

The debris that floated away

Among the most visually stunning and disturbing images of the Japan tsunami were those showing the sheer volume of debris being swept up by returning waves and pulled out to sea. Such was the power of the tsunami that the debris included fishing boats, entire houses and everything in between. Large numbers of cars could also be seen floating in coastal waters. Within days of the tsunami, the patches of disaster debris floating off Japan's coast were so large they were visible on satellite images.

Much of the heavy debris, such as automobiles, would have sunk to the seabed off the coast in the immediate aftermath of the disaster. Staff at a number of the municipalities visited during the UNEP mission mentioned they were aware of the presence of sunken debris along the coastline and at their ports. Many municipalities plan to recover at least the debris which ended up within their port facilities or which is considered likely to interfere with shipping or fisheries. Limited dredging has already been undertaken in Ofunato.

Professor Olof Linden
World Maritime University

"While it may still be possible to distinguish some of the floating debris from the tsunami event, unfortunately it's an almost insignificant addition to an already huge volume of floating garbage which has accumulated in the North Pacific gyre. So we should not focus on the tsunami debris itself, but use this as an opportunity to raise awareness about marine litter in general."

The masses of floating debris have since spread to a much larger area, aided by wind and currents. There are numerous mathematical ocean current-based models which predict that these patches of marine debris will eventually be washed over onto the west coast of North America and also onto South Pacific islands. It is already known that the debris is no longer moving in single or multiple spectacular patches and is unlikely to arrive on any coastline in a sudden and dramatic fashion.

Both the US Environmental Protection Agency and US National Oceanic and Atmospheric Administration (NOAA) have been proactively looking for any signs of the debris arriving on US shores, as have the Canadian authorities. The US authorities have also committed to collect and return to Japan any debris which is clearly identifiable as being of Japanese origin and that may have sentimental value. As of early May 2012, debris suspected to be from the tsunami had washed up on the coastline of Alaska and Washington state, among other areas, and was being documented.

Marine debris has been an environmental issue at the forefront of international concern for some time. In the 1980's research showed that floating garbage was accumulating in ocean gyres, i.e. the large circular currents that are formed in all oceans as a result of the large-scale circulation patterns due to the rotation of the planet, and dominating winds.

In the centre of such gyres, the accumulation of floating plastic material, wood and glass may more or less cover several thousand square kilometres. Such floating debris can cause both physical entanglement of sea animals and the accumulation of plastic micro-particles in plankton. Another effect is the impacts on certain seabirds such as albatrosses that feed on surface floating organisms such as squid and shrimps. The birds cannot


Tons of debris have been recovered from coastal waters in the Tohoku region

distinguish between the feed and floating plastic debris of similar size. As a consequence the parent albatrosses feed their chicks with an increasing portion of plastic material, with serious impacts on the populations of these birds. The arrival of unknown but large quantities of debris from the tsunami has compounded the problem.

In mid 2012, Pangaea Explorations, the Algalita Marine Research Foundation and the 5 Gyres Institute – organizations that specialize in research into plastic accumulation in the oceans – are due to conduct several expeditions in the Pacific looking for debris from the Japan tsunami.

While there is very little which can now be done to prevent the debris from accumulating at sea or washing up wherever the currents are going to take it, the media and public interest in the fate of floating tsunami debris could be used to raise awareness internationally of the growing challenge of marine debris.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This unmanned Japanese fishing vessel, Ryo-un Maru, drifted into the Gulf of Alaska in April 2012

In some instances, vehicles were stacked without having fuel and oil removed, creating potential safety and environmental hazards

Learning points for Japan

Having visited some of the impacted sites, the UNEP expert group was impressed with the speed at which the national and regional authorities had initiated the post-disaster clean-up effort and with the progress achieved in 12 months.

The Expert Mission team felt that while significant effort and resources had been invested by the Japanese authorities in dealing with this challenge, there was scope for further improvement. A strategic stocktaking of the ongoing post-disaster debris management operations would help the government to align this work with its reconstruction plans, as well as potentially save resources and ensure overall environmental benefits.

The following section outlines some of the key areas which should be considered during such an exercise.

