THE JOINT MASTER DEGREE PROGRAMME ON GROUNDWATER AND GLOBAL CHANGE - IMPACTS AND ADAPTATION

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ABSTRACT

The Joint Master Degree Programme on Groundwater and Global Change - Impacts and Adaptation (acronym GroundwatCh) offers a distinctive curriculum built on the cornerstones of hydrology, hydrogeology, climatology, impacts and adaptation.

Palavras-Chave: Groundwater, hydrogeology, climate change, Joint Master Degree, Erasmus programme

1. INTRODUCTION

As the largest liquid freshwater reservoir on earth, groundwater has both a huge environmental and economic value, and will be an essential resource for adaptation to climate change and reduction of socio-economic vulnerability, particularly in regions where freshwater availability is highly variable and frequently limited.

Several factors foster the need for a more comprehensive and multidisciplinary educational groundwater programme.

First, groundwater is a component of the water cycle interacting with all other components at various temporal and spatial scales.

Second, groundwater systems are largely interdependent with socio-economic development. The presence of important and productive aquifers can boost socio-economic development and alleviate poverty in low-income countries by providing water for public supply and sustainable irrigation, increasing (environmental-friendly) land use efficiency.

On the other hand, the continuous growth of the world population and the socio-economic development of many countries has already caused, and will continue to cause, large impacts on freshwater (including groundwater) systems through uncontrolled exploitation, causing depletion, seawater intrusion, reduction in baseflows in rivers and ecological flows sustaining freshwater ecosystems, or land subsidence.

Third, climate change is foreseen to affect freshwater availability globally, with several hotspots, among which many areas that currently already suffer periods of severe droughts and freshwater scarcity, such as the Mediterranean area of southern Europe and Northern Africa, northeast China, northern and south-western Latin America, large parts of Australia and the western United States, among others. Fourth, important feedback mechanisms exist between groundwater (and its use), climate and global change, which vary in time and space.

The existence of groundwater at shallow depths for instance has a large influence on processes occurring in the atmospheric boundary layer, whereas lateral groundwater flow towards rivers and wetlands sustains surface moisture levels that feed back into the regional climate. Groundwater-supported evapotranspiration can significantly contribute to the overall water balance, whereas groundwater-fed irrigation increases evapotranspiration rates overall, possibly affect the precipitation regime.

2. BRIEF DESCRIPTION

GroundwatCH seeks to offer a distinctive curriculum built on the cornerstones of hydro(geo)logy, climatology, impacts and adaptation, within a framework of human pressures, global change and feedbacks, around the following academic focal areas:

Hydrogeology;

Groundwater data collection, interpretation and modelling;

Climate processes and modelling;

Groundwater-surface water-climate interactions;

Integrated river basin and water resources management;

Groundwater and environmental impacts;

Groundwater, society and policies;

Groundwater in adaptation to global change.

With this curriculum GroundwatCH aims to address the current gaps in higher education with regard to the understanding of the interactions between groundwater, surface water, climate and global change, and how we need to consider and can benefit from these interactions when dealing with adaptation.

Regarding the key competences and skills that the Joint Master Degree programme aims to provide, they are linked to each of the thematic areas, several of which provide the basic skills required to address the other, more integrated fields, and ultimately the core thematic field, where the key distinctive and challenging skills and competences can be outlined.

These are:

a) profound knowledge of how global and climate change affect groundwater bodies and associated surface waters and ecosystems;

b) explaining feedback mechanisms between groundwater, land use and climate and how these are affected by changes occurring in one or several of the systems;

c) capacity to use a wide range of modelling tools for climate, groundwater and water resource management, to simulate these systems, existing feedbacks and induced stresses from human activities, calibrating and validating such models based on historical data and using them for scenario analysis;

d) ability to identify the consequences of the predicted impacts of climate change and climate variability for integrated water resources management, under the different levels of uncertainty intrinsically present in the CO_2 emission scenarios, the climate models and the downscaling and bias correction techniques;

e) capacity to integrate climatic change conditions at different time and spatial scales into (risk) management in the water sector;

f) setting up groundwater-based adaptation solutions for climate and global change, such as managed aquifer recharge, increased groundwater storage, limiting of freshwater demand (increasing efficiency, reducing losses);

g) knowledge on how to strengthen the science-policy interface and promote participatory adaptation in (ground)water resources management and policies, actively involving the stakeholders in the implementation process and adequately addressing uncertainty;

h) ability to apply the obtained know-how in a practical case, supervising an adaptation solution project for solving a complex problem by proper handling of individual tasks within a team;

i) capacity to perform advanced research on a specific scientific topic related to groundwater and global change, and to write a thesis, as well as an academic manuscript for publishing in a peer-reviewed journal.

