Masters programme in

Hydrogeology

Hydrogeology (or groundwater hydrology) is the “study of the occurrence, circulation, distribution, and properties of any liquid water residing beneath the surface of the earth”\(^1\). Throughout the globe, the issue of water scarcity, water security, water economics and health and sanitation all rely on high quality hydrogeology knowledge. This MSc will prepare students as functional hydrogeologists to meet the needs of industry, regulators, NGOs, government and consultants throughout the UK, Europe, N America and the rest of the world.

LEARNING OBJECTIVES

The MSc provides students with the theoretical and practical skills to succeed in a career as a hydrogeologist, preparing students for life beyond the course with extensive opportunities for developing practical skills and forging links with industry. Students are afforded the opportunity to work with hydrogeological organisations contributing to on-going projects; conduct their own laboratory experiments to reinforce taught theory; participate in discussions with visiting external experts; and conduct linked research/projects in Africa, the Middle East and Asia as part of a final thesis.

CAREER PROSPECTS IN HYDROGEOLOGY

Students who complete an MSc in Hydrogeology are in very high demand as there is an expected shortage of hydrogeologists that will continue for the next decade. Additionally, throughout the world the issue of water scarcity, water security, water economics and health and sanitation all rely on high quality hydrogeology knowledge.

WEEK LONG FIELD CAMP

In the spring semester of the MSc course the students are taken on a week-long field camp in Scotland where they get the opportunity to put much of the learned theory into practice. Site visits introduce the students to the geology and hydrogeology of the study area before they gain practical experience in conducting pump tests, recovery tests and chemical sampling. In addition to the fieldwork week, practical laboratory experiments are conducted weekly throughout the course to reinforce theory delivered during the lectures. By the time the students graduate they have developed sound fieldwork skills much sought after by potential employers.

LINKS WITH INDUSTRY

Suitable external experts working in industry are invited to give talks on their work and provide the students with insight into the variety of work undertaken by hydrogeologists as well as increasing their awareness of current works and projects. Students are also required to undertake a work placement module where they report to the offices of a hydrogeological organisation and actively contribute to one of their ongoing projects. This is a very valuable experience for the students as it allows them to work as hydrogeologists for a number of weeks exposing them to a working environment as well as allowing them to build up contacts within industry.

OVERSEAS MSC RESEARCH PROJECTS

For the final three months of the course the students undertake a thesis project which we encourage them to complete overseas. Strathclyde’s MSc course leader has extensive contacts in arid countries such as Malawi, Mozambique, Tanzania, Zambia, the Middle East and Asia, affording the students valuable, varied learning opportunities and practical experience around the world.

WORKSHOPS AND TRAINING
Groundwater modelling is taught to the students through lectures and a series of individual computer based problems to develop competency in the theory behind numerical simulations. External experts from the British Geological Survey host 2 day seminars instructing the students in the use of their standard groundwater modelling software ZOOM, and extends to solution techniques for both groundwater flow and contaminant transport. With this knowledge the students are then expected to develop their own groundwater model using the raw data obtained from the fieldwork visit, and are assessed through the preparation of a report summarising the results of their contaminant transport modelling scenario.

ACCREDITATION
The MSc Hydrogeology programme is accredited as meeting the requirements for Further Learning for a Chartered Engineer (CEng) for candidates who have already acquired an Accredited CEng (Partial) BEng(Hons) or an Accredited IEng (Full) BEng/BSc (Hons) undergraduate first degree. See www.jbm.org.uk for further information.

STRUCTURE OF THE MSC IN HYDROGEOLOGY
The MSc involves a curriculum of eight core classes (totalling 80 credits) and a range of optional classes (40 credits). Each module is taught two to three hours per week over 8 to 12 weeks. In addition, students also attend workshops and undertake a dissertation (60 credits). Progress to the dissertation is dependent on performance in the instructional modules. The Open Access programme allows professionals to take single modules for CPD purposes, or build up towards six modules (60 credits) to gain a Postgraduate Certificate.

