Nonscalability of ‘citizen science’ in post-Fukushima Japan: Unpacking articulations of Citizen Radiation Measuring Organizations (Accepted version)

Abstract

This article explores and discusses understandings of citizen science with members of Japanese Citizen Radiation Measuring Organizations (CRMOs) who began measuring radioactive contamination in food, soil, air, and human bodies after the 2011 Fukushima nuclear accident. Building on in-depth interviews with CRMO members and extensive multi-site fieldwork (2018, 2020), the article takes *shimin kagaku* (citizen science in Japanese) to examine articulations of citizenship and science, while discussing CRMO activities. Adopting Tsing’s notion of nonscalability, it draws attention to the manifold articulations of citizenship and science, unearthing frictions embedded in Japanese science-society relations. In this way, this paper outlines the diversity of notions of citizenship and science, and of citizen participatory practices in science. By bringing nonscalability to bear on an analysis of different articulations of *shimin kagaku*, this paper encourages scientists and public authorities to engage with citizen participatory practices reflexively and responsibly by considering local articulations and knowledges.

Keywords: Citizen science, Citizen Radiation Measuring Organization (CRMO), Fukushima, nonscalability, *shimin kagaku*

Introduction

Stepping into a radiation detection and measurement lab in Tokyo, Tanakaⁱ, a middle-aged woman, welcomes us in. On a table, next to a microscope, samples of urine collected from children in Iwaki (Fukushima prefecture) await testing for ionizing radiation. Tanaka’s lab belongs to a web of independent citizen radiation measuring organizations (*shimin hōshanō sokutei jo*) or CRMOs, set up in the wake of the 2011 Fukushima nuclear accident (Kimura, 2016; Morita et al., 2013). These organizations act as “field hospitals” (Interview with CRMO member, Iwaki, 2018, authors’ translation), supplying citizens with hands-on information and means to monitor radiation in the environment and humans. In the past, nuclear incidents and accidents have prompted Japanese citizens, such as Tanaka, to take measurement equipment to hand (Hasegawa, 2004). Tanaka’s commitment to radiation monitoring dates back to the 1990s, when she became involved in a citizen organization in Koganei city, which emerged in the

response to public demand to measure radiation after the Chernobyl accident (interview with Tanaka, Tokyo, 2018). Yet, the boom of citizen labs after Fukushima has been unprecedented, benefitting from scientific and technological developments, and the increasing accessibility of radiation monitoring to non-experts (Haklay, 2013).

In Japan, citizen engagement with science and technology transcends radiation monitoring; it is observed in environmental protection, public health and community planning, amongst other fields (Kenens, 2020). These engagements build on a long tradition of citizen participatory practices in science that have at times tested the relationship between science, technology and society by critically questioning the tightly knit structures between policy, science and economic development (Nakayama, 1991; Fujigaki, 2015). Public controversies, such as with Minamata disease (caused by severe mercury poisoning from industrial activity) in the 1950-1960s, gave rise to grassroots citizen movements seeking to safeguard the environment against various forms of pollution (Takagi, 1999; Avenell, 2010). In recent years, citizen participation in science has only grown. Concepts such as citizen science have found their way into Japanese policy discourse (Cabinet Office 2016), even though these references are scattered and generally signal top-down citizen engagement initiated by institutions or science professionals (Kenens et al., 2020).

Civic engagement with science and technology in Japan is bound up with global sociotechnical trends and economic developments, such as the rapid emergence of the internet and the distribution of modern crowd-sourcing technologies and new forms of digital participation. These and related trends are described in scholarly literatures on participatory science practices (Irwin, 1995, Bonney et al. 2009, Cooper, 2016; Russell, 2014; Hannibal, 2016; Curtis, 2018, Eitzel et al., 2017;). Some of these inquiries draw attention to how cultural differences help shape civic engagements with science and technology and how citizen participatory concepts and practices are being translated and calibrated in various habitats (Riesch and Potter, 2013; Eitzel et al., 2017, Strasser et al., 2018; Pritchard et al., 2017; Kenens et al., 2020; Weingart and Meyer, 2021). They indicate that many modes of civic engagement are now emerging under various designations: *participatory science*, *crowd science*, *community science*, *civic science* and *citizen science*, among others (Kasperowski and Kullenberg, 2016).

