An Overview of Research on Disaster Environment and Associated Outcomes following the Great East Japan Earthquake

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National Institute for Environmental Studies

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Foreword

The National Institute for Environmental Studies (NIES) is a leading institute implementing comprehensive environmental research across a wide range of fields, and is actively engaged in the dissemination of information aimed at facilitating the nation's understanding of the issues associated with disaster environment. Our scientific expertise has been reflected in policymaking for recovery and environmental creation from the Great East Japan Earthquake.

This booklet "An Overview of Research on Disaster Environment and associated Outcomes following the Great East Japan Earthquake, National Institute for Environmental Studies" summarizes the major initiatives and associated research outcomes aimed at the solution of the issues associated with disaster environment which have been newly undertaken at our institute since the direct aftermath of the disaster.

In addition to: ① Initial emergency response ② Initiatives for disaster recovery ③ Initiatives to understand actual environmental circumstances and impact assessment, and ④ Initiatives for the creation of a safe and secure society - we will also introduce forthcoming medium- to long-term initiatives.

2. Initiatives in the aftermath of the Great East Japan Earthquake

(1) Initial emergency disaster response (post-disaster to beginning of summer FY2011)

After having judged that we must contribute to the recovery and restoration of the devastated disaster zone, the Disaster Recovery and Restoration Headquarters was established on March 29 (Head: NIES President) and an immediate policy on the three pillars of: ① Measures for disaster waste ② Regional collaboration, and ③ Timely and appropriate information provision – was adopted.

While making use of our accumulated know-how in environmental research and a network unique to NIES, we rallied the expertise available at our institute in order to actively support the disaster zone on research fronts.

(2) Initial initiatives for research on radioactive materials and disaster environment (beginning of summer to end of FY2011)

The radioactive substances which spread within and beyond Fukushima Prefecture became a large social issue. In order to exercise our collective powers as an institute and advance in an integrated manner while responding with research relating to the disaster and radiation, we established the "Radioactive Substances and Disaster Environment Research Team" led by the Head of the Disaster Recovery and Restoration Headquarters (NIES President). We created a structure to further institute-wide initiatives with the "Waste and Related Group" and the "Research Group for Multimedia

Dynamics and Radioactive Materials" as the two keystones.

In addition, we made public "An Overview of Research on Disaster Environment" in April 2012 - which schematized and visually depicted the entire scope of research on disaster environment as well as the topics which should be clarified and resolved in respective fields.

(3) Formalization of research on radioactive substances and disaster environment (from FY2012)

The outcomes of "Research on Radioactive Materials and Disaster Environment", started under the third supplementary budget in FY2011 were regularly provided to and utilized by the Ministry of the Environment's "Disaster Waste Safety Evaluation Committee" and "Environmental Restoration Committee". We also endeavored to disseminate information to the public and held the "Recovery and Restoration Workshop" in Fukushima City and a public symposium with the theme of "Large Scale Disasters and Environmental Restoration – the frontline of environmental research in the face of disasters" in Kyoto and Tokyo.

Under the "Basic Policy for the Restoration and Renewal of Fukushima", approved by the cabinet in July 2012, the initiatives of NIES for waste research and environmental dynamics research, were specified. The Fukushima Prefecture Environmental Creation Center (provisional name), to be administered with the support of the Japanese government, was also positioned as a core research and development hub. In order to create a livable environment in which recovery is possible and stabilize a polluted environment, a sustainable research framework must be created.

3. Initiatives for disaster waste and radioactively contaminated waste

The Great East Japan Earthquake produced large volumes of disaster waste in every area of the disaster zone. Moreover the waste and soil, etc. contaminated with radioactive substances released from the accident at the TEPCO Fukushima Daiichi Nuclear Power Plant accident were spread over wide areas and in large volumes.

On the basis of our accumulated expertise, experience and network in the field of material cycles and waste management research, we advanced research relating to the treatment and disposal of this disaster waste and radioactively contaminated waste in a timely and appropriate manner. Below is an overview of the outcomes of this research.

