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The role of measurements in the co-expertise process after a nuclear accident: a contribution to mediating the reality

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Abstract

This chapter explains how radiation measurements play an important role in the co-expertise process after a nuclear accident. Because people cannot feel radiation by their senses, measurements help them to see the invisible situation in their daily life. Through working together with experts, residents learn how to interpret numbers and understand their own exposure. This process also supports them to make decisions for protective actions and regain autonomy in their community. A turning point in terms of individual external dose measurements came with the development and roll-out of the D-Shuttle personal dosimeter after the Fukushima accident. The D-shuttle experience demonstrated how measurements reshape residents' perceptions and everyday decision-making, not only from a technical perspective but also by building dialogue and trust. The chapter closes with a discussion on ethical aspects of measurements and the importance of continuous vigilance in contaminated areas.

Introduction

Radiation cannot be felt by the five senses. Facing this elusive reality, imperceptible to the human senses, the only way to cope with the radiological situation is to appeal to science and deploy radioactivity measurements to translate it into

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numbers. It takes some time for the people who decide to embark in radiological protection to master how radiation is measured, the meaning of units and how, more importantly, to interpret the results and finally to decide if there is a need for action or not. Needless to say, when a nuclear accident occurs and radioactivity invades the direct living environment of people, it is for them just an incomprehensible reality—one for which they have no experience, no words to describe it, and no knowledge how to grasp it or what meaning to give it (Lochard, 2026). What they generally know is that radioactivity is dangerous, because they have heard about the atomic bombs of Hiroshima and Nagasaki which killed instantaneously more than one hundred thousand people, not to mention the victims of cancer or other radiation-induced illnesses occurring later. In such dramatic and vague context what is the role of measurements in the co-expertise process?

Measuring radioactivity is one of the 3 pillars that structure the co-expertise process, in addition to dialogue and local projects. Measuring radioactivity is an effective way to engage residents living in affected areas to help them to understand when, where and how they are exposed in their day-to-day lives. By involving residents in the measurement of radioactivity it is possible to make visible what was invisible to them. Measurements raise awareness of the ways in which an individual is exposed and allow possible protective actions to be sought, at the individual or collective level, to reduce those exposures, which are avoidable. Engaging residents in measurements should be progressively developed based on a comprehensive approach performed by residents themselves (self-monitoring) and/or by the authorities and experts together with the residents living in affected areas. By doing so residents regain progressively control over the radiological situation they are confronted with.

The act of measuring one's environment transforms a difficult-to-understand situation into understandable, actionable information, that reduces anxiety and enables residents to make choices aligned with their own values, desires and life projects and to be able to express their views on the recovery strategy established by the authorities. The measurement activities demonstrate to those involved that scientific and technical knowledge, when shared and explained and rooted in lived experience, can support individuals in reconstructing meaning and regaining control in the aftermath of a nuclear accident. It is through this interaction between measurement, interpretation and development of the narrative framework, that is to say the linguistic process by which individuals make sense of their experiences, that communities begin to regain control of their present situation and to imagine possible futures (Ando, 2016).

1. The measurement process: making the invisible visible

1.1. *Before Measurement: Establishing the Conditions for Dialogue*

When an expert meets a resident of contaminated land in the weeks, months, or even years following a nuclear accident, and when residents' prior knowledge is limited to information circulating in the mass media, the expert is very likely to be confronted with a recurrent initial question: “Is it dangerous to live here?” — asked in the presence of others — or, in a more private setting, “Tell me, you are an expert, can I live here?”

At this stage, residents’ images of radioactivity are often extremely vague. Most people have never carried out any form of measurement, nor can they readily imagine what measurement entails or what purpose it might serve. As a result, residents are not necessarily inclined to engage in measurement at the outset and may even be sceptical of it. Some residents even refuse to engage in measurements because they are apprehensive about the result! At the same time, in the absence of measurement, their concerns and questions remain so indistinct that it is difficult to grasp how they might be addressed.