Acknowledging the vast array of citizen science forms and emergent participatory practices, this article explores through interviews and participant observations how members of fourteen Japanese CRMOs articulate citizen science or *shimin kagaku* (SK) – the conventional term for

citizen science in Japanese.ⁱⁱ The concept of articulation here is derived from the field of cultural studies (Clarke, 2015) and of environmental politics (Tsing, 1999). It entails the expression and exploration of different cultural meanings and interpretations of words, statements, and discourses, none of which are predetermined, absolute and essential for all time, but which define reality temporarily (Clarke, 2015, p. 278). In this theorization, cultural relationships are not fixed but emanate through conversation, negotiation, imposition, resistance, etc. As argued by Stuart Hall, among others, a theory of articulation urges one to consider what is being uttered or spoken *in situ* in relation to other signifiers and relative to the specific conditions which make language intelligible and which construct social meaning (Ibid.). Thus, our aim is not to generate a core definition of the concept of SK, a typology of Japanese citizen science, or even an enumeration of local understandings. Instead, we highlight the diversity of local readings of SK relative to the practices of Japanese CRMOs and the communities within which these organizations emerge. To gauge these articulations within their societal and historical context, we build on the work of Anna Tsing (2012, 2017), specifically her notion of nonscalability.

In her book “The Mushroom at the End of the World”, Tsing explores the world of the *matsutake* by situating the mushroom within the landscapes it grows and within the capitalist market it helps to sustain. By examining the network that runs under- and aboveground through a historical, socio-economic lens, she illustrates the situated, transformative relationships that are formed between the mushroom, the environment and human activity. To foreground the multiplicity of these relationships, she adopts the concept of nonscalability. By juxtaposing this concept with scalability, understood as expansion “without changing the framework of knowledge or action” (2012, p.509), Tsing accentuates the intricate entanglements which constitute and inform ways of being. Employing Tsing’s theory of nonscalability, researchers in the field of anthropology and STS (see for example Warin & Martin. 2018, O’Connor 2020, Yoshida 2020) have explored heterogeneity and examined practices of scaling in various contexts, including linguistics, technoscience and ecologies.

Nonscalability in this paper is used as a sensitizing concept (van den Hoonaard, 1996, Flemmen 2017) to relate SK within situated practices of Japanese CRMOs. We highlight “diversity-in-the-making” (Tsing, 2012), as citizens engage with radiation monitoring after Fukushima in distinct ways, and ground SK within a specific cultural and historic context (Kenens et al., 2020). This thick, contextually rich inquiry enables us to point to different scales at work, recognizing the continuity and linkages between present and earlier manifestations of civil society in Japan (including anti-nuclear activism and environmental justice movements in the

1960s, 70s and 80s), and acknowledging the existence of multiple enactments, or a “fractiverse” of disconnected and partially overlapping realities that link forms of citizen(ship) and science (Law, 2015).

These ideas will be discussed by first highlighting CRMO members’ articulations of citizenship before moving to articulations of science. In this way, the paper draws critical attention to the mosaic of “frictions” (Tsing, 2005) and overlaps between citizen participatory concepts and the practices of CRMO on the one hand, and between citizens, Japanese governmental, and scientific practices on the other. It invites researchers and policy makers to tend to these discrepancies when considering public engagement in science; a point to which we return below.

Methodology

This study draws on interviews and fieldwork conducted at CRMOs in Japan in February-March, November- December 2018 and January-February 2020.ⁱⁱⁱ The first author engaged in participatory and non-participatory observation at each CRMO and conducted fourteen semi-structured interviews with 26 members and one city official in Koganei city. The fieldwork sites were selected based on spatial distribution (Fukushima prefecture, Miyagi Prefecture, Tochigi Prefecture, Nagoya, Kyoto and Tokyo) and temporal dimension (initiated in 1970s, or following the Fukushima or Chernobyl nuclear accidents). While distinct, the sites also share important features: all the selected labs are initiated and managed by citizens; and measuring ionizing radiation is at the heart of each organization.

Based on these criteria, participants were recruited with help from Japanese contact persons and via snowball sampling. The interviews were complemented with field notes and literature research. When designing the interview protocol for interviews with CRMOs, the first author included the following questions to gain insight into the use and articulation of citizen science among CRMO members: What does citizen science (*shimin kagaku*) mean to you (*imi*)? , and Do you consider yourself a citizen scientist (*shimin kagakusha*)?

The following paragraphs will explore the results of this inquiry, while pointing to the personal, historical and societal context in which articulations of SK emerge. These articulations are examined by first discussing citizenship and then science in relationship to citizen science. Next,

articulations of citizenship and science are rejoined to discuss science-society relationships in Japan, in order to explore nonscalable articulations of SK in Japan.

