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History and Progress of Radiation Education Using Handy-Type Radiation Survey-Meter Named "Hakaru-Kun" in Japan

Takeshi Iimoto[1], Tomohisa Kakefu[2] and Yoichi Kiyohara[3]

[1]*The University of Tokyo (Committee chair of the Hakaru-kun project)*
[2]*Japan Science Foundation (Officer in chief of the Hakaru-kun project)*
[3]*Ministry of Education, Culture, Sports, Science and Technology in Japan (Committee member of the Hakaru-kun project)*

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History and progress of the Hakaru-kun project continuing around for a quarter century has been introduced. The core of the project is "Hakaru-kun", handy-type radiation survey-meters. The authors believe we Japan faced two big turning points on radiation education recently. One is the revision of the government curriculum guidelines for elementary schools and for junior high schools in 2008. In the revised guidelines, a keyword of "radiation" was re-involved at interval of about 40 years. Second is the accident of the Fukushima dai-ichi nuclear power plant of Tokyo Electric Power Cooperation in March, 2011. We should continue serious discussion on the relation and harmonization among environment protection, usage of science and technology, and also safety and security based on the facts and real data with international consensus. Usage of radiation and radioactive materials is now one of the most important discussion points. We should understand most of environment radiation can be easily detected by simple radiation survey-meters. This would be the first step to understand radiation, and then might be connected to public's real interest in radiation itself. We also hope this activity of the project in Japan would be a good example or model on radiation education in other countries.

Key words: radiation education, CsI (Tl) scintillation survey-meter, ambient dose equivalent, Hakaru-kun, the government curriculum guidelines in Japan, the Fukushima dai-ichi nuclear power plant of TEPCO

1. Introduction

The government curriculum guidelines for elementary schools and for junior high schools were revised in 2008[1)]. In the revised guidelines, a keyword of "radiation" was re-involved at interval of about 40 years. In addition, the Fukushima dai-ichi nuclear power plant of Tokyo Electric Power Cooperation in March, 2011[2)] has elevated public concerning on radiation and its health effect. The authors are feeling these two might be big turning points for Japan on radiation education.

Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT) has been continuing a big project on radiation education named "the Hakaru-kun project" for a quarter of a century[3)] under the Japanese

Takeshi Iimoto: The University of Tokyo (Committee chair of the Hakaru-kun project)
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8654, Japan
E-mail: iimoto.takeshi@mail.u-tokyo.ac.jp

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Fig. 1. Outlooks of Hakaru-kun series
DX-200, DX-300, Memory, Type II and CP-100 from left to right.

energy policy. MEXT has been developed several handy-type survey-meters, mainly focusing on estimating rough ambient dose equivalent. The series of the survey-meters are called as "Hakaru-kun", which is a nickname of the instruments. MEXT cooperating with some supporting foundations has developed the radiation education project using these.

Here the history and social background of the Hakaru-kun project as a national undertaking are introduced. In addition, recent status and future scope of radiation education, mainly using Hakaru-kun is also mentioned. Purposes of this article are to summarize the developing process of the Hakaru-kun project under the Japanese turning point on the keyword of "radiation", to be a trigger to discuss the future radiation education, and also to show the other countries one example of our Japanese experiences and present status on radiation education.

2. Development purpose of hakaru-kun

Hakaru-kun has been developed for the purpose of radiation education. This is designed as even elementary school students could handle it by themselves. Basically this is not designed for disaster prevention or precise radiation monitoring. According to the description of Hakaru-kun website[3], the purpose and background status for development and usage of Hakaru-kun are as followings.

"Some public might be fearful on radiation. However actually, radiation and radioactive materials exist everywhere in natural environments and our living surroundings, such as in the space environment, the earth, natural rocks, etc. We are always exposed to natural radiation in our daily life. Unfortunately we could not feel that this is really happening, even after reading or hearing the related story. How to measure radiation with any instrument? How about a daily radiation dose level? How about an effect of the daily life dose on health of human body? How different between the daily dose level and the level for health damage? These questions might arise one after another. It is very effective and important to detect radiation by oneself to understand a real radiation environment. Through this process, we could start to understand radiation rightly. 'Hakaru-kun' can detect photons emitted from natural ground and materials surrounding us as well as a part of space radiation. Especially Hakaru-kun Type II can also detect beta rays. Let' s survey various environments and materials using Hakaru-kun. You might find out or discover new facts on radiation around you."

