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MEMORANDUM

A workshop on citizen science in radioactivity measurements: empowering Europeans for better environmental monitoring

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Abstract

A 1 d workshop on citizen science in radioactivity measurements was organised by the French nuclear safety and radiation protection authority (ASNR) in June 2025 in Brussels, gathering nuclear safety authority representatives, research institutes, citizen radiation measurement networks and civil society representatives. The aim was to provide an overview of currently existing citizen radioactivity measurements projects in Europe, their structures and their objectives. An exhibition of selected technical materials was arranged. Key objectives of the workshop included ensuring the sustainability of citizen initiatives and integrating citizen data into decision-making processes, with a particular focus on widening participation in Eastern Europe. Participants also discussed existing gaps and difficulties and explored potential future projects.

1. Introduction

Citizen measurements of radioactivity appeared first during the 1990s' in Belarus, in settlements close to the Chornobyl exclusion zone. The objective of these citizen measurements was to promote a practical radiation protection culture through the development of measurement projects aiming at answering the questions of inhabitants about their daily living environment (Lepicard *et al* 2001, Hériard-Dubreuil 2006). The primary benefit of such citizen measurements of radioactivity is that they render radioactivity visible. This provides people with the ability to check the presence and level of radioactivity in their environment, to self-evaluate their own risks and to self-implement protective actions. This results in the increased confidence in daily living conditions, which in turn helps decrease adverse health and psychosocial consequences in the aftermath of a nuclear accident (Lochard 2007).

Following the Fukushima Daiichi nuclear power plant (NPP) accident, several citizen initiatives rose rapidly to measure ambient radioactivity (Ando 2015). An important driver was a loss of confidence in national authorities (Ando 2015, Lemarchand 2016) together with the desire to understand the prevailing situation. Moreover, new tools emerged during this period, powered by the increasing availability of social networks and internet connectivity. Notably, interactive mapping of results and communication through social media resulted in large data sharing. In such a post-accidental situation, the citizen measurement of radioactivity appears as a tool for adversarial debates between the population and experts. However, the final aims remain the same, i.e. allowing everyone to self-evaluate their own risks and providing field data in real time. Based on these lessons, the international commission on radiological protection (ICRP) embedded in its recommendation the support of citizen initiatives of radioactivity measurements in post accidental situations (ICRP 2020). In France, the OpenRadiation project, planned since 2013 and officially launched in January 2017, was set up mainly as a tool for educational purposes about radioactivity and radiation risks (Bottollier-Depois *et al* 2017, 2019).

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More recently, the interest for environmental quality check especially around NPP and the rapidly evolving situation in Eastern Europe with the Russian-Ukrainian war prompted the appearance of new projects, such as OpenRed in Spain (https://ibercivis.es/en/openred-eng/), TDRM in Germany (https://tdrm.fiff.de/index.php/en/) and CITISTRA in Central Europe, in the context of the European partnership for radiation protection research (PIANOFORTE) (https://pianoforte-partnership.eu/citistra/). It is noteworthy that all these projects are rooted in territories where there is almost no radiological issue for now, apart from naturally occurring radioactive materials and legacy sites. As a result, it can be difficult for the public to gain interest in such checks. This limited interest is one of the challenges that citizen radiation measurement networks are facing in Europe which prompted a 1 d workshop to discuss this and other issues.

2. Program of the workshop

The workshop was organised on June 4th, 2025, in Brussels, at the Maison Irène et Frederic Joliot–Curie, the representative of French research institutes at the European commission. It was organised in two sessions, starting with the welcome addresses by G. Pina, commissioner of the french nuclear safety and radiation protection authority (ASNR) and D. Rossetti Di Valdalbero, Deputy Head of Unit for Euratom Research (fusion and fission) and DG Research and Innovation (DG RTD) at the European commission. The first session was dedicated to the presentation of several citizen science projects of environmental monitoring and was moderated by J. M. Bertho, the current coordinator of the OpenRadiation project and Y. Tomkiv, president of the SHARE European platform for social sciences and humanities in ionizing radiation research. After a 'hands-on' session during which several radiation measurement tools and associated pedagogic documents were presented, the afternoon was dedicated to two round tables, the first one debating how to ensure sustainability of citizen initiatives, and the second one on the integration of citizen data into decision-making processes[4].

3. An overview of current citizen radiation measurement initiatives in Europe

This session started with an overview of societal impacts of citizen measurements by Y. Tomkiv, describing the usefulness of these actions as a support to decision making and as a tool to aid communication of health risks, but also as trustworthy data against disinformation. The support to citizen initiatives of radioactivity measurement is a part of the recommendations of the EU-funded SHAMISEN project (Ohba *et al* 2021) to improve health surveillance and living conditions in the aftermath of a nuclear accident, fully responding to the ethical values of ICRP such as beneficence/non-malevolence, prudence, dignity, justice, equity and inclusiveness (ICRP 2018).