Exploring articulations of *shimin kagaku* (SK)

‘*Shimin*’: ‘citizen’ and ‘citizenship’ in SK

On the outskirts of Nagoya, visitors are welcomed into a small building, located next to a church. Only a wooden sign reveals what is hidden inside: a CRMO. Saito, a founding member, explains how he and other residents made sure the lab area is earthquake proof, as he jokes that the whole building, except for this room, will probably collapse should an earthquake strike. Saito spent his career as a scientist, collecting datasets to expose environmental pollution across East Asia. He also joined the left-wing student protests in the 1960s, directed against the US-Japan Mutual Security Treaty. In the presence of other members of the Nagoya group Saito shares his views on SK:

“[...] I was an expert and did not do science together with citizens at that time. But I understood that [citizen science] was more about research that benefits citizens. It’s about fighting with the government, against the government. This is also citizen science (shimin kagaku). Thus there are many kinds [of citizen science]. I myself, I have been a scientist so far, and I’ve earned a wage in the field of science and technology. For me, working for citizens means making my [scientific] skills useful to the public as I’ve always tried to do myself. So, I am on the same track of ‘for the citizen’.” (Nagoya, 2018, authors’ translation)

While Saito explains, the other members listen, nodding in agreement: there is not one citizen science; it can take many forms of which many are valid. For Saito, SK informs his involvement as a citizen scientist in the Nagoya CRMO, thus enabling him to connect his experiences and knowledge with his current activities. By bringing his past to the table, Saito evokes the early days of SK, which entered the Japanese lexicon as “a science for citizens” (*shimin no tame no kagaku*) (Takagi, 1999) through the work of Takagi Jinzaburo, an antinuclear Japanese activist. Inspired by the rise of science shops in the Netherlands and Western citizen science movements (Von Hippel, 1991), Takagi, introduced SK as a way to criticize the close interweaving of science, industry and government (Kenens et al. 2020). His Citizen’s Nuclear Information

Center (CNIC) is one of the pioneers of citizen science in Japan and continues to adhere to Takagi's philosophy of SK. In an interview, a member of the CNIC shares his view on SK:

“Thus, I guess you could say from the position of a citizen, the scientist will, how to say it, will use science as a weapon (buki) to the benefit of the citizen.” (Tokyo, 2018, authors' translation)

Through the two narrations above, citizen-driven efforts in the West to “open up” scientific knowledge production to a lay public (Irwin, 1995; Science for the People, sd) connect with expectations among Japanese researchers to democratize science. Hence, these articulations illustrate how experiences and backgrounds of CRMO members instruct and link CRMOs to other citizen movements and to past and present efforts to democratize science.

Whereas Saito and the CNIC member use the term SK to account for their activities, other CRMO members are less inclined, reluctant, or even opposed to, using this term at all. “Frictions” (Tsing, 2005) exist among CRMO members as to what exactly is being done at CRMOs, as evidenced by contending understandings of the notion of citizenship, for instance. CRMO members recurrently dispute these and other terms, such as ‘antinuclear’, ‘citizen’ and ‘science’, laying bare larger fault lines and cleavages within Japanese society. The following excerpt from an interview with CRMO member Yamada illustrates this point:

“In Japan, it [citizen science] doesn't really have a good image. It's been thought of as people who only protest, it's not that positive, it's negative. And not really seen as constructive. In other words, it's seen as people who like to protest.” (Yamada, Tokyo, 2018)

In Japan, the notion ‘citizen’ (*shimin*) continues to feed articulations of citizenship as an unruly, anti-governmental practice, rooted in the uprisings of citizen activists in the 1970s. Because SK conjures up this particular form of activist citizenship, *shimin* can be at times a disabling factor towards the development of a more depoliticized reading of SK in Japan (Avenell, 2010; Author, 2020a, Abe, 2015).

In practices of rejection and appropriation, this politically charged notion of *shimin* is reproduced in the field. While sitting in a CRMO meeting room in Aizu Wakamatsu, members recount their weekly antinuclear protests; yet in a car driving back to the train station in Sendai, a local CRMO member firmly states to have no business with antinuclear activism, cautious

not to draw negative attention upon himself and his organization. In Tokyo, a CRMO member calmly prepares newsletters that call for a moratorium of nuclear power plants, undisturbed by the interview happening across the table between a researcher and the CRMO leader. At a CRMO in Koganei city, Iwamoto, who helped set up the organization in the 1990s after the Chernobyl accident, evokes memories through pictures: female members stand shoulder to shoulder with antinuclear activists; banners propagating “No Nukes, No War” decorate their stall at a local market. Today, it is hard to notice these antinuclear associations, except for one hand drawn poster in the measuring lab (figure 1)^{iv}. Iwamoto laments that younger members no longer openly talk about antinuclear activism. Nevertheless, she understands the younger generation: their organization wants to be as inviting as possible and antinuclear activism can scare people away.