1. **Waste volume estimations:** Estimating the volume of disaster debris is an important technical challenge facing any authority in the wake of a disaster. In order to scope the damage and calibrate the response, it is important that a reasonable estimate of the disaster debris is available to decision makers as quickly as possible. Debris estimates for disasters are rarely computed from ground measurements as that would be time consuming and potentially logistically challenging. Instead, estimates are generally made using satellite imagery or aerial photographs. However, in case of tsunamis, this approach is complicated by two factors:

    a. An unknown quantity of the debris is washed out to sea and currently there is no realistic way to factor this into calculations of total debris volume; and

    b. An unknown quantity of soil gets deposited onto the land after tsunami and without some ground-truthing (on-the-ground investigations by experts) this cannot be accurately estimated.

    As the overall debris management will be a multi-billion dollar operation, it is therefore appropriate that a re-estimation of the debris volume is undertaken. As most of the debris has now been collected and stored in controlled areas, such an estimation would be practically simple and could be undertaken quite quickly.

2. **Waste transport:** It is best to keep the amount of transporting of disaster debris and number of times the debris is handled to a minimum.

3. **Land reclamation and landfilling:** Land reclamation and landfilling are waste management options which have the potential to rapidly reduce the total volume of debris to be handled. When planned and implemented efficiently, this can be done in an environmentally acceptable and cost effective manner. Giving more flexibility to the local municipalities to use these options would potentially lower the cost and speed-up the reduction of waste volume.

4. **Handling tsunami sediments:** As the seawater receded after the tsunami, it deposited a large quantity of soil on the land. Despite having many such depositions in the past which have not deterred long term land use, Japanese municipalities are scrapping the soil deposited by the tsunami without a plan for its final disposal. The decision to recover, move and dispose of the deposited soil should be based on an analysis of the physical and chemical properties of the sediments and an analysis of how the residual soil may adversely impact the future land use.

5. **Management of hazardous materials:** The tsunami did not generate large quantities of hazardous materials mainly because most of the impacted areas were fishing towns or agricultural hubs. The main contributors to hazardous debris across most or all of the impacted cities were fire extinguishers, transformers and pesticides. The fear regarding radiation contamination has prevented this debris

UNEP hopes to use data from the mission to develop an international protocol for estimating the volume of debris in post-disaster settings from being sent to the national hazardous waste management centres. As it would not make economic or practical sense for each municipality to establish its own hazardous waste management centre, an appropriate solution would be for the impacted municipalities along the coast to collaborate and set up a single, shared Integrated Hazardous Waste Management area for the treatment and safe disposal of tsunami-related hazardous waste.

6. **Environmental monitoring:** While some type of monitoring was ongoing at all locations visited by the mission team, it was not consistent. Some parameters (e.g. radiation) are monitored by the respective contractors at each site, while other parameters (e.g. asbestos) are being monitored by the government agencies off-site. It would be more appropriate to have a consistent approach to monitoring, specifying the parameters to be monitored, the protocols to be used, the frequency and external reporting requirements. More credibility and consistency could be obtained if the monitoring was undertaken by the federal government agency responsible for environmental oversight (and not the contractor or contract managing department), preferably with the support of research institutes.

7. **Support to municipalities:** While the national government is underwriting the financial cost of tsunami waste treatment, the size of the debris management operation being undertaken in all of the municipalities is far beyond what is normally the task of municipal-level environment divisions. The local municipalities would benefit from a substantially increase in technical assistance, monitoring support and help with managing large-scale contracting.

8. **Local employment generation:** While in-principle there is guidance to promote local employment this is not being systematically followed through. Partly due to the strict deadline given to municipalities to complete the post-disaster clean-up, there is a high degree of mechanization in the debris handling. If local employment generation is deemed a priority, there is a lot more opportunity for process optimization to maximize employment opportunities.

9. **Process optimization:** The existing debris management centres could be seen as a huge industrial activity involving sequential steps with the risk that a bottleneck at one stage in the process would limit the overall progress. There is scope for reviewing the process pipeline at existing centres and any new centres, to optimize the throughput by avoiding bottlenecks in the interim steps in the process.

The incinerator in Sendai was designed, built and commissioned in six months

Sharing the lessons in managing post-disaster debris

The approaches to managing the post-disaster debris in Japan hold many lessons for similar situations elsewhere in the world. While differences in economic circumstances, land availability and the sophistication of technology mean that not all lessons are easily transportable elsewhere, the expert mission team concluded that many positive learning points could be employed in other countries on a case-by-case basis.

The UNEP expert team concluded that the support from the central government to fully underwrite the costs associated with the disaster debris management has been the core success factor behind Japan's disaster debris management operation. Further lessons from the Japan experience which can help inform disaster preparedness and post-disaster response efforts for the management of debris are as follows.

