Research Activities of the Nuclear Safety Research Group of KURRI with Belarussian, Russian and Ukrainian Colleagues about the Chernobyl Accident

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The 12th anniversary is coming soon since the Chernobyl accident on April 26, 1986, the worst accident in the history of the commercial use of nuclear energy. In Japan we say ″JUNEN HITO-MUKASHI″. It means that a period of ten years is one era. Literally, there happened a series of historical events during these 12 years which brought drastic changes in the world. The USSR, which had to take the primary responsibility for the Chernobyl accident, disappeared at the end of 1991. ″JUNEN HITO-MUKASHI″ also means that we tend to forget events in the past. The concern of the world to Chernobyl seems to become gradually diminishing as time goes on. However, a vast amount of contaminated territories remains and will remain regardless of the main events in the world (Table 1).

The sufferers by the Chernobyl accident are categorized into the followings:

- ✧ Staffs of the Chernobyl NPP and firemen directly involved in the accident: 1,000 - 2,000 persons
- ✧ Liquidators who worked for elimination of the consequences of the accident (including soldiers and workers for construction of so-called Sarcophagus, the containment of the destroyed reactor): 600,000 - 800,000 persons
- ✧ Evacuees from the 30-km zone during the first weeks after the accident: 135,000 persons
- ✧ People resettled from the contaminated areas: more than 115,000 persons
- ✧ Residents in the contaminated areas: over 6 million persons (Table 2)

In April 1996, at the time of the 10th anniversary of the Chernobyl accident, an international conference was held in Vienna by IAEA together with EC and WHO [6]. One of main purposes of the conference was announced to distinguish ′myths′ and ′speculations′ from scientific facts about the consequences of the Chernobyl accident. Conclusions of the conference can be summarized as follows.

<The only long-term health effect that could be observed so far due to the Chernobyl accident was the increase of thyroid cancer among inhabitants around Chernobyl. Other health effects were difficult to be observed even with following-up investigations of wide-scale. Reports indicating health deterioration of Chernobyl sufferers were made by scientists in the

Table 1. Areas contaminated with ^{137}Cs in three affected countries, km^2 [1].

	Level of ^{137}Cs density (Ci/km^2)				
	1 - 5	5 - 15	15 - 40	>40	>1 total
Russia	48,800	5,720	2,100	300	56,920
Belarus	29,900	10,200	4,200	2,200	46,500
Ukraine	37,200	3,200	900	600	41,900
Total	115,900	19,120	7,200	3,100	145,320

- According to Chernobyl laws in these countries, the contaminated territories are divided into the following categories depending on ^{137}Cs density: higher than 40 Ci/km^2 - zone of alienation, 15-40 Ci/km^2 - zone of obligatory resettlement, 5-15 Ci/km^2 - zone of guaranteed voluntary resettlement, 1-5 Ci/km^2 - zone of radiation control.

Table 2. Number of people living in the contaminated territory, thousands of persons.

Country (year of data)	Level of ^{137}Cs density (Ci/km^2)				
	1 - 5	5 - 15	15 - 40	>40	>1 total
Russia(1991.1.1) [2]	1,883	347	93	-	2,323
Belarus(1995) [3]	1,485	314	41	0.283	1,840
Ukraine(1995.1.1) [4]	1,732	653	19	-	2,404
Total	5,100	1,314	153	0.283	6,567

- According to the GOSPLAN report in 1990 [5], the numbers of residents in the area of 15-40 Ci/km^2 and over 40 Ci/km^2 were 234 thousands and 33.8 thousands, respectively. So, 115 thousands were at least resettled since 1990.

affected countries, but they were not reliable from the scientific point of view.>

We can interpret the above conclusion as follows: the health effects of the Chernobyl accident were very small except thyroid cancer, mortality of which is relatively low, although the Chernobyl accident was the worst one. The fact in 1991 at the conference of International Chernobyl Project by IAEA [7], however, should be remembered that experts of IAEA neglected protests of Belarussian and Ukrainian scientists insisting serious increase of child thyroid diseases around Chernobyl against the conclusion of the International Chernobyl Project that there was no health effect there. Five years later the same experts of IAEA had to recognize ′myth′ of thyroid diseases to be facts.