When Chernobyl caused Japanese citizens, like Iwamoto, to start monitoring ionizing radiation, citizens devoted great attention to foreign products imported from Europe such as blueberry jam (Hasegawa, 2004; Tokyo Gakugei University Center for the Research and Support of Educational Practice, 2016). In 2011 their interest has shifted. This change becomes tangible when comparing the contents of a newsletter sent out by the Koganei CRMO. While page 2 of their newsletter in August 2010 narrates “The story of blueberries”, page 2 of October 2011 features a letter recounting the ever-increasing number of food samples from Japanese soil and number of visitors wanting to learn how to measure radiation (id.). Unable to attain the

Figure 1 A hand-drawn poster hangs in the measurement lab of the Koganei CRMO. The poster titles “The radiation that surrounds us: natural occurring radiation is dangerous, manmade radiation is even more dangerous” (picture taken by first author).

necessary data and information from institutionalized science and authorities, citizens felt compelled to measure themselves (Morita et al., 2013, Morris-Suzuki, 2014). Thus, the Koganei CRMO saw its scope shifting: the problem no longer emanated from abroad, but domestically, affecting not only food products, but entire livelihoods.

During a first encounter, Suzuki, a former beauty specialist and mother, describes how she was first hired to insert numbers into a computer, but soon learned to measure ionizing radiation herself. She explains that the data measured by her organization is directed neither against the government, nor against professional scientists. It exists because what she wants to know is “[...] *how can I get the data that tells me about my child, my family, my body.*” (Interview with Suzuki, Iwaki, 2018, authors’ translation). From Suzuki’s experience, SK is a science that “*directly taps*” (*chokketsu*) into daily life (Id.). Connecting the citizen to the production of situated knowledge (Haraway, 1988), Suzuki’s understanding suggests an idea of citizenship not rooted in activism. Takeyama, a male CRMO member, active in Fukushima city, echoes this notion of multiple co-existing datasets, while comparing governmental and citizen data:

“You can trust this data [governmental data]. After all, these are scientifically correct data. However, when you prioritize politics, then you will present these data. But if you take the most strict data for the sake of the children, then your perspective changes. [. . .] Since I am just a parent, I think it is best for me to think this way [protecting children]. It is the government’s job to protect the city, so if it [the government] chooses this [strictest data] then everyone will be evacuated. If it [the government] does this, then the entire Fukushima prefecture will be gone. This of course cannot happen. So the government chooses this [political perspective]. [. . .]. When thinking for what side we work, as citizens, we work for the weakest people, because if the weakest people find it easy to live, then everyone else will also find it easy to live..” (Fukushima, 2018, authors’ translation)

Takeyama, like Suzuki, does not devalue government and scientific institutions’ data, but locates their value outside his field of interest. Measuring radiation is thus not solely a scientific act: there are different ways of doing science and interpreting its outcomes (Wynne, 2016; Epstein, 1996). Central to Takeyama and Suzuki’s understandings is the question where the citizen is located within radiation measurement and data. Placing the citizen at the start and finish of measurement activities, CRMOs endeavor to attune science to citizens’ demands and needs. This entails for example measuring at walking speed “*so it is perfect for measuring the walking course to school or to work*”, as a brochure created by a Fukushima CRMO narrates

(see also figure 2). It also brings about and facilitates the transformation of abstract figures and numbers to actionable data (Morita et al., 2013) not shying away to search for alternative, more suitable approaches and means, including informative comics (figure 2) and online maps (see for example the Safecast website).

Figure 2 An organization in Fukushima published a brochure to explain their activities and measurement method (picture taken by first author).

SK also takes on a new connotation, namely that of a socially driven science, aiming to provide useful data and information to citizens and their communities. At the same time, it offsets citizen-oriented forms of science from institutionalized science, which largely failed to accommodate citizens' demands (Morita et al., 2013):

“The part [of citizen science] that concerns science for the citizen is definitely strong, after all the information coming from the government is very limited and whenever they provide lots of information, it is hard to understand. It’s like we are going against the poor access to information, low transparency, and we are trying to provide information that is as comprehensible as possible, we try to match to needs of each individual, and we try to provide information that is actually useful in our lives. We have come a long way to improve the way we provide information, visualizing the info, and [...], providing a kind of counseling, that is essentially ‘for the citizen’.” (Tokyo, 2018, authors’ translation)

To what kind of citizen does this member allude? Are these citizens (*shimin*) or residents (*jūmin*) (Hasegawa, 2004)? Do these citizens live in the present or the future? A brochure picked up at the Tokyo CRMO mentioned above, partially addresses these questions: “To measure, to know, to live (*kurasu*) What we can do to protect children from radiation” (Hattori, 2016). The Minna no Data Site map (2018), contains a similar message, forecasting levels of soil contamination in 17 Japanese prefectures Japan for the near and distant future (2021, 2031, 2041, 2111). These documents illustrate how the notion ‘for the citizen’ may exceed the local and present by asserting the lingering presence of nuclear debris in time and space. Consequently, the need to monitor radiation continues. At the same time, this need contradicts claims that the nuclear accident is settled, as made by the Japanese government, indicating diverging experiences and senses of when the nuclear accident is over (Morris-Suzuki, 2014).