Nacho Sáez presented the OpenRed project (Spain), developed by the Ibercivis Foundation. The aim of this foundation is to develop citizen-based scientific projects in numerous fields, such as biodiversity and soil quality. Among those, the OpenRed project has two main objectives, promoting both a citizen network for measuring environmental gamma radiation in Spain and a citizen culture fostering radiological protection. The OpenRed project was developed in three phases, a state-of-the art analysis that allowed definition of the design of the infrastructure, then the deployment of this infrastructure, and community activities to improve the detectors and the interactive map. Today, OpenRed appears as an independent, citizen-based radioactivity measurement platform.

Maria Davidkova presented the CzechRad initiative, which originated in 2015 with measurement actions in schools using a Safecast detector. This action was pursued through different projects such as RAMESIS (https://starfos.tacr.cz/en/projekty/VI20152019028, 2015–2019), IMPAKT (https://starfos.tacr.cz/en/projekty/VJ01010116, 2021–2025) and CITISTRA (https://pianoforte-partnership.eu/citistra/, 2024–2027). CITISTRA is currently deploying a fleet of 300 detectors in the Czech Republic, Poland and Slovakia thus providing an environmental radioactivity monitoring network in these three countries. Current developments of the CITISTRA project are linked to the rapid evolution of the situation in Ukraine and fears of nuclear plant damage during war actions, focussing on the usefulness of citizen data during emergency or armed conflicts. This embark several ethical and safety issues for the users which were addressed through technical modifications of the detectors, such as automatic data saving to a memory card, delayed publication of the results and reinforcement of user's anonymity. Such modifications better protect the user from potential threats.

[4] All the presentations are available at www.maison-joliot-curie.eu/fr/events/65/citizen-science-in-radioactivity-measurement-empowering-europeans-for-better-environmental-monitoring.

Jean–Marc Bertho presented an overview of the OpenRadiation project with the focus on data accuracy:

- What is the reliability of detectors and measurement results? An intercomparison study was conducted with OpenRadiation and professional detectors. This study showed that measurement results with citizen detectors were of comparable quality as the ones obtained with professional detectors (IRSN 2019). This suggested that the main uncertainties in citizen measurement results are linked to the measurement protocols used by contributors, highlighting the need for information and training.
- What moderation for publication of measurement results should be used? For openradiation, the initial choice was to publish all the results, under the contributor's responsibility. This is essential to keep confidence of contributors but also supports an auto-moderation of the results. Nevertheless, OpenRadiation operates with a threshold value, above which a procedure of inquiry and search for explanation is triggered, and a comment is posted with the explanation. OpenRadiation sees this as an excellent way to interact with the project's contributors, empower them on measurement quality and responsibility linked to result publication, thanks to direct and lively contacts with radiological protection and dosimetry experts.

The current activities of OpenRadiation aim at developing the use of citizen data as a research tool in various fields such as environmental monitoring, epidemiological studies and decision-making in emergency situations.

Peter Kammering presented the TDRM network measuring atmospheric radioactivity around the Tihange and Doel NPPs. Initially, the sensors were dedicated to record dose rate data, using a Geiger–Müller (GM) tube. However, it appeared rapidly that other atmospheric parameters should be registered, including meteorological data, atmospheric pollutants and other physical parameters (noise, pressure, etc). Such multiparametric sensor stations may be able to access information on meteorological conditions around NPPs, but also observations of atmospheric pollution, traffic loads etc. Thus, TDRM is developing an open, flexible, multi-sensor station, able to accept up to 16 flexible adapter cards to connect a set of commercially available sensor modules, which match a user`s query. One of the projects in course of development is to include in this station a spectrometer able to identify radioactive isotopes. The TDRM network provides an environmental monitoring network complementary to the expert networks around the two NPPs.