(1) Initiatives for the treatment and disposal of disaster waste

1) Collation of information and know-how via the Disaster Response Network and conveyance to the disaster zone (see 2.2.2)

1) We set up the Disaster Response Network just after the Great East Japan Earthquake and drafted technical reports for many kinds of problems that came up in disaster areas. These activities significantly contributioned to on-site handling procedures for disaster and residential waste. The outcomes of these studies and activities were reflected in the various directives and guidelines issued by the Ministry of the Environment (see 2.2.2).

2) We conducted field studies and offered guidance based on emergent researches on issues such as ensuring the safe incineration of seawater-covered waste wood; establishing the chemical properties of tsunami debris; and procedures for the prevention of fires in temporary disposal sites. These outcomes were reflected in directives and guidelines issued by the Ministry of the Environment (see 2.2.3).

(2) Initiatives for the treatment and disposal of waste contaminated with radioactive substances

1) There is a considerable divergence in the elution characteristics for radioactive cesium depending on the type of waste. We clarified that this is due to the differences in the chemical form of the radioactive cesium. Moreover, we also clarified that there is a considerable divergence in the sorption characteristics for radioactive cesium in leachate from incineration ash depending on the type of soil for landfill (see 3.2.1).

2) In regards to the temporary storage of putrefactive waste including vegetation, it is necessary to have fire prevention apparatus for accumulated piles, installation areas, and limits on clearance. Furthermore, we established the conditions for ash washing conditions in which over 90 % of radioactive cesium is eliminated in fly ash. The ash washing technology can reduce the elution and activity of radioactive cesium in highly contaminated fly ash (3.2.2).

3) Through studies on the circumstances in existing incineration facilities, we clarified that in high temperature incinerators, etc. due to the accumulation of radioactive cesium in heat resistant materials, there was variance between areas where air dose rates were high and areas where adhesion ash had high concentrations of cesium, and that this was a result of radioactive cesium accumulating by osmosis in heat resistant materials. Moreover, we also clarified that there is a divergence in peak activity and peak time of radioactive cesium in leachate from landfilled waste depending on the leachibility and the amount of rain water penetrating landfilled waste. To maintain the waterproofing of landfilled waste, impermeable soil layers must be in place above and on all sides of the landfilled waste (see 3.2.3).

4) In association with other related institutes we drafted and made public at an early stage a provisional manual on surveying and measuring radiation in waste, etc. This was used as the basis for national guidelines. Furthermore, we verified the countermeasures against technical issues in the sampling method for waste gas from incineration facilities and the representativeness of incineration ash samples (3.2.4).

5) Using the data from general waste incineration facilities in all towns and prefectures of Eastern Japan, it was confirmed that there were seasonal variations accompanied by attenuation such that the concentration of radioactive cesium in incinerator ash, etc. rose in early summer and autumn.
For the transfer rate to incinerated waste for radioactive cesium volumes deposited in all regions, we clarified that this was less than 1% in incineration facilities for general waste, and that there was a

tendency for high transfer rates for incinerated waste for areas of high population density (3.3.5).

4. Understanding actual environmental circumstances and impact assessment

In order to combat the environmental contamination from radioactive substances released following the accident at the nuclear power plant which accompanied the Tohoku Region Pacific Coast Earthquake, we established the actual circumstances of radioactive materials in the environment in the direct aftermath of the accident, and clarified the dynamics of those substances. Moreover, we implemented research with the aim of predicting forthcoming trends. The following are the major research outcomes which were obtained.

1) We clarified the nuclide composition and particle size distribution by measuring radionuclides in the atmosphere in the direct aftermath of the accident (see 4.2.1).

2) The behavior of radioactive substances for Mt. Tsukuba and Kasumigaura was measured, beginning in the direct aftermath of the accident, and we achieved a grasp of the accumulation, cycles and movement of radioactive substances in forests, marshlands, and waterways - contributing to measures being considered for forest contamination (see 4.2.2).