Ideas on the future may also require a different type of citizenship, as a member of Safecast, an international CRMO, demonstrates:

“You know the internet of things, is kind of a big part we’re doing [...], but it is going to be increasingly possible for people to collect information and radiation, you know, environmental reading or radiation readings in a very very passive way. Simply by having a device or having a sensor with them that they don’t even have to pay attention to.” (Tokyo, 2018)

With the help of an international group of volunteers and their compact bGeigie counter (Brown et al., 2016), Safecast has managed to establish the largest presence online, despite occupying the smallest physical space among the researched CRMOs. The above quote highlights how different understandings of citizenship inform a science *for* citizens in Japan. This quote does not only attest to different ontologies, but also to a broad “*spectrum*” of institutional and grassroots citizen science (Interview with CRMO member, Tokyo, 2018). Building on these points, the paper will next dive into notions of science and scientists.

‘Kagaku’: ‘scientists’ and ‘science’ in SK

In the preceding section, members of CRMOs expressed diverging visions and aims of science, often juxtaposing institutionalized science with SK and the activities developed at CRMOs. As a member active in Tokyo explains his understanding of SK, he touches upon his vision of *kagaku*, or science in Japanese:

“When it comes to citizen science (shimin kagaku), then the anticipation of science (kagaku) also comes into play. Science in today’s society is considered very important, as something right, as something of value. Because it [citizen science] has this dimension, it becomes zero in total, as ‘citizen movement’ drags it down, and ‘science’ brings it back up.” (Tokyo, 2018, authors’ translation)

By placing the concepts of science and citizen in the same equation, this member demonstrates how these two concepts can balance each other out, referring to ‘citizen’ as negative (see previous section) and science as positive. From this zero-sum game, a conflict inherent in SK arises, as science translates as something of value and right, and stands in opposition to citizen, which is perceived as negative and disruptive. How do CRMOs tend to these tensions?

For the majority of CRMO members not trained in physics or chemistry, the past decade has proven to be a steep learning curve in new fields of expertise. However, during our fieldwork, farmers, parents, former English teachers and beauty specialists begin the tour of their CRMO by instructing us how to operate devices and how to read data and graphs. In their learning process, CRMOs maintained diverse relations with professional scientists (Kenens et al., 2020). To support their activities, the group in Iwaki for example relies on a consulting group of five experts, from various backgrounds. One of the consulting experts, Sakurai, a dosimetry expert, invited us to accompany her during a visit to the organization. While we are shown a book recently published by the lab, entitled “How to measure strontium 90”, explained with the help of Professor Rabbit (*Usagi sensei*), Sakurai sits down with lab members, checking their measurements and answering their questions.

After Iwaki, Sakurai travelled with us to Aizu Wakamatsu. As we start our descent on foot from the station to the local CMRO, she pulls out her hotspot finder^v to start measuring. The next day, she sets out to participate in an event organized by Fukushima Prefecture, “Fukushima interior $\triangleleft$ exterior discussion” (*fukushima uchi<>soto discussion*, 1/02/2020). Then she returns to Nagoya, where she is associated to a university and to the local CRMO. Sakurai is not the only professional scientist we encountered during fieldwork. In Aizu Wakamatsu, the first author met and interviewed doctor Komada, who assists the local CRMO offering consultations on any concern (mental or physical) related to the Fukushima accident. Yamamoto, the representative of the CRMO in Aizu Wakamatsu, explains the importance of citizen scientists (*shimin kagakusha*) like doctor Komada:

“Well, it’s maybe also a certain way of going against those persons in power, or certainly a way to negotiate with those in power. Science will certainly be necessary to negotiate on how to form society for the next generation. However, when considering what is most important to science, we often say that there are two different languages; a language of scientists and a language of ordinary citizens as living people. The scientists do not possess the words of the ordinary citizens. So, they keep saying ‘It’s safe, it’s safe’. And the ordinary citizens only have their words, so they say ‘I’m afraid, I’m afraid’, ‘I’m anxious, I’m anxious’. So, we sometimes say that they’re incompatible. Yet there are people like doctor Komada, who while being a doctor, thus possessing the words of the scientist, also possess the words of ordinary citizens. These people [who have words of both sides] think about how to save our lives and that of the next generation as their top priority. [. . .]” (Aizu Wakamatsu, 2018, authors’ translation)

Yamamoto recalls how she desperately searched for a doctor, willing to listen to issues brought up by citizens. She recounts how doctors dismissed mothers without acknowledging their complaints. These experiences, like other popular notions including “damaging rumors” (*fuhyō higai*) and “radiation brain” (*hōsha-nō*, 放射脳) describe how governments, scientists, and others discarded the responses of mothers by framing these responses as irrational (Kimura, 2017). At the same time, they embody the inability of scientists to incorporate a citizen language and knowledges into what science should be.

