Book of Abstracts

GEOETHICS & GROUNDWATER MANAGEMENT CONGRESS

PORTO · PORTUGAL

MAY 18-22 · 2020

Edited by M. Abrunhosa, A. Chambel, S. Peppoloni & H.I. Chaminé

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Book of Abstracts of the Geoethics & Groundwater Management Congress

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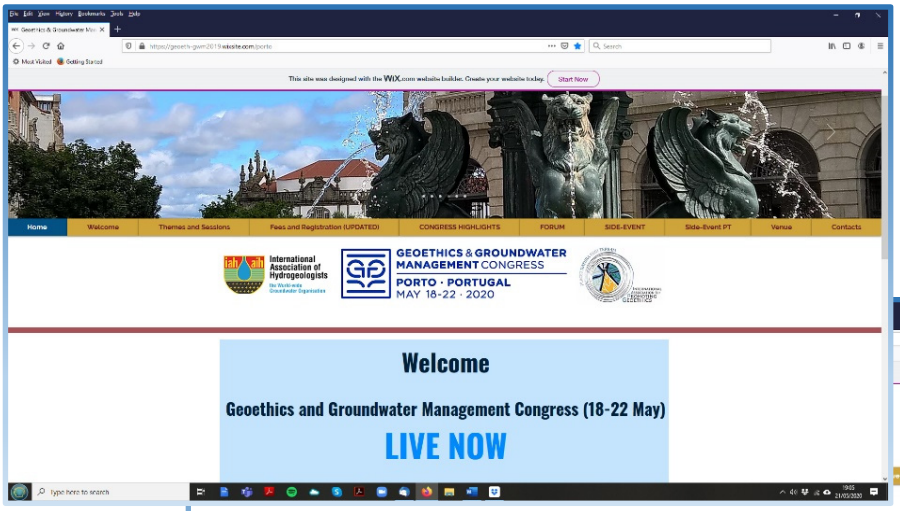
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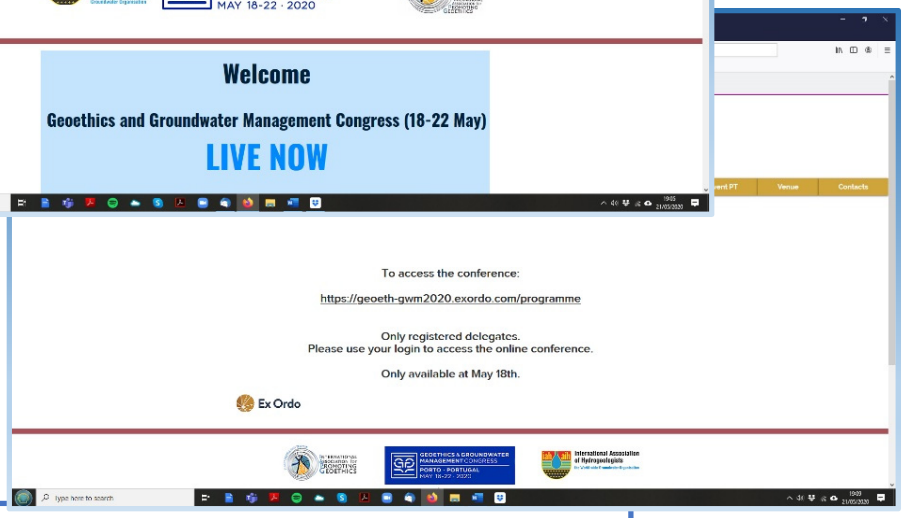
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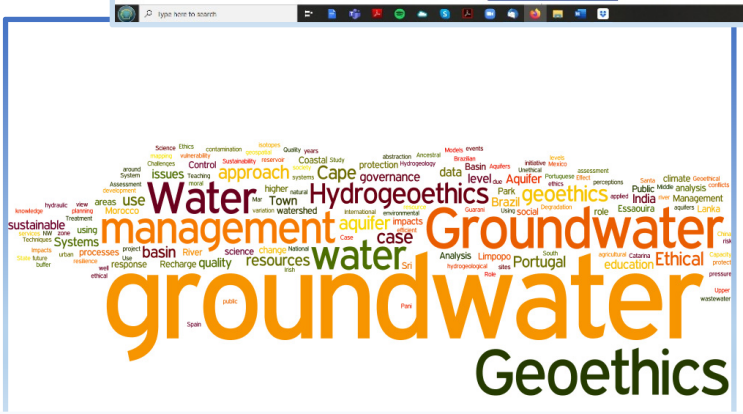
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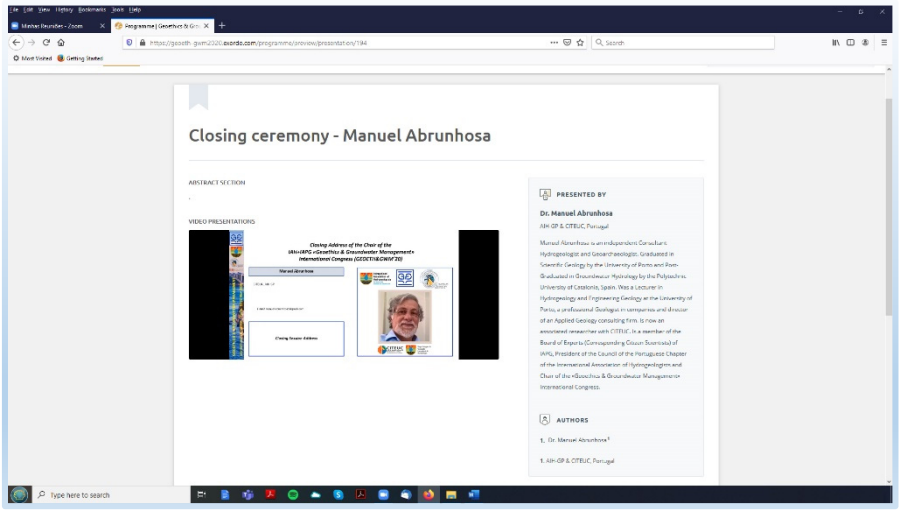
Closing ceremony - Manuel Abrunhosa
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PRESENTED BY
Dr. Manuel Abrunhosa
AUTHORS

Foreword

Groundwater is, by far, the most abundant and widespread source of liquid freshwater on the planet. When fresh-water 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. In general, groundwater keeps being a disregarded subject by citizens, decision makers and even scientists in some way related to water resources, ignoring its interlinked and essential roles in the water cycle, the ecosystems, and the functioning of society. Insufficient knowledge motivate a lack of proportional and responsible actions. This may be at the source of threatens to groundwater water resource with consequences in terms of changes in the quantity and the quality of water, not only groundwater, due to intensive and inappropriate anthropogenic actions coupled to stresses coming from the natural dynamics of water resources, climate change, population growth and patterning, economic development, and also insufficient investment in knowledge, public awareness, governance and management at all levels, from local to global. Meanwhile, there are aquifers that remain untapped in regions or periods of water scarcity.

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.

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 geoscientists in conducting their activities while interacting with the Earth system, where groundwater is one of its undisputed important components.

The wide diversity, scale, significance and increasing magnitude of the interactions of anthropogenic behaviour with aquifers and groundwater involves some degree of conflict of budgets, and also of values or interests, decisions and demands from the agents involved, call for a responsible and human approach to groundwater use and management.

This joint congress emerges from an Agreement for Cooperation signed on the 5th April 2017 about common grounds by the IAH – International Association of Hydrogeologists (iah.org) and IAPG – International Association for Promoting Geoethics (geoethics.org). Following its terms, the international Congress "Geoethics & 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 groundwater specialists, scholars and professionals, as well as educators, students, and early career colleagues in 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 has the goal to stage manage a 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.

IAH and IAPG delegated the task to organize this Congress to the Executive Council of the Portuguese Chapter of IAH (AIH-GP) who appointed the Organizing Committee (OC), which I am honoured to chair, with representatives of the co-organizer ISEP – School of Engineering, Polytechnic of Porto, and the Spanish Chapter of IAH (AIH-GE). A vast multidisciplinary Scientific Committee (SC) from the Science, Engineering, Law, Social Sciences, Geoethics, Environment fields assisted the OC in assuring the quality of the event, as the framework of the conference and its general themes, the acceptance of the proposed special sessions, the peer review of all submissions, and the quality of the sessions and activities.

We are honoured to count on the support from Portuguese and international professional and scientific organizations and research units with leading roles in fields related to the study and management of groundwater and the High Patronage of the President of the Portuguese Republic.

The OC and the SC called for participation to take stock of 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.

This joint IAH and IAPG Congress proposes to the scientific and cultural community and the society stakeholders a moment of reflection and an opportunity for the foundation, in respect to 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 expected this is not the mere sum of Hydrogeology (with its diverse branches) plus the principles and action-based approaches in Geoethics toward the natural and anthropic world.

It is considered that there is a real potential of development of a new transdisciplinary geoscience capable to produce its own developments and feedback positively into the root sciences of their contributors through its autonomous progress and contributions to a better world in peace, justice and sustainability.

This growing concept has been named as Hydrogeoethics by A. Chambel and M. Abrunhosa, since 2017.

Three Major Themes were considered to correspond to the main areas of THEORY and PRACTICE regarding the global conjunction between Groundwater in all possible conceptual dimensions and the Geoethical approach:

1. *Fundamentals of Hydrogeoethics*: Cultures, principles and geoethical values in the philosophy of groundwater resources, legal frameworks, policies, management models, professional practices, and citizen action.
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*: Education and professional training of geoethics in groundwater management.

Due to COVID-19 pandemic and consequent world restrictions, the OC of the GEOETH&GWM'20 congress decided in early March 2020 the following: i) the conference is changed from face-to-face to online; ii) conference date was kept (18-22 May 2020); iii) the fees were adjusted; iv) the book of proceedings continue in preparation for publishing by Springer supported by the SC; v) the conference headquarters maintains at ISEP–School of Engineering, P.Porto and its laborious Local OC; vi) joint venture with Ex Ordo – Conference Management Software (Ireland) to build a complex but friendly Viewing Platform for a 100% online 5-day congress composed of pre-recorded video contents emulating as much as possible the experience of a face-to-face conference; vii) add a structured forum in the congress website allowing full interaction between presenters, authors and attendants in each presentation and network in the general hall of a forum.

To the former motto of the congress "Leaving no one behind", and given the dramatic times brought by COVID-19 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". This is our geoethical commitment to the groundwater and the wider community for whom we worked hard.

This publication contains the response from the scientific community, represented here by the "short abstracts" only of 112 peer reviewed accepted communications involving 277 authors from 47 countries of all continents (Europe 17, Africa 11, America 10, Asia 8, and Oceania 1).

We warmly thank all contributors that made this amazing Congress possible. Let me highlight my Colleagues of the Local Organizing Committee Helder I. Chaminé, Liliana Freitas, José Teixeira and accountant Alexandra Paz dos Reis PRC for their extraordinary coordinated skills, dedication, and competence in these so difficult times of confinement. The designer Joel Vilas Boas (ISEP), created a powerful logo that will remain a symbol of Hydrogeoethics. Then, the members of the outstanding Scientific Committee that we are proud to have with us. They were essential in the quality assurance of all scientific contents. A word of appreciation to all chairs of the major themes and special sessions for their kind support. Last, but not the least, we are grateful to all authors, and presenters that were burdened by the demanding standardized pre-recorded presentations, by their exciting and insightful work, covering all major themes proposed for discussion and, most of them, addressing the transdisciplinarity that is at the core of methodologies for a foundational Hydrogeoethics. This novel scientific field integrating all aspects of Geoethics in Groundwater theory and practice is born right here. We are looking forward with excitement and hope for your active next realizations. Be welcome to Porto and Portugal, next time face-to-face.

Porto, 22 May 2020

Manuel Abrunhosa

Chair GEOETH&GWM'20

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Supporting Organizations are all those legally registered organizations, being public, private, professional, scientific, educational, governmental or non-governmental, national or international bodies, in any way non-discriminating, non-profit oriented, that are recognized as having a significant supporting relationship with geosciences, engineering and social/human sciences.

Their participation in the Congress is welcome and is the result of acceptance from an invitation by the Organizing Committee (OC). No fee or any economic counterpart is demanded to Supporting Organizations. The OC endeavours in providing the Supporting Organization in due time and updated information about the Congress.

Each Supporting Organization is expected to provide information about the Congress to its members or the followers community. In recognition, the OC asks for the designation of a recognized member to be included in the Scientific Committee and publishes logos in all main documents of the Congress. We are proud to announce the following Supporting Organizations to the GEOETH&GWM'20:

- *APG – Associação Portuguesa de Geólogos (Portuguese Association of Geologists)*
- *APRH – Associação Portuguesa dos Recursos Hídricos (Portuguese Association for Water Resources)*
- *OE – Ordem dos Engenheiros (Portuguese Instituition of Chartered Engineers)*
- *OET – Ordem dos Engenheiros Técnicos (Portuguese Instituition of Chartered Technical Engineers)*
- *SPG – Sociedade Portuguesa de Geotecnia (Portuguese Geotechnical Society)*
- *UNESCO – United Nations Educational, Scientific and Cultural Organization – International Hydrologic Programme*
- *EFG – European Federation of Geologists*
- *APPBG - Associação Portuguesa de Professores de Biologia e Geologia (Portuguese Association of Teachers of Biology and Geology)*
- *ABRH - Associação Brasileira de Recursos Hídricos (Brazilian Association of Water Resources)*
- *CEHIUMA - Centro de Hidrogeología de la Universidad de Málaga (Hydrogeology Research Centre of the University of Malaga, Spain)*
- *FCIHS - Fundación Centro Internacional de Hidrología Subterránea (Foundation International Centre of Groundwater Hydrology in Barcelona, Spain)*
- *LNEG – Laboratório Nacional de Energia e Geologia (National Laboratory of Energy and Geology of Portugal)*
- *CNU - Comissão Nacional da UNESCO, Ministério dos Negócios Estrangeiros, Portugal*
- *aeISEP - Associação de Estudantes do ISEP, Porto, Portugal*

Publications

The Conference has a partnership with Springer to publish the proceedings and the full papers. The peer reviewed proceedings presented at the conference will be published in a special volume of the Springer ASTI series.

The chairs of the conference are also organizing a Topical Collection (TC) or Special Issue (SI) in journals "Springer Nature Applied Sciences" (TC), "Sustainable Water Resources Management" (SI) and "Mediterranean Geoscience Reviews" (SI) after the congress. The submission on several TC/SI will be open by July 2020 to May 2021 and the expected themed volumes will be published in late 2021 or early 2022. During June 2020 will be shared more information about the TC/SI related to each journal.

Congress Logo

A powerful logo was designed by Joel Vilas Boas (GDM|ISEP) for the Congress that we expect will inspire all of us. In its apparent simplicity it represents a large amount of symbolism underlining the place and aims of the Congress. The overall shape and colours are reminiscent of the square ceramic wall tiles in contrasting white and cobalt blue that are a recognized hallmark in Portugal's civilian, religious and military buildings, since the XVI Century, as you will experience here in Porto. They were used domestically and exported worldwide, not only as a commodity hand made by the millions, but also as a fortunate association of its technological excellence and usefulness with the expression of new values, ideas and aesthetics proposed to other cultures around the world, not without setting a distinct permanent mark from its origins we, as Portuguese citizens, are proud of.

In the composition of the logo only four simple glyphs in ten arrangements were used, harmoniously distributed inside a line bordered square. An undrawn but distinct central vertical axis of symmetry defines a path for a bottom-up reading of several symbols that set out by deconstruction and recomposing to define, in quite a few lines what, in our view, Geoethics and Groundwater Management is. A bottom line could represent the strong foundations of Geoethics and Groundwater Science, from which emerge recognized symbols of drawdown curves, and with them the consequences of the exploitation of aquifers underground. Above, is what could be a water well head and the processes that may occur on the surface in interaction with the society and the underground. Then, the acronym of the Congress is brought to our minds through face to face double-G physiognomies of what might be Geoethics and Groundwater Science and Engineering, a wide M for Management below. This opposing, often conflicting views, and the need of an informed dialogue, together with the underlying reflections on all values involved and on the consideration of foreseeable consequences of actions and omissions, are the correct supporting paths to foster the emergence of responsible Management tools. This could be the readings underlining the perseverance and quality for the construction and maintenance of the sequence of arch bridges connecting the extremes on top of the logo. They evocate the at their times innovative six bridges of Porto over the Douro River, fed in Summer by far away aquifers in its vast transboundary basin. This support a safe road to the future of the society and nature in resiliency and sustainability, through the combined efforts of geoscience, engineering, and humanities, to cope with the challenges of change.

T1. Fundamentals of Hydrogeoethics

Cultures, principles and geoethical values in the philosophy of groundwater resources, legal frameworks, policies, management models, professional practices, and citizen action

Major Themes 1: Short Abstracts

T1. Fundamentals of Hydrogeoethics

Cultures, principles and geoethical values in the philosophy of groundwater resources, legal frameworks, policies, management models, professional practices, and citizen action

General Chairs

Giuseppe Di Capua (Rome, Italy) & José Teixeira (Porto, Portugal)

Co-Chairs

Rute Saraiva (Lisbon, Portugal) & Alexandra Aragão (Coimbra, Portugal)

Chairs Address

This major theme provides insights on geoethics in water management and policies with inputs from environmental ethics and legal frameworks. Cultural implications and values associated, societal concerns about water depletion and sustainability needs, expectations and demands by different stakeholders, including local and indigenous communities, governance problems, best practices and techniques in monitoring, databases utilization are issues that are highlighted by numerous presentations. The goal of this theme is to explore the complexity of problems associated to water and the importance to face its management with multi-perspective approaches. Only the awareness of this complexity is capable to produce an advancement in developing a more responsible and sustainable approach to this essential georesource that needs to be carefully managed and whose lacking leads inevitably to the destruction of social structure of human communities.

Highlights

- Groundwater ethical issues
- Legal frameworks
- Societal perceptions and concerns
- Water governance
- Groundwater management-society-policy interface
- Multi-perspective approaches in groundwater management

Keynotes

Relational Value as an Argument to Protect Geological and Hydrogeologic Goods

Alexandra Aragão[1*]

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Abstract ID#24

What are the reasons to protect the geologic resources? Are there any ethical arguments to prevent extraction and support the "in situ" preservation of ordinary geological goods that are not covered by other legal protection regimes? And what about the geological goods which do not even have a market value because they are not economically interesting or because they are not in the market? Are not there any ethical arguments for "in situ" protection of these geological goods against development plans, programs, or projects? The legal rationale for the protection of geological goods — both with and without economic relevance — will be based on their relational value. The relational value is key to understand the fundamental reasons why people want to protect geological goods despite their non-biotic nature and regardless of their direct utility, economic value. The big question here is: how is it possible to know if and how much people care about certain geological objects or sites? The answer lays in cultural geo-ecosystem services. Recognizing the relational value of geological goods by using the ecosystem services language can help prevent conflicts and promote socially and environmentally sustainable development.