In this report of our international collaborative project, we have included reports and information that the experts of IAEA would see as ′myths′ or ′speculations′. The present author believes that there are ′myths′ reflecting the truth, and that one important task of science is to find out the truth hidden behind fragmentary information.

By the way, during these years the number of nuclear power plants in Japan increased to 53 reactors (total 45GWe) in January 1998 from 33 reactors (total 25 GWe) at the moment of the Chernobyl accident.

Activity of Japanese members before the collaborative project

The Nuclear Safety Research Group of Research Reactor Institute, Kyoto University (KURRI), to which the present author belongs, has been working on safety problems of nuclear facilities for more than 20 years. Main tasks of our group have been the followings: analyses of engineering problems of PWR and other reactors, assessment of radiological consequences by hypothetical severe accidents at nuclear power plants in Japan, measurements of radioactive contamination in the environment, investigation of the Three Mile Island NPP accident in March 1979 in the USA, etc. [8-11]. Through these works, our group has been providing the public with information about risks accompanied with the commercial use of nuclear energy.

It was quite natural for us, when the Chernobyl accident happened, to begin one more task to investigate its consequences from our point of view. We measured radioactivity from Chernobyl in Japan, collected information on all aspects of the accident including contamination data from all over the world, and made the assessment of radioactivities released by the accident [12-15].

By the end of 1986, we succeeded in making outline of radioactive contamination in the northern hemisphere except in the territory of the former USSR. Our estimates of irradiation dose in Japan due to fallouts from Chernobyl are shown in Table 3. Table 4 includes our assessment of released activities made in the first years after the accident. Although the results of our analysis, which was made based on small data presented in the 1986 USSR report on the accident [16], indicated a very high level of contamination in the territory of Belarus, we did not have measures to confirm it for several years. The fact should be kept in mind that there was a vacant period of information for about three years, when we retrospectively try to investigate the Chernobyl accident.

In the process of *perestroika* and *glasnost* within the USSR, the first detailed map of contamination was published in Belarus in February 1989 [17]. A vast amount of contaminated areas showed the validity of our assessment in the first years. We were also surprised to know that high levels of contamination extended even to 200 - 300 km from the Chernobyl site, which could not be supposed from our accident assessment for light water reactors.

Imanaka and his colleague Seo (deceased in 1994) made the first visit to the USSR in the summer of 1990 [18,19]. Through the visit to Moscow/Minsk/Kyiv, we knew that there were amounts of data about radioactive contamination taken by Soviet scientists at the initial stage of the

Table 3. Estimates of irradiation dose in Japan due to fallouts from Chernobyl for the 1st year after the accident [13].

Thyroid Organ Dose, μSv

	Path				Total
	Inhalation	Tap water	Leafy vegetable	Milk	
Children	60	14	290	43	~400
Adults	30	4	110	6	~150

Total Body Dose: μSv

	External		Internal				Total
	Cloud	Ground	Inhalation	Tap water	Leafy vegetable	Milk	
Children	0.02	3	0.2	0.07	0.7	1.2	~5
Adults	0.02	3	0.2	0.04	0.5	0.4	~4

Table 4. Estimates of released radioactivity of major nuclides by the Chernobyl accident.

Nuclide	Half life	Inventory, MCi	Estimated released radioactivity, MCi			
			USSR report [16] (1986)	Seo [14] (1988)	Dobrynin [21] (1993)	Imanaka 1993 [20]
I-131	8.05 d	36.5	7.3 (20)*	25.40	19.0	17.0
Cs-137	30.2 y	7.7	1.0 (13)	4.35	2.3	2.5
Ru-103	39.3 d	110	3.2 (2.9)	10.40	3.8	3.3
Zr-95	64 d	119	3.8 (3.2)	5.60	4.0	5.9
Ce-144	284 d	85.7	2.4 (2.8)	4.60	3.6	3.4

- All activities are decay-normalized to values on May 6, 1986.
- Values of reactor inventory are cited from the 1986 USSR report.
* Values in () are released percentage to inventory.

accident.

"Toyota" project in 1993-1994

The collapse of the USSR at the end of 1991 changed the situation around Chernobyl problems. This allowed as a possibility to start a collaborative work with former USSR scientists.

