Sharing Knowledge and Data About Groundwater in EU: The EIGR Metadata Inventory of the KINDRA Project

Marco Petitta, Balazs Bodo, Adrienn Cseko, Isabel Fernandez, Clint García Alibrandi, Mercedes Garcia Padilla, Eva Hartai, Klaus Hinsby, Viktoria Mikita, Peter Szucs, and Peter van der Keur

Abstract

Groundwater knowledge and research in the European Union is often scattered and non-standardised, because of different subjects involved and different approaches from member states. The Horizon 2020 project KINDRA has conducted an EU-wide assessment of existing groundwater-related practical and scientific knowledge based on a new Hydrogeological Research Classification System, identifying more than 280 keywords related to three main categories (namely operational actions, research topics and societal challenges) to be intersected in a 3D-diagram. The classification is supported by a Web service, the European Inventory of Groundwater Research, which acts not only as a knowledge repository but also as a tool to help identify relevant research topics, existing research trends and critical research challenges. The metadata included in the inventory at the end of the project are about 2300, and the analysis of the results is considered useful for producing synergies, implementing policies and optimising water management in Europe. Using the three-axes classification, occurrence and relationship of different topics in groundwater research have been highlighted. The EIGR inventory is a powerful and useful took for sharing information and data about groundwater issues following the FAIR principle, in agreement with an ethical approach.

Keywords

Groundwater framework directive • Inventory • European Union • Metadata • Classification

1 Introduction

Water is a key-topic in modern society, requiring several interconnections in research and in practical applications, as balancing human needs and environmental requirements, governing the water–food–energy–climate nexus, impacting the concepts of circular economy and smart cities, applying nature-based solutions, among others. Groundwater is the largest and most widely used resource for drinking water supply, globally, and is an important part of the hydrological cycle sustaining life on earth. The general understanding of the importance of groundwater is often low, even within related natural science disciplines partly because it is hidden below ground and the interactions with surface water are difficult to quantify. Nevertheless, groundwater role is frequently underestimated, and practical and scientific knowledge are scattered amongst various actors in Europe.

In this context, the mission of KINDRA (EC framework program H2020, Grant Agreement No. 642047) was to make groundwater visible by demonstrating its transdisciplinarity and importance to all the grand societal challenges of Horizon 2020 and EU water policies and by providing an overall view of the scientific knowledge that exists across Europe. This approach has also the aim to raise the awareness of citizens of science affecting their daily lives and, at the same time, will allow the correct management and policy development of groundwater at EU scale, as recommended

M. Petitta (✉)
Earth Sciences Department, Sapienza University, Rome, Italy
e-mail: marco.petitta@uniroma1.it

B. Bodo · A. Cseko
La Palma Research Center for Future Studies, Santa Cruz de La Palma, Spain

I. Fernandez · E. Hartai
European Federation of Geologists, Bruxelles, Belgium

C. G. Alibrandi · M. G. Padilla
Agencia de Medio Ambiente y Agua de Andalucia, Sevilla, Spain

E. Hartai · V. Mikita · P. Szucs
Faculty of Earth Science and Engineering, University of Miskolc, Miskolc-Egyetemvaros, Hungary

K. Hinsby · P. van der Keur
Geological Survey of Denmark and Greenland, Kobenhavn, Denmark

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also by the Blueprint Document (European Commission 2012). In addition, the project is based on the geoethical principle of sharing information and data to improve groundwater management and protection, providing a geodatabase (named EIGR) useful for geoscientists, stakeholders and users.

A dedicated groundwater research and knowledge classification system was developed to enable population of the new European Inventory of Groundwater Research (EIGR) with **F**indable, **A**ccessible, **I**nter-operable and **R**eusable metadata on groundwater research according to the "FAIR" principles (Wilkinson et al. 2016). The EIGR repository was filled by metadata by the useful support of the National Associations of Geologists throughout Europe, under the umbrella of the European Federation of Geologists. Collected metadata include both scientific resources, i.e. peer-reviewed literature as well as reports and other resources with little, uncertain or no peer review ("grey literature"). The latter category of resources includes a large number of data reports, maps and other relevant work published by, e.g. authorities, consultants and geological surveys, which contribute substantially to the knowledge pool, but which is often difficult to find (e.g. Lawrence et al. 2015).