- **The importance of being prepared:** Japan has decades of experience in planning for, and responding to, disasters. The major municipalities have documented plans for disaster debris. This is extremely beneficial as allows the government authorities to move swiftly into "emergency mode" after a disaster. Vulnerable countries should prepare a disaster debris management plan as an essential part of their national or regional contingency planning.
- **Swiftness of response:** Japan's Ministry of the Environment came with a clear guideline for the local municipalities on how to deal with the disaster debris. This included a guidance note on segregation, storage and treatment. This enabled the municipalities to have a consistent framework to deal with the debris. Individual municipalities trying to figure out a sorting strategy would have created different waste streams in different municipalities making any final consolidation difficult.
- **Technical backstopping:** Dealing with disaster debris is a specialized technical task, something which local municipalities, at least the smaller ones, generally lack the technical capability to implement. Thus providing them only with a guidance note would have been inadequate. The decision by the Ministry of the Environment to deploy staff from the national government to the prefecture and local level was a welcome initiative which provided technical backstopping to the local experts.
- **Central financial support:** The disaster produced such vast quantities of debris that the local municipalities would never have been able to handle the clean-up burden on their own, even during a normal period. However, the disaster debris had to be handled at a time when their revenue dropped sharply due to the destruction of economic activity and the relocation of local populations. The national government's decision to fully underwrite the costs associated with the disaster debris management has been the core factor behind the success of the disaster debris management operation in Japan.

Ronnie Crossland

Environmental Protection Agency, USA

"There has been a tremendous effort to remove almost all of the loose debris from the field and place it in debris management areas. In order to ensure that the progress continues expeditiously, the response will need to minimize the number of times debris is handled prior to recycling or disposal."

Members of the UNEP expert mission team meet Japan's Minister for Foreign Affairs, Koichiro Gemba

- **Collective contracting:** The scope and scale of contracts needed for disaster debris management was also far beyond the capability of the local municipalities. The prefecture governments assisted the local municipalities by entering into area-based contracting with major Japanese contractors which brought in the required scale of resources and equipment relatively quickly. Local interests were taken care of by joint venture arrangements.

- **Health and safety practices:** No concessions were permitted when dealing with health and safety considerations on-site in the affected areas, even during the emergency phase. Good health and safety practices were being followed at the sites, which should ensure that there are minimal or no secondary impacts on the staff involved in disaster debris management.

- **Use of local resources:** Efforts to maximize the use of local companies to deal with disaster debris either, was done when appropriate. This ensures that more resources are pumped into the local economy while also promoting local ownership and aiding the emotional recovery of survivors who get to contribute and feel part of the clean-up effort. This is yet another practice which should be integrated into disaster debris management contingency plans.

Acronyms and abbreviations

CCA	copper chrome arsenate
cm	centimetres
g	acceleration due to gravity
GIS	Geographic information system
IETC	International Environmental Technology Centre
km	kilometres
m	metres
Mw	moment magnitude
NOAA	National Oceanic and Atmospheric Administration
PCB	polychlorinated biphenyls
t/day	tons per day
UNEP	United Nations Environment Programme

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Tokyo Metropolitan Government
Sendai Television Broadcasting Enterprise Corporation
Japan International Cooperation Centre
Japan National Press Club
United Nations Information Centre, Tokyo
National Oceanic and Atmospheric Administration, USA
International Recovery Platform

About UNEP's International Environmental Technology Centre

The International Environmental Technology Centre (IETC) is a branch of the United Nations Environment Programme (UNEP) within its Division of Technology, Industry and Economics. Based in Osaka, Japan, its main function is to promote the application of environmentally sound technologies in developing countries and countries with economies in transition.

UNEP IETC currently focuses on identifying and showcasing environmentally sound technologies and management practices in waste management. It offers a range of activities including technical assistance, demonstration and pilot projects, capacity building and advisory services.

In 2005, UNEP IETC developed a fully-fledged portfolio on waste management, which initially comprised two focus areas: resource augmentation by utilizing waste and integrated solid waste management. This has since been expanded to address specific waste streams such as waste electrical and electronic wquipment, or 'e-waste', waste agricultural biomass, health care waste, waste oils, waste plastics and disaster debris. UNEP IETC serves as secretariat for the Global Partnership on Waste Management. For more information, please visit: **www.unep.org/ietc**

About UNEP's Disasters and Conflicts Sub-programme

From Afghanistan to Lebanon, Sudan and China, UNEP has responded to crisis situations in more than 40 countries since 1999. As the international community has shifted its focus from post-crisis intervention to crisis prevention, UNEP has expanded its operational range, adding disaster risk reduction and environmental cooperation to its core services of environmental assessment and recovery.