Ethical and moral issues relative to groundwater

Emilio Custodio[1,2*]

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Abstract ID#219

Groundwater is the major freshwater continental resource and reserve. Its quantity and quality is characterized by the delayed and damped response to external action and the large storage with slow renovation rate. This is not known to everybody and is difficult to be experienced personally, as groundwater cannot be directly observed. Therefore, specific knowledge is needed to address correctly the ethical and moral issues related to aquifer use and management. Poor consideration cause deviated policies, social disturbance, inefficiencies and negative impact on the environment and the services it provides. The subject of ethics is humans, but not Nature and the environment as such. This is something that some powerful organizations and minorities try to reverse, by subverting the principles of ethics and trying to erase the God-related fundamentals of moral. Groundwater ethics deal with present circumstances, as well as with the future, represented by scenarios that, to be ethically acceptable, should be non-biased, scientifically feasible and free of pre-set orientations aimed at other objectives. Ethics play an important role in water policy making, especially for groundwater. Science and technology cannot produce unique solutions to existing human and environmental problems if conditions are not previously set by a well-informed society and administrative, legal, social and economic agreements bound the objectives. This involves deep ethical and moral implications. Science and technology contribute the means to convert objectives into assessments that help in decision making at a higher level.

Some Basic Considerations on The Applied Ethics to Water Resources Management

María Feliciana Fernández [1*], Manuel Ramón Llamas[2], Emilio Custodio[3] and Francisco Javier Neila[1]

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Abstract ID#34

This study is a contribution to the analysis of ethical factors in water governance. Obviously, the issue is very broad, as water is a "polyhedral" resource, that is, it has many different facets according to the multiple roles it plays in the environment, in economic activities, in public health, in the liturgies of the different cultures and religions, and even in the current issue of gender difference. It is enough to remember that in poor countries women and girls are who normally take care of providing water to their family at the cost of losing education. These different facets have a diverse nature. Some are quantifiable like the amount of water needed in each climate and soil and with a specific technology to obtain a specific crop; on the other hand, there are others that are hardly measurable or even impossible to measure. Even in the measurable aspects, there is a great variety of circumstances. For example, the water supply and sanitation system of an area is very important for public health, whose care normally falls in almost every state into a health or similar title department.

The Precautionary Principle and Groundwater

John Cherry[1*] and Ian Stewart[2]

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Abstract ID#248

The 'precautionary principle' implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found or has good reason to suspect a plausible harm, however this principle is rarely if ever applied to protect groundwater. Groundwater problems are out of sight and mostly out of mind. Like rivers and lakes, groundwater suffer from the tragedy of the commons. Now, in most developed countries after more than 70 years of relatively uncontrolled releases of deleterious chemicals onto the landscape, such as fertilizers and pesticides from chemical agriculture, or into the subsurface from leaky tanks, pipes, septic systems and ditches, there are almost no aquifers left that do not show the presence of anthropogenic chemicals. Pristine groundwater is rare, and the mixtures of groundwater contaminants are expanding. After the chemical inputs into most rivers and lakes are brought under control, contaminants are rapidly flushed out but not so for aquifers where contaminant residence times are commonly decades or centuries. For progress toward groundwater sustainability the precautionary principle is needed to play an important role because the record of groundwater contamination shows that deleterious impacts are nearly always much greater than anticipated.

Communications

Geoethics for Operating in the Human Niche

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Abstract ID#18

Geosciences co-shape the human niche; hence geoethical thinking is pertinent for geoscientists. Within the human niche, geo-endowments, like water, are shared resources that are commons. As a societal context, the human niche is a planetary network of natural and cultural environments. Geoethical thinking explores cultural substrates that nurture the skills of human agents and the operational circumstances that they encounter in the human niche. Initially, geoscientists conceived geoethics for their professional circumstances. Subsequently, geoethics evolved into an epistemic, moral hybrid for citizens that are interacting with the Earth system. Furthering geoethics – that is, combining it with Kohlberg's 'hierarchy of moral adequacy' and Jonas's 'imperative of responsibility' – leads to formulating in a 'geoethical rationale', namely, to act 'actor-centric, virtue-ethics focused, responsibility focused, knowledge-based, all-actor-inclusive, and universal-rights based'. Uniting geoethical thinking with thinking about moral adequacy and responsibility for future generations strengthens the applicability of Geoethics. The geoethical rationale is formulated at a normative meta-level to apply in any societal or scientific context that is relevant for geosciences. Furthermore, the geoethical rationale supports any human agent (geoscientists or citizens) in navigating the human niche, for example, by framing how to handle a diversity of cultural, social and scientific circumstances.

Cross-Cutting Role of Groundwater in Achieving the SDGs and an Ethical Approach

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Abstract ID#117

Water is the basis of sustainable development. The SDGs recognize through SDG 6 the importance of water issues as human right and as a requirement to realize many of the other goals. This work presents an analysis of the cross-cutting role of water (with emphasis on groundwater) in the SDGs, shows some comparisons between the goals in Latin American countries, and proposes an ethical approach of groundwater in the context of the SDGs. Water resources and the services that provide contribute from poverty reduction, food and human health to economic growth, reduction of inequalities and environmental sustainability: 33 social, environmental and economic targets including indicators directly or indirectly related to groundwater have been identified. Some comparisons between these indicators in Latin American countries show possible relationships or trends. To address the ethical aspects of groundwater, it is proposed to formulate a conceptual framework through the analysis and application of the ethical principles proposed by UN to SDG 6, the interaction of each SDG with groundwater and the creation of an interdisciplinary working group that integrates the social sciences and earth and water sciences.

Inclusion of Indigenous Communities in Water Resources Management in The Middle West of Brazil: A Proposal

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Abstract ID#36

The relationship between indigenous people and water is beyond the use and quality criteria usually present at techno-scientific standards. Indigenous communities commonly assign to water some culture and spiritual values, which are normally neglected in Brazilian watershed management planning. Historically, these people have close relationship to surface water, such as rivers and lakes, an abundant resource in the country. However, due to the reduction and delimitation of their land, in conjunction with some non-traditional land use, indigenous communities are mainly supplied by groundwater. In this paper, it is presented the case of Ivinhema river watershed, in Middle West of Brazil. This watershed is one of the Parana basins. It has the major indigenous population in the region, with frequent land use conflicts between indigenous people and farmers. The main economic activities are agriculture and livestock. The state´s water resources and Ivinhema river watershed planning are from 2010 and 2015, respectively. In both cases, indigenous population and their water knowledge were not considered. The paper examines watershed diagnosis and management proposals according to Geoethics concepts and United Nations guidelines for water resources development in order to base a future revision of the management actions.

Ganga River: A Paradox of Purity and Pollution in India Due to Unethical Practice

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Abstract ID#10

In India, river Ganga is believed to be a goddess and it is being worshipped by people. Despite all the respect for the river, the condition of the river is worsening, and we Indians are unable to maintain pureness of the river. The Ganga is believed to be the river of faith, devotion and worship. Indian accept its water as "holy" which is known for its "curative" properties. However, the river is not limited to these myths but is also one of the major sources of water, working as the life-supporting system for the people of India since the ancient times. The Ganga river and its tributaries come from cool, Himalayan-glacier fed springs which are pure and unpolluted. But when the river flows downgradient, it meets the highly populated cities of the country, and finally pours out into the Bay of Bengal. From its origin to its fall its water changes from crystal clear to trash-and sewage-infested sludge. Thousands of years passed since river Ganga along with its tributaries is providing substantial, divine and cultural nourishment to millions of people living in the basin. Nowadays, with the increasingly urbanization, Ganges basin sustains more than 40 percent of India's population in it, and due to the major contribution of growing population and rapid industrialization along its banks, river Ganga has reached alarming levels of pollution.

Evaluating Public Opinion on Groundwater Extraction from Public Comment Submissions and Google Trends

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Abstract ID#110

When hydrogeologists evaluate new groundwater takings, they frequently must consider whether such takings are in the public interest. This often means that hydrogeologists will consider public opinion in their evaluation. But how can hydrogeologists understand public opinion, when groundwater is rarely a subject of properly designed public opinion surveys? In lieu of survey data, hydrogeologists might turn to comments submitted as part of a formal environmental assessment process. However, hydrogeologists might suspect that these comments were submitted by motivated individuals and may not reflect the views of the general public. This paper includes a study of thousands of public comments regarding bottled water takings in Ontario, which is arguably the largest recent groundwater conflict in Canada. The paper compares these results to data from Google Trends and other sources to evaluate how those comments might reflect the wider population. The results highlight the roles geographic proximity and droughts might play in forming public opinion.

Public Perceptions and Attitudes Towards Groundwater and Climate Change: the Case of the Barbate River Basin

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Abstract ID#100

This work presents some of the results obtained from a survey research that is currently being conducted among water users in the Barbate river basin area. The purpose of the survey questionnaires is to evaluate the use, opinions and extent of knowledge of the local population about water resources, especially groundwater, in the region. The questionnaires are also aimed at assessing citizens´ perception of potential impacts on surface and groundwater resources, their evolution in the last decades regarding aspects such as quantity and quality, or the effects of climate change among others through the lens of their own experience. This information is of major importance in a space such as the Barbate river basin, where the marked seasonal pattern of precipitation, the prevalence of the primary sector (agriculture and livestock farming) as the main economic engine of the region and the increasing pressures and demands on hydrogeological systems, are decisive factors in the development of management strategies. First-hand knowledge of citizens´ perception is crucial to promote the cooperation between water users, manage conflicts and create synergies in a context of global change.

Ethical Issues of Intensive Use of Groundwater in Stressed Spanish aquifers

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Abstract ID#220

Intensive groundwater abstraction in arid and semiarid areas of the world often approaches and even overcomes available resources. The consequences are important groundwater level drawdown, loss of quality, salinization and other negative externalities, such as land subsidence, increasing cost of water and social changes. There are positive and negative consequences, both direct and as externalities. Each situation is different and requires a detailed study; although there is a background, whose knowledge helps in understanding other cases. Changes involve ethical issues as they affect humans and their activities. They affect current and the future generations, given the slow reaction of groundwater to changes. These ethical issues go beyond hydrogeological considerations and include economic, administration, management and policy aspects, which should back sound water governance. Some of the driest areas of the European Union are in Spain, where there is long tradition of groundwater use, mostly for intensive crop irrigation. Here, part of the ethical and moral point contents of this experience is considered, based in two recent reports, experience in water planning, and the dominant use of groundwater resources in irrigated agriculture.

Public Geospatial Data for Groundwater Governance: The Brazilian Case

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The present work presents two databases available in Brazil related to groundwater governance applications, exposing their applicability, gaps and potential geoethical discussions. The first database is the Rural Environmental Registry (CAR), that is a national electronic public record, mandatory for all rural properties. The second database is the Groundwater Information System (SIAGAS) developed by the Geological Survey of Brazil (CPRM), which consists of a continuously updated database of wells. CAR has a record of 1,892,067 water springs located within rural properties and SIAGAS has 322,922 registered wells. Publicity of CAR data is ensured by law. Both are public databases, so their use does not generate legal conflicts. CAR data is self-reported (by landowners) and requires validation by the Government. For this reason, its use currently requires care to avoid distortions caused by errors in the georeferencing of springs. SIAGAS also has a small number of wells registered, and it is estimated that 88% of wells in Brazil are clandestine. SIAGAS and CAR are examples of databases of great applicability to groundwater governance, both by government initiatives, which require validation and improvements in order to be expanded and applied with greater reliability.

An initiative for protection of the transnational Guarani Aquifer System based on Geoethics

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A contemporary question interesting to Brazilian society refers to the access and use of groundwater, especially for the strategic Guarani Aquifer System (GAS). The name identifies a transnational groundwater reservoir occupying an area of over one million km2, comprising portions of central-south-southeastern Brazil, northern Argentina, eastern Paraguay and northwestern Uruguay. The "GAS Science Diffusion Program" intends to make people aware that water is exhaustible, although being abundant in Brazil. The program is strongly based on Geoethics, which represents a recognition of the human responsibility towards the Earth (or an ethics before the planet). To raise people awareness on the subject, an open debate about related issues is required. It is also urgent to promote a movement for expanding awareness among governments and public agents about the singular geological characteristics of the critical reserves. Ignoring the geological dynamics can lead to irreparable human tragedies, as documented in recent hazards scattered on many Brazilian municipalities.

Geoecological Mapping to Identify Groundwater Ecosystem Services Conflicts in a Brazilian Municipality

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Abstract ID#109

This study applies geoecological-based mapping techniques to identify the natural potential of the landscape to promote groundwater ecosystem services. In addition, from this diagnosis, was analyze its relationship with land use to identify groundwater geoethical conflicts in Brotas municipality, Brazil, which is completely included in the Guarani Aquifer System, one of the largest world natural groundwater reservoirs. In the analysis, we used spatial data of geology, soils, land use, terrain forms, DEM and lineament density. The results of land use analysis indicate that the main economical drive force for the study area is the sugarcane production. On the other hand, the analysis shows that local geoenvironmental conditions of this region are favorable to the groundwater production. Finally, the Geoethics Conflicts Chart, produced from the interaction between land use and the potential to provide groundwater ES's chart, showed that 59% of the study area has geoethics groundwater conflicts, i.e, places where anthropic activities endanger the quality and availability of groundwater ecosystem services. The results obtained can support decision-making in Guarani aquifer areas for several countries as Brazil, Argentina, Uruguay and Paraguay.

Current Status and Future of Groundwater Management in Japan

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Abstract ID#20

In Japan, groundwater has been used as a water resource since the 1900s. As a result, land subsidence occurred due to consolidation of urban clay layers. In order to deal with this, each city set conditions for groundwater pumping control to suppress land subsidence. This has raised the groundwater level. The Basic Law on the Water Cycle was established in 2014 for groundwater management. Under this law, groundwater in groundwater basins that are managed and monitored is treated as "public water". However, at present in Japan, groundwater is still "private water". In 2019, the government granted permission for the use of groundwater to heat and cool buildings in the Osaka area. Such use is expected to be developed throughout Japan. Under such circumstances, how to conserve and manage groundwater for each groundwater basin is a major issue in Japan. This paper describes the followings.: (1) Japan's past groundwater use situation and countermeasures; (2) Research on measuring method of seepage characteristics and monitoring method of groundwater for multiple aquifers; (3) Establish effective groundwater use plan and management.

How Im(moral) is the "Nimby" Stance? Elements into The Ethics of "Environmental" Conflicts

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Abstract ID#68

The extensive use of the acronym NIMBY ("not in my back yard") by social scientists and society at large (i) is supposed to describe an existing phenomenon, even if it is admittedly ill-defined and elusive and (ii) became the indicator of a set of social, ideological and moral choices, and is used as a tool to depreciatively qualify the resistance and protest of communities against the implementation of projects affecting them (in particular their water resources). The argument relies on two oppositions: (i) at the social level, between "private" (namely individual) interests and the "general interest" or "common good" and (ii) from a moral perspective, the split between an egocentric or selfish attitude and an altruistic one. From a methodological perspective, Nimbyism tends to be analyzed at the individual level: attitudes, motivations, self-interest calculation and rationality. We will consider this complex phenomenon on a social scale, considering convergence of interests and solidarity among concerned individuals, propagation of protests beyond the local level, and the process of aggregation of actions to constitute genuine social movements. A reappraisal of the ethics of so-called "Nimbyism".

Recharging Groundwater Security by Ensuring Polycentric Governance and Social Learning Strategies

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Abstract ID#93

The natural water cycle has been altered by human actions. Groundwater is an essential part of this cycle and, an important source for human consumption. Climate change effects carry also ethical implications, where most-favored-nations are able to cope better with water scarcity issues than the other countries. Here phenomena such as "urban sprawl", the "tyranny of small decisions", the "Jevon paradox", and "intergenerational injustice" are presented, showing that it is impossible to have groundwater security without taking into consideration the human nature itself. Several examples are presented, showing that many individual minor actions can induce big transformations in the water cycle, and therefore, in groundwater security. Effective groundwater management processes must incorporate polycentric governance and social learning strategies. Moreover, citizens should be involved emotionally. Public participation in the groundwater governance is a trend that needs to be cherished and fostered, since Geoethics is dependent of the knowing. Due to its nature, groundwater ethical exploration depends greatly on the regular water users' will, introducing challenges in its governance. However, politicians and decision-makers point out that water management has been poorly conscious.

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

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Abstract ID#99

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 Horizon2020 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.

Groundwater Conjunctive Use

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Abstract ID#82

The volume of water stored in aquifers varies from tens of times the annual recharge in small aquifers, to thousands of times in big ones, additionally the volume of aquifer storage provided by a relatively small fluctuation in the piezometric head in most unconfined aquifers exceeds considerably the available or economically feasible storage in dams. In many cases, aquifers used in conjunction with surficial components meet water needs, avoiding more expensive structures, less appropriate for the environment. Two conjunctive use methods exist: artificial recharge and Alternate Conjunctive Use (ACU). Artificial recharge stores volumes of water that cannot be used directly. With ACU, more surface water is used during wet periods and more groundwater in dry ones. This allows the increase of water supply with lower dam storage and important socioeconomic and environmental advantages. Modelling of groundwater and surface water components jointly is needed in the most contentious or complex cases, particularly in systems of various dams, aquifers and conduits, with multiple alternatives for periods of several tens of years. Variability of the surface contributions aggravated by the uncertainties of climate change requires simulating more alternatives. The eigenvalue method simplifies modelling greatly. Aquifer heads can be explicitly calculated only at given points, the aquifer-river flow interaction in various river stretches, volumes stored in the aquifer or different areas of the aquifer, and flow exchanges between several couples of two contiguous areas. But even in many developed countries groundwater is not duly considered by decision makers and government officials, so the problems caused by intensive exploitation (overexploitation) or misuse of aquifers are exaggerated, thus down placing the important role of aquifers in favour of water works that are more expensive and less environmentally friendly. Consequently, this involves ethical considerations.

