Preface

Ethics are moral principles and values that govern the actions and decisions of an individual or group. Ethical behaviour comprises of honesty, trust, treating others fairly and loyally. Ethical perception may vary from person to person, among societies and countries. […] Choices based on the best obtainable detailed scientific information, guided by ethical considerations, offer the best hope to protect groundwater from depletion and pollution (Datta 2005).

Groundwater stored transiently in aquifers is, by far, the most abundant and widespread source of liquid freshwater on the planet (e.g. Shiklomanov 1998, Zektser and Everett 2004, Richts 2011). Its importance to societies is attested by the facts that worldwide about 50% of the public water supply, 40% of irrigation and 35% of industrial uses rely on groundwater. Rivers maintain a baseflow between sparse rainfall events in the basin because groundwater discharges invisibly and continuously to those water bodies that are often incorrectly considered as examples of surface waters originated by overland and run-off flows. Ecosystems dependent on groundwater constitute important repositories of biodiversity, areas of carbon sequestration and food production and have a significant role in local climate. Groundwater plays a determinant role in many engineering interactions with the subsurface, in seawater intrusion and in geothermal energy use, and a sink of energy needed for pumping water from underground. Groundwater is also an important part of climate change adaptation process and is often a solution for people without access to safe water. The quality of groundwater, natural of affected by pollution, has considerable impacts on human and crop health. Natural springs, besides being the most ancient direct access to groundwater, traditionally valued also by the quality of water, normal or mineral with attributes in health treatment, is also a symbol of purity that cultures and religions cherish and protect. However, when freshwater resources come forward, mostly rivers, lakes and artificial reservoirs are mentioned, forgetting groundwater that, by its nature, is a mostly hidden component of the water cycle. Gleetson et al. (2020) state an impressive thought: "holistically understanding, evaluating, and maintaining the water cycle's role for a resilient Earth System is extremely challenging and urgent in the Anthropocene, as the societal complexities interlock with the complex dynamics of the Earth System". In general, groundwater keeps being a disregarded subject by citizens, decision-makers and even scientists, other professionals and the citizens in some way related to water resources, ignoring its interlinkage and essential roles in the water cycle, the ecosystems and the functioning of society. Tortajada and Biswas (2017) highlighted a key issue focused on the quality of water as a human right and contributing to the balance of the ecosystems. Insufficient knowledge motivates a lack of proportional and responsible actions. This may be at the source of the threats to groundwater despite the importance of the economic, ecological, geological, health and cultural services it provides. As a consequence, and at their peculiar rhythms, the quantity and the quality of groundwater change due to intensive and inappropriate anthropogenic actions coupled to stresses coming from the natural dynamics of the Earth, climate change, population growth and patterning and health, economic development and also an insufficient investment in knowledge, public awareness, proper governance and management at all levels, from global to local. Meanwhile, there are aquifers that remain untapped in regions or periods of water scarcity. To raise global awareness about the roles played by the hidden groundwater, the UN-Water (2015) decided that "Groundwater: making the invisible visible" would be the theme

for the World Water Day 2022. This is a promising step forward, but probably insufficient because nothing really new will be added. This situation configures a case of "the tragedy of the commons" because to "look for solutions in the area of science and technology only, the result will be to worsen the situation" (Hardin 1968), whereby an effective step forward can only be addressed if coupled with a shift in the paradigm of integrated (in substance and values) water resources management in sustainable development.

Hydrogeology is an established geoscience that studies the occurrence, movement and quality of groundwater as a basis for understanding this essential natural resource as a component of the water cycle and in the society, providing the scientific support for the management of its diverse environmental and anthropogenic uses (Freeze and Cherry 1979).