3) Using an atmospheric simulation model, we were able to more speedily clarify the distribution of deposition from the diffusion of radioactive substances in the atmosphere and on the land surface. This was made public and contributed to the decision-making process (see 4.2.3).

4) We constructed a wide area environmental dynamics model for radioactive substances and began environmental simulations including future projections (see 4.2.4, 4.2.5).

5) We measured exposure rates for the various exposure routes for households and established the aggregate human radiation exposure rate (see 4.2.6, 4.2.7).

5. Creation of a safe and secure society

In the process of regional recovery and restoration after the Great East Japan Earthquake, rapid progress is being made towards the provision of primary lifelines and recovery for households. At the Center for Social and Environmental Systems Research, we applied an eco-city assessment system using a Geographic Information System (GIS) - developed as part of research on eco-cities - to cities in the disaster zone. We also formulated a collaboration framework, including the signing of an agreement with the designated future eco-city Shinchimachi (March 13, 2013).

At the same time, in the light of the review of energy supply and demand after the nuclear power plant accident, and reform in climate change policy, we began a further review of such issues as national energy supply and demand and scenarios for low carbon society. Below is an overview of the

results obtained.

1) We formulated a forecasting system using geographical information in order to contribute to post-disaster town planning for recovery in the field of regional energy systems (see 5.2.1).

2) We conducted a case study with nine coastal towns in northern Fukushima Prefecture and southern Miyagi Prefecture as target. As a result of comparing the public supply and demand and energy reserves, we established that it would be possible to regenerate these towns in an effective manner using the ample existing resources alongside renewable energy (see 5.2.1).

3) In regards to energy and climate change policy in the wake of the disaster and the accident at the nuclear power plant, we established the impact on GDP, household consumption expenditure, and GHG emissions, etc. for the share of nuclear power plants in the short to mid-term as a result of a review of the integrated assessment model (see 5.2.2).

6. Impact evaluation for tsunami and earthquake on the environment, human health, and ecosystems

The tsunami which followed the Great East Japan Earthquake caused the dispersal of seabed sediment containing chemical pollutants throughout the disaster zone. In addition, the disaster caused topographical changes, and modified the living environments of the area's inhabitants as well as natural coastal habitats. NIES investigated and evaluated the influence of the various environmental changes caused by the disaster on the environment, human health, and ecosystems. The following are the major research outcomes of this research.

1) Since the direct aftermath of the disaster we have continuously investigated and monitored the impact on the atmosphere and on aquatic environments of seabed sediment conveyed by the tsunami to the disaster zone. We have disseminated the outcomes of these investigations and monitoring activities to the public (see 2.3.1).

2) Coastal vegetation in the Sanriku Region underwent extensive disturbances from the tsunami with variations in the degree of such disturbances among those habitats with and without flood walls. The tsunami also casued modifications to the macrozoobenthic community and to sediment environments in a brackish lagoon facing Sendai Bay. We have recognized the necessity to continuously monitor the recovery process of coastal ecosystems (see 2.3.2).

3) The devastating tsunami of March 11, 2011 destroyed several petroleum tanks in the Tohoku coastal area of the Pacific Ocean. Vast volumes of of fuel oils and polycyclic hydrocarbons (PAHs) generated

by fires which followed the tsunami became thoroughly mixed with the enormous amounts of eroded sediment produced by the tsunami, and these settled on the seabed in coastal areas. As a consequence, sediments became heavily contaminated with various hydrocarbons in certain bays. We have monitored contamination in sediments by hydrocarbons in selected bays in the Tohoku coastal area and recognize the necessity for long-term monitoring of sediment-contamination status (see 2.3.3).