Enforcement of Groundwater Drilling and Abstraction Sites: Beyond the Backyard

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Abstract ID#84

Enforcement plays an important role in groundwater governance and management. Not only does it provide a crucial end-of-pipe view on the success or failure of imposed regulation, it also acts as an advocate for good groundwater governance and management. As groundwater drilling or abstraction is often not the core-business of inspected operators, a lack of knowledge on good installation and maintenance of the installations is often reported. A 'not in my backyard' or NIMBY-vision is also often encountered with stakeholders living near to inspected installations. At the same time however an 'only my backyard' or OMBY-vision comes into play with regard to groundwater supply and use. A broadening of these visions is necessary, not only in the field, but also at the governance level to facilitate best practices. Since enforcement translates this governance and best practices to the field, it is also important to broaden the view to an international level regarding is successes and failures in doing so. Cooperation and sharing information about lessons learned during enforcement of groundwater drilling and abstraction sites aids in getting the enforcement business out of its own backyard. Resulting adaptation of legislation and enforcement tools or methods are a benefit for good groundwater governance and management, as this valuable resource does not adhere to these administrative boundaries.

On the Relevance of Environmental Law Evolution as a Fundamental Pillar of the European Union

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Abstract ID#125

Environmental law is a main pillar of European Union construction. It has changed throughout the decades to encompass the new visions and strategies for Europe, towards a more sustainable future. We analyze a number of EU legal documents to assess the development of several concepts throughout the decades, pinpointing the key challenges throughout the evolution. If at the beginning of the period in appreciation key principles of openness, equity and accountability are important in the legal documents, they seldom appear in more recent documents, where the recently coined challenges of circular economy, nature base solution and new green business models are more dominant. Climate change and risk assessment and management are pervasive topics, witnessing the European Union concern with these matters for several decades. The vertical and horizontal integration with international institutions and with the member countries and European regions is also a dominant worry of European environmental legislation, providing the freedom for adaptation to the local and national cultural and societal characteristics. In fact, in contrast to the commonly believed by the citizens, due to the subsidiary principle, the enforcement of European legislation is performed, in an adapted manner at country level.

Geoethics In the Design and Implementation of Temporary Groundwater Control Systems

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Abstract ID#221

Geoethics are required at almost every stage of the design and implementation of Temporary Groundwater Control Systems. Although these systems are designed for temporary purposes, they can have long-lasting impacts on the environment if they are not designed and installed with geoethics in mind. These impacts can include (i) transfer of contaminants, (ii) saline intrusion, and (iii) damage to local watercourses. Engaging effectively with geoethics during the implementation of Temporary Groundwater Control Operations involves more than simply having a caring attitude. Effective engagement requires training, extensive knowledge, careful assessment of risks and meticulous planning and management. Experience shows that in cases where Temporary Groundwater Control Operations are implemented without active engagement in geoethics, there are not only environmental impacts, but also later consequential costs and project delays. Therefore, careful consideration of geoethics in Temporary Groundwater Control can be viewed as positive both morally and also commercially. This paper documents some of the key stages in the design and implementation of Temporary Groundwater Control Systems at which issues of geoethics are encountered. The paper also discusses the importance of a Design Risk Assessment (DRA) and an Inspection Testing & Monitoring (ITM) Plan in addressing identified issues of geoethics.

Remote Sensing for Irrigation Water Use Control: the Case of the Benalup Aquifer (Spain)

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Abstract ID#111

In recent years, the Copernicus programme developed by the European Space Agency (ESA), has enabled to improve our knowledge on the functioning of hydrological systems and water management. The added value of Copernicus lies in its open access and adequate time-space resolution, that in combination with other datasets on land use, climate or hydrology, makes it a powerful tool to monitor irrigated areas, assess irrigation performance or identify illegal abstractions. The present work is focused on the exploitation of the Benalup aquifer, which is located in the Barbate river basin (Southern Spain) and has been declared as in poor quantitative and qualitative status by the Public Administration. The use of remote sensing techniques has allowed to identify the time-space distribution of irrigation in agricultural plots supplied with groundwater, the only available hydric resource in the area. The results obtained reveal a marked seasonality in the existing crops and a mismatch between the irrigated plots that have been identified by remote sensing techniques and those with irrigation license. This study evidences the potential of remote sensing for promoting a sustainable water use through the identification of illegal groundwater pumping, what is of major importance in a context of climate change.

Considerations About Wastewater Reuse in Areas Subjected to Strong Pressures in the South of Spain

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Abstract ID#126

Treated wastewater reuse is essential for water supply in areas where the pressure over water resources is high. This is the case of Costa del Sol and the Guadalhorce Valley, where a lot of water is required for urban, agricultural and recreational uses. Most of this water is coming from natural sources instead of being reused, which percentage varies over Spain. In these areas, located in the Málaga province (Andalucía region), less than 6% of treated wastewater is assigned for any kind of use (garden irrigation and golf courses is the major one). Trying to solve this lack of reclaimed water, a wetlands restoration project was carried out in the Guadalhorce River Mouth, near the city of Málaga. Several lagoons were created using treated wastewater. Results were satisfactory with a clear increase in biodiversity, but employing a reduced amount of replenished water, due to the very strict requirements of the regional government. So, a great effort must be done to improve water reusing, especially in parts were freshwater is scarce (like S Spain and Mediterranean area), but also to hire well trained technicians.

Stakeholder View of Efficient Risk Communication in Contaminated Sites

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Abstract ID#96

Environmental risk communication comprises an essential step in the management of contaminated sites. However, in Brazil there are no legal guidelines specifying how this communication should be performed. This research aims to identify the relevant aspects for risk communication in contaminated sites, from the perspective of stakeholders, such as responsible for contaminated sites that performed risk communication, environmental agencies, consultancies, and people affected by risks. The Q-technique was used, a methodology capable of identifying people's point of view and their subjectivities. The Q-set consisted of 67 statements that were judged and organized by 24 individuals in a value matrix, according to the opinion of each respondent, representing a group of actors involved. Five factors were identified representing the view of the research subjects: factor 1 demonstrates concern about the health of those affected by the risk; factor 2 demonstrates the importance of safe communication, being responsible for the liability responsible for the process; factor 4 is strongly related to the legal issues that permeate the process; factor 5 exposes the concern to communicate aspects directly related to risk. All factors show concern with social factors and the rejection of forms of communication through social networks.

Urban Planning and Aquifer Management Using Recession Curves Method

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Abstract ID#102

The expansion of cities and population growth can intensify the use of water resources. The management of these resources presents several interfaces with urban planning, since water is a fundamental element in urban and regional management, due to its potential to induce or hinder social and economic development. An assessment of the regulatory reserves in the Cafezal stream was carried out using the recession curve analysis method, as well as the current groundwater consumption. Hydrographs were made to observe the recession period based on the selected date from 2008, considered a dry year. Data were obtained from 88 wells drilled in the area with a total discharge of 1005.39 m^3/h, with an average of 11.42 m^3/h and annual consumption of 4.04 x 106 m3/year. Regulatory reserves total are 39.48 x 106 m^3/year, with 10.23% of their potential being used through deep wells. Thus, the aquifer has a current exploitation under its potential and the discharge is considered safe, causing no damage to the aquifer system.

T2. Lessons for a Resilient and Sustainable Future with Hydrogeoethics

Case studies of geoethics in groundwater science-engineering, profession, and management

Major Themes 2: Short Abstracts

T2. Lessons for a Resilient and Sustainable Future with Hydrogeoethics

Case studies of geoethics in groundwater science-engineering, profession, and management

General Chairs

Rodrigo Lilla Manzione (São Paulo, Brazil) & José Manuel Marques (Lisbon, Portugal)

Co-chairs

Manuela Simões (Lisbon, Portugal) & Tiago Abreu (Porto, Portugal)

Chairs Address

This major thematic session counted with 2 keynotes, 27 oral and 4 poster/oral presentations, addressing many aspects of geoethics in groundwater science and practice, mostly from key studies around the world (Africa, Asia, Europe, and South America).

The case studies bring an overview of topics where geoethical thinking and behaviour is essential, like groundwater quality assessment, wastewater treatment, agriculture practices vs. groundwater pollution, the role of groundwater in the sustainable development of urban areas, hydrodynamics and hydro-ecological effects, groundwater environments (e.g., coastal areas), conservation of natural resources and learning.

The presentations deal with the ethical, integrity, eco-responsibility, cultural and social implications of geosciences knowledge, education, research, practice, and communication, enhancing the concern of geoscientists, engineers, and water experts-related in conducting their activities.

Risk and hazard-based assessment is key for deliver feasible solutions for groundwater quantity and quality maintenance for cities, rural communities, and ecosystems. High-level analysis should be encompassed with geoethical principles in order to ensure it.

Considering different groundwater settings (confined/unconfined aquifers, karst/porous/hard-rock media, and surface/underground storage) is also a critical requirement for successful actions and police-making.

In a changing world, threatened by global warming and competing claims for water resources, the role of geoethics and groundwater management emerges as a not compulsory posture for the actual and next generation of groundwater experts if a resilient and sustainable future is desired.

Highlights

- Challenges in groundwater use, quality, and management in coastal regions
- Wastewater treatment
- Agriculture vs. groundwater pollution
- Managed artificial recharge and groundwater conservation
- Groundwater and sustainable development of urban areas
- Integrity, eco-responsibility, and ethics in groundwater science and practice

Keynotes

Water Resources Management Under Climate Change Pressure In Limpopo National Park Buffer Zone

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Abstract ID#76

This study aims to give an insight and reflection about water resources as key elements of human civility and nature. Despite Scientific Community has developed excellent concepts such as equity and sustainability, water it is not only a natural and environmental question, but it is also an ethic question. The 2030 Agenda for Sustainable Development issues an ambitious challenge to change our world and leave no one behind: Sustainable Development Goals (SDGs) include targets for access to safe drinking water, sanitation, and better water management. Three out of ten people do not have access to safe drinking water. Almost half of these people live in Sub-Saharan Africa. The starting point of this study is the outcoming of hydrogeological and hydrogeochemical studies carried on the framework of the SECOSUD Phase II ("Conservation and equitable use of biological diversity in the Southern African Development Community - SADC") project, supported by the Italian Ministry of Foreign Affairs in South Africa Development Countries. More people in sub-Saharan Africa has lack access to clean water than anywhere in the world, and they continue to depend mainly on rivers, lakes, and ponds, but some of these reservoirs are naturally polluted or vulnerable to anthropogenic pollution.

Evaluation of protective capacity of unconfined aquifers using geoelectric techniques: a case study from north India for supporting sound geoethics

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Abstract ID#77

In this work, a technique is proposed for evaluating the protective capacity of unconfined aquifers by using a geoelectrical parameter viz. Total Longitudinal Conductance of the unsaturated vadose zone overlying the aquifer. The approach has been tested in Saharanpur town of Uttar Pradesh, India from available data of electrical resistivity soundings. Interpretation of the resistivity soundings yielded data of total longitudinal conductance of the unsaturated sedimentary overburden (vadose zone) which ranged between 0.03 to 0.74 mho. The perusal of the total longitudinal conductance map of the area and its comparison with a Potentially hazardous Activities Map of the area was found to match quite well indicating the effectiveness of the technique in finding degree of protection of the unconfined aquifer vis a vis the hazardous chemicals percolating downwards with the infiltrating runoff in the area. This approach when used in combination with groundwater vulnerability estimates can prove to be of considerable helping planning groundwater protection and governance issues in alluvial and coastal areas of the country.

Communications

Ethical Aspects of Water Use in the Campo de Cartagena and the Associated Impacts on the Mar Menor

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Abstract ID#214

In recent years, the Mar Menor, a large and emblematic hypersaline lagoon on the Spanish Mediterranean coast, has seriously deteriorated. This lagoon and the entire surrounding area is one of the main sources of wealth in the Spanish southeast, and an ecological asset. Consequently, has generated great controversy, confronting researchers, managers and citizens in general. At a general level, the lagoon undergoes a eutrophication process (excess of nutrients) caused by different factors, which go beyond merely scientific ones. In contrast to the intense fall in groundwater levels detected in most aquifers in the area, the water table level in the Campo de Cartagena aquifer has a rising trend and water quality loss, mainly due to irrigation returns. However, the lack of clarity in knowledge, enough data and good cooperation are major handicaps for sound management. This is compounded with poor ethical behaviour in what refers to increasingly limited water resources, insufficient attention to scientific knowledge and data availability, maintaining corporate and institutional privileges, and looking for illusory fast politically-worth results instead of medium- to long-term solutions to problems that have been cooked for decades.

Spatiality of Ethical Challenges in Use and Management of Groundwater in Coastal Regions, Sri Lanka

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Abstract ID#188

Agglomeration of anthropogenic activities in coastal zone is remarkable in Sri Lanka as an island nation. Since water is essential for human survival, coastal communities of Sri Lanka utilize surface water as well as groundwater. In this concern, anthropogenic drivers on groundwater contamination induced by saltwater intrusion has become critical issue during recent past. Hence, this study was conducted to identify extent of this issue and its spatial characteristics. Studies carried out during recent two decades have utilized as database to construct this review paper. According to the study it has been found out that the major reason associated to saltwater intrusion is over extraction of groundwater through pumping. The groundwater extraction is concentrated more in Jaffna peninsula as majority of the population is dependent on groundwater for their sustenance. The natural geographical location with micro-climatic setting of lagoons in the area makes the problem a major one. The wet zone coastal stretch has plenty of surface water for potable and irrigation needs but extracting groundwater raises the improper utilization of water as a resource. Therefore, other than negotiate this problem between authorities and general public it is better and more effective to follow suggested mitigatory measures to overcome future challenges.

Rural water supplies in Galicia

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Abstract ID#119

A large part of the water catchments in Galicia do not comply with the sanitary standards of supply water due to bacteriological contamination and concentrations of nitrates and some metals which in some cases exceed the admissible limits. This situation is due to shortcomings in: (1) Infrastructure; (2) System maintenance and (3) Territorial planning to take into account the protection of water catchments. This situation poses a public health problem that needs to be addressed. Who is responsible and how should this problem be tackled is here analysed. The Administration has the responsibility to provide all residents with a water supply suitable for human consumption and should find ways to improve the small autonomous rural supply systems groundwater quality. This includes to raise awareness among the population about the need to obtain and preserve water that meets the quality standards so that the owners of the systems are the ones who are concerned about and work together with the Administration. Hydrological planning and groundwater protection measures should be established in a coordinated manner between the different administrations, the productive sectors involved and neighbors and with a multidisciplinary point of view that integrates environmental, hydrogeological, economic and social aspects.

Assessment of Groundwater Balance and Importance of Geoethical Approach for Upper Kabul Sub-Basin, Afghanistan

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Abstract ID#235

To conduct an integrated groundwater management, understanding the situation of recharge, discharge, balance, and potential of groundwater resources is required. Therefore, purpose of this study was assessment of upper Kabul sub-basin and find out balance and potential condition of groundwater resources in this sub-basin. During data collection, meteorological and hydrogeological information including water table measurements, storage coefficient, effective porosity and transmissibility of aquifer have been collected from 2008 to 2018. Method of balance calculation has been developed according to the available information and physical–geographical condition of the study area and then a modified balance equation has been applied. Results of this study indicates that recharge was 11.17 million cubic meters (MCM), discharge was 25.74 MCM and groundwater balance is negative significantly (-14.75 MCM) in upper Kabul sub-basin in 2018. This negative balance value proves a significant difference between recharge and discharge in the study area. Moreover, urban utilization is the main discharge parameter. Therefore, to reduce water demand and usage by population in the study area, developing geoethical approach is a key factor. Geoethical approach can affect on reducing water usage rate and help to manage groundwater balance in upper Kabul sub-basin positively.

Water Level Dynamic and Hydro-Ecological Effects of Typical Karst Wetland in Southwest China

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Abstract ID#207

Huixian wetland is the largest karst wetland in China, which has important ecological and environmental functions. Based on field fixed-point monitoring data, the seasonal water level change and the response to precipitation in Huixian wetland were studied by statistical methods, and the influence of wetland water-level fluctuation on ecological environment was further discussed. The results showed that there were significant spatial differences between the surface and groundwater levels in Huixian wetland, both of which responded quickly to precipitation and have significant characteristics of multi-peaks and multi-valleys. The surface and groundwater in the area are frequently changed and the hydraulic connection is close. Wetland groundwater supplies surface water with a stable intensity all the year round, which is an important recharge water source for Huixian wetland. Pearson correlation analysis showed that there was a significant negative correlation between wetland surface water level and water conductivity (R= -0.7808), and the concentration of nutrients in water increased during the decline of water level, which might induce eutrophication of water body. However, the correlation between wetland groundwater level and shallow soil water content was not significant, and the disturbance to wetland habitat was small.

The Role of Temporary Groundwater Control Recharge Systems in Water Conservation

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Abstract ID#215

The conservation of water is a prominent issue of Geoethics and is becoming increasingly important due to widespread groundwater quality and quantity deterioration in a number of regions worldwide. This deterioration in groundwater quality and quantity is often caused by over-abstraction from aquifers and has resulted in global groundwater resource sustainability concerns. Construction groundwater control operations are usually temporary in nature; however, the impacts of these operations on groundwater resources and water conservation can be significant. This is especially true when temporary groundwater control operations are required in areas where groundwater resources are already strained. In light of the water conservation issues faced, Groundwater Control Recharge Systems are increasingly being designed and implemented in order to mitigate the impact of temporary groundwater abstraction on groundwater resources. Where used, these systems (i) reduce the net abstraction of the temporary groundwater control, and (ii) provide an alternative approach to the conventional means of groundwater discharge (i.e. discharge to watercourse or sewer etc.). This paper discusses the principle of utilizing Temporary Groundwater Control Recharge Systems as a means of water conservation along with their advantages and disadvantages. A recent case study from the UK is also presented.