In responding to such questions, experts may be tempted to draw on their technical knowledge of radioactivity and to provide more or less precise explanations based on available data on the radiological situation. However, this approach often serves only to reinforce residents’ distrust of anything perceived as “official.”

An alternative response is for the expert to suspend premature explanation and instead return the question to the resident’s living context: “I do not know because it depends on where and how you live. Tell me about your home, your occupation, your eating habits, and other aspects of your daily life that I do not yet know.” Such a response may initially unsettle residents, but it often arouses curiosity. It is at this point that a dialogue can begin. By asking a few seemingly innocuous questions — such as “Where do you live?” or “What do you do for a living?” — the expert invites the residents to speak about their everyday life. Such an alternative asks for a radical change in the expert standpoint, from a top-down, scientific and technical discourse about the situation, which represents sometimes a working life-long experience, to an open-minded, language-adapted posture, respectful of residents’ concerns and opinions. In these conditions, gradually, a narrative begins to emerge.

Within this informal dialogue, residents start to hint at the concern that motivated their initial question. This concern may relate, for example, to a daughter who left the village with her children at the time of the accident and no longer wishes to return, leaving the resident fearing that they may never see their grandchildren again. It may also concern something quite different, such as whether it will ever be possible to resume gathering bamboo shoots or blueberries in the forest bordering the village.

Importantly, the concerns that residents articulate at first are not always those that most directly shape their daily struggles. When confronted with an unprecedented situation, only a small minority of people are able immediately to recognize what they are struggling with and to communicate it clearly to others. Vague anxieties and mistrust are therefore often expressed through episodes drawn from personal memories or second-hand accounts — for example, stories heard about long-term health effects among atomic bomb survivors. While such narratives are meaningful, they do not necessarily correspond to the underlying source of concern. As a result, no definite response can be found, no matter how extensively they are discussed.

For this reason, attentive listening is essential. Dialogue prepares the conditions under which residents can, through conversation, arrive by themselves at the issue that motivates their concern. Only once this concern has been identified does it become possible to consider how to address it. If the concern is related to radioactive contamination, the carrying out of measurements can then be proposed. From this point onward, dialogue continues, in which the expert shares knowledge in everyday language, while the residents describe their daily life in greater detail, articulating questions, fears, and hopes.

This scenario is necessarily simplified and somewhat artificial. Nevertheless, it illustrates a central point: When grounded in dialogue, measurement can become a meaningful contribution to address residents' concerns and set the co-expertise process in motion.

1.2. *Implementation of measurements in the field*

Technically, measurements should involve ambient dose rates, external/internal exposures, and foodstuff contamination. For measurements to be meaningful, they should be conducted step-by-step from sources of exposure to the exposures received by individuals through the various exposure pathways. At the same time, interviewed experts mentioned that, when performing measurements, the most important aspect to pay attention is to listen and understand the concerns expressed by affected people (Thu Zar et al., 2022). By grasping resident's concerns and expectations, it becomes possible to provide measurement instruments adapted to the stakeholders' need, to accompany them in the definition of the monitoring programme, and to support them in interpreting the results. It is also the responsibility of the expert to provide advice on instruments to be used that must be adapted to the situation, reliable, robust, easy to use, and if possible, include the possibility to share the results in an easy way as illustrated by the D-Shuttle and OpenRadiation in the next sections. The aim is for the residents to be able to think about what the measurement results mean for their own lives. The involvement of residents in analysing the results of measurement, and in sharing them with members of their community, is crucial for understanding their meanings (Ando, 2016).

In most cases, particularly at the initial stage, simply looking at numerical measurement results does not allow residents to judge whether the values are high or low. One reason is their limited knowledge of radiation risks. Another is that low-dose exposure inherently lies in a grey zone in which judgment is difficult. As a first step, many people therefore seek reference points that allow them to assess their own situation through comparison. In this context, comparing their exposure levels with those of neighbours or other members of the community can be a powerful means of helping residents understand the factors that shape their own exposures. In addition, placing radiation exposure alongside more familiar exposure, such as those associated with daily life activities, can help residents to put in perspective the risk associated with the exposure they receive.