7. Forthcoming initiatives in the mid- to long-term

(1) Initiatives for disaster waste and waste contaminated with radioactive substances

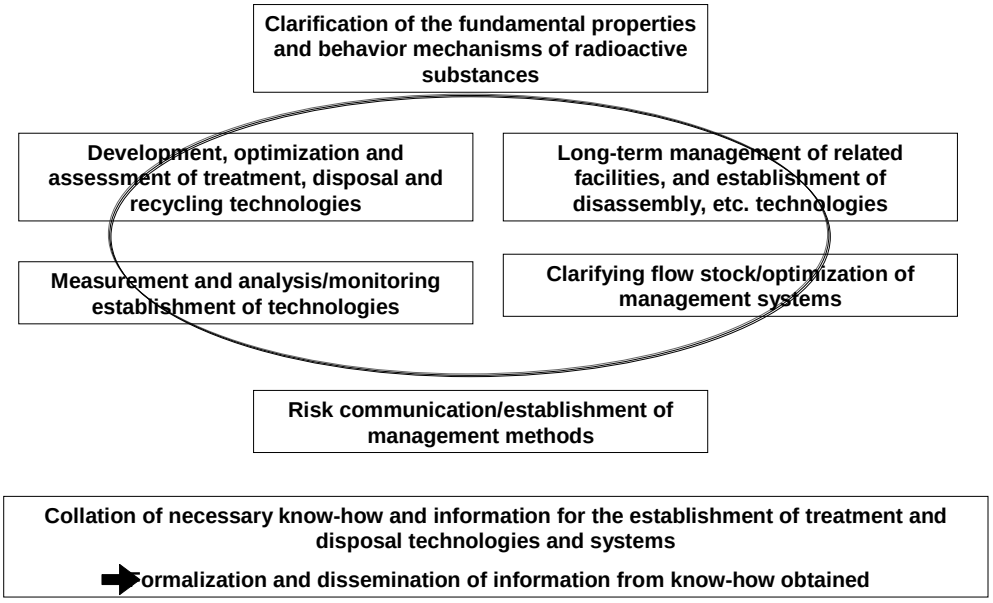

Fig. 1: Initiatives for disaster waste and waste contaminated with radioactive substances

With the research framework as shown in the above figure as the foundation, we intensified research relating to disaster waste and waste contaminated with radioactive substances from a mid to long-term viewpoint. Along with feedback to strengthen the future academic base for ongoing and forthcoming research, we are also engaged in efforts to formulate the academic framework in relation to disasters and the environment.

(2) Initiatives to understand actual environmental circumstances and impact assessment – future projections on the movement of radioactive substances and impacts on organisms