In 1993, we succeeded in getting a research grant of the Toyota foundation for a collaborative project with Belarussian scientists under the title, "Radioactivity Releases from the Chernobyl-4 Accident and Dose Estimates in Its Early Stage" (leader Seo T.). The Japanese side consisted of 4 members of the Nuclear Safety Research Group. The Belarussian side includes 5 scientists of Academy of Sciences of Belarus, Belarussian State University and Hydrometeorology Committee. The Japanese side was going to refine the old analysis of contamination patterns around Chernobyl and reevaluate released activities on the basis of the new data that were obtained from the Belarussian side. In the course of this project, frankly speaking, the Japanese side met a lot of difficulties: differences in the tradition how to promote cooperative researches, difficulties to keep close communication (e-mail was not available, air mail was not a sure way, fax was relatively expensive), differences in the tradition how to manage the finance, etc. In addition, the team leader, Seo T. unexpectedly died of lung cancer during the project. In spite of these difficulties, some valuable results were obtained by this first project [20]. Our new estimates of released radioactivities are shown in Table 4 together with old values and by others. Our new estimates are consistent with the estimation by Dobrynin et.al. [21].

"Toyota" project in 1995-1997

We have passed over the application to the Toyota foundation in 1994 and rearranged the frame of cooperation during this period. Considering the experiences through the first project, the base of collaboration was converted from a relation between groups of equal partnership into a network of personal relation coordinated by Imanaka. The way of working was also changed from face-to-face discussion between members to preparing reports by each member for his own themes.

In 1995 we received a new research grant under the title, "Investigation of Research Activities about the Radiological Consequences of the Chernobyl Accident in Russia, Belarus and Ukraine after the Collapse of the USSR". At the time of the application to the Toyota foundation, the members were limited to Imanaka and Matsko in Minsk in order to keep a flexibility of the project. Then, three members, Koide at KURRI, Ryabzev in Moscow and Nasvit in Kyiv joined the project. The members in CIS countries were expected to make their report concerning the situation of research activities in each country about the radiological consequences of the Chernobyl accident. In addition, Imanaka asked preparation of special reports for our project to several scientists who are engaged in interesting studies. Through the 1995 project, we succeeded in making 8 reports, including 4 special reports. Four of them were published in English or Japanese [22-25].

In 1996 we succeeded in extending our research grant under the title, "Investigation of Research Activities about Radiological Consequences of the Chernobyl Accident and Social Activities to Assist Its Sufferers in Russia, Belarus and Ukraine". A theme concerning social aspects of Chernobyl problems was added in this year. The following 4 new members joined the project; Malko in Minsk, Yaroshinskaya in Moscow, Tykhyi in Kyiv and Sugiura in Minsk. In January 1997, we had a meeting of all members in Moscow to discuss the contents of the project and decided the following 5 sub-themes (names of responsible member):

A. General description of research activities concerning the radiological consequences of the accident (Matsko, Ryabzev, Nasvit, Malko).
B. Investigation of the current situation of epidemiological studies in each country (Matsko, Ryabzev, Nasvit).
C. Investigation of acute radiation syndrome among inhabitants around Chernobyl (Yaroshinskaya,

Imanaka, Koide).

D. Overview of social activities to assist sufferers by the accident (Yaroshinskaya, Malko, Tykhyi, Sugiura).

E. Preparation of special reports of interesting studies (Imanaka and all others).

The 1996 project formally finished at the end of October 1997.

Here in this KURRI report we present 32 papers we could prepare through the collaborative works in 1995-1997. They are classified into the following categories by the report number in CONTENTS:

- Member reports in the 1995 project; 4, 5, 6 and 7,
- Special reports in the 1995 project; 8, 11, 22 and 25,
- Member reports in the 1996 project; 1, 2, 13, 14, 15, 16, 28, 29, 30 and 32,

Special reports in the 1996 project; 3, 9, 10, 12, 17, 18, 19, 20, 21, 23, 24, 26, 27 and 31.

Besides already mentioned, No. 19 by Sugenoya, No. 21 by Lazjuk and No.12 by Lupandin were published in Japanese [26-28]. No. 28 by Tykhyi will be published soon [29].

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