During a group interview with eight CRMO members in Nasu, similar mixed experiences with scientific experts quickly became a topic of discussion. Members unanimously express gratitude to a university professor who contributed to the CRMO’s creation and who triggered interest amongst the local population to start measuring. However, their tone changes, when discussing other scientists:

“I think we’re all thinking generally the same about scientists. A famous scholar has declared thyroid examinations of children as unnecessary, especially in our prefecture, and all other doctors in the local medical association follow him [without any discussion]. So, we cannot believe them at all.” (Nasu, 2018, author’s translation)

Over the years, this CRMO has changed. Young mothers have dropped out, leaving behind a group of older members to measure ionizing radiation to protect children. Many of these members have relocated to Nasu (a town in Tochigi prefecture close to the southern border with

Fukushima prefecture) to retire. One member explains how he chose Nasu after carefully considering the risk of volcanic eruptions, tsunamis and earthquakes. The risk of nuclear power plants crossed his mind, but he never imagined that a nuclear fallout could reach this far. Now, his property has lost its value. Other members experienced other losses, including that of a carefree retirement, cultivating and sharing vegetables with their children.

Like other citizens, the Fukushima accident urged these members to learn the “language of experts” (Interview with Yamamoto, Aizu Wakamatsu, 2018, author’s translation; Morris-Suzuki, 2014; Perko, 2016) to make visible the infringement in their livelihoods. Despite the catastrophic events preceding the creation of CRMOs, some members recognize the value of citizen participation in science, expressing confidence in citizens’ capabilities to produce scientifically solid data. Takeyama, active in Fukushima city, explains:

“I don’t know about that, I am just a parent. I am also not an expert (senmonka), but if I have to say what is important about citizen science (shimin kagaku), then it is that people, who are not experts, can come this far. Having the appropriate measuring equipment, knowing about radioactivity accurately, using [the equipment]. No matter who is measuring, the same numbers come out. That is important. Usually they say that it’s best to leave it to the experts, but when we did this accident [Fukushima] happened [. . .].” (Fukushima city, 2018, authors’ translation)

Takeyama lives alone in Fukushima city after evacuating his family to west Japan. Inspired by his daughter, a toddler at the time, Takeyama sought ways to measure at three different heights simultaneously, namely 10cm, 50cm and 1m (figure 3).^{vi} While we measure at a bus stop and a park, he explains how toddlers, unlike adults, experience the world from these heights, squatting down, sitting in a stroller and standing up. Over the years, Takeyama scoured streets and parks, using a pink stroller and hotspot finder to document radiation exposure of children.

Although Takeyama attaches value to citizen-generated data, he does not express whether SK parallels professional science. Apart from one CRMO member in Sendai, who proudly points to a certificate on the wall stating the successful completion of a radiation measuring course, other CRMO members express less confidence about identifying their involvement as scientific. Tanaka (see p.1) for example feels she does not qualify as a scientist, because *“I studied philosophy at university. So, I disliked science.”* (Tokyo, 2018, author’s translation). Another member, active in Nagoya, feels that *“I gained a lot of knowledge from citizen scientists (shimin*

Figure 3 Takeyama, a member of an organization in Fukushima demonstrates how he simultaneously measures at three different heights (picture taken by first author).

kagakusha) whom I can trust. [...], maybe after 100 years I might become a citizen scientist.” (Nagoya, 2018, authors’ translation). A member in Koganei, echoes these opinions:

“Interviewer: So in the end the citizen scientist (shimin kagakusha) is the scientist?”

Member: the scientist...like, it’s better that it’s a person who has a solid [knowledge] base. [...] It’s just my ideal picture. You know, the bar is set high. [laughs]” (Koganei, 2018, authors’ translation)

While the above quotes suggest conflicting SK identities centered on a perceived lack of expertise, other research participants hint at clashing roles. The following excerpt illustrates this point.