Groundwater Contribution to Alpine Ponds Recharge in Serra da Estrela Natural Park, Portugal

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Abstract ID#89

Groundwater data from 15 springs at Serra da Estrela mountain, located at the Seia-Torre-Covilhã sector, were collected between 2010 and 2011 along 6 fieldwork campaigns. Isotopic (2H; 18O and 3H) and chemical determinations were performed. The data were compared with the isotopic and chemical composition of 7 alpine ponds located within the same area. The local meteoric water line (δ^2H=6.58(±0.29)+1.31(±1.23)) was calculated using groundwater isotopic data. The results show that the springs located at the highest altitudes are more depleted than those located downhill. A slightly different isotopic fractionation with altitude was found between the western and eastern slopes of Serra da Estrela Natural Park (0.12 ‰ vs. 0.10 ‰ /100m in δ18O, respectively). The groundwaters are hyposaline, mainly Cl-Na-type waters, with slightly acidic pH reflecting a shallow and short flow path and small residence time. The alpine ponds also show Cl-Na facies and are mainly recharged by direct precipitation. However, in two alpine ponds (L2 and L6) evidences for groundwater recharge were identified. The physical, chemical, and isotopic composition allowed the identification of: i) contribution of de-icing into the groundwater and alpine ponds systems; ii) contribution of the shallow groundwater flow towards the alpine ponds systems recharge.

An Analysis of Spatio-Temporal Variability of Precipitation and Contours of Water Management in the Upper Teesta River Basin, India

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Abstract ID#49

In mountainous regions, it is problematic to calculate the rainfall distribution because of the rugged, hilly terrain as well as poor obtainability of rainfall points. Rainfall estimation is vital for land use patterns and zoning and resource analysis. In this context, geostatistical techniques have been developed for mapping rainfall in the upper Teesta river basin with the help of data extraction using DEM and long-term mean monthly rainfall (MMR) data of 10 rain gauge stations. Interpolation technique was applied to standardized rainfall depths associated with elevation, as the primary varietal with the help of ArcGIS. The study has been successful in bringing out the rainfall pattern in the Teesta region which is helpful for the locales because Teesta is considered as "The Lifeline of Sikkim". Assessing the variability in rainfall will consent the people to choose the precise technique for management of the river water also serving them with ideas to regulate flash floods. This paper will provide an insight to the people of Sikkim who are reliant on the river water to step a foot towards development.

Analysis of Phreatic Levels in Riparian Forest and Pasture in An Agricultural Watershed, Santa Catarina, Brazil

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Abstract ID#53

This study analysed the short-term behaviour of groundwater levels under two different conditions, riparian forests and pasture, in Concórdia watershed, Lontras, SC, Southern Brazil. Data referring to 3 piezometers were used. PZMC is installed in a riparian forest and PZ2127 and PZ3 in pasture areas. PZ2127 is located near the watershed's outlet. Water levels of the river outlet installed near PZ2127 was also used. Storm events were selected considering the historical record, from April 23, 2012 to September 2, 2015. Water levels that exceeded 60% of the maximum amplitude recorded in all piezometers was the criteria for the storm event selection. Ascension and recession coefficients were calculated for the entire duration of each event, for phreatic levels and water levels, at 2 hours intervals. The difference between water and phreatic levels peaks was calculated. Decay of the mean coefficients of ascension and recession can be observed as consequence of the increase of distance and depth. Ascension movements are faster than recession movements for piezometers and water level. This result is important to develop the knowledge about local hydrological processes that involves phreatic aquifers, in view of watershed management.

Variation of Salinity Levels in Water Bodies in and Around Weligama Bay Due to Effect of Hydrological Processes

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Abstract ID#210

Waligama bay in Sri Lanka is an important coastal region where there are many social and economic activities are taking place. However, people live in closer to Weligama bay are facing a serious problem related to water quality. Surface water bodies and groundwater in this area highly contaminate with saline water. This study has focused on understand the influence of natural hydraulic processes and geological conditions on the variation of salinity levels in water bodies in the study area. Fifty sample points which are radially distributed away from the bay and are located at different distances away from the coastline are selected (distances to theses sample points including dug wells, tube wells and canals from the coastline are measured using GPS coordinates). Water samples were collected from each sample point and their pH, EC, salinity levels, depth to water table in wells were measured twice a month for four months from July to October 2017 (after Southwest monsoon period).Digital thematic maps were produced to understand the distribution pattern of these water quality parameters in the study area for different periods. Also variation of groundwater table with respect to precipitation data and tidal heights for these periods were recorded. According to the analysis of data, it has been observed that salinity levels decreases with the increase in precipitation while increases with high tidal periods. Also it is significant that the salinity levels decreases away from the coastline towards land. However, at some locations within low salinity levels record high salinity specially where there is high porous and high permeable subsurface material. Therefore, there is a clear relationship between salinity levels of the area with natural hydraulic processes such as precipitation, infiltration and tidal activities.

Variation of Victoria Reservoir Water Level and Its Effect on Fluctuation of Groundwater Level Closer to The Reservoir

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Abstract ID#196

Water level of dug wells can be fluctuated due to changes in water level of a reservoir specially which are located lower elevation and closer to the reservoir. To identify the relationship between water level fluctuation of the Victoria reservoir and how it can be effected to water levels of dug wells in Wewegama village which is situated closer to the Victoria reservoir, ten dug wells having different depths to water level and located different distances to reservoir are selected. Water levels of dug wells were measured weekly for five months during SW monsoon and inter-monsoonal period from May to October in 2016 and water levels of the same date of the reservoir are obtained from the Mahaweli Authority of Sri Lanka. By plotting reservoir water levels, corresponding well water levels and by correlation analysis it was found that there is a close relationship between fluctuation of reservoir water levels and water levels of some wells throughout the study period. However, a correlation analysis which was conducted between closest distance between reservoir and each well and the change in water levels of reservoir in each week, it was found that there is no such strong relationship. Therefore, according to the results of this study it can be concluded that with the variation of reservoir water level, well water levels which are located closer to the Victoria reservoir are also varies accordingly.

Modeling Short-Term Ground Water Level Fluctuations Using Multi-Variate Adaptive Regression Spline

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Abstract ID#94

The study investigates accuracy of two machine learning methods, neuro fuzzy system with grid partition (ANFIS-GP) and multi variate adaptive regression spline (MARS) in prediction of 1-day to 6-day ahead ground water levels (GWL) using data from two wells, USA. The outcomes indicate that the ANFIS-GP provides inferior results compared to regression based simple MARS method. The MARS method which is much simpler than the ANFIS-GP is recommended for short-term GWL prediction.

For a Better Understanding of Recharge and Salinization Mechanism of a Cenomanian-Turonian Aquifer

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Abstract ID#184

The Cenomanian-Turonian aquifer of the Ouazi basin, is the only source of drinking water for the local population, as well as irrigation water for agricultural needs. The aim of the present work was to understand the origin, geochemical evolution of deep groundwater by using a group of years of piezometric, hydrochemistry and isotopic data. The deterioration in groundwater quality of the study area is explained by the decrease in the precipitation due to climate change and overexploitation. The hydrochemical study shows that the chemical composition of groundwater in the study area consists of Cl-Ca-Mg, HCO3-Ca-Mg, Cl-Na, and SO4-Ca chemical facies for the years 1995, 2007, 2012 and 2019, respectively. Results show that electrical conductivity increased from 1995 to 2019, and that this could be explained by a decrease in annual precipitation, in relation to climate change and the characteristics of water-rock interaction. Geochemical and environmental isotopic data show that the water-rock interaction and cation-exchange process are the major geochemical mechanisms controlling hydrochemical evolution of groundwater in the Cenomanian-Turonian aquifer. The diagram of δ2H=f (δ18O), shows that the isotopic contents are close or above to the Global Meteoric Water Line, which suggests that the aquifer is recharged by precipitation of Atlantic origin.

Salinization as Groundwater Contamination in Estarreja Shallow Aquifer, Aveiro (Portugal)

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Abstract ID#130

Agriculture, chemical industry and livestock activity are the main activities in Estarreja since 30's of the XX century. In this century, particularly in the 50's, the installation of the Estarreja Chemical Complex (ECC) took place with a huge investment in the chemical industry mainly in the production of ammonia for the manufacture of nitro-ammoniacal fertilizers used in agriculture. Despite the relevance of agricultural and industrial sectors in this region, these activities have been generating an increase of Estarreja shallow aquifer vulnerability, particularly surface water and groundwater, due to contamination by raw materials and/or final products, as well as wastewater, nitrogen and natural fertilizers such as animal manure. Beside these kinds of contamination, groundwater can be also liable to salinization as Estarreja is a coastal zone, near to Ria de Aveiro. The main goal of the present study is the identification of salinization phenomenon in Estarreja shallow aquifer through mapping of variables as well as the application of stable isotopes such as hydrogen and oxygen isotopes. Results show that two different types of salinization could happen, one related to natural phenomenon, the saline intrusion, and the other associated to industrial activities.

How to Control Groundwater Quality Degradation in Coastal Zones Using Mar Optimized by Galdit Vulnerability Assessment to Saltwater Intrusion and Gaba-Ifi Models

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Abstract ID#236

To counteract harmful, eventually with catastrophic consequences, today and future groundwater quality degradation due to saltwater intrusion into coastal aquifers, Managed Artificial Recharge (MAR) is considered the best solution, a sound, safe and sustainable solution. MAR, in coastal areas, depends on the availability of water including waste water appropriately treated. How to control saltwater intrusion in coastal zones implementing a MAR facility? The parameters required to answer that question, include the selection of the most appropriate technology and the best location for MAR. The appropriate location must have good infiltration rates; enough space to store underground the recharged water; guarantee that the travel time of the recharged water in the aquifer is long enough, compatible with the expected frequency of drought periods; economic efficiency maximization; availability of areas for MAR; and, positive impacts on the society. GABA-IFI model addresses those parameters allowing the selection of the most appropriate area for the location of MAR. Complementary, mathematical models are available to quantify MAR water injection rates required to recover groundwater depleted levels. Where should the injection be located? GALDIT is probably, today, the most used model worldwide to assess the vulnerability of saltwater intrusion in costal aquifers by a numerical calculation.

Driving Factors of Karst Wetland Degradation from the Perspective of Hydrogeology: A Case Study in SW China

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Abstract ID#158

As the largest karst wetland in the low latitude region, Huixian wetland is located in the watershed belt of Liujiang River and Lijiang River in SW China. It is of great significance on water resources regulation and ecological health maintenance for Pearl River. Recent decades, Huixian Wetland degraded and the water covering area gradually reduced. The insufficient understanding of the hydrogeological background weakened the restoration effort. In the view of karst hydrogeology, the driving factor of Huixian Wetland degradation was analysed. Firstly, the rapid conversion of ground- and surface water is one of the reasons. The short response time of groundwater to precipitation leads to the frequent occurrence of drought and waterlogging in wetland. Secondly, the underground karst pipes are narrow and easy to be blocked which resulting in the outflow of recharge water. It would reduce the storage of water resources in the core area of Huixian Wetland. Thirdly, the karst rock desertification makes a large amount of lost soil deposited in wetland. It obviously decreased the capacity of wetland regulation. With the aggravation of the rocky desertification, the sedimentation would be more intensified in the future.

Groundwater Vulnerability Assessment in the Naturtejo UNESCO Global Geopark, Portugal

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Abstract ID#28

Nowadays, groundwater vulnerability assessment has become a useful tool for groundwater contamination prevention. Groundwater vulnerability maps provide useful data to protect groundwater resources and work as a tool for the improvement of changes in agricultural patterns and land use applications. The study area of this research survey is the Naturtejo UNESCO Global Geopark, located in central inland Portugal and corresponding to a mainly rural territory where intensive agricultural practices showed a rising tendency in the last decades. The most used method of vulnerability evaluation is the DRASTIC index. In this survey, a modified DRASTIC method, DRASTICAI, is introduced. A new attribute designated as Anthropogenic Influence is introduced. Map algebra in a GIS environment allowed the computation of two maps by overlaying the needed attributes. The Vila-Velha-de Rodão and Idanha-a-Nova municipalities show moderate to high vulnerability and, therefore, in need of monitoring, since intensive agricultural practices are the main economic activity. The algebraic subtraction of DRASTIC and DRASTICAI maps revealed a considerable increase in the risk of contamination, over the surveyed area, namely in Idanha-a-Nova where it is observed risk increase up to 45 points, changing from moderately vulnerable to highly vulnerable and, therefore, stressing the importance of anthropogenic activities.

Concentration of Chemical Species in Piezometers in An Agricultural Watershed, Santa Catarina, Southern Brazil

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Abstract ID#54

This study aims to analyse the concentration of chemical species in piezometers installed in riparian forests and in pasture, and in river, in Concórdia watershed, Lontras, SC, Brazil. Water samples were collected during both baseflow periods and storm events. Samples were analysed to determination the of concentration of chloride (Cl-), nitrate (NO3-), phosphate (PO43-), sulfate (SO42-), and the carbon series of total organic carbon (TOC), inorganic carbon (IC) and total carbon (TC). The carbon series concentrations were bigger in summer. TOC concentrations were higher in piezometers than in river. Higher IC concentration in summer may be related to higher turbidity related to more intense rain events. The mean anion concentrations were higher in the piezometer located in the watershed outlet. Concentrations in river were more diluted when compared to piezometers.

Effect of Subsurface Geological Conditions on Variation of Groundwater Quality in Part of Kurunegala, Sri Lanka

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Abstract ID#189

Majority of the people in rural areas in Sri Lanka still depend on surface water bodies, dug wells and deep tube-wells for their water requirements. Most of surface water bodies in dry zone and arid areas like Kurunegala district go dry during dry seasons. Therefore, people in Kurunegala district are mainly depend on dug well and deep tube-well water during dry seasons. There are few water quality issues recorded in this area. After preparing water quality distribution maps for calcium and total hardness, iron, fluoride and nitrate using groundwater quality analysis data of sixty three wells, it was found that there is a different distribution pattern of the above parameters in Southwestern part of the Kurunegala district. To understand whether there is a relationship between subsurface geological conditions and the variation of different water quality parameters, bore-hole log data of the area are considered. After correlate with these log data, it was found that high concentrated iron, calcium and total hardness, and fluoride and concentrated wells are located closer to laterite and biotite gneiss, marble and biotite gneiss rocks respectively. Wells with high nitrate concentration are located at highly populated areas and are located closer to toilet drainage pits within high permeable subsurface soil profiles. Therefore, water quality parameters are influenced by the existing subsurface geological conditions of the area.

Nitrate Pollution in Groundwater of the Ouazi basin: Case of Essaouira (Southwestern Morocco)

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Abstract ID#176

Morocco is a semi-arid country with scarce and irregular precipitation; thus, surface water and groundwater resources are important for socio-economic development. For this reason, aquifers are intensively exploited to satisfy growing agricultural, industrial, and domestic needs. In addition to water scarcity, Morocco suffers from the degradation in groundwater quality, linked to the depletion of groundwater. In this paper, we zoom on the case of the Essaouira basin, were nitrate is one of the main pollutants that affects groundwater. The objective of this study is to obtain a better understanding of electrical conductivity and nitrate distributions in the aquifers during a period of 24 years. The results obtained indicate that the spatiotemporal distribution map of the electrical conductivity is become very important from 1995 to 2018 and The NO3 concentrations ranged from 0 to 375 mg/L based on 151 groundwater samples. The distribution of high nitrate content in groundwater is consistent with the urbanization and cultural practices, where it has sewage discharge. Groundwater extraction, rapid urbanization in the central of the study area accelerate the deterioration of groundwater quality. The results of this study could provide valuable information on the state of nitrate water concentrations in the Essaouira region.

Hydrochemical Analysis and Evaluation of Groundwater Quality in Ouazi Basin (Essaouira, Morocco)

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Abstract ID#199

Groundwater plays a dominant role in arid and semi-arid regions; it is among the most available water resources in Essaouira basin, where groundwater is the most important source of water supply. The aim of the study is to assess water quality with respect to agriculture and drinking for a better management of groundwater resources. To achieve such objectives, water analysis was carried out on 50 groundwater samples. The Piper plot reveals that the facies characterising Ouazi basin was a combination of Ca-Mg-Cl type, Mg-Ca-HCO3 type, SO4-Ca-Mg and Na-Cl water type. The sustainability of groundwater for drinking and irrigation was assessed based on the World Health Organisation (WHO) and on Wilcox and Richards's diagrams. The obtained results show that the consumption of groundwater in the study area requires a treatment before use as drinking water and most of the groundwater samples fall in C3S1- C4S1 indicating very high salinity and high to low sodium alkalinity hazard. Thus, groundwater quality is ranging between good to permissible and doubtful to unsuitable for irrigation uses under normal condition, and further action for salinity control is required in remediating such problem. The groundwater remains suitable for plants supporting high salinity.

Use of WQI and Isotopes to Assess Groundwater Quality of Coastal Aquifers (Essaouira, Morocco)

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Abstract ID#178

In the aquifers located along the Morocco coast, high mineralization of the groundwater is caused by dissolution processes of evaporitic rocks and carbonates and human impact from agriculture. The aim of the present work was to assess the origin and groundwater quality in the coastal aquifer of Essaouira synclinal basin. Therefore, 28 groundwater samples were used in the calculation of the Water Quality Index (WQI) during the period of March 2019. Eleven physico-chemical parameters were taken into account for the calculation of the WQI. The results obtained showed that the WQI values range from 110 to 890. The results obtained indicates that poor groundwater quality was specially found in the downstream part of the study area due to several factors such as: the dissolution of evaporite minerals (e.g., gypsum, halite, and anhydrite), the use of pesticides and sea water intrusion. In addition, stable isotopes, oxygen 18 (18O) and deuterium (2H) showed that the aquifer of study area is recharged by rapid infiltration (without evaporation) of meteoric waters ascribed to oceanic precipitation. Results obtained showed that this basin sensitive and vulnerable to any climatic variation and therefore climate change.

Tritium and carbon-14 Content as a Diagnostic Approach in Groundwater Resources Management and Protection

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Abstract ID#64

Groundwater isotopic composition is widely used nowadays in the management and protection of water resources. This work will focus not only on the temporal and spatial variations of tritium content in precipitation and their relationships with groundwater active recharge, but also on the radiocarbon groundwater dating. The 3H levels determined in groundwater can be used as a complement to the carbon-14 dating of aquifer systems and in the identification of mixing between different water units or in the dynamics of water resources (transit time, definition of the main flow lines, for instance). Regional variations between the coast and the inlands of Continental Portugal will be analysed considering the influence of climatic and regional parameters in the isotopic composition of the groundwater. Two case studies will be discussed: (i) the study of Melgaço–Messagães aquifer, located in the NW of Portugal (granitic region), will be based on an isotopic approach that allowed the identification of the main origin of the dissolved carbon in the aqueous system; (ii) the Moura-Ficalho aquifer system, situated in SE of Portugal, where 3H and 14C measurements were applied to identify the active recharge of the system and in the characterization of two main flow paths with completely different velocities and apparent ages (2 and 17 ka BP).