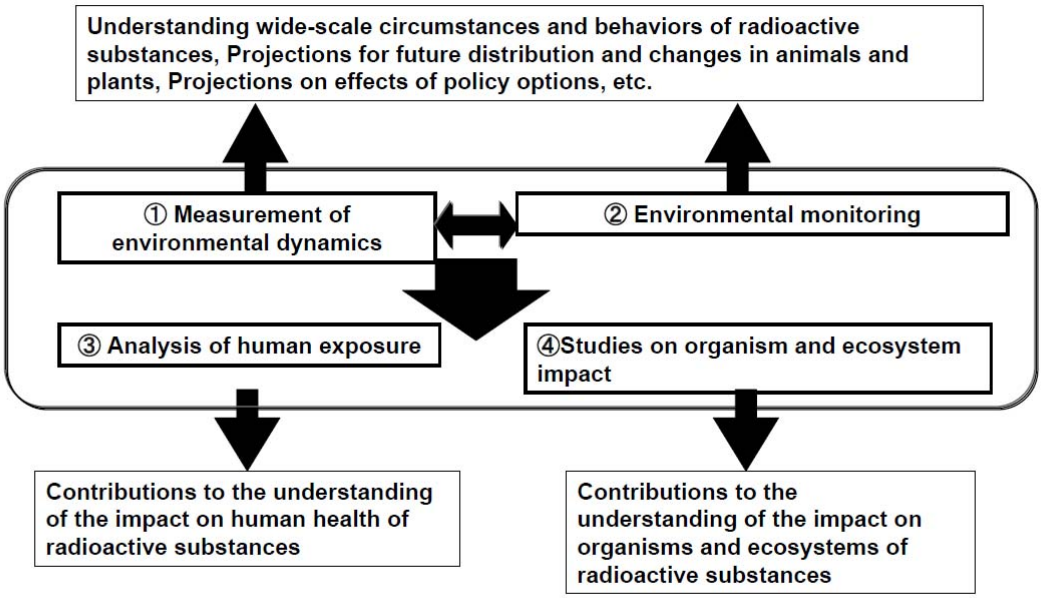

Fig.2 Research overview of "Dynamics of radioactive substances in the environment and impact assessment"

As shown in the figure above, we have implemented integrated studies on: ① Measurement of environmental dynamics ② Environmental modeling ③ Human exposure assays ④ Impact assessment for organisms and ecosystems - and collated and disseminated basic scientific know-how and information to restore a safe and secure habitable environment for contaminated regions.

(3) Initiatives for the creation of a safe and secure society – formation of a sustainable society by means of the integration of the broad fields of environmental science.

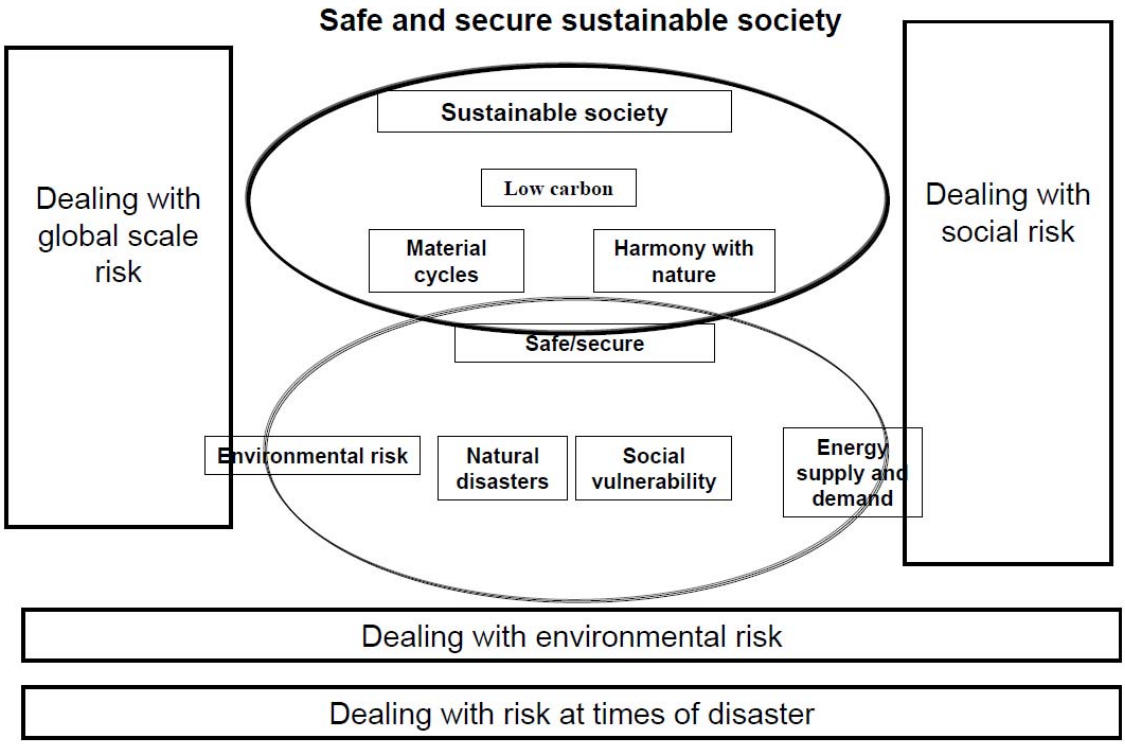

Fig. 3 Safe and secure sustainable society

It is necessary to consider environmental issues on a global scale and in broad fields including natural disasters, industry and public lifestyles from an environmental perspective in order to create a safe and secure society. We are pursuing initiatives for the formation of a safe and secure sustainable society to respond to those aspects which must be considered from the perspectives of safety and security risk for global scale risk, societal risk, environmental risk and risk from disasters.