“There are also people, who stand in the same position as me [. . .], so that of a mother, but who collect data scientifically and write reports. Although there are also citizen scientific moms, I am more or less thinking about data and listening to everyone’s ideas from a psychological perspective. So not so much as a physics or a scientific mathematical problem, but a little more as, how should I put it . . . I know more about

things related to the mental state of mothers in society. I don't know whether you can call someone like me a scientist.” (Fukushima city, 2018, authors’ translation)

After witnessing the attention devoted to preparing samples and placing them in the measurement devices and after receiving explanation on measurement equipment, methods and results, it seems paradoxical that some members refrain from acknowledging their activities as scientific (Leblanc, 1999). Hamaya, a mother working in Aizu Wakamatsu, describes how she realized she strayed too far off towards professional science, after becoming too excited to measure radiation, unintentionally exposing herself to radiation in the process. After all, she explains only a few minutes after demonstrating each step of the measurement process of food samples, she is a mother, not a scientist. During the demonstration, she mentions the difficulties of working in a place not designed to function as a lab, but rather as a kitchen of a daycare center (figure 4). The samples too pose problems: sandy, fresh vegetables, kids’ clothing or socks covered in gravel from the playground. Though washed, they may still contain sand, jeopardizing the accuracy of scientific results. Yet, in the end, she reminds herself that despite these challenges her measurements tell her what she needs to know: “is it safe or not?” These encounters raise questions about what is being done at CRMOs: is it (citizen) science? Though

Figure 4 Measuring lab in Aizu Wakamatsu (picture taken by first author).

these questions may seem contradictory to pose while visiting citizen labs, they gauge the uneasy relationship between science and society in Japan (Gabrys et al., 2016). In the following section, we will examine this relationship in detail.

Turning scales: SK and CRMOs after Fukushima

By foregrounding articulations of SK, we have sought to explore a variety of meanings in context, remaining close to the experiences and perspectives of Japanese CRMO members (Tsing 2012, 2017). These articulations create a mosaic, composing a “spectrum” (Interview with CRMO member, Tokyo, 2018) of notions of *citizen participatory practices*, *science* and *citizenship*; narrating the lived experiences, values and knowledges of citizens (Tsing 2017, Haraway, 1988; Wynne, 2016). Thereby, the different ontologies in CRMOs attest to nonscalability of SK (Mol, 2013). By inquiring the multiple meanings of SK, mismatches between articulations recurrently surface. These “frictions” (Tsing, 2005) suggest that SK in Japan is caught up in a tense science-society relationship, whilst offering a lens through which to assess Japanese science and society after Fukushima. In the following paragraphs, we bring the notions of citizen and science back together to probe these science-society relationships.

When used as a lens, SK appears as a scale to weigh experiences and practices against values and knowledges (Morris-Suzuki, 2014); but also to express social distances between citizens, science and governance (Irwin, 1995). In the wake of the Fukushima nuclear accident, distance is a recurrent issue iterated by CRMO members (Morita et al., 2013; Kimura and Kinchy, 2019; Morris-Suzuki, 2014). On the one hand, distance manifests as a lack of closeness. In her study on the Japanese housewife, Leblanc (1999) alludes to the literal translation of close or *mijikana* in Japanese, meaning close (近) to the body (身), thus pertaining to issues of boundaries and of scale.^{vii} Likewise, CRMOs produce data and information that responds to issues “directly connected” (Interview with Hamaya, Iwaki, 2018, authors’ translation) to the individual experiences of the nuclear disaster (Kimura and Kinchi, 2019) and to one’s body, including foodstuffs, clothing and urine. The outcomes and knowledges of citizen groups, emphasizing accessibility and transparency, embody this descaling of (citizen) science, attuning to smaller scales than institutionalized science. On the other hand, distance is perceived as a problem of temporal and policy scales. By incorporating an outlook on ongoing and future consequences, CRMOs broaden the implications of their data, prolonging the scale the impact of the Fukushima nuclear accident is felt. This in turn generates discrepancies between the ways

citizens and the Japanese central government make sense of the nuclear accident, as our study illustrates (Kimura 2016).

The concept of SK does not always appear as an adequate answer to manage these distances. Some understandings of SK demonstrate how the concept at times appears as an inclusive form of science, while at others as a way of doing science in which citizens feel they cannot fully participate. Some CRMO members use the concept of SK to distinguish their practices and other citizen scientific practices from professional science. Thus, SK can be understood as an alternative science (Takagi, 1999) able to bridge the perceived distance between Japanese society and science.^{viii} SK is however not always able to do so; rather some articulations may conjure up anti-establishment connotations, thus reinforcing existing cleavages in Japanese society. Similarly, CRMO members argue that citizen science evokes expectations of professional science, requiring professional scientific qualifications and prompting rigid adherence to criteria of scientific rigor (Ottinger, 2010).