Impacts of Irrigated Cultures (Paddy-Rice) in Groundwater Quality in Tejo Alluvial River Basin, Portugal

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Abstract ID#179

Tejo river plains, specially "Lezírias" from Vila Franca de Xira, are an important agricultural region where irrigated cultures prevail. Different water sources provide the demand fulfil for the agricultural practices. Surface waters, in particular those from Tejo river, are the most common in the region. Climate change future scenarios would affect hydric availability in quantity or quality. Irrigated cultures are introducing a stress in groundwater bodies where important nitrates concentrations have been already recognized. In addition, irrigation could increase fertilizers leaching to soils and, in depth, groundwater bodies. Ninety-eight water samples with different origins have been analysed and classified according to Piper and Wilcox diagrams. Piper classification was mostly chloride-sulphur-sodium type and Wilcox classification ranged from C1S1 to C4S3 with a great prevalence of C3S1 and C4S2 categories, meaning a salinity hazard that could pose a quality issue and compromising the soil fertility. Groundwater, as being a source where salinity is neglected, could be a valuable option as a water source. Considering it as an option has an increased pressure to groundwater bodies, where regulation and good agricultural practices are solutions to be considered.

Sustainable Resource of The Hydrogeosphere to Anthropogenic Impacts with Urbanization

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Abstract ID#7

The main processes of changes in the upper part of the underground hydrosphere that occur in urban areas associated with engineering and construction activities of man are considered. An analysis was made of the causes of such changes and the consequences, which are often sharply negative. Some examples of incidents at urban infrastructure facilities are presented that are associated with deficiencies in forecasting and accounting for changes in the hydrosphere in urban areas as a result of building activity. Based on the indicator sustainable resource to external influences, a typification of Kharkiv city territory hydrogeological conditions stability was carried out with an assessment of the negative engineering and geological processes development possibility associated with building. This scheme can be used when choosing a development strategy and placement of construction projects. The concept of sustainable resource or resilience of the resource to external influences is quite universal; several examples of its application to various natural and natural-technogenic systems are given. The necessity of transition to a strategy of regulated interaction with the geological environment, in which ethical principles will be aimed at maintaining rational homeostasis of natural-technogenic systems, is emphasized.

Tiber Middle Valley: Hydraulic Risk Management and Urban Development of the Areas

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Abstract ID#166

This paper deals with different implications of hydraulic risk management in the Middle Valley of Tiber River, which is the Tiber River Basin part, starting from the Corbara dam and ending where this important river approaches and goes inside the large metropolitan area of Rome. It means that the hydraulic risk management in this area is strongly related to hydraulic defence of Rome town, and all its ancient and historically very important monuments protection. Here they are presented the technical solutions, proposed for the hydraulic defence of the municipalities arising inside this area, without increasing the hydraulic risk in it, but also in the metropolitan area of Rome. This is quite a historical problem started at the end of seventies years of 20th century, when the social and urban development of large part of these areas have been frozen as they have been chosen to be the natural flooding areas in case of 100-year and 200-year return time meteoric and hydraulic extreme events. In the aim of respecting this target this paper present the hydraulic works plan, aimed to guarantee a sustainable urban development of these areas, without increasing hydraulic risks in the neighbouring areas and in the metropolitan area of Rome.

Risk Assessment for Groundwater: A Case Study from a Municipal Landfill In Southern Poland

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Abstract ID#11

Environmental Risk Assessment (ERA) is an analytical method suitable for assessing environmental impacts which uses historical data collection, identification of sources of regional risks, as well as a probability and impact estimation of signal risk type. It currently constitutes one of the practical aspects of geoethics. In this paper, EIA was performed with respect to groundwater quality in the region of a municipal landfills system in southern Poland. The consequences and causes analysis, the effect/probability matrix and SWOT method were used for assessing the impact of various factors on the quality of the groundwater in the region. In this paper, we indicated that the best method for a groundwater risk assessment in the region of the municipal landfills system was the SWOT analysis. It involved five strengths, six weaknesses, and opportunities and threats. The monitoring data of spatial and temporal variability of leachate quality and groundwater quality were considered and a simulation of the longevity of both the top and bottom security system was performed. Moreover, the spatial planning was conducted, as well as an analysis of the impact of other objects on the groundwater and an examination of the terrain and climatic conditions were carried out. The total risk assessment for the groundwater in that region obtained using the SWOT method was determined as -4.

Effects of Nanoplastics, Lithium and Their Mixtures on *Corbicula fluminea*: Preliminary Findings

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Abstract ID#92

The effects of polystyrene nanoplastics (NP), lithium (Li) and their mixtures were investigated using the exotic invasive bivalve *Corbicula fluminea* as test organism for ethical reasons. In a 96h laboratory bioassay, groups of bivalves were exposed to water (control), 0.8 mg/L NP, 3.2 mg/L NP, 1 mg/L Li, 4 mg/L Li, 0.8 mg/L NP + 1 mg/L Li (Mix1) or 3.2 mg/L NP + 4 mg/L Li (Mix2). Effect criteria were filtration rate (FR), lipid peroxidation levels (LPO), and the activity of the enzymes cholinesterases (ChE), isocitrate dehydrogenase (IDH), octopine dehydrogenase, glutathione S-transferases and glutathione reductase. Bivalves exposed to NP alone or in mixture had IDH activity inhibition (22%) and LPO reduced by 33%. Bivalves exposed to Li alone or in mixture had 22% of ChE inhibition. Bivalves exposed to Mix2 had FR induction (2-fold). These results suggest that the NP tested may decrease the cellular energy production by anaerobic pathways despite providing some reduction of lipid oxidative damage, that Li has anticholinergic effects, and that NP and Li may cause toxicological interactions in bivalves exposed simultaneously to the two substances. Further studies are needed to understand potential toxicological interactions between NP and Li under different abiotic conditions and exposure periods.

Reuse of Treated Effluents in a Food Processing Industry

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Abstract ID#183

In view of the constant population growth, the unrestrained economic development and the consequent demand for water resources for different sectors (e.g., industrial, agricultural and domestic), the water stress index became alarming in several countries and the scarcity of water is an increasingly frequent and worrying phenomenon. International policies to mitigate water consumption, as well as the reuse of water resources, emerged with the aim of reducing imminent risks for the coming decades. The sectors of agriculture and industry are those with the highest consumption of fresh water, it is expected that the annual global use of water, in industry will increase. The circular economy emerges as a very useful tool in the reuse of treated wastewater in the industrial sector, contributing to the sustainability. The present work deals with a case study in a food-processing industry, where the implementation of a wastewater treatment process is explored in a concept of circular economy. New stages in the treatment process are proposed, which allows to reuse treated wastewaters.

Diagnosis of a Conventional Water Treatment Station: Qualitative Analysis of Treatment Capacity

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Abstract ID#33

Analysis and proposal of Low Filtration Rate Filter readjustment of a Conventional Water Treatment Station in order to increase the treatment capacity and agree the parameters of Water Quality Index recommended by the Ministry of Health. The case study is the Water Treatment Station of Nova Crixás, city locate in the interior of the state of Goiás (Brazil), which was analyse in the last semester of 2018. In Nova Crixás, the expansion and concomitant population growth had result in the impairment of the treatment components of the station, making them possible spots of water contamination, and consequently in its inefficiency (in the case of the Filter). In order to perform the efficiency analysis of the system as a whole, the authors based in projects and calculation memorials to verify the design parameters. According to the technical norms and values proposed by bibliography, it is evaluated that the Treatment Station operates within the normative parameters, but within the limit of its operating capacity. According to the results is clear that the Decanter's Treatment Capacity is within its operational limit, and the Filtering Capacity influences the Water Quality Index.

Combination of Adsorption in Natural Clays and Photo-Catalytic Processes for Winery Wastewater Treatment

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Abstract ID#162

The winery wastewater (WW) in study holds high organic contaminant levels expressed in chemical oxygen demand (COD, 2145 mg O2/L), total organic carbon (TOC, 400 mg C/L) and total polyphenols (22.6 mg gallic acid/L), which are very hard to degrade. With the objective of treat the WW, it was combined adsorption with heterogeneous photocatalytic oxidation. The adsorption was carried out by addition of a sodium montmorillonite natural clay (Na-Mt), which achieved a COD and TOC removal of 68.1 and 52.6% respectively. The Na-Mt was then converted into a heterogeneous catalyst (Fe-Mt), and it was performed heterogeneous photocatalysis. With the optimization of operational conditions, it achieved a TOC removal of 75.4% (heterogeneous photocatalysis), however when both processes were combined it was achieved a COD and TOC removal of 93.0 and 88.3%, with an Fe2+ leaching value of 6.8 mg/L. In conclusion, the use of Na-Mt for adsorption and photocatalytic processes can be adapted to WW treatment.

Geoethics from Geophysical Exploration to a Glass of Mineral Water, including Iberian Thermal Medicine

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Abstract ID#283

Often, when we speak about mining exploration, we resort rapidly to the idea of the exploration relating to metallic and not metallic minerals, and we omit, though in an unconscious way, the hydrological exploration, as if this one was not forming a part of the geological resources. We forget the water as a raw material to explore. The thermal Spas, are an example of the hydrological exploration. In the whole of the territory of the Iberian Peninsula there is a heritage and a thermal tradition that often is not known and needs major valuation. The thermal and natural mineral springs are the result of a topographic, lithological, structural and tectonic system that, regarding its therapeutic properties and benefits for the health can be exploited. We, in the Iberian Peninsula, are holders of numerous testimonies of these thermal practices, from the Roman times, more 2000 years ago. We are favored and responsible of the conservation and diffusion of this Iberian heritage. It is extremely relevant for a better management, knowledge and sustainability of the aquifers, the application of geophysical methods, with detailed reach and deeper scales, as well as chemical control associated with the characteristic microbiology of each water in particular. In addition to recognizing the pertinence geoliteracy of the populations within this geological wealth.

T3. Scientific and Humanistic Components of Hydrogeoethics

Education and professional training of geoethics in groundwater management

Major Themes 3: Short Abstracts

T3. Scientific and Humanistic Components of Hydrogeoethics

Education and professional training of geoethics in groundwater management

General Chairs

Maurizio Barbieri (Rome, Italy) & Rosário Carvalho (Lisbon, Portugal)

Co-Chair

Susana Neto (Lisbon, Portugal)

Chairs Address

Introducing the session some case studies coming from Spain, Portugal, Ireland and Brazil about the groundwater management practices and use of some tools, even isotopes, to diagnose the current conditions of water in the actual water crisis scenario and the risk to increase contamination under extreme weather events.

Following a Canadian regional initiative stress the importance of groundwater data transfer, that becomes an information exchange process as an essential tool facilitating the sustainable management of groundwater resources.

Geoethics is intrinsically linked to sustainability, as it provides tools that allow reflection before action, in the earth systems best interest. A real-life application from Portugal checks and to promote knowledge about geoethics and groundwater sustainability among the youngest, using a project-based teaching approach.

Citizen Science, in particular for groundwater management, is increasingly seen as an approach to gather information with unprecedented time and territorial resolution, especially after the introduction of new IT solutions.

Citizen science bears the promise of a higher level of involvement and commitment of the commoners into subjects relevant to society. The proposed study from Portugal provides the context for higher levels of citizenship and democracy-building that we need to pursue if we are aimed to create a better society.

Finally, geoethics concerning the professional approach:

- the moral decisions to be made regarding the undertaking of the pure and applied hydrogeology in practice;
- the appropriate professional use of the scientific advancements in groundwater science, technology, and management.

Highlights

- water crisis scenario
- extreme weather events
- groundwater data transfer
- geoethics and groundwater sustainability
- citizen science
- geoethics and the professional approach

Keynotes

Over Fifty Years of Hydrogeological Practice and Geoethics: An Intergenerational View of a Changing World

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Abstract ID#193

The exercise of professional hydrogeology is a privilege that requires sound scientific and technical knowledge, field training and interpersonal skills. A skilled hydrogeologist is required to have ethics, deontology, integrity, eco-responsibility, leadership, and behaviour but also the acceptance of the high-standards and codes of ethics and boundaries to avoid discrimination and harassment. In addition, the hydrogeology practice must encompass the geoethical approach. Water supply and infrastructure design and construction for groundwater monitoring are not popular nowadays around the scientific and technical community. However, thousands and thousands of wells and boreholes are drilled worldwide annually, without appropriate hydrogeological support. A professional hydrogeologist cannot support, for example, policies of abandon of fieldwork, leaving the aquifer exploitation restrained to high levels of management and governance. Those practices must be developed through proper conceptual site modelling based on field and laboratory data, complemented by GIS mapping, geovisualization techniques, numerical tools to predict scenarios and climate change understanding. On the ethical point of view, this systematic methodology underpins personal scientific integrity but also a comprehensive understanding of the problem to solve. That includes the moral decisions to be made regarding the undertake of the pure and applied hydrogeology in the practice, as well as the professional appropriate use of the scientific advancements in groundwater science, technology, and management.

Communications

Ethical Issues on the Use of Citizen Science Approaches

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Abstract ID#133

Citizen Science is an increasingly seen as an approach to gather information with an unprecedented time and territorial resolution, especially after the introduction of new IT solutions. This allows citizens to interact with researchers and provide detailed information about the scientific questions under appraisal in real time, and documented with extra information (e.g. photos, sound, videos, etc.), and be of high value for groundwater management. Nevertheless, these new approaches are flaw with problems and profound ethical significance. To start with, the Orwellian type of problems. By adhering to a citizen science activity, one may lose some of his/her privacy that becomes public domain. In addition, there is the risk of misuse, due to poor preparation or to evil behaviour. Also, there are ethical problems related with data property, and with the feedback of the results to the citizens, in a format that they can understand. Yet, citizen science bears the promise of a higher level of involvement and commitment of the commoners into subjects relevant to the society. This provides the context for higher levels of citizenship and democracy building, that we need to pursue, if we are aimed to create a better society.

Expedition Piracicaba: for a Resilient and Sustainable Hydro-Future of a Watershed

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Abstract ID#59

Expedition means that a group of people go on a journey with the particular purpose of exploring and investigating a fact, object or region, usually on a scientific basis. The objectives of the Expedition " For the Life of the River " were to diagnose the current conditions of water in the Piracicaba Basin in a "water crisis" scenario; measure the flow capacity; to reiterate the need for water preservation; discuss the importance of environmental appreciation; and to foster debates with a socio-environmental and cultural scope, promoting the mobilization of urban and rural populations. Currently, by large mining enterprises and reckless groundwater extraction in the Piracicaba basin could reduce the basic river discharge, drain wetlands and springs, reduce soil moisture that sustains the natural or cultivated biomass, or cause other forms of environmental impacts. For the use of groundwater, it is fundamental to differentiate a well from a simple hole from which water is extracted. To this end, there must be a federal, state or municipal control of well drilling as well as groundwater abstraction, to ensure that the constructed, operated and abandoned wells are adequately based on the tripod: Ethics, Sustainability and Economy.

Teaching Geoethics and Groundwater Sustainability Through a Project-Based Approach

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Abstract ID#98

Groundwater is a natural resource of great importance. In addition to the demographic growth and the consequent raise in global demand to meet people's water needs, the vital role of groundwater is undermined by significant threats such as pollution, urbanization, or climate change. Combined with misuse and ineffective management systems, these factors determine its scarcity, quality degradation and reduction of replacement rates, enhancing the challenges of its sustainability. Geoethics is intrinsically linked to sustainability, as it provides tools that allow reflection prior to action, in the earth systems best interest. The aim of this investigation was to check and to promote knowledge about geoethics and groundwater sustainability among the youngest, using a project-based teaching approach. The sample consisted of a group of sixteen 11th grade students, from a school in the city of Porto (north of Portugal). The final aim was the collaborative development of a video related to the theme. The study relied on qualitative methods and some educational research techniques. The results demonstrate the increase of students' content knowledge, as well as their higher awareness on the importance of ground water sustainability. These results support the potential of this approach in promoting Geoethics awareness.

Exploring Groundwater Management in La Galera and Tortosa Aquifers: A Geoethics Approach

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Abstract ID#39

The irrigated citrus farming around the Ebro River and the olive trees at the foothills of the Tortosa-Beseit mountain range shape the distinct landscape of the lowlands in the Ebro River Basin. The inhabitants of this region express a strong connection with their land through a hydro-social network of “Canals i Sequias” (channels and ditches) whilst the “pagesia” (farmers) hold strong identity values. Since the 1990 extensive use of groundwater for citrus trees was boosted in the region resulting in a water table decline developing a culture of water hoarding contrasting with a well-established traditional surface water management. The work explores the groundwater management dilemma around La Galera aquifer and provides some insights about the values that underpin groundwater management and governance in the region.

Engaging Communities and Extending the Lives of Water Systems with Technology

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Abstract ID#101

It takes more than just good intentions and money to provide a community with a reliable source of clean water. Most water systems installed in Africa will fail within the first few years because of insufficient technical planning, lack of community investment and improper maintenance. We have developed a customizable and easy-to-use app to help train and assist community members to perform regular maintenance and diagnosis issues with their water systems. Additionally, the app is equipped with tools for tracking and reporting usage measurement and system evaluation. This information will provide our technical team with data about the frequency and commonality of issues which can teach us how to mitigate such issues in the future.

A regional Initiative for The Efficient Transfer of Groundwater Knowledge Between Experts and Stakeholders

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Abstract ID#66

Recent hydrogeological mapping throughout the Saguenay-Lac-Saint-Jean region in Quebec, Canada, has yielded a very comprehensive geodatabase (GDB) on groundwater and aquifer systems, designed to fulfil the requirements of groundwater management at the regional level. The high density of observed hydrogeological data points also makes the GDB useful for many local or sub-regional applications. Recently acquired data from continuing geotechnical or groundwater-related activities must be integrated into the GDB in order to maintain its relevance for a variety of problems concerning groundwater quality, its management and its protection. When it is consistently updated, such a hydrogeological (HG) GDB also stands as a critical and constantly evolving link between the scientific community, Government agencies, regional and municipal authorities, and ultimately the population who draw upon the groundwater resource. The HG-GDB represents a central hub of effective collaboration between scientists and data users, and the intent is that it may lead to more appropriate decision-making when faced with different issues and/or when taking actions, that may include applied groundwater research projects. Groundwater data transfer becomes an information exchange process, an essential tool facilitating the sustainable management of groundwater resources.