With regard to the basic concepts and units of radiological protection — which at first glance are often incomprehensible to non-specialists — the experiences of Chornobyl and Fukushima have shown that the most effective way for residents to learn how to use them is through individual measurements in which residents are directly involved and interact with experts to interpret the results (Lochard, 2013;

Ando, 2016). During the measurements, experts can progressively introduce concept and notions on radiation exposure. These experiences have also shown that sharing measurement results in order to discuss the situation of the community is a powerful means of enabling residents to understand their own situations and to identify opportunities to improve their protection. Measurements implemented within a co-expertise process can thus support the adoption of self-help protective actions adapted to each individual and if necessary to require additional collective protective actions, as well as the organization of radiological monitoring within the community to ensure collective vigilance.

What is important here is to develop expert discussion on the properties of radioactivity starting from concrete, individual measurement results. Abstract, textbook-style explanations, or knowledge about radioactivity presented in the form of general statements, often lack clarity as to whom they are meant to be meaningful for. As a result, such discussions rarely lead to self-help–oriented action and instead tend to degenerate into inconclusive debates. By contrast, when concrete measurements are carried out in the environment of the community, numerical values and related concepts acquire meaning in relation to one's own life or that of one's family. From this starting point, understanding of radioactivity and its properties and the way residents are exposed can progress substantially.

As far as the implementation of the measurements is concerned, it requires the use of appropriate measurement instruments, and it is the role of experts and authorities to support residents to get these instruments. Conducting individual measurements requires both the competence to perform measurements and access to suitable instruments. Public and/or private support to residents is therefore necessary to acquire these instruments, and their use by residents inevitably mobilises technical and human resources (Figure 1).

When the process is not supported from the outset by a specific organization, those leading the co-expertise process must seek the necessary support from local or national authorities, experts or academic institutions. This can be a demanding and time-consuming task, requiring tenacity, as illustrated by the experience of the Suetsugi district (Ando et al., 2026).

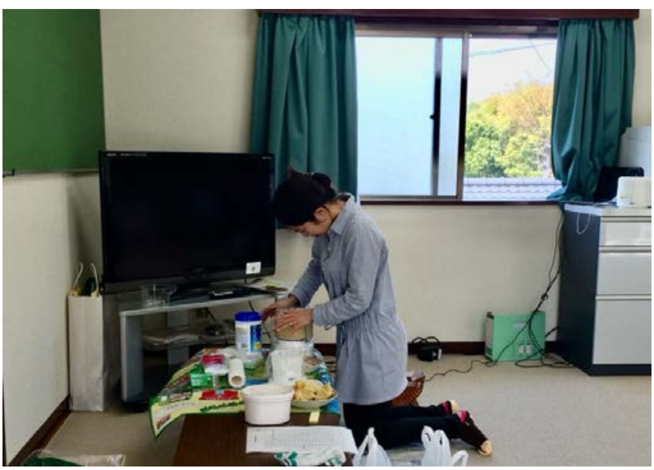

FIGURE 1. The food measuring station in the Suetsugç community house (Ando et al., 2026).

2. Taming the rays: the D-Shuttle experience in Japan

2.1. *Early limitations in post-accident co-expertise*

In the co-expertise initiatives after Chornobyl, such as ETHOS and related projects, residents did not have easy-to-use portable devices to measure individual external dose in their daily life. Measurements focused mainly on ambient dose rates and on internal exposure using whole-body counters. Therefore, individual external exposures had to be inferred indirectly from ambient data and time individuals spent in different locations and activities, rather than being measured directly for each person's routine. This imposed additional calculations and modelling within the co-expertise team to turn people's questions into practical, self-help actions based on their real activities.