The essential skills and competences obtained within the first seven thematic areas, following a learning curve that ultimately leads to the previously described competences of thematic area 8, are listed below.

1) With regard to general hydrogeology, developed competences and skills include:

a) explaining groundwater occurrences, aquifer classification and aquifer properties in the many different geological environments;

b) carrying out comprehensive hydrological flow systems analyses in surface water and groundwater systems in different hydroclimatic regions and geological settings;

c) performing detailed groundwater balances, interpreting and working with the concepts of groundwater recharge, storage and discharge, which represent the interaction of groundwater with the other components of the hydrological cycle;

d) knowledge of the steady state and transient groundwater flow processes and their physical description, and application of analytical solutions to solve the many flow problems that exist, both under natural conditions and caused by groundwater exploitation.

2) The obtained expertise in groundwater data collection, interpretation and modelling involves:

a) interpretation of hydro(geo)logical time series and spatial data;

b) knowing the underlying principles of methods applied to groundwater exploration, such as hydrogeological mapping, geophysical surveys and pumping tests;

c) planning and carrying out a groundwater investigation programme and interpreting the obtained results;

d) designing or optimizing a groundwater monitoring network using known procedures;

e) building numerical models for groundwater flow, reactive transport and saltwater intrusion, using the model results for groundwater resources management and protection.

3) Regarding climate processes and modelling, the obtained expertise will lie in:

a) explaining the functioning of climate system components (atmosphere, ocean, land surface with humid, semi-arid and arid subsystems, cryosphere) and their interdependencies (feedbacks) on different spatial scales;

b) applying associated methods for interpretation, with mathematical detail of the chemical, radiative, dynamic and thermodynamic processes that occur;

c) determining the role of land use in climate-groundwater interrelations, simulating water and matter fluxes in soils using soil-vegetation-atmosphere transfer models;

d) modelling principles in climate research, including global circulation models and regional downscaling, model application and evaluation, uncertainty and performance analysis.

4) Developed competences and skills on groundwater-surface water-climate interactions, include:

knowledge on existing feedback mechanisms between groundwater and surface water bodies, and between groundwater and climate, through the contact of the aquifers with the soil zone, rivers, wetlands, vegetation and the atmosphere.

5) On integrated river basin and water resource management, competences and skills include:

a) advanced knowledge of water resources planning, protection of water bodies and aquatic ecosystems, water use licensing and management;

b) application of mathematical models for solving water planning and management problems, including the protection and efficient use of water resources;

c) designing, constructing and operating water resources systems;

d) knowledge of the application of the Water Framework Directive in the EU, its goals and principles, largely focused on ecological integrity, and consequences for national water related laws.

6) The developed expertise in groundwater and environmental impacts involves:

a) explaining the consequences of intensive groundwater (over)exploitation: theory behind seawater intrusion, sea-level rise, land subsidence, decline in environmental flows and consequences for dependent ecosystems;

b) knowledge of the concept of hydrochemical facies analysis, distinguishing geogenic from anthropogenic factors;

c) knowledge of the concepts of tracer hydrology, with emphasis on environmental isotopes;

d) predicting the occurrence, transport and fate of the main pollutants in aquifers, including saltwater/fresh water interface movements in coastal aquifers, using analytical and/or numerical techniques;

e) delineating wellhead protection perimeters and other zones of aquifer protection using analytical and numerical simulations;

f) proposing remediation strategies and implementing groundwater monitoring networks.

7) With regard to groundwater, society and policies, the acquired skills and expertise include:

a) identifying the basic principles of environmental policies and the concept and dimensions of sustainable development, as well as the role of participatory analysis involving society, stakeholders and politics;

b) interpretation of the global environmental and sustainable development issues, within the context of the United Nations, and also how they are addressed within the EU;

c) knowledge of the institutions responsible for the global environmental policies, and employed policy tools.

This Erasmus Mundus GROUNDWATER AND GLOBAL CHANGE Master course is developed in IST, Lisbon (Portugal), IHE-Delft (Netherlands), TUDresden (Germany) , began in the 2015-2016 school year and has recently seen its continuity for another 4 years 2019-2020 until 2025. In this EU-funded program, 20 grants are awarded annually in a competitive manner. The elaboration so far of 31 master's theses, mostly of excellent quality, on the most varied subjects is a guarantee that the topics covered in the 5 proposed lines of research will reflect on the quality of the dissertations presented in this master's degree