Groundwater Contamination and Extreme Weather Events: Perception-Based Clusters of Irish Well Users

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Abstract ID#112

Extreme weather events may significantly increase pathogenic contamination of private (unregulated) groundwater supplies. Given the current paucity of guidance in this context, well owners may be ill equipped to undertake responsive actions. With rising cases of waterborne illness documented in groundwater-dependent rural regions, a better understanding of well-user risk perception is required to develop appropriate interventions. To this end, a survey was developed to identify current risk perceptions among Irish private well owners concerning extreme weather events and groundwater contamination. Respondents were surveyed on actions taken in the aftermath of five recent national weather events including drought and floods and clustered based on perceived consequences. Results suggest that well owners are not inclined to undertake systematic well maintenance in the wake of an event, with only 13.1% (n = 37) of affected respondents subsequently testing their water. Two-step cluster analysis identified three distinct respondent groups based on perception of climate change impacts on well contamination, with perception level significantly related to respondent age ($p = 0.003$), education ($p = 0.000$) and gender ($p = 0.002$). These findings may enable development of customized risk information for private well owners and reduce the risk of human illness associated with groundwater.

Environmental Isotopes as Tools in Sustainable Groundwater Management: Essential or Dispensable?

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Abstract ID#63

In this work a special emphasis is given to the role that environmental isotopic techniques can play in sustainable groundwater management practices. A brief review of two case studies is made, in which isotopic techniques combined with other tools of Geosciences (e.g., Geology and Geochemistry) have proved to be fundamental in the sustainable management of different types of groundwater resources. In the case of a study on Caldas da Rainha thermal waters, the multidisciplinary approach involving conventional geochemical and isotopic techniques (e.g., $\delta 2H$, $\delta 18O$, 3H, $\delta 34S(SO4)$ and $\delta 18O(SO4)$), led to the conclusion that the Caldas da Rainha thermal waters are "geologically protected" from anthropogenic contamination ascribed to intensive agriculture practices in the soils of the Upper Jurassic geological formations. In the case of the study of the Santa Margarida Military Camp, the use of environmental isotopes ($\delta 2H$ and $\delta 18O$) clearly showed no mixing between the waters from the ponds (projectile impact zones associated with real fire training) and the groundwaters of the region.

During and Post COVID-19: Challenges in Water Sector and Ethical Issues

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Abstract ID#266

During and post COVID 19, the main challenges in water sector are (i) access to safe water, and (ii) sanitation. A huge amount of clean water is being consumed for hand washing as a protective measure against the spread of the COVID-19 which goes as wastes. Increased consumption of drinkable water at the times of depleting groundwater levels will aggravate the adversity in this sector. This situation will further deteriorate in countries having water stress and water scarcity conditions. Presently, efforts should be made on monitoring of the water usage, augmentation of depleting water levels, conservation of water resources, finding the sustainable ways for treating the wastewater and reuse of this treated water. If needed, new regulations and control mechanisms must be practiced. Finally, a hydrogeoethical approach shall be persecuted by all in the sustainable management of water resources.

SS 1. Socio-Hydrogeology to Support Ethical Groundwater Management

Special Session 1: Short Abstracts

SS 1. Socio-Hydrogeology to Support Ethical Groundwater Management

Convenor

Viviana Re (Pisa, Italy)

Convenor Address

Socio-hydrogeology is recently developed discipline fostering the systematic inclusion of the social dimension in hydrogeological assessments targeted to support groundwater governance. The key aspects of socio-hydrogeology are: (1) Assessing the impact of human activities on groundwater resources; (2) Evaluating the (socio-economic) impact of groundwater resources (and its changes in terms of both quality and quantity) on human life and wellbeing; (3) Unveiling how social relationships (their patterns and structures) influence attitudes and behaviors towards groundwater use and its governance; (4) Promoting better use of the outcomes of a hydrogeological investigation, thus ensuring their use in the promotion of science-based management practices for groundwater protection; (5) Contributing to bridge the gap between science and practice; (6) Demystifying science and scientists.

Overall, the discussion would permit to highlight the potential of socio-hydrogeology to: support ethical groundwater governance, incorporate geoethical values in hydrogeology, foresee conflicts of interests, and ensure an effective interaction with water users and all relevant stakeholders. Eventually, the session would permit to pave the way for promoting a more conscious engagement of groundwater scientists willing to contribute to the long-term management of global groundwater resources.

Highlights

- Specific examples of integrated socio-hydrogeological assessments in different cultural and geographical contexts
- Importance of participatory approaches, stakeholder's analysis, and public engagement for effective groundwater management
- Innovative and multidisciplinary frameworks to tackle groundwater issues
- Challenges and opportunities raising from the integration of hydrogeology and social sciences
- The role of hydrogeologists and groundwater scientists in fostering geoethics in scientific research and daily life actions

Keynotes

Socio-Hydrogeology and Geoethics. State of the Art and Future Challenges

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Abstract ID#37

This contribution aims at exploring the nexus between the recently developed discipline of socio-hydrogeology and geoethics. Socio-hydrogeology targets the inclusion of social sciences into hydrogeological assessment, with the overall goal of assessing the reciprocity between people and groundwater. For doing so it promotes the integration of hydrogeological assessments with tools and activities typical of the social sciences (e.g. social network analysis, social impact assessment, public engagement). A closer look at the social implications of any hydrogeological assessment would not only permit to better frame the research and propose more adequate science-based managed practice, but also to ensure that (still existing) gap between science and society is effectively bridged. Indeed, socio-hydrogeology fosters the development of mutual trust between scientists and concerned stakeholders: a fundamental requisite for the sustainability of any action targeted to the long-term protection of water resources. Socio-hydrogeology hence encourages hydrogeology go beyond classical sectorial approaches, by looking at ethical, social, and cultural implications of hydrogeological assessments. As a result, they will be capable of promoting new management strategies that will not only based on sound scientific knowledge, but also on the adequate assessment of the social dimension of groundwater.

Communications

Responsible Water Scientists: Bringing Socio-Hydrogeology in our Daily Life

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Abstract ID#113

Responsible Water Scientists (RWSci) was created with the ambition of encouraging a broader discussion on the lifestyle changes that can make scientists real advocates of (ground)water protection for a more sustainable world. Created in 2016 by two early career hydrogeologists, the Responsible Water Scientists blog, is currently a platform for international debate on the social responsibility of water scientists, providing practical examples on how to "walk the talk". In the era of globalization, dominated by communication and social media, engaging firsthand in water saving and pollution reduction is definitely something that can contribute maintaining the credibility of researchers in the eyes of the general public. Indeed, too often researchers and academics are still perceived as being isolated from the real world, and "the theory without direct commitment" could actually be seen as a lack of interest. To avoid this, RWSci gives the chance to water scientist to dismantle this stereotype, not only by sharing practical experiences of their direct engagement, but also providing practical tips for those interested in taking a new path towards sustainability "one drop at a time".

Gender-Responsive Indicators to Close the Sex-Disaggregated Water Data Gap

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Abstract ID#47

The first official recognition of the role of women in water management was made as early as 1977 during the UN Water Conference at Mar del Plata, and now, over 40 years later, the gap between policy and practice remains to be bridged, as gender inequality in the water sector continues to be the norm. Sex-disaggregated water data are essential for understanding and addressing gender inequalities in the water realm. However, the scarcity of water and gender data is hampering this process at the national and regional level. The UNESCO World Water Assessment Programme (WWAP) released in 2019 a new Toolkit on Sex-disaggregated Water Data. The publications contain a set of gender-responsive indicators, along with a Methodology, Guidelines, and Questionnaire for the collection of sex-disaggregated water data on a variety of water-resources related topics, including groundwater resources. It comes as a response to the wide international recognition of the UNESCO WWAP 2015 methodology and takes into account the results of field-testing in Southern Africa and Central-America, as well as of the 2030 Agenda for Sustainable Development with its interlinked Goals and Targets.

"Pani Check – The Sisterhood of Water": A Transdisciplinary Documentary Film Project

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Abstract ID#50

The transdisciplinary cooperation between a hydrogeologist and a freelance filmmaker resulted in two films about a participatory and interdisciplinary socio-hydrogeological project of Freie Universität Berlin, Germany, which took place in India between 2016 and 2019: Rekha Devi and Zeenat Begum have a problem: the little water in their slum is of poor quality. German hydrogeologist Theresa Frommen is asked to help. But can illiterate women learn the scientist's complicated methods? And is the hydrogeologist prepared to get involved in the social structures of an Indian slum? A story of women empowerment in slums of India, where water supply is a challenge every day. It shows a contrasting picture of scientific research and its impacts on the social structures. "Pani Check – The Sisterhood of Water" is a 52 minutes documentary about the project, where the camera itself served as a research instrument and thus made new insights possible. The conclusion: The more different the ways of thinking and working are, the broader a team is positioned in terms of its resources in order to solve a problem in a complementary and creative way.

"Pani Doctors – Join the Sisterhood of Water": A Participatory Film Project and An Educational Musical

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Abstract ID#51

The transdisciplinary cooperation between a hydrogeologist and a freelance filmmaker resulted in two films about a participatory and interdisciplinary socio-hydrogeological project of Freie Universität Berlin, Germany, which took place in Jaipur, India, between 2016 and 2019: The documentary "Pani Check – The Sisterhood of Water" and the educational short film "Pani Doctors – Join the Sisterhood of Water". In the latter, the peri-urban low-income area Khara Kuaa transforms into a colourful theatre stage as Rekha Devi, Zeenat Begum and their neighbours unpack the scientific water testing kit and explain it to other women. "Pani Doctors – Join the Sisterhood of Water" is a 10-min short film and educational musical about groundwater monitoring which is developed in a participatory way by the director, the scientist and the Indian women, who took part in the socio-hydrogeological model project, together. New ways of science communication and education are followed with this approach. On the one hand, the film design was adapted to local viewing habits and on the other hand, the target group – in this case poor urban women in India – were included into the creation process itself.

Transformative Art Applied to the Social Hydrogeology of the Cape Flats, South Africa

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Abstract ID#81

The Cape Flats Aquifer (CFA) is a primary coastal aquifer under the low-lying eastern suburbs and townships in the City of Cape Town (South Africa). It was identified as a major groundwater source since the 1970's but only intermittently explored and monitored until 2018, when Cape Town initiated an emergency programme in response to a prolonged drought. The objectives in this programme -still in progress - include detailed mapping of aquifer extent and properties, establishment and maintenance of a monitoring programme, and design and implementation of a Managed Aquifer Recharge abstraction scheme. Sustaining the potential of the CFA requires a holistic approach, considerate of the social, cultural and economic context. Support from the local communities is essential if this natural resource is to be harnessed for the benefit of all, as a supply and a means to store water for re-use from waste-water treatment works situated above the aquifer. CFA development can potentially help heal many of the historic societal wounds arising from the apartheid system of segregation and discrimination. The practices of Transformative Art may provide a practical and useful way to consider and structure the necessary "edges of engagement" in the socio-hydrogeological and environmental context.

Socio-Hydrological Analysis Protocol Adaptation to NW São Paulo State, Brazil

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Abstract ID#69

Groundwater is an economically viable resource for the supply of agricultural, industrial, public and small rural areas. However, there is a lack of knowledge about groundwater quantity and quality issues, being a passive resource for depletion and pollution. Given that the agricultural sector is one of the largest consumers of water and that it is an essential and strategic component of food security, proper control and administration enables balanced use management. At present, effective procedures for bringing water users and technicians closer together are not structured to ensure the application of practices that lead to sustainable groundwater use in agriculture. Therefore, this work aimed to create ways to bring farmers and rural communities closer to the theme of groundwater, to ensure its preservation and good use, by using socio-hydrogeology approaches. These approaches targeted to bridge the gap between technicians and water users by disseminating information and discussions on groundwater management, this work intends to develop and implement a groundwater communication protocol in rural communities based on previous studies. Modification and adaptations of the analysis protocol are proposed to the northwester part of São Paulo State, Brazil.

A Comprehensive, Up-To-Date Evidence Base to Inform Public, Planning and Policy for Australia's Great Artesian Basin

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Abstract ID#107

The Great Artesian Basin (GAB) (Australia) is one of the world's most iconic groundwater basins, and the lifeblood of much of Australia's interior with high eco-hydro-socio-economic importance. Nonetheless, the GAB is currently mostly perceived and managed based on outdated hydrogeological conceptual models, which give rise to over-simplistic and incorrect public understanding of the basin. Capitalizing on 10 years of research, mainly in areas targeted by gas and mining industries (e.g. Surat Basin), this project aims to contribute to updated conceptual understandings of the GAB that can lead to more informed discussions and management of the basin. It also explores how the knowledge gained from intensive work conducted in the Surat Basin can inform research and management in other parts of the GAB. This is firstly achieved through (i) the 2020 interdisciplinary Hydrogeology Journal Special Issue "Advances in hydrogeologic understanding of Australia's Great Artesian Basin". Secondly through a science-communication and public-engagement program, targeting a range of publics, aiming at societal education on GAB-related groundwater science and management, which includes a dedicated website (temporarily https://natural-gas.centre.uq.edu.au/gab) with all produced scientific and communication material (informational videos, other educational material and links to the Special Issue articles).

Private Groundwater Supply Management as a Response to Flooding Events: Perceptions of Irish Well Owners

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Abstract ID#75

Over 720,000 people in the Republic of Ireland rely on private groundwater resources (i.e. private wells) for daily consumption, and as these extractions are unregulated, users are solely responsible for managing/mitigating contamination risks to their supplies. However, low levels of exposure to appropriate guidance on well water protection and ongoing maintenance are not uncommon, particularly regarding responses to sporadic environmental threats, such as significant flooding. Despite this, very little is known regarding the factors leading to (or inhibiting) preparedness among groundwater-reliant individuals in the context of health threats triggered by flooding events. Accordingly, the purpose of this study is to bridge this knowledge gap and explore current behaviours, knowledge, risk perception and experience relating to this issue in the Irish context. This was attempted via a combination of quantitative and qualitative methodologies, including a nation-wide online survey with 405 Irish well owners and six localized focus group meetings. Results show the need to go beyond knowledge-based interventions, and use socio-hydrogeological and/or socio-epidemiological approaches to target risk perception and potential structural constraints as a mean to turn protective intentions into protective actions when dealing with adverse effects of sporadic natural events; particularly in a changing climate.

Multisector Collaborative Groundwater-Surface Water Modelling Approach to Improve Resilience to Hydrological Extremes in the Limpopo River Basin

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Abstract ID#80

It is necessary to combine the understanding of physical environmental drivers with social, economic, cultural, and political perspectives and information to build resilience to future flood and drought hazards. We present a flexible collaborative modelling approach to improve resilience to hydrological extremes in large basins with application to the Limpopo River Basin (LRB). It uses an iterative, knowledge co-production process to strengthen crucial bridges between scientists and water management stakeholders on the appropriate scale(s). In the proposed collaborative modelling approach, the integrated hydro(geo)logical model is combined with regional to transboundary people's knowledges and policies. We analyse the effect and importance of stakeholders' feedback on the numerical model prediction. The proposed methodology is applied in the Limpopo River Basin (LRB) where floods and droughts are recurrent events. Through this iterative multisector collaborative modelling approach, we aim to develop a reliable and feasible management instrument to help reduce the impact of alternating droughts and floods and increase the resilience to hydrological extremes.

SS 2. Ethical Issues in Neglecting Groundwater Functioning, a Costly Lack of Respect in Decision Making

Special Session 2: Short Abstracts

SS 2. Ethical issues in neglecting groundwater functioning, a costly lack of respect in decision making

Convenor

Joel Carrillo Rivera (Ciudad Mexico, Mexico)

Convenor Address

The proposed topic in this Special Session was looking for participants to express their views and experience on groundwater activities related to unethical responses by government institutions or private holdings. A main involvement of participants was aiming for reports on unethical decision-making and their impact on society due to neglecting groundwater functioning. Such reports could describe unethical specific actions, or lack of actions, that may include any of the following:

- The development of country or region in terms of industry, urban, and agriculture where actions are directed to the dispossession of groundwater rights from socially vulnerable groups of the population;
- The creation of public opinion by neglecting scientific facts and results based on well-established myths to develop strategies to bring society away from proper land planning and social justice;
- The needed education, teaching and application of knowledge on the actual functioning of groundwater seeing its integrative actual conditions from a local to a regional scale rather than biasing results meeting a predetermined improper model away from field conditions;
- Government activities related to permits and groundwater concessions made against local or international groundwater pacts where its managing responds to political corruption criteria, where laws and regulations are hardly applied to water and environmental protection;
- Proper groundwater functioning definition requires a correct review from basic sampling methods to data analyses avoiding estimates erasing "interference" of selected data by standardizing samples presenting "anomalies", which could mean valuable endmembers;
- Report water policy showing corruption via flaws on international obligations or authoritarian use of water policymaking reinforced by unethical use of words and concepts that need consistency and transfer to a proper scientific application of related groundwater jargon.

Highlights:

- The reality of the unethical decision-making and their impact on society
- The needs of a correct and clearer communication with the public and colleagues grounded in scientific facts and results
- The key importance of the education, training, and application related to the functioning of the groundwater flow systems
- Groundwater functioning definition requires a correct review from basic sampling methods to data analysis
- The need to acknowledge the spirit of local and international treaties in decision making
- The unethical use of words and or concepts from some players need consistency and transfer to a proper scientific application of related groundwater jargon

Keynotes

Groundwater mismanagement: impacts on society due to a response lacking geoethics in Mexico

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Abstract ID#60

Correct information dissemination on the best way the environment may be managed is seldom a practice reaching society. Public opinion is constructed by the media often neglecting scientific results. Furthermore, many enforced legal actions are based on words and concepts lacking an accepted sound definition. Regularly, words are used proposing kind of synonymous suggesting the integrity of the water supply is endangered of getting dry or having a saline-water inflow that would eventually make a city or agriculture water user to collapse. A lack of education or teaching on the actual functioning of groundwater is recurrently missing not only on the public domain but in the decision-making. Proper groundwater management is ignored in cases where sustainability should have been the core of the water policy. Environmental impacts are practically divorced from groundwater issues by well-established myths; developing strategies bring society away from proper land planning and social justice. The resulting application of terms as overexploitation, among others, is making Mexican small private groundwater users scared of using groundwater, abandoning agricultural practices that has resulted in increased immigration affecting them beyond the prevailing water market where groundwater efficient use is repeatedly invoked but is actual functioning is neglected.