"Disasters and Conflicts" is one of the organization's six priority areas of work. The Disasters and Conflicts Sub-programme comprises of four operational pillars: post-crisis environmental assessment, post-crisis environmental recovery, disaster risk reduction and environmental cooperation for peacebuilding. The Post-Conflict and Disaster Management Branch (PCDMB) is tasked with coordinating the theme across UNEP.

More information may be obtained from: **www.unep.org/disastersandconflicts** or by email: **postconflict@unep.org**

www.unep.org

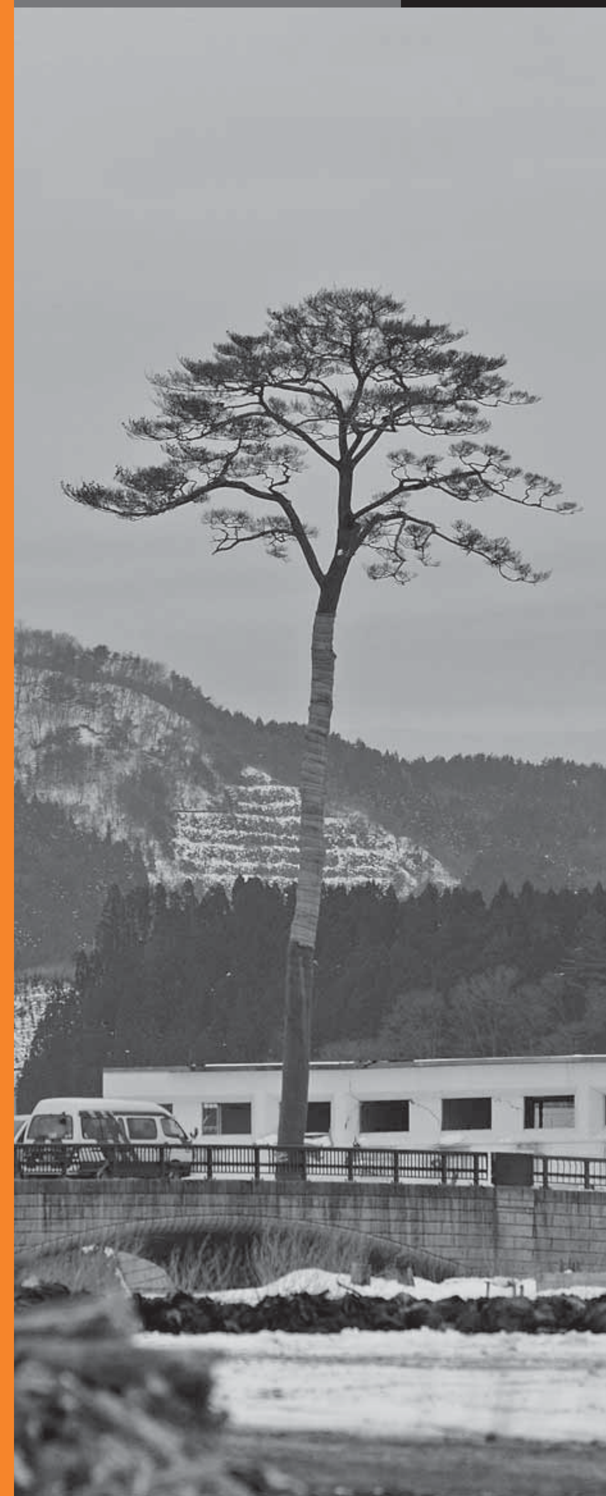
United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel: +254 (0)20 762 1234
Fax: +254 (0)20 762 3927
Email: uneppub@unep.org

UNEP

In March 2011, a massive earthquake off the north-east coast of Japan triggered a tsunami that created an unprecedented volume of debris.

The debris management operation which is currently ongoing along the Tohoku coast is the largest of its kind in the world.

In order to share international experiences in disaster debris management and to document the lessons from the Japanese experience, a UNEP international expert team visited the Tohoku area in early 2012.



United Nations Environment Programme
Post-Conflict and Disaster Management Branch
International Environment House
15 chemin des Anémones
CH-1219 Châtelaine, Geneva
Switzerland
Tel.: +41 (0)22 917 8530
Fax: +41 (0)22 917 8064
E-mail: postconflict@unep.org

www.unep.org/ietc
www.unep.org/disastersandconflicts