In order to develop a database system for population with heterogeneous data resources and determine the degree of (peer) review and other types of quality assurance within the KINDRA project, keywords and categories have been identified to allow for an effective and useful classification according to the FAIR principles, i.e. with easy access to and reuse of the resources. This effort has enabled networking, mutual recognition, trust and visibility across the hydrogeology communities. At the same time, collected metadata, including scientific papers, research projects, articles and data, represent a concrete manifestation of Open Science (Fernandez et al. 2017). In this sense, KINDRA can be considered as a reference project in implementing Open Science which could be copied by other scientific areas.

The aim and the results obtained by the KINDRA project show a good fitting with the ethical and social requirements that geoethics indicates as indispensable for scientific research to transform in a real benefit for society (Peppoloni and Di Capua 2016; Bobrowsky et al. 2017; Peppoloni et al. 2019). Moreover, the methodological approach followed in this project is adherent with several geoethical values such as cooperation, respect for colleagues, openness to multidisciplinarity and sharing. Furthermore, it is evident the long-term usefulness of such a tool in the protection of groundwater that are considered as a resource and common good, not only at local but also global level (in this case relating to the European community).

2 Methods and Materials

The KINDRA project proposes a comprehensive approach with a new classification system (Van der Keur et al. 2018) specifically developed for groundwater field, tested and approved by the research community, the professional community in geology and the wider public at large. It is a multistep venture from a well-defined thematic categorisation to the complete roll-out as an open searchable service.

The classification starts from the definition of a keyword list, able to comprehend the different topics of groundwater research and at the same time to allow searching options among the database. To establish a common terminology and approach to carry out the analysis presented here, various academic, industrial and research classification schemes have been reviewed to create a hierarchical structure and a selected list of keywords from relevant EU directive documents. Notably, these documents include the Water Framework Directive (WFD, European Commission 2000), its daughter directive the Groundwater Directive (GWD, European Commission 2006) and the Blueprint to Protect Europe's Water Resources (BWR, European Commission 2012). Supplementary identification of relevant keywords and topics from the most important scientific journals publishing groundwater research has been performed. The combined final keyword list counts about 284 keywords to be considered in the classification system.

To compare and intersect research products in groundwater, the KINDRA project group categorised all groundwater research according to a 3D-approach, identifying three main categories (Petitta et al. 2015): (1) Horizon 2020 societal challenges (which represents the impact of groundwater in the society) (2) Operational actions (corresponding with the main activities of hydrogeologists and other groundwater scientists and practitioners) and (3) Research topics (resuming the interdisciplinary role of groundwater).

From the original seven societal challenges (SC) identified by H2020 European programme, five societal challenges relevant for groundwater have been selected: (1) Health; (2) Food; (3) Energy; (4) Climate, environment and resources; (5) Policy, innovation and society. The five main operational actions (OA) characterising the activity of geologists have been identified by the help of an end-user survey performed during the project, as follow: (1) Mapping, (2) Monitoring, (3) Modelling, (4) Water Supply, (5) Assessment and Management. The Research topics (RT) correspond to the higher number of keywords grouped into the main natural science disciplines: (1) Biology, (2) Chemistry, (3) Geography, (4) Geology, (5) Physics and Mathematics.