Communications

Science and Policy: How Ethical Is Groundwater Management in Mexico (1948-2018)

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Abstract ID#86

The management of groundwater in Mexico corresponds to the President of the Republic, who has three legal instruments for its ordering: forbidden decrees, regulated zones, and reserve zones. In 2013 President Peña, to preserve groundwater decreed a ban affecting 332 administrative aquifers covering 99% of the national territory. In 2018, the same President decreed the temporary suspension of the previous decree to issue entitlements and renewing groundwater concessions, contravening the objective to protect and preserve groundwater and contradicting international commitments, which can be considered unethical. Our essay uses an interdisciplinary approach (Political Geography, Hydrogeology and Political Science), to identify and analyze the components of groundwater rights management policy in Mexico and warns that its spatial manifestation should be the relationship between technical science, regulatory framework of water and public policy. In the period from 1948-2018, groundwater management has responded, fundamentally, to political and water rights management criteria, which favors political loyalty to the President, and ignoring ethical aspects of environmental management and a general groundwater administration based on ethical criteria.

Impacts of Unethical Practices on Groundwater Quality and Quantity in Raipur City, Chhattisgarh, India

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Abstract ID#52

In the present study area unethical practices such as overexploitation of groundwater, improper disposal of Municipal Solid Waste (MSW), rapid increase in industrialization, urbanization, use of chemical fertilizer are led to groundwater resource to depletion and degradation. Due to imbalance between demand and availability, management approaches are facing various ethical dilemmas. To assess the effects of LULC change in groundwater quality different Physio-chemical parameters viz. pH, Nitrate, Calcium, Fluoride, Chloride, Hardness, Sodium, Potassium and Bicarbonate were considered. Land use Land cover (LULC) map of the year 1999 and 2016 and groundwater quality data of year 1999 and 2016 revealed that groundwater quality is highly affected in settlement area by anthropogenic activity. In the Raipur city, there is no earmarked site for dumping of Municipal Solid Waste (MSW). Hence, to minimize the existing groundwater problem, there is a need to develop an ethical practice for proper development and management of groundwater resources.

What is the Way Forward to Protect the Ecological Values of Groundwater?

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Abstract ID#90

In recent years, groundwater systems have finally been seen as true ecosystems, and not only their enormous value as a resource has been appreciated, but also their relative susceptibility to contamination, which increase the need to learn more about its function and resilience capacity. However, there are several gaps in knowledge and a lot of uncertainty for what is important in decision-making in water and ecosystems connections and management programs. The difficult accessibility has long challenged the evaluation and development of scientific theories and how to advance in the understanding of their functioning. In general, they are not easy to perceive, however in recent years, it has been found that they can contain high diversity of living forms with particular adaptive characteristics that maintain water quality and particular ecological functions providing numerous services to humanity. Due to the increase of natural resources demands and the intensive and unplanned land use in the last years, which has led to environmental degradation and diverse social conflicts, studies on groundwater and ecosystems, or the ecology of groundwater, are gaining momentum. Thus, holistic perspectives are encouraged in order to properly understand these connections, their functional roles and visualize proper management perspectives under different scenarios of global changes.

Ethical Dilemmas Behind Groundwater Sampling, Laboratory Testing Processes and Data Analysis Outcomes

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Abstract ID#70

In modern hydrogeology, it is essential to interpret information following an integrative approach which considers actual groundwater conditions rather than biasing results to meet certain predetermined concept or models. In the last decade, the usage of statistical methods (i.e. multivariate analysis) to characterize and monitor groundwater quality has become an unethical myth that has been largely used; this brings to question the margin of uncertainty, reliability and degree of risk of having results which are not explicitly representing the real field conditions. An ethical dilemma rises here as usually, most of these statistical analyses are based on estimates and inferences of a selected population omitting and standardizing the samples that might present a degree of "anomaly" which may reflect end-members. In hydrogeological sciences where exact boundaries between different components are unclear, data cannot be treated based on inductive logic since all parameters are connected and data-analysis must be conducted following a multidisciplinary characterization where all information including anomalies are reported and thoroughly examined.

SS 3. Geoethics in Groundwater Education

Special Session 3: Short Abstracts

SS 3. Geoethics in Groundwater Education

Convenor

Tibor Stigter (Delft, The Netherlands)

Convenor Address

Geoethics should be a fundamental aspect of groundwater education and training. Meanwhile for many people its concept remains vague and is rarely addressed explicitly. The aim of this session is to launch the theme with conferences on the subject at several education levels and forms in Portugal and within an international perspective.

Some of the **highlights** of the session are mentioned below:

- Although geoethics is not formally integrated in the analyzed curricula of Portuguese secondary education, the principles, and moral values about the importance of preserving the Planet are clearly explored, providing pupils with geoethical awareness and responsibility.
- On a higher education a more explicit integration of geoethics into the training of groundwater experts is needed, to promote scientific accuracy, impartiality, and capacity to assess different social, cultural, and political contexts. This can be actively promoted by explicit surveys and discussions with students on the importance and integration of geoethics.
- Groundwater education is not merely a transfer of knowledge and skills; it is an interactive process of exchange of ideas, experiences, and wisdom, in which all come out with enriched knowledge.
- Co-construction of knowledge, whether through education, training, or research, is a process that requires time, mutual respect and strong investment by all parties involved.
- The growing availability of groundwater expertise in the world is essential to support groundwater resources management as well as the debate on its geoethical implications.
- Continued and improved communication on these geoethical implications through different channels and platforms will promote lifelong learning and awareness.
- Stimulating the debate on groundwater and geoethics within the context of international cooperation is crucial to promote the conservation and adequate use of this precious resource for global development.

Keynotes

The importance of geoethics in groundwater education: an international perspective

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Abstract ID#12

This keynote provides a perspective on some of the geoethical aspects we have to deal with while working in international graduate education in the field of groundwater, with a focus on developing countries. Different types of education and training each bring their own set of geoethical virtues, obligations, and challenges. Longer-lasting MSc programmes have the "geoethical virtue" of investing a lot of time and resources in the in-depth education of a person. Such education however is expensive and has the "geoethical obligation" to be subsidized; the question whether that subsidy should strive for excellence or stimulate a broader access to education, clearly touches on another geoethical dilemma. Once entering the programme, participants and lecturers need to work on levelling the playground and need to be fully aware that education is an interactive process of exchange of ideas, experiences and wisdom, in which all come out with enriched knowledge. More generally, co-construction of knowledge, whether through education, training, or research, is a process that requires time, mutual respect and strong investment by all parties involved. That knowledge is essential to support an informed debate and decision-making on the human activities altering the state of groundwater resources, and their geoethical implications.

The Role of International Cooperation in Sustainable Groundwater Development

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Abstract ID#161

Groundwater plays a key role in the achievement of the Sustainable Development Goals contributing to many of them, such as ensure availability and sustainable management of water and sanitation for all, poverty eradication, food security, gender equality, sustainability of cities and human settlement, combating climate change and protecting terrestrial ecosystems. But, groundwater, along with water resources, is very vulnerable to population growth and climate change and groundwater stress is a present and increasing issue worldwide that needs to be addresses in the decision-making processes leading water resources management. In the context of International Cooperation, it is a priority that programs directly or indirectly dealing with groundwater address groundwater sustainable management and conservative approaches based in scientific knowledge, invest in adequate boreholes constructions with proper planning and supervision and enhance investment in preliminary research, training and implementation of participatory approaches.

Communications

And if the Spring that Provides the Farm with Water Should Run Dry? – A Geoethical Case Applied in Higher Education

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Abstract ID#164

Geoethics is a scientific discipline in development whose primary concern is to instill a better relationship between citizens and the planet they inhabit. With a multiplicity of ethical, social, and cultural values, the significant input geoethics can have on decision-making worldwide is recognized. Knowing how the planet Earth works is the basis for all geoscientific knowledge and essential for the resolution of the great challenges that humankind faces every day. The Geoethics Outcomes and Awareness Learning (GOAL) Project is the first to focus on taking geoethics to higher education curricula, to spread a geoethical perspective across our society. One of the educational resources, developed by the GOAL team of experts, was implemented on a higher education course. The results showed that students (n=10) are aware of the strict relation between human actions and Earth system dynamics. Students also expressed the concern to educate citizens on the global problems faced, as for daily decisions. They take a preventive position when it concerns human action impacting Earth's balance. This study is important to develop the students' geoethical background, as well as to look for ways to improve it, hopefully contributing to a better future on Earth.

Teaching Groundwater Resources and Geoethics in Portuguese Secondary Schools

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Abstract ID#73

The growing importance of geoethics justifies its inclusion in formal education, particularly when related to essential themes to the sustainability on Earth. In Portugal, the study of groundwater resources is part of the curriculum of subject areas, such as Geology and Geography. In order to evaluate the possibility of approaching geoethics while teaching groundwater resources in secondary education, we analysed the curriculum reference documents of Biology and Geology (11th grade), Geography A (10th grade), Geography C (12th grade) and Geology (12th grade). The data obtained show that, although the concept of geoethics is not formally integrated into the analysed curricula, it is possible to explore the principles and moral values about the importance of preserving the Planet, throughout formal activities. This is important as we consider fundamental that, by the end of upper secondary education, students should have acquired a responsible and geoethical awareness that could influence their daily life actions. In our opinion, this should not only be a competence of earth science professionals but, should involve all professions and all citizens, to which the promotion of non-formal activities can also contribute.

Geoethics Calls for Action: An Interactive Module to Communicate Geosciences

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Abstract ID#165

In a society that is facing problems related to the planet's sustainability for humankind's survival and where science is part of the daily life of any citizen (in a more prominent or hidden way), it is increasingly essential to establish a correct and coherent geosciences' communication. This latter emergency is particularly significant in the geoethics' scope, since it leads to dilemmas that affect humanity and the planet itself, being essential to promote public awareness about their actions. However, we live in a society where conscious effects of human dependence on the Earth are not fully understood, and it is still extremely required. The change in our daily behaviours is urgent and necessary. In geoethics' field of study, human interaction with the Earth' subsystems – geosphere, biosphere, atmosphere, hydrosphere, and cryosphere – is the primary concern, but there is yet a lack of proposals for communicating geoethics principles and values among the citizens. Within this context, an interactive geoethics communication module – "Geoethics calls for action"–, which may be applied in a museum or science centre, was created to reach a broad public and to provide a reflection on human actions and their consequences on planet Earth. The citizens' engagement with the geoethical dilemmas, present in the module related to the human interactions with the Earth, may develop a geoethical thinking and more conscious actions. Finally, it could raise people's awareness regarding geoethics and its importance. Underlying these intents are not only the geoethics communication but also the endorsement of higher respect for planet Earth and its subsystems.

Training in Groundwater science and technology in Portuguese higher education (2018-2019)

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Abstract ID#211

In order to develop a review on the current higher academic training in groundwater science in Portugal, a comprehensive survey of the national offer of undergraduate, master and post-graduate specialization courses was carried out. This survey consisted of an extensive research on institutional websites and an inquiry. This allowed the identification of curricular units (common name: discipline) that include significant groundwater topics. An analysis of the obtained data made it possible to recognize that the training offer included a considerable number of courses from science, engineering, technology, health, and humanities. Taken globally, the identified curricular units include subjects from probably all scientific and technological areas in which groundwater is subject of study and intervention. Ethics topics have some relevance in the training. It is thus possible to conclude that there is higher education offer in Portugal covering the diverse areas of scientific and professional knowledge on groundwater. Factors other than the unavailability of qualified professionals and scientists with a higher education degree obtained in Portugal with at least some significant knowledge on groundwater, may explain the existing perception that there is a current deficit in the capacity to intervene in relevant matters in which groundwater plays an essential role.

Geoethics in Higher Education of Hydrogeology

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Abstract ID#123

The education and training of Geosciences (where Hydrogeology is included) should be marked out by: (1a) a total scientific accuracy with adequate detail, depth and scope; (1b) the use of appropriate and updated teaching methodologies and didactic means; (2a) a full respect for the trainees' scientific and cultural background, as well as for the socio-economic reality of the local (continent, country or region) of education or future practice; (2b) the regional, national and supra-national legislation about groundwater and water resources; and, fundamentally, (3) with a maximum respect for the Earth natural processes and ecosystems. The teaching and training of Hydrogeology with ethics prepare Geosciences experts, whose activity is crucial to promote the social and ecological balancing, and consequently to avoid local and regional conflicts.

SS 4. Geoethics of decision making under uncertainty

Special Session 4: Short Abstracts

SS 4. Geoethics of decision making under uncertainty

Convenor

Rui Hugman (Umvoto Africa, South Africa)

Convenor Address

Uncertainty is inherent in groundwater management. Yet decisions must be made which can have long lasting impacts. As practitioners we strive to reduce or define that uncertainty when informing a decision so that decision-makers are informed of the risk.

With growing pressure on water resources and the expected increase in climate volatility, what are the ethics of our management decisions? What are the ethical implications of implementing management decisions when uncertainty is high? And on the other hand, what are the ethical implications of inaction?

In this session we aim to explore the ethics of taking (or avoiding) decisions affecting groundwater and other linked systems, as well as how we can geoethically use the tools at our disposal to guide our decisions.

We hope to develop insights into how groundwater professionals, regulators, and society in general address (or fail to) uncertainty in their decision-making process, and what implications this has on society's resilience in a rapidly changing world.

Highlights:

- An exploration of how ethics can brought into the decision-making process to assist practitioners to better understand and resolve water governance issues in groundwater conflicts.
- Several case studies of responsible decision taking under uncertainty during extreme events;
- Demonstrated implications of inaction and an exploration of the ethical responsibility of geoscientists to contest the lack of action;
- The rise in computational tools and capacity has opened new ways to assimilate information and inform decisions. But what new ethical dilemmas accompany these new technologies?

Keynotes

Geoethical Issues Around Water-Security for Cape Town and Groundwater Resilience in Uncertain Circumstances

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Abstract ID#58

In early 2018, Cape Town faced "Day Zero," the date when it was expected to run out of water, and when all municipal supply would be rerouted to emergency collection points. A three-year drought, considered ~1-in-400-year hydrological event, had brought the level of its largest storage reservoir to around 11% of full capacity. Day Zero was averted by relatively good rainfall early in 2018. Two years on, water security remains precarious and uncertain in the face of rapid urban expansion, slow environmental degradation, and long-term climate change. The wider catchment region contains two important subsurface resources: the Palaeozoic Table Mountain Group (TMG) Aquifer System, and the Cenozoic Cape Flats Aquifer (CFA). The development of these groundwater options is confronted by challenges related to environmental and societal impacts. In the case of the TMG resource, which underlies mountain biosphere reserves of the extraordinary Cape Floral Kingdom, geoethical concerns arise in the context of uncertainties related to anticipated impacts on stream flow and floral biodiversity. In the CFA case, geoethical issues revolve around uncertainties related to impacts on the coastal environment, the groundwater-seawater interface, and the power-generation costs of groundwater management and treatment under constraints imposed by South Africa's fossil-fuel dependence.

Communications

Cycles of Uncertainty: An Exploration of 40 Years of The Atlantis Managed Aquifer Recharge Scheme Through a Geoethical Lens

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Abstract ID#45

The Atlantis Water Resource Management Scheme (AWRMS) in the Municipality of Cape Town (South Africa) is recognized as one of the first large scale managed aquifer recharge schemes in the world. It was implemented during 1970's and ran (apparently) successfully for almost 30 years. However, in the early 2000's it was essentially abandoned and replaced with surface water supply. Most of the infrastructure was allowed to deteriorate and monitoring of the aquifer system was carried on without proper scientific purpose. Due to the recent drought crisis, in which Cape Town almost ran out of water to supply over 3 million people, the need for groundwater as an additional source of supply was once again recognized. As one of several projects to increase the City's resilience to drought, the AWRMS was targeted for refurbishment and re-design. Although there have been many technical challenges, perhaps the most complex to solve has been coordinating the various disjointed, and often opposed, institutions and entities that affect the functioning of the Scheme. The fundamental geoethical principles of scientific practice, communication and the education of all those who affect and are affected by the scheme are paramount to ensure the long-term sustainability of the system.

Geoethical Groundwater Modelling: Aligning Decision-Support Models with the Scientific Method

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Abstract ID#27

Management of groundwater resources is increasingly reliant on numerical simulation. Unfortunately, decision-support modelling is often conducted under the premise that predictive reliability increases with modelling complexity. In truth, while modelling complexity can support quantification of predictive uncertainty, the latter is a function of data availability. Excessive complexity can often erode, rather than enhance, a model's ability to quantify and reduce the uncertainties of decision-critical predictions by reducing its capacity to assimilate prediction-salient information. We submit that a groundwater model is more productively viewed as a data assimilator for decision-pertinent information than as simulating subsurface processes, even though the latter role (though imperfect) underpins the former. Assimilated data may, or may not, allow rejection of the hypothesis that a certain course of management action will have adverse consequences. Either way, the decision-making process requires that this hypothesis be tested. In the following document we outline how decision-support environmental modelling can be implemented with the scientific method, and discuss how uncertainties of decision-salient predictions can be addressed with appropriate model complexity so that stakeholder expectations are better aligned with what models can and cannot deliver to the decision-making process.

Geoethics of Bulk Groundwater Abstraction in An Ecologically Sensitive Area: Steenbras Wellfield (Cape Town)

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Abstract ID#43

The City of Cape Town initiated its "New Water Programme" in 2017 to diversify its bulk water supply, thereby improving long-term water security and resilience against future droughts – this includes bulk groundwater abstraction of potentially ~140-400 Ml/day from the major fractured Peninsula and Nardouw Aquifers of the Table Mountain Group (TMG; in the mountain catchments to the east of the city). Current TMG groundwater exploration and wellfield development is taking place in the vicinity of Steenbras Dam, in the form of the ~15-20 Ml/day Steenbras Wellfield scheme. The TMG aquifers are also essential in sustaining groundwater-dependent ecosystems associated with the Cape Floral Kingdom – a global biodiversity hotspot with exceptional endemic diversity, but also a global extinction hotspot. A strong geoethical, "no-regrets" approach is therefore required to develop TMG wellfield schemes for the City of Cape Town (and other towns/cities in the Western/Eastern Cape), in order to reduce the risk of any negative ecological and environmental impacts, while still enhancing the drought resilience of the city, providing water for future urban growth, and meeting Sustainable Development Goals 6 and 11.