Geoethics is an emerging scientific field that deals with the ethical, social and cultural implications of geosciences knowledge, research, practice, education and communication, and with the relevant social role and responsibility of geo-professionals in conducting their activities while interacting with the Earth systems (e.g. Wyss and Peppoloni 2015, Bohle 2015, Bobrowsky et al. 2017, Peppoloni and Di Capua 2017, 2018, Bohle 2019 and references therein), where groundwater is one of its undisputed important components. Besides, the landmark publications related to the geoethics through the languages of the world and sharing ethical principles through cultural diversity (Peppoloni 2015, 2018) are an inspirational backbone aiming the scientific and technical integrity and culturally diverse approaches.

The ancestral relationship between early human evolution, settlements and water includes, among others, groundwater as a human evolution driver, pile dwellings on lakes and use of canals associated with rivers, rainwater-harvesting systems, wells, aqueducts, water mines, springs, and underground cisterns (e.g., Wittfogel 1956, Pétrequin 1984, Tempelhoff et al. 2009, Angelakis et al. 2012, Chaminé et al. 2014, Cuthbert and Ashley 2014, Lugo-Enrich and Mejías 2017, Ollivier et al. 2018). The wide diversity, scale, significance and increasing magnitude of the interactions of anthropogenic behaviour with aquifers and groundwater, sets the dilemma of ecocentric versus anthropocentric visions aggravated by lack of explicit consideration of the cultural and religious visions (Ribeiro 2017), involves some degree of conflict of budgets, and also of values or interests, decisions and demands from the all agents involved, calling for action for a water ethos grounded in eco-sociocultural responsibility, security concerns, technical-scientific integrity and societal approach to a sustainable groundwater use and management. Those needs of a responsible water ethics perspective are highlighted, among others, by Llamas (1975), Leopold (1990), Custodio (2000), Soromenho-Marques (2003), Llamas (2004), Datta (2005), Arrojo-Agudo (2010), Braga et al. (2014), Ribeiro (2017) and Abrunhosa et al. (2018). In a recent interview, Dr. John Cherry highlighted some impressive thoughts related to the key role of the water in society: "To make groundwater more visible, we need to get people to ask more questions about water and groundwater in particular", and also "We need more curiosity about water in the educational system" (SW 2020). In addition, the solutions must be sustainable and ethically designed with nature (e.g. McHarg 1992; Chaminé 2015; Chaminé and Gómez-Gesteira 2019). In fact, that transdisciplinary approach is an amazing opportunity to contribute decisively to a path to the sustainability of the hydrological cycle that could lead to a better future for all life on Earth (Attenborough 2020).

This Joint Congress emerges from an agreement for cooperation signed on 5 April 2017 about common grounds by the IAH—International Association of Hydrogeologists and IAPG—International Association for Promoting Geoethics. Following its terms, the International Congress "Geoethics and Groundwater Management: Theory and Practice for a Sustainable Development" (GEOETH&GWM'20) aims for the first global approach on the vast subjects of geoethics in groundwater management and its recognized need of reflection for correct and prudent actions. GEOETH&GWM'20 convenes specialists, scholars and professionals of distinct fields of science, engineering, humanities, law and culture as well as educators, students and early career colleagues in some way related to groundwater. They met and interacted online in May 2020 during the most frightening times of COVID-19 and in global lockdown for the first specialized world forum for discussing theory and practice, sharing

values, knowledge, research, educational projects, best practices and strategies aiming at the responsible integrated management of groundwater resources for a resilient and sustainable future. In a world asking for answers, GEOETH&GWM'20 had the goal to stage-manage a courageous scientific and professional community that is capable of proposing synergetic scientific, cultural and practical answers to the complex problems affecting society in all its connections with groundwater.

This Joint IAH and IAPG Congress proposes to the scientific, the cultural community and the society stakeholders a moment of reflection and an opportunity for the foundation, in respect of their own deep roots, of a new logic resulting from the production of new transdisciplinary scientific and cultural added value on geoethics of groundwater. It is considered that there is a real potential of development of a new transdisciplinary geoscience capable to produce its developments and to feedback positively into the root contributor sciences through its autonomous progress and contributions to a better world in peace, justice and sustainability. This growing concept has been named hydrogeoethics by António Chambel and Manuel Abrunhosa, since 2017. Its field is soundly grounded in hydrogeology and geoethical principles, including the engineering, socio-economic, legal, environmental, arts and cultural dimensions.