2.2. *A turning point: individual external dose measurement with D-Shuttle*

The gradual use of D-Shuttle in Fukushima created new opportunities. D-Shuttle is a small silicon personal dosimeter that records hourly personal dose (Figure 2). It shows when and how much exposure happens during the day. Combined with GPS logs and time-activity diaries, residents and experts could interpret the numbers together and link directly dose patterns to places and actions. Large campaigns from 2013 to 2019, including several hundred participants in both non-evacuation areas and former evacuation zones, produced realistic distributions of individual external doses and their variation across jobs, locations, and routines (Naito et al., 2016, 2017).

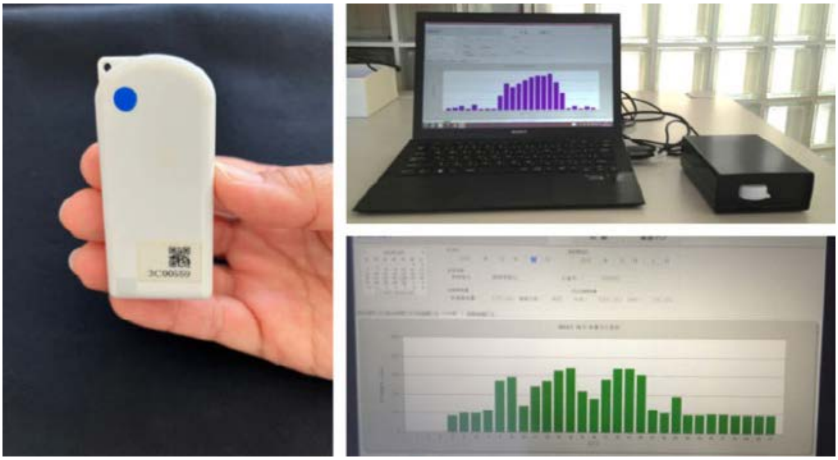

Figure 2. The left side shows the D-shuttle device. The upper right shows the management unit and an example of hourly dose display, while the lower right shows the daily dose (photos: W. Naito).

Across studies, average additional individual external doses measured with the D-Shuttle were often lower than estimates provided by the authorities and expert bodies based on airborne monitoring and conservative assumptions concerning the times of exposure indoors and outdoors of the residents. At the same time, differences between people from the same community were meaningful and reflected their time — activity patterns (for example, outdoor work, commuting routes, or time at specific indoor/outdoor sites). This combination — lower population averages but useful variation between individuals — shifted attention from abstract debates about "areas" to concrete, person-specific factors that people can manage.

Importantly, D-Shuttle was not used by one team only. Beyond the series of studies by Naito and colleagues, D-Shuttle was also used in school-based projects and other resident-led or researcher-supported efforts. For example, a high-school project compared students' individual doses inside and outside Fukushima, including students from Belarus, France and Poland, and helped them communicate their findings in simple terms (Adachi et al., 2016). Such cases broadened participation and showed that non-experts can collect and discuss personal dose data, if the process is well guided.

2.3. *What residents actually learned: from numbers to everyday choices*

Beyond the scientific characterization of individual doses, the D-Shuttle experience revealed how measurement reshapes residents' perceptions and everyday decision-making. For many residents, wearing a dosimeter did more than give a total number. It changed how they looked at daily life. Hour-by-hour profiles discussed with experts showed that dose depends not only on where one lives, but also on how one moves and spends time. In some cases, commuting by car through certain road segments or working outdoors at particular sites contributed most; in other cases, time at home mattered more, depending on house conditions and routine schedules. These insights helped residents separate what was unavoidable from what was avoidable. Small adjustments — changing a route, shifting the timing of an activity, or re-balancing indoor and outdoor time — were often significant to improve individual external exposure, without disrupting family or work plans.