8. Future developments in research on disaster environment

(1) Maintaining and progressing the course and orientation of "An Overview of Research on Disaster Environment"

"An Overview of Research on Disaster Environment" was based on the experiences of NIES in its initial activities in the direct aftermath of the Great East Japan Earthquake, and the accumulated know-how from research initiatives undertaken over the first year of research on disaster environment, including those relating to environmental contamination from radioactive substances. We have lost none of our spirit of innovation and rationality in terms of the content outlined in this booklet.

Based on the practical and in-the-field experiences from that time, the six issues therein collated and conveyed as future lessons/precepts "Towards the development and continuity of Research on Disaster Environment", we will continue to endeavor to apply these as an institute in our governance and research activities.

(2) Dissemination of research outcomes accompanying research development, and framework development for contributions to environmental policy

The theme of restoration of the disaster zone in the wake of the Great East Japan Earthquake is pressing and urgent for Japan as a whole. We contributed to environmental policy by means of timely provision of the outcomes of research on disaster environment including those relating to the treatment of rubble and the environmental dynamics of radioactive substances as soon as these became available.

Moreover, we have summarized the outcomes and topics at critical junctures such as the institute's open days and at symposiums, with a view to disseminating our research outcomes and information on our activities.

With the further progress of research, in order that these new outcomes help to bring to fruition the restoration of the disaster zone and environmental creation, we will strive to develop a framework to make a reality of the contribution of research on disaster environment to environmental policy, and disseminate these research outcomes to an expanded audience.

(2) Consolidation of the framework for development of research on disaster environment

Two years have passed since the Great East Japan Earthquake, and we have now come to a period of transition where research on disaster environment – which was initiated as part of an emergency response - is becoming sustainably stable.

For this reason, we must clarify the position of disaster environment among the other research at our institute in the mid-term objectives, our five-year year plan and operations grant, which are the systematic backbone for the research undertaken at NIES. We believe that it will be on this basis that we must position ourselves for progress.

Moreover, activities at the Fukushima Prefecture Environmental Creation Center (provisional name) - preparations for the establishment of which are ongoing - and the NIES laboratory in Minamisouma, Fukushima Prefecture, should be closely linked with studies, research and provision of environmental information being carried out at our main base in Tsukuba, and we would like to thereby position ourselves to exert the collective power of research on disaster environment in an integral manner and to its full potential.

9. Message from NIES

This booklet has provided an overview of research on disaster environment developed at NIES and its prospects. However, the studies, research and technical development spurred by the Great East Japan Earthquake are being diligently advanced by many actors and agencies including national and local government, universities, industry, and NGOs.

NIES expects that the wide fields of research organized in "An Overview of Research on Disaster Environment" will not only be implemented by our institute but that progress will also be dependant on these various actors and agencies and we as such hope to pursue such ties with them.

With this booklet as the first step in the summarization of the particular research outcomes, etc.

of NIES, in view of directives relating to our mid-term objectives we have received from the Minister of the Environment - that NIES should be the core institution for environmental research - we will, for example, create opportunities to schematize and introduce the initiatives and research outcomes of these various actors and agencies. We wish thus to work so that the outcomes of research on disaster environment are used to hasten recovery, restoration and environmental creation.

We greatly look forward to the outcomes not only of the research on disaster environment at NIES but also the wide variety of initiatives being forwarded by these various actors and agencies.