3 Results and Discussion

After definition of the classification system KINDRA European Inventory on Groundwater Research (EIGR), a tool for classifying information sources regarding Research and Knowledge product in Europe has been realised (Garcia Alibrandi 2018). The EIGR is a relevant new tool for mapping and analysis specifically of groundwater research and knowledge that range somewhere between the peer-reviewed research tools (Web of Science and Scopus) and other broader databases and tools such as Google Scholar, Mendeley and ResearchGate. The added value of EIGR is to provide direct access to important metadata about available groundwater research and knowledge publications including "grey literature", which has been classified according to a policy relevant classification system based on the grand societal challenges of the EU Horizon 2020 programme. The EIGR is a permanent resource, publicly still available at https://kindraproject.eu/eigr/ as open access searchable repository also after the end of the KINDRA project.

As stated above, the EIGR allows for the insertion of different information products (papers, technical reports, database, project, maps, guidance, books and proceedings, etc.). A fundamental novelty in KINDRA, respect with other existing scientific databases, is the inclusion of documents different from peer-reviewed papers. In fact, the inventory aims to consider not only the research products, but also the knowledge products, which includes national reports and documents and the grey literature in general.

For this reason, in the process of inserting information in the EIGR, users are guided to classify the uploaded information and distinguish between "research" and "knowledge" according to four different classes identified by the level of the performed quality assurance the uploaded work has received. The "research" classes include not only the papers in peer-reviewed journals (class 1) but also conference proceedings and books included in international scientific databases as Web of Science and Scopus (class 2). In the "knowledge" group, there are Class 3, including reports and information having a review, which act as a quality assurance (QA), as reports from national official organisations, and Class 4 which refers to reports, journals and newsletter with no certain quality assurance.

As KINDRA is most concerned to explore gaps within societal challenges, the approach of exploring resources at the intersection between research topics and operational actions for societal challenges is adopted. Clearly, in this project developed EIGR has a population which is much smaller compared to large scientific databases as Scopus (or Web of Science) and also contains mainly Class 3 and 4 information. However, inspecting and analysing EIGR data give insight in research topics and operational action, associated to groundwater management and operation, which is not available in the Scientific Scopus database, i.e. Class 3 + 4 resources.

Based on the data provided by the National Associations of EFG, the EIGR has been populated in the form of a Web service, with a total of more than 2300 records, most of them completely public available (2200 records). Remaining unpublished records inserted in the EIGR are about 130. These records cannot be published because they contain incomplete information and consequently are not useful for the gaps and trends analysis. Actually, it is mandatory when inserting records to specify the category and the overarching group of the classification system HRC-SYS; by this way, all records contain at least this information.

An in-depth analysis of the EIGR inserted information, crossing the three main categories is described in detail in Petitta et al. (2018).

4 Concluding Remarks

The performed analysis of the records inserted during the KINDRA project in the EIGR has demonstrated the advantages and the potential of the inventory and has led to recommendations for improvement and further development of the groundwater research and knowledge repository covering all relevant research disciplines. The EIGR database includes additional data and has significant advantages, benefits and added value compared to existing research databases, as follow:

- Easy access to metadata on research projects, reports, databases and maps without formalised peer review, produced at international and national scales, not easily available, which have been classified according to European Societal Challenges as defined in Horizon 2020;
- EIGR focuses exclusively on groundwater research and knowledge, increasing the precision and relevance of information retrieval conducted in the database;
- Access to a dedicated platform, integrating information on groundwater research and knowledge of relevance to the whole community of researchers and practitioners, extending across groundwater relevant disciplines and EU member states organisations and sectors to the benefit of all;
- Improvement of the overview of the vast amount of groundwater research, knowledge and data, especially within the non-peer-reviewed segment, conducted in Europe, making access to related studies easier and duplication of work less likely;
- Dynamical features, like adding new relevant keywords by users as they emerge in the future.

In terms of geoethical approach, both the aims and the obtained results of this project are promoting and applying geoethical values such as cooperation, respect for colleagues, openness to multidisciplinarity and sharing information and data. At the same time, the subject of groundwater protection and management has a dramatic relevance also from the societal point of view, requiring not only technical solutions, but common visions and widespread knowledge of scientific principles and practical solutions, as previewed by the KINDRA project.

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