Interviews done when returning results showed different reactions to similar numbers. (Naito and Uesaka, 2018). Some residents felt reassured once they saw that their usual habits led to doses below familiar reference values. Others focused on short peaks and asked for concrete options to reduce them. The lesson is clear: measurement alone is not enough. What matters is the shared interpretation — the dialogue that connects numbers to places, routines, and personal goals — so that residents can choose and act with confidence, and if necessary, call for additional actions from the authorities.

The studies in Fukushima also showed a double-edged sword of personal dose measurements. If results were sent without proper explanation, or if short-term peaks were compared directly with annual radiological criteria, anxiety could increase. In addition, because D-Shuttle clearly shows differences by lifestyle and location, residents may be tempted to avoid "higher" spots even when the differences are small and not practically important. And, as noted in the previous section, residents naturally compare their results with those of neighbours to understand their own situation. When D-Shuttle reveals distinct living-pattern differences, those with higher readings may feel they are at a disadvantage, which can harm well-being at both individual and community levels. Co-expertise therefore needs reliable devices and prepared support for explaining, comparing, and following up on results, so that numbers build capability rather than worry. Experience in Fukushima suggests a practical way to reduce these negative effects: present doses as ranges rather than isolated values. By showing where a person's exposure sits between familiar reference levels—such as natural background radiation, a commonly used guideline for additional dose—attention shifts away from small numerical differences. This banded presentation helps residents focus on the overall exposure level and supports calmer, more balanced decisions.

2.4. *What D-Shuttle changed in the co-expertise process*

Bringing easy-to-use individual dosimetry into co-expertise shifted the focus from places to lives. Instead of speaking only about contaminated "areas", residents and experts could see how exposure changes hour by hour within real daily routines. This helped residents make protective choices based on their own values and practical needs, rather than on abstract maps.

It also shifted the focus from averages to distributions. Community-level averages often hid important differences. Personal dose data showed who was more exposed and for what reasons, making it easier to support fair and proportionate actions for those who needed them most.

Finally, it shifted the focus from one-way explanation to co-interpretation. Numbers gained meaning through dialogue. Residents were able to act more autonomously in everyday protection and to discuss recovery options with authorities in a concrete and constructive way. At the same time, the Fukushima experience highlighted the importance of ensuring that participation in individual measurements is voluntary, and that people clearly understand how their data will be used. Particular care is needed to protect individual privacy, especially when results reflect personal lifestyles or places of living. When measurement data are shared beyond the individual level, explicit consent is essential, together with safeguards to prevent identification and misuse.

In short, the D-Shuttle experience in Fukushima did not simply add another device to the measurement toolbox. It changed measurement into a mediating practice that makes the invisible visible for someone, in a specific place, at a specific time. Through this process, co-expertise supports understanding and enables residents to act with greater autonomy.

3. The main ethical aspects of measurements

While measurement plays an essential practical and cognitive role, it also brings forward fundamental ethical issues within a co-expertise process. Three main ethical aspects of the measurements in the co-expertise process can be highlighted: contributing to the autonomy of residents, identifying and addressing inequities, and ensuring vigilance.

3.1. *Contributing to autonomy*

Engaging a community in measurement campaigns aims first of all to characterize the local radiological situation and the specific exposure features. As mentioned above, participating to this characterization, residents gain progressively, with the help of the experts, a capacity to better understand the local radiological situation and the way they are exposed. This step allows them to acquire the radiological protection culture and contribute recovering their autonomy on their day-to-day life.

This autonomy gives them the capacity to identify specific self-protective actions to reduce their exposure and to take informed decision on their implementation. It also contributes to their capacity to evaluate and judge the recovery program developed and implemented by authorities. Gaining in autonomy, they can engage a dialogue with experts and authorities to identify the relevant actions to be implemented for improving the situation of their community and envisage the future.