Figure 1 shows the outlook of the series of Hakaru-kun. These all install CsI (Tl) scintillators as detectors for photon measurements. Hakaru-kun type II also installs a small Si semiconductor detector for beta ray measurement. Sensitivity for photon of them is more than 10 cpm under 0.01 μSv h^{-1}. Detectable dose range is from 0.001 to 9.999 μSv h^{-1}. Detectable photon energy range is from 150 keV to 3 MeV. Energy responses for photon are shown as Figure 2[4]. We would like to take note here that this data is only based several test experiments using photon checking sources of ^{57}Co, ^{133m}Ba, ^{137}Cs and ^{60}Co. The complementing line between points especially around 200 keV could not show their right energy responses[5]. DX-100 (no photo in Fig. 1) is the prototype of the Hakaru-kun series. It worked from 1989 to 1990. DX-200 from 1991 and DX-300 from 2005 are designed as smaller, lighter and easier to be operated than the prototype of DX-100. Memory from 1998 can record measured data in its internal memory. Type II from 1997 installs a Si semiconductor detector as well as a CsI(Tl) scintillator to detect beta rays. The newest CP-100 from 2011 shows the best energy response feature for measurement of ambient dose equivalent.

3. Radiation education project as a national undertaking

The Hakaru-kun project has started since 1989. Strategy of the project has been leaded by a committee under the discussion with MEXT. The committee for the project consists of a several members selected from exparts on radiation measurements and risk communication as well as from teachers of elementary schools, junior high schools and high schools. They discuss mainly specification and

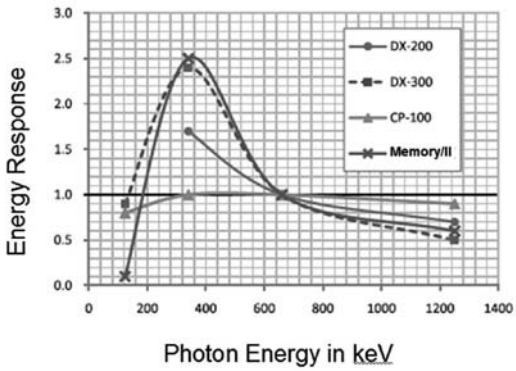

Fig. 2. Rough energy response of Hakaru-kun.
*This data is only based on several test experiments using photon checking sources of ^{57}Co, ^{133m}Ba, ^{137}Cs and ^{60}Co. The complementing line between points especially around 200 keV could not show their right energy responses.

Fig. 3. Radioactive sample kit for measurement by Hakaru-kun.

Fig. 4-1. Experiment kit to test radiation features using Hakaru-kun.

Fig. 4-2. Installation example of the radiation feature test kit.

design for next generation of Hakaru-kun, preparation of instruction manual, preparation of worksheet examples on Hakaru-kun experiments, how effectively to use Hakaru-kun in schools, how effectively to lend Hakaru-kun to schools, or how to spread use of Hakaru-kun to schools, and etc.

Here two kits supporting to the usage of Hakaru-kun are introduced as examples. The first example is shown in Figure 3, which is a radioactive sample kit. The kit consists of 1) paint for the bottom of a ship containing natural radioactive thorium, 2) mineral encrustations left by hot springs containing natural radioactive radium and thorium, 3) granite rock containing natural radioactive potassium, 4) potassium-enriched salt, and 5) lantern mantle containing radioactive thorium. These are good samples to be surveyed by Hakaru-kun to understand radiation emitting from some materials surrounding us and to recognize a range of dose level.

The second example is shown in Figures. 4-1 and 4-2, which is an experiment kit to test radiation features. The kit consists of 1) the above radioactive sample kit, 2) four Hakaru-kuns, 3) three vacant bottles to test some additional materials such as soil or natural rock, etc., 4) several radiation shielding boards which are acrylic resin, aluminum, stainless steel and lead, 5) setting boards for experimental items. Students could survey various samples as well as environmental radiation. Students also could recognize relationship between distance and radiation dose by this kit. Students could identify the shielding feature of various materials focusing on difference of material and its thickness by this kit.

In order to promote the usage of Hakaru-kun in schools as well as to investigate new ways to use it, the project has held a contest every year. Everyone can apply for the Hakaru-kun contest to show their experimental fruits gained by the small instrument. For teachers, how to use Hakaru-kun in their class in order to educate radiation to their students is also welcomed. For example in the results of the contest in 2011, applications of 4,307 were submitted, and 17 works from elementary school students to teachers/professors were received awards based on strictly fair judgment by the contest committee[3]. This contest takes an important part and is very effective to motivate students as well as teachers to access natural radiation.

Through the above activities and others which could not be introduced in this article, this historical project has been developed. Figure 6 shows the variation of annual lending

Fig. 5. Surveying environmental radiation using Hakaru-kun in a school.

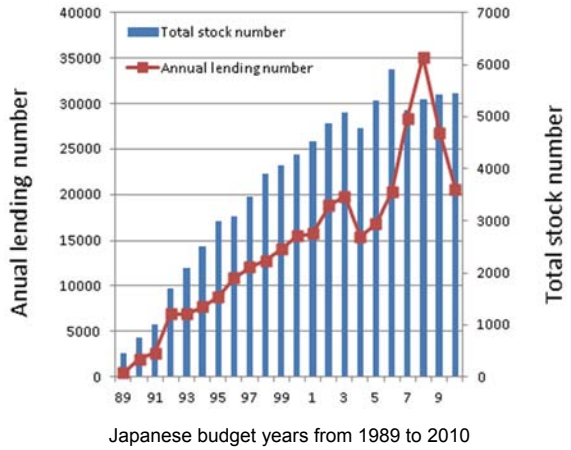

Fig. 6. Variation of annual lending number and total stock number of Hakaru-kun.

number and total stock number of Hakaru-kun[6]. This is the main history of the Hakaru-kun project. Since 2009, the project strategy has dramatically changed. Lending only to elementary schools, junior high schools and high schools other than personal application can be permitted from 2009. It is not appropriate directly to compare the annual lending number before-2008 and that of after-2008.