4. Identification of common features

This overview of citizen-based radioactivity measurements projects showed that they have several common features:

- The choice of the detection technology. The majority of the projects use GM tubes, some with variations in the geometry of the sensor. This technology is reliable and robust, allowing development of low-cost detectors. The use of GM tubes, provided they are tested before use, provide reliable measurement results, which is essential for citizen engagement and confidence. This is also important point for the financial accessibility of these detectors to citizen. However, not all the projects use GM tubes. Openred, from Fundacion Ibercivis, also uses commercially available devices that integrate a CsI (Tl) scintillator crystal. The work carried out at Openred includes the testing and characterization of several low-cost devices by the laboratories of Universitat Politècnica de Catalunya. This allowed the selection of devices affordable for the public with sufficient sensitivity and repeatability, adding the utility of being able to perform spectrometry to determine the isotopes responsible for the observed ambient dose rate.
- The development of pedagogic activities towards school and university students and awareness-raising actions towards the public, beside (and whatever is) the main objective of the projects. Education, especially among children, is vital to counter misinformation and build awareness of radiation as a natural phenomenon, and to create the next generation of informed participants and scientists. Engagement in pedagogic activities is also justified by the need for sustainable activities within these projects, beyond the objectives of an environmental monitoring network or a warning network.
- The usefulness of citizen measurements and their usability for other purposes is still being questioned, especially when the radiological issues are very limited or absent. Examples of citizen radioactivity measurement data use for scientific purposes are infrequent (Bertho *et al* 2019, Trompier *et al* 2024), while such uses are a strong factor of citizen engagement in other projects such as the ones linked to the natural sciences (Frigerio *et al* 2021).

5. Citizen radioactivity measurements: addressing challenges

This overview of European citizen-based project of radioactivity monitoring finally highlights two challenges: how to make these projects sustainable in the long term, and how to integrate citizen data into decision-making processes, either in environmental monitoring or in emergency situations. These two issues were explored during the two round tables.

5.1. Ensuring sustainability of citizen initiatives

Participants to the first round table were Malcolm de Butler (NTW), Christine Lajouanine (Planète Sciences), Marie Davidkova (SURO, representative of CzechRad), Meritxell Martell (Merience) and Dorte Riemenschneider (European Citizen Science Association ECSA) and was moderated by Y Tomkiv (NMBU).

The discussion highlighted that sustainability must be considered at multiple levels: citizen engagement, data preservation and project continuation. Moreover, citizen radiation measurement initiatives bring unique aspects of a strong risk communication component, due to public concern, negative imagination and high risks of misinformation.

Regarding citizen engagement, the motivation to participate is driven mainly by intrinsic factors (curiosity, personal interest and contribution to science), especially in adults, while younger people respond to extrinsic factors (meaning and recognition). In this context, gamification (with rewards) was found effective, especially with students (Martell 2025). Furthermore, community building and feedback loops on data use help to maintain engagement, since people wish to be part of something meaningful and recognized for that. In this regard, the best way to engage citizens is to co-create projects in which citizens are considered as partners instead of just data providers. Such co-construction is considered as the best model for citizen science and the most efficient (Houllier *et al* 2016), increasing project ownership and sustainability.

Data aspects are also crucial for sustainability. Apart from the reliability of detectors (as mentioned above), measurement data are:

- made with various protocols,
- associated with a variable set of metadata and
- stored in different formats using different tools.

Current radiation measurement initiatives remain fragmented, developing their own independent databases. Although this independence of each initiative helps to build citizen trust locally, data standardisation and data storage is increasingly becoming a priority subject, especially in a European context, where the population faces a variety of threats. Interoperability of data coming from different areas and different citizen science projects could become a paramount challenge in the near future. The workshop participants proposed to launch a reflection process about a standardised data format, potentially compatible with a shared platform, so that authorities can count on reliable and robust comparable datasets. Such a shared platform would ensure a long-term usability of datasets, thereby sustaining citizen-led initiatives of radioactivity measurements in the long term.

Furthermore, a crucial need for coordinated actions between the various European initiatives was identified. National radiation protection authorities consider citizen science data as potentially useful but ask for robust frameworks and validated protocols. Moreover, the proposal of a standardisation of data format in a shared platform calls for a strong coordination between the different initiatives. D. Riemenschneider, the ECSA representative, highlighted the potential value of exploring a coordinated approach, for example through a working group to coordinate citizen radioactivity measurement initiatives, as a first step forward. ECSA is currently working on the development of a concept for a citizen science research infrastructure, the RIECS-concept, aiming at addressing the challenges of fragmentation in the citizen science landscape across Europe (Soacha-Godoy *et al* 2025). This project might be beneficial and inspiring for citizen radiation measurement projects.

In summary, participants to the round table agreed that the sustainability of citizen-based initiatives requires:

- Tailored engagement strategies according to the targeted audiences.
- Community-building and co-creation with citizens.
- Clear feedback loops and recognition.

- Data and protocol standardisation for reliability and long-term use.
- Institutional support, coordination, and funding.

The first round table closed with a strong call for cooperation at European and international levels to ensure citizen science continues to thrive and contributes meaningfully to both research and public decision-making. This cooperation could start with the creation of a working group within ECSA dedicated to citizen science initiatives on radiation measurement.