In this perspective, the promotion of autonomy through co-expertise is not aiming at residents fend for themselves and therefore isolate themselves but rather to promote this autonomy in the context of the community together with the support of experts as necessary. In addition, the role of measurements is not aimed at explaining to the residents that there is no significant radioactivity in their surroundings but rather to provide them the capacity to judge by themselves on the situation, to take relevant protective actions and to request specific support from authorities when necessary.

3.2. *Identifying and addressing inequities*

Most of the time, when residents of a community ask an expert about the level of exposure where they live, they are completely unaware that their exposures depend on their location within the community, their daily activities, and their dietary habits. They have a vague belief that the situation is identical for everyone in the community and that the expert will be able to easily answer the question. In fact, if the expert, as described in the first section, engages in dialogue and implements measurements to consider each person's situation, the collaborative assessment process will inevitably reveal radiologically disparate situations on an individual level. Few residents are aware of this fact because, living in the middle of a community, everyone thinks they share the same situation as their neighbours, and this thought is supported by the implementation of protective actions by the authorities established on potential large geographical scales, far beyond the local community. In practice, each radiological situation is characterized by a distribution of exposures, which translates into a distribution of doses received by each individual. This phenomenon is not limited to differences between neighbours in terms of the distribution of contamination, but can also exist within the same family depending, for example, on significant differences in each person's diet. Measurements carried out in Belarusian villages participating in the ETHOS project have shown very significant differences concerning internal contamination of children within the same family consuming highly contaminated milk for example when one of the children disliked milk and never drank it, while their brother or sister was very fond of it (Lepicard and Hériard-Dubreuil, 2001). This example shows that without individual measurements grounded in daily practices, such disparities remain invisible and therefore unaddressed.

In this perspective, engaging residents in measurements is useful both for the residents to identify their own radiological situation and for the experts to identify the dose distribution due to the specific local characteristics and habits of the community. Without this detailed assessment of the situation provided by the co-expertise process, it is not manageable to engage a more individualized approach to cope with the inequity in the distribution of exposures.

Regarding the distribution of individual exposures, the International Commission on Radiological Protection (ICRP) has long recommended aiming for equity, that is limiting individual exposures to correct any disparities in the distribution of individual radiation doses within exposed populations (ICRP, 1977). Thus, the Commission recognizes that any exposure situation, whether natural or man-made, can lead to a wide distribution of individual exposures. Furthermore, the implementation of protective measures can also introduce potential distortions in this distribution, which could exacerbate inequities. In this context, the protection criteria of the radiation protection system play a dual role. First, these criteria aim to reduce inequities in the distribution of individual exposures in situations where some people might be subjected to significantly greater exposure than others. Secondly, they aim to ensure that exposures do not exceed the values beyond which the associated risk is considered not tolerable in a particular context (ICRP, 2018). These "ethical" principles can only be verified through measurements.

Moreover, to make such figures meaningful, experts must put them into perspective by relating them to exposure situations that are familiar to residents. At the same time, the use of comparison requires particular caution. It is important to distinguish between the characteristics of the exposure situations which are compared such as imposed exposure vs. voluntary exposure. Without such distinctions, comparisons may have adverse effects, especially in terms of general trust. Only when reasonable comparisons are provided, together with the necessary caveats regarding the exposure situations, are people more likely to be able to assess satisfactorily the situations they face (Murakami, 2018; Covello et al., 1988). If risk comparisons are not conducted carefully, they can be even counterproductive. For example, when differences in exposure levels within a community are substantial, comparisons among community members may foster a sense of inequity and, in some cases, lead to stigmatisation. For this reason, comparisons with neighbours are generally more appropriate in communities where differences in exposure levels are in the same range.