To the former motto of the congress "Leaving No One Behind" (United Nations World Water Day 2019), and given the dramatic times brought by COVID-19 pandemic risking to stall the ongoing efforts of implementing the conference as it was conceived, and mainly the need in groundwater progress in science and protection, we added "The Science Must Go On" (Fig. 1). This was the geoethical commitment for the groundwater community, related water fields and society.

This book comprises the selected proceedings during the 1st Congress "Geoethics and Groundwater Management" (GEOETH&GWM'20), Porto, Portugal, 18–20 May 2020. The groundwater community involved in science, exploration, abstraction, use and management of this evermore essential natural resource is becoming more and more aware that ethical issues pervade all our attitudes from concept to action and need to be addressed coherently. Diverse values and cultures, science and education, law and policies, human and natural environments, the public and the economic sectors foresee groundwater and its values and/or roles differently. We believe that in a globalization intertwined world a common ground must be discussed and agreed for peace, human development and sustainability. A multidisciplinary Scientific Committee from the science, engineering, law, social sciences, natural philosophy, geoethics, environment fields assured the quality of the event and the current publication by earlier proposing themes. That aims for discussion in the conference and assuming the peer review process that addressed scientific, philosophical and legal approaches, analysis of case studies from around the world, management models or proposals, educational views, innovative transdisciplinary knowledge, research or projects on responsible groundwater management, including decision-making under uncertainty and in neglecting groundwater functioning.

In this volume were considered 6 major topics to correspond to the main fields of theory and practice regarding the global combination between groundwater in all possible conceptual dimensions and the geoethical approach (Fig. 2):

1. Fundamentals of hydrogeoethics: cultures, principles and geoethical values on groundwater science and engineering
2. Lessons for a resilient and sustainable future with hydrogeoethics: case studies of geoethics in groundwater science engineering, profession and management
3. Scientific and humanistic components of hydrogeoethics in groundwater education and professional training
4. Socio-hydrogeology and ethical groundwater management