5.2. Integrating citizen data into decision-making processes

Participants to the second round table were Azby Brown (Safecast), Peter Kammerling (TDRM/FIfF e.V.), Daniel Lisbona (Ibercivis), Teemu Siiskonen (STUK), Cornelia Bischoff (BfS), Geraldine Pina, (ASNR) and was moderated by J E Kruse, representative of the Pianoforte European partnership.

As underlined by participants, citizen data have a tremendous value that goes beyond making large datasets available to the community and research institutes. While citizen measurements may not show the same level of detail and precision than the ones from professional radiation experts who use a variety of measurement devices in a large array of configurations, they encourage public engagement and can complement official monitoring, especially if uncertainties are communicated transparently: 'no map without data' as stressed by a participant. Moreover, given the potential very large amount of data collected, citizen data can capture trends that are valuable for potential alerts. The inherent uncertainties of citizen data can be at least in part reduced through diffusion of recommended measurement protocols, highlighting the need for exchanges about measurement quality.

Another aspect is that citizen data can captures local specific situations often differently detected or overlooked by experts. For instance, citizen measurements may capture unusual local radiological situations, opening local debates about radiological safety in which different risk perceptions could emerge (Perko 2014). Similarly, the territory coverage of citizen-generated data, mainly centred around living places, is very different from that from the monitoring networks, usually centred on nuclear facilities. Regulators should be prepared to integrate such inputs in environmental monitoring in both normal situation or during emergencies. Since public confidence is also a key aspect of sound regulation, regulatory bodies cannot blind themselves from vast amounts of data arising from public measurements. Thus, authorities must be able to respond quickly either in normal situation or during emergency, even to uncertain or social media-driven information.

Citizen participation brings legitimacy and knowledge to the policy-making table, strengthening trust across society. However, this is accompanied by a collective responsibility of citizen radiation measurement initiatives to earn credibility through transparency and careful communication. As a whole, citizen participation enables an inclusive dialogue through inclusion of citizen measurement data in decision-making, a necessary condition to reach consensus.

In summary, participants to the round table agreed that the integration of citizen data into the decision-making process faces several challenges:

- Data quality and validation. Large citizen datasets are now available, at least at the European level. However, the need for reliable citizen datasets for decision-making is a strong requirement. This can be reached by citizen empowerment through quality protocols but also through specific analytical tools to apply to large citizen dataset developed by expert institutes. As stated by one participant, regulators should adapt tools and procedures to work with citizen data rather than expecting citizens to meet professional standards.
- Data use. In an accidental situation, data requirements will differ for emergency response, post-accidental phase and research activities. Precision requirement in an emergency can be lessened to favour territory coverage and a rapid evaluation of radiological risks. By contrast, the precision of the publicly available data is a strong requirement for either research activities or post-accident risk evaluation. This asks for some agility in data collection and use, to adapt to the situation at stake.
- Misinformation and fake news. Radioactivity measurement data inherently bring a political dimension and can be prone to contestation and manipulation, especially in a crisis period. This is particularly true given the rapid spread of information (and especially fake news) on social media, which conflicts with the inherent complexity of radioactivity measurements, including technical issues, measurement protocols variability and contextual information. This requires careful communication and framing.
- Coordination and integration. A main challenge is linked to integration of various initiatives with inconsistent data formats and sharing platforms and the lack of formal structures for collaborations. Current cooperations mainly depend on informal networks. With this regard, the ECSA proposal for a

working group for the coordination of citizen initiatives dedicated to radioactivity measurements should be taken into account.

6. Conclusion and perspectives

This workshop offered a unique opportunity to bring together authorities, research institutes, citizen networks and civil society actors to discuss the challenges associated with the growing importance of citizen-based radioactivity measurement data. These discussions highlighted the need from both sides to cooperate before the occurrence of a crisis. Such cooperation will foster democratic engagement, transparency and trust. In turn, efficiency of post-accident policies and resilience could be greatly enhanced.

Therefore, authorities are called to support citizen initiatives by offering guidance, interoperability, and preparatory dialogue. Additionally, long-term funding and infrastructure are crucial to sustain citizen measurement networks. Operators of citizen science initiatives should continue to develop education and awareness-raising actions. These are essential for sustaining citizen engagement in radiation monitoring, which deals with sensitive and political issues. Last but not least, there is a strong need for coordination and cooperation between citizen networks to exchange protocols, pedagogical tools, and experiences, but also to elaborate, together with expert institutes and authorities, common standards, shared platforms, and guidelines for measurement, interpretation, and communication. Such actions will undoubtedly foster confidence of authorities in including citizen data into decision-making processes, either for emergency management, for environmental monitoring or for research purposes.

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Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

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