3.3. *Ensuring vigilance*

Although the combined action of decontamination efforts by public authorities and the natural decay of radioactivity significantly reduced the ambient dose rate in the areas affected by nuclear accidents, allowing for the gradual lifting of protective actions, many residents still wish to take measurements to better characterize the radiological situation of their living areas as well as its evolution. In fact, radioactivity is distributed heterogeneously in the environment and moreover it is not fixed in the environment and can migrate and accumulate due to erosion, rain, flood and other natural phenomenon or anthropic activities. In this context, vigilance is defined as a protection behaviour against the danger represented by the presence of radioactivity in the living environment and its evolution (Figure 3).

Figure 3. A school teacher checking the ambient exposure rate during a forest excursion with her students during the ETHOS project in Belarus (1996-2001) (photo: J. Lochard).

In this context, the NPO Fukushima Dialogue (NPOFD), an NGO dedicated to promoting dialogue on radioactivity in the Hamadori region of the Fukushima Prefecture, recently received several requests from some residents of Fukushima Prefecture to take measurements. Building on the collaboration with OpenRadiation, a French citizen initiative for radioactivity measurement (Bottollier-Depois et al., 2019), the NPOFD provided radioactivity detectors to residents wishing to perform ambient dose rate measurements in their environment. In fact, the objective is not anymore to assess individual exposure, as it was made by using D-shuttle, but rather to implement environmental monitoring able to answer questions from land users or customers about the presence of radioactivity. Interviews were also conducted with the residents who performed these measurements in Japan to identify their motivations and interests. Results indicated that the main motivation was to answer questions about radioactivity from potential users. Most of them were not surprised by the results, globally low. However, some specific points gave unexpected results, which highlighted the variability of results according to both the place of measurement and measurement protocols and the need for vigilance.

Despite the motivation of reassurance, the participants shared some doubts about the usefulness of sharing the results on a local scale. Reasons including avoiding risks of stigmatization of places in which evacuation orders were lifted and avoiding risks of conflict with local authorities. However, they all agree on two points. The first point is making measurement results available on-demand, and the second point is the agreement to publish these results at an international level. This later reason seems to be linked to the wish to show that the situation is comparable to other places in the world (the objective being reducing stigmatization).

From a radiation protection perspective, the main motivation remains concern about the presence of radioactivity in the environment or in foodstuffs and clearly relies on the vigilance principle. For instance, measurements made along the Fukushima Hamakaido Trail showed some places where ambient dose rates were surprisingly elevated. This was due to the proximity with a forest. These measurements, as well as those carried out as part of the "Kobito no Mori" project or along the Pacific coast at Suetsugi, clearly demonstrate that even 14 years after the Fukushima accident, citizen-led measurements are still relevant (Ando et al., 2026), even if the underlying questions are different from those arising in the first two years after the accident (Ando, 2016). This observation was also previously highlighted in a study carried out near the Chornobyl region in the late 2010s (Bertho et al., 2019), where citizen-led measurements in a Belarus village close to the exclusion zone highlighted three hotspots, due to ashes remaining from fireplaces. This study also highlighted the need for individuals to be vigilant, both as a means to evaluate radiological quality of the environment and also to reduce further environmental contamination if necessary.

4. Measurement as mediation to reality

Although Paul Ricœur, a well-known French philosopher of the 20th century, was more interested in the study of human behaviour than in the direct study of physical phenomena, his reflections on the concept of "mediation" provide an interesting perspective on the role of measurements in the co-expertise process. For Ricœur, our access to reality is always mediated by language, symbols, or instruments. Measurements implemented in the physical sciences, such as those of radiation in the radiological protection domain, are technical mediations that allow us to objectify the presence of radioactivity and communicate this reality of the world. Like narratives, measurements allow us to explain the reality that surrounds us. Generally, measurements transform subjective observations into objective ones, shareable, and verifiable, making phenomena understandable and open to debate. Indeed, Ricœur is comparing reality as a text to be interpreted and our access to reality is always mediated by language, symbols, or instruments. The measurements of radioactivity are technical mediations that allow us to objectify the presence of radioactivity and to communicate this reality of the world. In his work "The Conflict of Interpretations: Essays in Hermeneutics" (Ricœur, 1969), he distinguishes scientific objectification and practical judgment. Measurements serve the objectification of reality. They are legitimate and indispensable for explaining facts using a theoretical framework and models, but they say nothing about the views of the people involved and the meaning they attribute to these facts. Thus, in the field of science, they allow us to structure reality so that it can be interpreted according to common rules shared by scientists in a given field.