4. Resent status and future scope of radiation education in Japan

Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT) revised the government curriculum guidelines in 2008, which enforced officially in 2011 for elementary schools and will enforce in 2012 for junior high schools. In the revised guidelines, important two keywords of "energy" and "radiation" can be found. Especially for science classes in junior high schools, education on specification and usage of radiation is re-involved in the revised guidelines after interval of about 40 years. According to the instruction manual for the guidelines, the following additional explanation can be found. "Type of energy resources used in our daily life and social activity such as oil, natural gas, sun light etc. and how to obtain these natural resources should be understood by junior high school students. Mechanism and features of electric power generations due to hydraulic power, thermal power, nuclear power and solar power etc. should also be understood. In this process, the following points should be taken up in the class; energy due to nuclear power is generated from nuclear fuels such as uranium etc.; nuclear fuel emits radiation; radiation exists in natural environment; radiation passes through some materials; radiation is used in medical fields and industrial fields, etc." In our opinion these education items could be strongly connected to the important keywords of "development of science and technology", or "protection of natural environments and usage of science and technology" in junior high school classes. These are also found in the guidelines. We hope wider and deeper education and classes on science and technology could be developed by the guidelines.

Furthermore, we Japan experienced a major turning point on the keyword of "radiation". This is very the accident of the Fukushima dai-ichi nuclear power plant of Tokyo Electric Power Cooperation after the great east Japan earthquake (11 March, 2011). The accident elevates

background level of environmental radiation around the wide east Japan. Public is still anxious for receiving every information on radiation. Their targets are not only ambient dose level or contamination levels of ground surface and foods/drinks but also the features of radiations and radioactivity, radiation effect on human body, or safety criteria of radiation, etc. This is occasionally the education items directly related to the new government curriculum guidelines. Public strongly requested the government or their local governments to monitor the ambient dose equivalent rate precisely and officially especially immediately after the accident. However, actually it took much more time than they expected to start precise radiation survey around our daily-life area. A lot of elementary schools and junior high schools have used Hakaru-kun and the project both to educate students on radiation and to survey their school-life areas. This is the fact that Hakaru-kun is useful and helpful to find out relatively dose-elevated points or areas in a lot of school yards as the results. This is not the genuine purpose of the Hakaru-kun project. However through this process a lot of students, teachers and parents recognized environmental radiation and its spatial variation. We think this is also one of the very important effectiveness of radiation education using the Hakaru-kun.

Revision of the government curriculum guidelines in 2008 and the accidents of the Fukushima dai-ichi nuclear power plant of Tokyo Electric Power Cooperation in 2011 would change our future radiation education not only in Japan but also in the world. We should understand most of environment radiation can be easily detected by simple radiation survey-meter such as Hakaru-kun. To make more opportunity to detect radiation by oneself and to recognize it through this experience is very effective not only for students but also for the other public in order to understand existing radiation around us and environmental radiation dose spatially varies. This would be the first step to understand radiation, and then might be connected to public's real interest in radiation itself.

5. Conclusion

Here we have introduced the history and progress of the Hakaru-kun project which is one of the largest radiation education programs in Japan leaded by the Japanese government. "Decision making process", "stakeholder involvements and engagements" and "sustainable society" are also the important keywords found in the revised government curriculum guidelines and related instructions. We should continue serious discussion on the relation and harmonization among environment protection, usage of science and technology, and also safety and security based on the facts and real data with international consensus. Usage of radiation and radioactive materials is now one of the most important discussion points we face. We believe Hakaru-kun and the project would take a greater part under this situation. We hope the spread of use of Hakaru-kun in Japan more and more, the spread of understandings of radiation, and also the spread of cooperation and support on radiation education from all persons and parties related or concerned. In addition finally, we also hope this activity of the project would be a good example or model of radiation education in other countries.

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The Hakaru-kun project has its long history for around a quarter of a century. A lot of experts, teachers, officers and manufacturers have been involved in the projects so far. We express our great gratitude for all of the related persons on this project. We especially appreciate valuable information on the history of the Hakaru-kun project provided by Dr. and Prof. Chizuo MORI, Aichi Institute of Technology, the former committee chair of the project and Mr. Kiyonobu NAKAMURA, Institute of Radiation Measurements, the former officer in chief of the project. In addition, we appreciate effective private communication and information on the energy response of Hakaru-kun from Dr. Hideo HIRAYAMA, Director of Applied Research Laboratory, KEK (High Energy Accelerator Research Organization).

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