Long-term Planning During Emergency Response –A No-Regrets Approach and Long-Term Vision for The Development of the Cape Flats Aquifer (Cape Town)

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Abstract ID#44

The Cape Flats Aquifer (CFA) is a primary coastal aquifer that underlies the City of Cape Town (South Africa), identified as a major source of water by hydrogeologists since the 1970's. Scientific specialists called for its protection so that it could be used for bulk water supply to the City. Unfortunately, the resource was largely ignored by the municipality, resulting in the degradation of the underlying aquifer over time to the point where groundwater from some portions are non-usable due to contamination. In 2015-2017 Cape Town experienced its worst drought since 1904, driving the municipality to look at alternative sources of water such as desalination, re-use of treated effluent and various groundwater schemes; of which the CFA was one. Given the time-constraints of an emergency response project, long-term testing, and study of the system to support design and implementation have been significantly reduced. A no regrets approach was therefore adopted by the team to reduce the chance of any negative impact such as saline intrusion, reduction in water levels that would negatively affect existing users that rely on groundwater for their livelihood and sensitive ecosystems. We aim to present the geoethical question of developing an emergency scheme with limited data on its sustainability and costing versus not developing it and risking a City of ~4 million people running out of water.

The ethics of Groundwater Governance: Evaluating a Methodology in Philippi in Cape Town

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Abstract ID#180

When South African policymakers compiled the National Water Act and started implementing Integrated Water Resources Management, they assumed that social cohesion and shared values existed in the divided communities that characterized the post-apartheid South Africa. Moreover, they naively anticipated that both governments and communities were able to engage effectively in transdisciplinary, multi-stakeholder platforms on water governance. Water governance is a normative concept that implies a shift from government being in control of water management to it being a shared responsibility between diverse stakeholders in a context. Value analysis can play a critical role in understanding the multitude of conflicts that arise among the different stakeholders in water governance. It can create platforms for meaningful engagement that could lead to the resolution of a conflict. This work evaluates the impact of an ethics methodology in South Africa, discussing how the value-driven process was able to achieve improved social cohesion within the divided community in the Philippi Horticultural Area (PHA). It compares this methodology with others arguing that its persistent focus on values and process, rather than content and outcome makes it more useful than other forms of participatory action research to hydrogeologists wanting to involve ethics in contested water governance issues.

Decision-Making in Groundwater Management: Where Artificial Intelligence Can Really Lead Geoscientists?

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Abstract ID#83

In this modern and dynamic society, threatened by climate change, poverty, hungry and economical systems collapse, artificial intelligence (AI) emerged as a promise field to solve many actual problems. Although AI do not give absolute answers. The outputs of AI methods are subjective and, in many situations depend on human-based decisions. It has a strong impact on decision-making processes and geoscientists are highly exposed to this question. Specifically, on groundwater, issues involving water quality and water quantity deserve special attention for monetary resources applications, urban supply, ecosystemical services should be balanced in order to avoid biased solutions. This paper aims to present some AI methods and discuss where it they can lead geoscientists with and without an ethical posture. A study case using monitoring water levels data is presented.

The Geoethics of Using Geospatial Big Data in Water Governance

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Abstract ID#213

Geoethics encourage us to reflect dialectically on the consequences, opportunities, risks and benefits of our actions using geotechnologies in a rational and transparent way. This paper presents insights into how geoethics can guide more conscious and transparent decisions in the use of geospatial data in water management. The concepts of microethics and macroethics are also presented in the context of geoethics. Water governance must provide water security in terms of quality and quantity for all citizens, making it necessary to ensure that everyone receives water (equity) with transportation methods that avoid losses (efficiency), maintain quality (responsibility) with forms of monitoring and control that equalize the freedom (autonomy) and power (representativeness) of all agents involved. Following the principles of ensuring autonomy, equity, responsibility, efficiency and representativeness, the use of geospatial data must be made in order to achieve these objectives. For this, geoethics has a crucial role in providing guidelines to decision makers and society that guide them in an inclusive, equitable and transparent way. The self (microethics) and societal (macroethics) responsibility and geoethical implication is distributed to all the components that constitute the complex system to which they are inserted, in different degrees of importance in decision-making.

SS 5. Groundwater: geological, legal, social and ethical challenges of a unique natural resource: *in memoriam* Professor Luís Ribeiro (IST-U.Lisbon, Portugal)

Special Session 5: Short Abstracts

SS 5. Groundwater: geological, legal, social and ethical challenges of a unique natural resource: *in memoriam* Professor Luís Ribeiro (IST-U.Lisbon, Portugal)

Convenor

Patrícia Ferraz de Matos (Lisbon, Portugal)

Convenor Address

This Special Session aims to reflect on the challenges that groundwater, as a unique natural resource, raises, both in the present as well as in the past, and in different geographical contexts (Europe, Latin America, North Africa, and Asia).

The contributions include aspects related to climate change, sustainability, and efficiency, in rural and urban contexts. It is intended to have technical perspectives from hydrogeology and groundwater, but also take into account aspects provided in the law that protect, or not, groundwater, and to reflect on the effects that these subjects have on people's lives, seeking, whenever possible, a social perspective, since the reflection on ethics should include this knowledge and the learnings acquired with the ethnographic methodology.

The session has two keynote presentations, one on the protection and management of groundwater and another on the groundwater-fed plot-and-berm agroecosystems. It also has eight presentations on subjects that include ancestral groundwater techniques, governance and social participation, management of aquifer systems (with also a presentation on a special aquifer system), and impressive examples of music inspired in groundwater and the hydrological cycle.

The purpose of the presentations is to articulate the knowledge of geology, and specifically about groundwater, with the ethical issues raised, seeking to contribute with new approaches.

Highlights:

- Ancestral groundwater techniques and ethics;
- Governance and social participation;
- Sustainable management of aquifer systems;
- Impressive examples of the music inspired in groundwater and the hydrological cycle;
- Interlinkage of the knowledge of geology, and groundwater, with ethical issues.

Keynotes

Protection and Management of Groundwater, an Invisible Vital Resource

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Abstract ID#79

In many regions groundwater is the main source for water supply, irrigation, and industry. Groundwater reservoirs, the aquifers, can contain important reserves of groundwater mitigating the effects of drought and other phenomena related to climate change. Furthermore, groundwater is less vulnerable to many types of contamination, although when contaminated its restoration could be more problematic. Groundwater resources are renewable but not unlimited, often subject to overexploitation which has negative consequences: economic, environmental, subsidence, etc. Definitions of criteria to be used as a guide to sustainable management have been proposed by several authors. However, the enforcement of those criteria can be challenging because they have to reconcile opposed interests. Aquifer modeling and monitoring are useful tools for guidance in aquifer management. This one can be modified according to the results of the actual exploitation (adaptive management). The most widespread type of contamination results from agriculture. This problem is difficult to deal with because population growth implies more food production. Population growth and the crescent tendency to migration from the country to big cities pose big stress on water resources resulting in widespread contamination due to poor sanitation conditions.

Groundwater-Fed Plot-and-Berm Agroecosystems in Aeolian Sand in the Mediterranean Basin

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Abstract ID#224

Overcoming liabilities of loose sand such as scarce nutrients and low water retention remains an agricultural challenge. "Plot-and-berm" (P&B) agroecosystems, situated in dune fields, consist of sunken agricultural plots between 1-5 m high berms, overcome these constraints. The plots situated over a 1-3 m deep and perched groundwater table ease and control access for crop roots and/or human water extraction and may make this agrotechnology resilient to short-term drought. Refuse and organic material enrich the sandy soil in plots. The agroecosystems require significant resources for construction and maintenance. The earliest agroecosystems are Early Islamic (9th-early 12th centuries A.D.) ones along Mediterranean coastal dune fields of Israel. Arabic literature reviews have not found descriptions of P&Bs, but this effort may be an original type of mawāt (Arabic: "dead") unowned wastelands reclamation, an important issue in Islamic economic history. Partially active and similar P&B agroecosystems along the southern Mediterranean region in Northern Sinai/Gaza Strip, Algerian Sahara, and Iberia, yield fruit and vegetable crops, and date back to the Middle Ages. Their concept may have originated from the Early Islamic ones. Being in stressed environments, P&B agroecosystems can be reestablished into groundwater-efficient community-farming econiches that can nurture geoethical relations between science and local populations.

Communications

Music Inspired in Groundwater and other Components of the Hydrological Cycle

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Abstract ID#160

Water as a symbol of fertility, death and rebirth, appears associated with many classical music works. Rivers, seas, lakes, glaciers are the leitmotivs of many composers who used them in different musical forms: symphonies, suites, symphonic poems, operas. The river, as a watercourse in continuous flow, is described in the various stages of its life (Smetana: Vlatva), in its exuberance (J. Strauss: Blue Danube), as a privileged setting (Handel: Water Music) or as a celebration (Telemann: Wassermusik), or as a journey of fantastic trips (Wagner: Siegfried's voyage along the Rhine) or as a generator of life (Schubert: The trout). In the sea, the water appears metamorphosed, in the movement, in the sound and in the colour that constitute the elements of the waves (Debussy: La Mer), represented as a terrific force (Verdi: Otello), as a scenario of storms (Vivaldi: La Tempesta del Mare), or pacificator (Mendelssohn: Calm Sea and Happy Travel) and as a stage for ancestral legends (Wagner: Der Fliegende Holländer) or as theme of several narratives: (Rimsky-Korsakov: Shererazade; Britten: Peter Grimes; Zemlinsky: Die Seejungfrau) or pure poetry (Vaughan Williams: Symphony The Sea). Also, in the lakes it is represented as a heady element (Liadov: The Enchanted Lake) or as a spell (Tchaikowsky: The Swan Lake). The water appears invisible (Denisov: Légendes des Eaux Souterraines), static, in magnificent glacial landscapes (Vaughan Williams: Antarctic Symphony) or as a scenario of a battle (Prokofiev: Alexander Nevsky) or pretext for beautiful architectures (Respighi: The Fountains of Rome). Rain inspires storms (Sibelius: The Tempest) and bonanzas (Beethoven: Pastoral Symphony) or as daydreams (Takemitsu: I Hear the Water Dreaming).

Revisiting Ancestral Groundwater Techniques as Nature Based Solutions for Managing Water

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Abstract ID#132

To achieve water sustainability and a more efficient use of water we should base on the ancestral water and territory management knowledge and grained in the culture of the people, This work is inspired in Nature Based Solutions (NBS) for managing water availability, particularly groundwater and aquifer-related NBS that hold major unrealized potential for alleviating adverse impacts of progressive climate change, namely to increase water security/drought resilience. In some cases, more ecosystem-friendly forms of water storage, such as natural wetlands, improvements in soil moisture and more efficient recharge of groundwater, could be more sustainable and cost-effective than traditional grey infrastructure such as dams. The core of this study is centred in the pre-Inca and Inca civilizations and how these communities have developed ingenious NBS solutions to adapt to extreme climate scenarios such as prolonged droughts, managing water resources in a holistic way and how they understand clearly the global water cycle in all the components specially groundwater. The work is divided in three interlinked phases: to sow water, by implementing ancestral aquifer recharge solutions, to retain water by improve hydraulic efficiency in terms of infiltration and drainage and to collect water by improve the performance of extraction in the subterranean aqueducts in arid regions.

Groundwater vulnerability mapping and ancestral systems of water-galleries (Porto urban area, NW Portugal): a design on natural-base solutions

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Abstract ID#237

Water resources are crucial to the settlement of populations, but their quantity and quality are essential to the development of urban areas. In fact, nature-based solutions for water were considered in many places using ancestral systems of water-galleries and springs to supply urban areas. That design based in natural solutions had proven during centuries to be much less demanding and resourceful. A multidisciplinary approach was applied in Porto urban area (NW Portugal), to assess the urban groundwater supply and ancestral network of water-galleries and springs. The Infiltration Potential Index in urban areas (IPI-Urban) is dependent on several parameters (e.g., lithology, structure, weathering grade, morphotectonics, land use, drainage, slope, rainfall, anthropogenic and urban hydraulic features, like the water supply, the sewer and the stormwater networks) which can be overlapped and cross-linked in a GIS environment. Moreover, several vulnerability indexes (DRASTIC, GODS, DRASTIC-Fm, SINTACS and SI) were outlined within a combined approach. Therefore, those old underground structures could be a positive asset as economic, social, and environmental drivers if are used natural-base solutions and good geoethical practices.

Rethinking the Role of Science in Society? Groundwater Science, Critical Reflections and Learnt Lessons

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The need to rethink the role of groundwater science in risk assessment and society results of a joint reflection between a sociologist and a hydrogeologist and arises from a research collaboration in a long-term highly contaminated area. The objective is to bridge social and natural sciences in the reflection of ethical questions and their implications for technical reporting, scientific production, and societal impacts. The authors aim to understand the various social, economic, and political components of long-term hydrogeological investigations and to test the application of ethnographic methodology in ethical issues. The investigation addresses three experiences that pose ethical challenges: the access and use of public domain monitoring data; the dissemination of scientific research data and its controversial character; and, the lessons and necessary connections between scientific results, policy regulation and the design of water governance programs. Ethical issues should be addressed by the scientific community as are technical results discussed and scrutinized in conferences and scientific papers. In the framework of hydrogeological investigations in contaminated areas, ethics should help scientists to move from the present situation (based on science) to what should be in the future (based on environmental, human health and societal protection goals).

The International Agreement of the Guarani Aquifer System: A Transboundary Aquifer

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Abstract ID#38

The hydrogeology associated with Environmental Law is essential in the discussion of transboundary aquifer management. The "Guarani Aquifer Agreement", although not yet in force, presents the instruments for shared management of the Guarani Aquifer System (SAG), located in parts of the territories of Argentina, Brazil, Paraguay and Uruguay, countries that form MERCOSUR. It is recognized as the largest aquifer on the planet in superficial extension, crossing political borders, river basins and hydrogeological provinces, as well as it supplies large part of the population of these countries. This agreement is one of the few treaties signed in a precautionary and preventive context; both are fundamental principles of Environmental Law. It is noteworthy that this agreement does not come from a prior existence of conflicts, as has already happened in several regions of the planet when dealing with transboundary water resources. The Guarani Aquifer System Environmental Protection and Sustainable Development Project (PSAG) was an important instrument that brought together both the researchers and the political power of the four countries to identify the characteristics and potentialities of the SAG, so that cooperation existing during the project and the results obtained favored the creation of this Agreement.

Role of Groundwater as a Climate Change Adaptation Strategy in Dry Zone Farming Systems, Sri Lanka

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Abstract ID#170

Water related uncertainties are a troubling concern for farming communities in the dry zone Sri Lanka. Farmers have to manage available water or seek alternative ways to fulfil the water requirements needed to maintain their livelihoods. Within this context, a comparative study was conducted in Horivila-Palugaswewa and Sivalakulama dry zone farming systems in order to discover the role of certain climate change adaptation strategies to cope under climate related vulnerability. Key Informant Interviews and questionnaire surveys facilitated the data collection process. The data was analysed through the development of an Adaptation Strategy Index and the application of Cronbach's Alpha Reliability Test. The findings show that the use of alternative water sources in terms of agro-wells as the first ranked adaptation strategy in both study sites. This finding was further confirmed with Cronbach's Alpha Reliability Test as the same strategy has taken the highest reliability in the test results also. Although number of adaptation strategies have been included in the Adaptation Strategy Index development, overall, the farmers tend to prioritize the use of alternative water sources (agro-wells) while neglecting methods of managing the available water sources. With a growing reliance on water from agro-wells, there is a clear need to focus towards groundwater management to ensure that over extraction does not become a major issue. This is particularly important as agro-wells have an increasingly enormous role in supporting farming communities in both study sites.

Safeguarding of Groundwater Abstractions by Enforcement of Source Protection Zones

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Abstract ID#55

Groundwater provides 80% of the drinking water in southern and eastern England. To protect water quality, the environmental regulator defined groundwater Source Protection Zones, to show the risk of contamination based on travel times to the abstraction. Application of this policy requires the regulator to oppose developments with bulk storage of hazardous substances within the inner, 50-day zone. It appears that the policy is not consistently applied, thus allowing recent developments close to strategically important groundwater abstractions. The ongoing dialogue on the real levels of risk, effectiveness of engineered mitigation and threats to security of public water supplies requires hydrogeologists to use their geoscience knowledge, apply the principles of hydrogeoethics and influence awareness of society. The issues are illustrated with an example of a proposed petrol filling station inside the inner source protection zone and only 200m from a public water supply borehole. The borehole abstracts groundwater from the Cretaceous Chalk aquifer, with karstic features and potential preferential flow pathways requiring a large source protection zone. Although the environmental regulator allowed reliance on engineering solutions, the water company's objection was upheld by the planning system because of unacceptable long-term risk to strategic public water supplies.

Sustainability and Management of the Menzel Habib Aquifer System, Southeastern Tunisia

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Abstract ID#22

In arid and semi-arid areas, the water quantity and quality is a great problem. Salinization is the major threat in the region of Menzel Habib (north-western Gabès, southeastern Tunisia). The region is a large basin which is essentially represented by sandy-clay formations and bordered by cretaceous reliefs. Geochemical and statistical approaches are reported in the Menzel Habib Aquifer system to examine groundwater salinization processes and factors controlling its mineralization. Geochemical studies were developed in 25 groundwater samples from the shallow aquifer to identify the origin of groundwater salinization. Groundwater geochemistry shows a high correlation between salinity and Na, Cl, Ca, Mg and SO4. These elements are mainly associated to the evaporitic Triassic by dissolution of halite, anhydrite and gypsum which occur on the area and is related to the tectonic context of the region. Additionally, bivariate diagram between Na and Cl, and Ca and SO4 have also provided a comprehensive understanding of other salinization processes that are involving in Menzel Habib shallow aquifer such as cation exchange and reverse cation exchange.

Ancestral Techniques of Water Sowing and Harvesting in Ibero-America: Examples of Hydrogeoethical Systems

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Water Sowing and Harvesting (WS&H) consists of a series of ancestral procedures by which humans collect and infiltrate (sow) rainwater and runoff underground, so as to recover (harvest) it downgradient at some later time. This management of the water has made it possible for various regions of Ibero-America that is, Latin America plus the Iberian Peninsula to overcome dramatic cultural and climatic changes over the centuries. The principles governing WS&H coincide with those pursued under the present paradigm of Integrated Water Resource Management. Moreover, WS&H implies a better use of water and enhanced conservation of the environment and patrimony, as well as recognition of rural communities as vital custodians of the land and of its relevant cultural aspects. The main WS&H systems that serve Ibero-American countries are described here, emphasizing the principles underlying this means of water management as exemplary of hydrogeoethical systems.

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