It is also important to remember that, for Ricœur, objectivity results from a collective process that makes it possible. This shared process is a constitutive element of confidence in the results and contributes to fostering confidence among the participants (Figure 4).

FIGURE 4. The midwife and the dosimetrist from the village of Olmany checking the quality of the milk in the presence of an interpreter from the ETHOS team during the ETHOS project (1996-2001) (photo J. Lochard).

However, regarding radiation protection, an additional dimension has to be taken into account — that the objective reality of the world is represented by a measurement of radioactivity (with a result in Becquerel, the unit for measuring this physical phenomenon). The presence of radioactivity in the environment can be judged as illegitimate on an individual basis, but is a representation of the physical, objective reality of the world to the whole community. This is in accordance with the concept of interpretation of reality. For Ricœur, objective reality is clearly a social construct, but it is also important to bear in mind that while measurements allow us to interpret a part of objective reality, they indicate absolutely nothing about what the people involved in the measurement evaluate as an acceptable risk for themselves.

The expert thinks about comparing the results with the applicable standards, and the resident wonders about the presence of radioactivity and its impact on their grandchildren. These intimate personal experiences are only accessible through the social sciences. In short, for Ricœur, measurements are mediations that make reality accessible and require interpretation through collective conventions within the rationality of society. In conclusion, one could say that measurements of radioactivity allow us to objectify a part of reality. They are a very useful medium for acting on this reality and also for talking about it, embarking other dimensions to grasp their full meaning (see box 1).

Box 1. Belarus farmer and his potatoes

During a visit to a potato field belonging to a Belarusian farmer, who had come to check if they were ready for harvest, he pulled on a stem to retrieve one. He first cleaned it by hand to remove the soil, then took out a folding penknife that he never left behind and, with a steady hand, cut the vegetables in half. He then brought one half to his nose to smell it and, turning towards the field, declared with conviction: "it's perfect. I'll come back tomorrow for the harvest with the whole family". Then, looking around him, he added a little later, somewhat sadly, "and to think the potatoes might be 90 becquerels like last time"!

It was once he returned to the village, after measuring the potatoes, which turn out to be only 30 becquerels per kilo, and after a dialogue with the family and a radiation protection professional, that the farmer was able to combine the quality of his potatoes with the measurement result. He finally decided that part of the harvest would be for the family's own consumption and the rest would be sold at the market.

Concluding remarks

Since the Fukushima accident, the ICRP has reaffirmed its recommendation to support citizen initiatives aimed at regaining control of the radiological situation after a nuclear accident, by promoting the implementation of an inclusive co-expertise process involving radiation protection authorities, experts, NGOs, and local communities (ICRP, 2020). This approach has already been implemented after the Chornobyl accident, notably during the ETHOS project. The availability of user-friendly sensors after the Fukushima accident enabled the rapid development of citizen-led environmental radioactivity monitoring around the world. As a result, the amount of publicly accessible data has increased considerably and now feeds into ambient dose rate monitoring networks. These measures can be used to inform the general public about radioactivity, but also to strengthen preparedness for nuclear accidents. For younger generations, this is a way to confront the memory of the Chornobyl and Fukushima accidents and to understand that radioactivity measurements taken by residents of contaminated areas are essential for fostering dialogue between the public, experts, and government representatives in order to manage the radiological, social, economic, and environmental consequences of such accidents. By learning that these measurements are indispensable for enabling residents to develop a culture of radiation protection and to participate in radiation protection strategies, they will certainly be better prepared should they one day encounter radioactivity in their daily environment.

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