Compulsory Core Classes
- CL952 Aquifer Mechanics (2nd Semester)
- CL954 Contaminated Land (2nd Semester)
- CL946 Global Water Policy (1st Semester)
- CL951 Groundwater Flow Modelling (2nd Semester)
- CL935 Hydrogeology (1st Semester)
- CL931 Research Protocols for Science and Engineering (1st Semester)
- CL906 Site Investigation and Risk Assessment (1st Semester)

Optional Classes (five to be chosen)
- CL962 Environmental Chemistry (2nd Semester)
- EV939 Environmental Impact Assessment (2nd Semester)
- LLMXX International Environmental Law (Law Dept) ** (TBA)
- CL960 Fundamentals of Environmental Forensics ** (2nd Semester)
- CL958 Geographical Information Systems (GIS) (2nd Semester)
- CL973 Independent Study in Collaboration with Industry ** (1st or 2nd Semester)
- CL904 Waste Management and Landfill Design** (2nd Semester)
- EV921 Water Environment Management ** (1st Semester)

** Strongly Recommended Optional Modules

THE DEPARTMENT AND COURSE DELIVERY TEAM
The Department of Civil and Environmental Engineering at Strathclyde has one of the strongest Geo-Engineering foci of any related department in the UK, and is currently working with the British Geological Survey (BGS) to develop hydrogeology in sub-Saharan Africa. The Department has strong links with the Middle East and with SADC (South African Developing Countries) such as Malawi, Mozambique and Tanzania.

SUGGESTED READING
COMPULSORY MODULES

CL952 Aquifer Mechanics (Prof Bob Kalin, Civil & Environmental Eng) In many parts of the world, groundwater resources are under increasing threat from growing demands, wasteful use, and contamination. To face the challenge, good planning and management practices are needed. A key to the management of groundwater is the ability to mathematically describe the movement of fluids and contaminants in the subsurface. The purpose of this module will be to construct conceptual and mathematical models that can provide the information required for making decisions associated with the management of groundwater resources, and the remediation of contaminated aquifers.

CL954 Contaminated Land (Dr Christine Switzer, Civil & Environmental Eng) This class introduces the problem of urban land reuse, the regulatory framework and risk assessment and the various remedial techniques to enable an understanding of the role of land recycling in urban development. It will allow the student to possess knowledge of the relevant planning advice and legislation and determine appropriate remediation technologies and strategies. It will also allow decisions on land recycling based on technical solutions, risk management, planning and financial constraints to be made.

CL946 Global Water Policy (Dr. Francesco Sindico, Law Department, External Lecturers) This class will introduce students to the law and policy of global water resources. Through interactive sessions key legal and policy instruments applicable to a number of crucial global water security issues will be discussed. Seminars on the law and policy of trans-boundary surface-water and of trans-boundary aquifers will be framed in the context of the wider international debate on global water security. The debates surrounding water as a human right and trade in water (including the debate on virtual water) will also be present. The module will have a strong legal component, but will be tailored to a non-legal audience.

CL951 Groundwater Flow Modelling (Prof Bob Kalin, Civil & Environmental Eng with the British Geological Survey) The aim of the module is to promote the use of numerical methods by hydrogeologists in their daily work. The course will provide a background to the theory of groundwater modelling and to its practical application. The course will consist of six “sub-modules” as follows: 1. Conceptual modelling; 2. Recharge process and quantification; 3. Water Balance calculations; 4. Pumping test analysis; 5. Regional groundwater modelling; and 6. Solute transport. The course will provide skills in the mathematical modelling of groundwater.

CL945 Hydrogeology (Prof Bob Kalin, Civil & Environmental Eng) The objective of this class is to serve a diversity of interests, including those of geologists, practicing hydrogeologists and engineers, geochemists and geophysicists interested in subsurface fluid dynamics and contaminant transport. The lectures will present information on the hydrologic cycle, the porosity and permeability of porous material, and on fluid, energy and mass transport in porous media.