While SK builds on these connotations, it is at the same time woven into the experience and politics of the Fukushima nuclear accident. Here, the transformation of common household goods and places are indicative of reinterpretations of citizenship and science (Ottinger, 2010): kitchen cabinets and everyday objects, including plastic water bottles in colorful cardboard boxes, metal plates and foam boxes, are repurposed to become part of radiation measurement activities. Even those (few) CRMOs who have access to a lab dedicated to radiation monitoring, have attached stickers of nonprofit organizations on measuring equipment, reminding visitors how the organization came into being. As goods and places are transformed into CRMOs, they exemplify the intertwining between life before and after the accident. This in turn translates into rearticulating SK, representing a shift of what it means to be a citizen (Kennely 2009) and emphasizing practices of independence and self-help – or a “pragmatic citizen activism” (Avenell, 2010).

The above examinations lead to questions, including whether SK adequately addresses issues experienced by citizens. During an interview, Takeyama, a father active in Fukushima city, attends to these issues:

“Instead of citizen science (shimin kagaku), they should bring science closer to the side of the citizen. There is no need for the citizen to become a scientist; you should just lower the bar of science.” (Fukushima city, 2018, authors’ translation)

This remark should by no means be understood as a devaluation of a science *by* or *for* citizens; it urges a critical inquiry into the context and purpose of science, addressing persisting discrepancies between science, governance and Japanese society (Fujigaki, 2015). On a broader scale, this quote paraphrases conventional, mostly western renditions of citizen science (Fan & Chen, 2019). In order to recognize these scalable interpretations at work, we must do justice to the various ways of knowing and being of citizens involved in scientific activities. This in turn means to attend to nonscalable practices and concepts. They allow to foreground local ways of doing and to attend to sites of friction (Tsing, 2005) and of coordination (Mol, 2002; Law, 2015).

Conclusion

Drawing on interviews and participant observation, this article explores how members of Citizen Radiation Monitoring Organizations (CRMOs) in Japan articulate *shimin kagaku* (SK). It compares and contrasts these articulations with practices of CRMOs witnessed during fieldwork. The article presents these articulations as “nonscalable” (Tsing, 2012, 2017) to draw attention to the multitude of articulations related to citizen and science, and the context in which CRMOs develop. From these articulations, a “spectrum” (Interview with CRMO member, Tokyo, 2018) of understandings emerges, unearthing entanglements of SK and the Japanese political and social realities that have formed after the Fukushima Daiichi nuclear accident. Our analysis points out discrepancies between the experiences of CRMO members and Japanese government’s policy on crisis management and post-disaster recovery, and to physical and conceptual transformations of place and citizenship. It also hints at how different practices and understandings of science and citizenship inform the SK concept at times complicating a more widespread adoption of the term. In these ways, nonscalability generates a better insight into the heterogeneity of civic practices and engagements with science and identifies misapprehensions within CRMOs and amongst scientists and policymakers, which cloud the full spectrum and potential of SK and CRMO practices within Japanese society.

By illustrating how nonscalability foregrounds grassroots articulations of SK and sensitizes researchers and participants to meaningful diversity, this study contributes to academic literature on citizen participatory practices. Its observations can help to increase awareness of the multiplicity of grassroots and citizen participatory practices and in turn, encouraging scientists, public authorities and citizen science researchers to engage with citizen practices reflexively and responsibly, taking into account local interpretations, histories, and knowledges.

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ⁱ Pseudonyms are used to guarantee the anonymity of the participants in this research and the confidentiality of the data.

ⁱⁱ The prevalent term for citizen science in official policy discourse is “shichizun saiensu” (シチズンサイエンス). See e.g., the Fifth Science and Technology Master Plan (Cabinet Office, 2015).

ⁱⁱⁱ Ethical approval for this study was obtained from the Social and Societal Ethics Committee (SMEC) at KU Leuven, Belgium (case number: G- 2018 02 1110).

^{iv} All pictures in this article were taken by the first author.

^v A hotspot finder is a type of measurement instrument designed to detect hotspots, or places with higher levels of radiation. This Japanese device can be connected to a tablet for direct results and with GPS data.

^{vi} Another CRMO in Fukushima city employs this measuring method.

^{vii} *Mijikana* or closeness is not limited to a physical closeness, but should be understood in a broader sense. This is because *mi* or body in Japanese exceeds the physical body, encompassing notions of family, neighborhood and environment.

^{viii} This remark concurs with a national survey conducted by the Japanese government in 2010, where respondents were asked whether they perceive of a scientist or engineer as someone who stands close to them (*mijikana sonzai*), or as someone familiar (*shitashii*). 73.9 % (n=1916) disagreed with this statement. The scores were especially high amongst people between 20 and 40 years old (Cabinet Office, 2010).