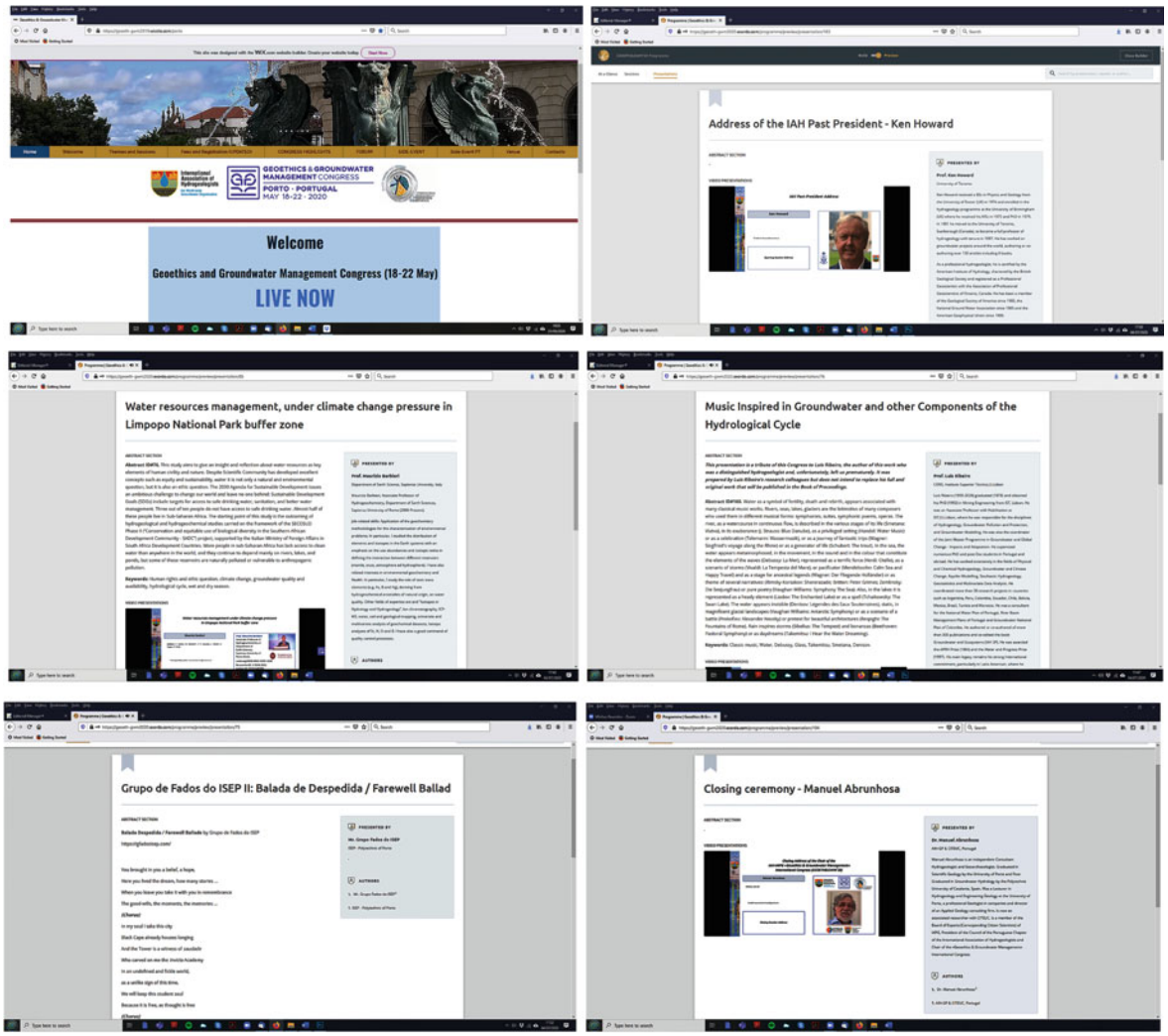

Fig. 1 Some key moments on the GEOETH&GWM'20 Online Congress: (i) when live in inauguration day, May 18; (ii) address of Ken Howard, IAH Past President; (iii) a keynote lecture; (iv) an oral presentation; (v) a musical moment by the "Grupo de Fados" from ISEP; (vi) closing ceremony by the chairman Manuel Abrunhosa

Fig. 2 Word cloud based on all abstracts of the special volume on "Advances in Geoethics and Groundwater Management: Theory and Practice for a Sustainable Development" (generated using http://www.wordle.net/)

5. Geoethics of decision-making under uncertainty and ethical issues in neglecting groundwater functioning
6. Groundwater: geological, legal, social and ethical challenges of a unique natural resource

The special volume has a core of 95 original proceedings grounded on the scientific sessions and 14 outstanding keynote lectures. The keynote speakers gave interesting insights from the philosophical principles in hydrogeoethics, to hydrological hazards focused on hydrogeomorphology and disasters, geotechnical hazards highlighting the role of groundwater, as well as landslide risks and flooding hazards and hydraulic design and the role of geoethics in groundwater modelling. The volume gathered over 227 authors of the academy, research centres, state laboratories or industry from 47 countries of all continents (Europe, Africa, America, Asia and Oceania).

The volume will be of interest to researchers and practitioners in the field of hydrogeology, hydrology, water resources management and groundwater engineering, as well as those engaged in earth sciences, environmental sciences, law, social sciences, natural philosophy, education and culture. Students, geoscientists, engineers, environmental lawyers, social scientists and water-related professionals beyond research in water, earth, environmental and social sciences will also find the book an inspirational and unique asset.

Porto, Portugal — Manuel Abrunhosa
Évora, Portugal — António Chambel
Rome, Italy — Silvia Peppoloni
Porto, Portugal — Helder I. Chaminé
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