CL931 Research Protocols for Science and Engineering (Dr Helen Keenan, Civil & Environmental Eng) The course will familiarize students with basic research methodology, including the use of scientific literature, quantitative and qualitative methods, the maintenance of laboratory notes and the use of scientific English. Particular assistance is given on research techniques to prepare students for the dissertation/project stage of the course.

CL906 Site Investigation and Risk Assessment (Dr Philippe Sentenac, Civil & Environmental Eng) This class explores the complete sequence of a site investigation (Desk study, Site sampling organisation and techniques, Data collection and Chemical analysis) followed by data modelling and interpretation using risk assessment models.

OPTIONAL MODULES (in alphabetical order)

CL962 Environmental Chemistry (Dr Helen Keenan, Civil & Environmental Eng) The course will also familiarize students with basic concepts of chemical analysis relevant to the environment, establish outline knowledge of a range of common analytical techniques and provide practical experience in analytical chemistry.

EV939 Environmental Impact Assessment (Dr Elsa João, Civil & Environmental Eng) This class provides an introduction to the methods used to predict environmental impacts, and evaluates how these may be used to integrate environmental factors into decisions. The class draws principally on the UK planning context of environmental impact.
assessment of individual projects (project EIA), but also takes account of EIA experience in other countries and international organizations.

CL960 Fundamentals of Environmental Forensics (Prof Bob Kalin, Civil & Environmental Eng)  This class sets environmental forensic science in an overall legal and professional context, introduces the structure and integrated functions of the legal processes for environmental litigation, illustrates different legal systems through case studies, competency and ethics for Environmental Forensics. The class also introduces students to the range of environmental forensic applications.

CL958 Geographical Information Systems (GIS) (Dr Elsa João, Civil & Environmental Eng)  This class provides a thorough introduction to the rapidly growing field of Geographical Information Science. The Class covers the key theoretical principles but also provides many practical exercises using current state-of-the-art Geographical Information Systems (GIS). The Class evaluates how GIS can be used for spatial query and analysis, while at the same time assessing the quality and the effectiveness of the resultant products in terms of their use.

CL973 Independent Study in Collaboration with Industry (Industrial Link Supervisor)  Graduates increasingly need highly developed transferable professional skills to prepare for and to gain future employment. This module will allow students carrying out placements and projects with industry to develop and refine professional skills while gaining credits in the process. Approval of students being able to take this module would be done on case-by-case basis by MSc course leaders as an individualised learning contract. Students will be selected by competitive application and CV.

CL904 Waste Management and Landfill Design (Dr Tara Beattie, Civil & Environmental Engineering)  This class covers organizational and regulatory aspects of waste management practice in the UK: legislation, composition of domestic and industrial wastes, storage, collection, reception, and disposal of solid wastes, clinical wastes, sewage sludge disposal, recycling and recovery.

EV921 Water Environment Management (Dr Tara Beattie, Civil & Environmental Engineering/Environmental Health)  To develop an understanding of the physical, chemical and biological parameters within surface water and how these relate to water quality, water quality objectives and pollution control strategy. To provide knowledge on the design and process involved with the control of water and wastewater treatment.

KEY STAFF
Professor Bob Kalin (USA) is the Course Leader of the MSc in Hydrogeology. He has expertise in site specific biogeochemistry of contaminated land and groundwater (including engineering design of sustainable remediation methods); to hydrogeology and paleohydrology of local to regional scale groundwater systems; and study of global biogeochemical cycles and climate change. He has extensive international links (e.g. USA, China, Middle East and Africa).

Dr. Francesco Sindico (Italy) is Reader in International Environmental Law at the School of Law at the University of Strathclyde. Dr Sindico is an expert in International Law and has published on trans-boundary aquifers and water and trade and has worked on projects on the Guarani Aquifer System in Latin America. Dr Sindico will be teaching on the Global Water Policy module together with academics from the IHP-HELP Centre for Water Law, Policy and Science at the University of Dundee.

FOR MORE INFORMATION ABOUT THE MSC IN Hydrogeology
Detailed class descriptions can be provided upon request. For more information please check www.strath.ac.uk/civeng/pg/ or Email: Robert.Kalin@strath.ac.uk