Groundwater for Sustainable Development in the MENA Region
Abstract n°2689

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A year ago, in September 2015 the international community agreed on an ambitious 2030 Agenda for Sustainable Development that includes a set of 17 Sustainable Development Goals (SDGs) and 169 targets. The United Nations Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs) proposed in December 2015 a set of 231 global indicators that were adopted by the United Nations Statistical Commission (UNSC) in March 2016 as global SDG indicator framework and as practical starting point for monitoring progress towards the achievement of the SDGs by 2030. It was also noted that the indicators are subject to further technical refinement . Based on the current understanding water and groundwater, well managed and in sufficient quantities and qualities will be essential for achieving many of the SDGs. This in addition to the specific SDG 6 Ensure availability and sustainable management of water and sanitation for all . In the Middle East and North Africa (MENA) with a generally higher water scarcity than in many other parts of the world and with larger quantities of renewable freshwater already utilized, sustainable water management has been challenging for many years. Groundwater in this region has been especially burdened with inappropriate governance, over exploitation and pollution - to name only a few challenges. How will the MENA region cope with the new goals of the 2030 Agenda for Sustainable Development in the current times of transition with fragile states, crisis, war, civil unrest and occupation? Based on recent studies the presentation analyzes the current situation and derives proposals to focus on specific aspects in which groundwater can better contribute to the overarching goals for sustainable development. It will also provide guidance for improved governance of groundwater resources in the region and offer a way forward to a more just socio-economic development for the people in the MENA region.

Numerical modeling for groundwater management and protection – The case of the Nyanzare well field in Gitega, Burundi
Abstract n°2178

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The majority of the water supply for Gitega city, located in the center of Burundi, is derived from the Nyanzare well field which produces around 5000 m3 day. The study area is characterised by hills of ancient formations composed of metamorphic rocks as alternating schist, quartzite, and phyllite. Due to population growth, the water demand for the second largest city of Burundi is increasing. Concurrently, progressive urbanization, clay mining, agriculture, coffee industry, and fuel depots represent a growing risk for drinking water quality. To provide for a groundwater management tool, a 3D numerical groundwater flow model of the Nyanzare catchment was developed. The model was set up using the finite element software SPRING. It contains the relevant lithological units of the highly inhomogeneous valley as well as lineaments that act as preferential flow paths leading to great efficiency in some of the pumping wells. A transient recharge calculation was carried out taking into account spatial and climate data of the area. The model was successfully calibrated using water level data from three observation wells collected during the past 3 years. The resulting flow field in the valley was applied to determine average flow velocities and to establish protection zones based on the 50 day travel time around each well. A strategy for sustainable use requires an assessment of available groundwater resources combined with changes in socio-economic and climatic conditions. Several scenarios were tested to simulate the effects of (1) increased water demand after the installation of another well and (2) the variation of pumping intervals. Furthermore, a decline in recharge caused by (3) stresses from climate change and (4) the expansion of build-up areas spreading further into the catchment area was simulated. Results show that scenarios (1) and (3) are the most hazardous.

A case of natural contaminants in groundwater- High uranium concentrations in water supply wells in Burundi
Abstract n°1993

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KEYWORDS: Water supply,Natural contaminants,Burundi

Groundwater is often preferred over surface water as a source of potable water supply because of its favorable characteristics in terms of availability and bacteriological quality. However, the presence of natural contaminants is a risk that should be assessed. In areas with igneous or volcanic rocks, elements like fluorine and uranium often occur in groundwater at concentrations above drinking water standards. This contribution presents a case study from northern Burundi where dissolved uranium concentrations exceeding 700 Ig L have been encountered. The study area is located south of Lac Cohoha, on the border between Burundi and Rwanda. The geology is dominated by granitoids of the Kibaran belt system, which have a uranium content between 5 – 15 ppm. The original rocks have been highly weathered, and the weathered sequence forms unconsolidated aquifers that can reach a thickness of at least 91 m in the study area. The predominant land use is subsistence agriculture, with the main crops being beans, sweet potatoes, maize, cassava, banana, and sorghum. Groundwater recharge is estimated about one fifth of the mean annual rainfall, which is just over 1000 mm, and groundwater discharge occurs in valley bottoms and along the shores of Lac Cohoha. There, intense evapotranspiration occurs, and it is believed that this is the process that leads to the enrichment of dissolved uranium, which is supported by geochemical model calculations using PHREEQC. Based on a conceptual model of dissolution of feldspar minerals from the uranium-containing rock during groundwater recharge and flow, and evaporative concentration in the discharge area, the major trends of the groundwater chemistry, including uranium concentrations, can be reproduced. Whilst dissolved uranium concentrations may be influenced by other processes as well, the overriding influence of evapotranspiration highlights the need for caution when developing water supply wells near discharge zones in other regions where similar conditions exist.

Aggregation of hydrogeological information at national and (sub)-regional scales for coherent knowledge transfer and support for decision making
Abstract n°2678

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The process of semantic and geometric harmonization and aggregation of geological information is crucial for providing coherent information valid at and transferable between multiple overview scales. Recently, the lithological description of the International Hydrogeological Map of Europe in a scale of 1-1,500,000 (IHME1500) of initially 1065 map units was generalized in five hierarchical aggregation levels based on a new taxonomic scheme and subsequent rock class grouping, resulting in ten rock classes and a ternary classification attributed to consolidated, partly consolidated and unconsolidated geologic materials as the highest generalization level. Additionally, IHME1500 represents basic information on general potential aquifer characteristics (productivity) for the lithologically defined map units based on expert knowledge. This presentation describes the application of this methodology to harmonize information on material compositions and potential aquifer productivities at the national scale (adopting the hydrogeological map of Germany HUEK200), as well as (sub)-regional and pilot zone scale (~400 kmC) in technical cooperation projects in Niger and Chad. The analyses involves various degrees of data availability and quality, showcasing difficulties and challenges in up- and downscaling processes. Furthermore, this contribution will highlight the need to move on to integrated hydrogeological mapping at overview scales, facilitating decision making processes on short- and mid-term time scales This may be achieved combining the aggregated map units with information from various fields in science and engineering, as well as developing comprehensive, yet comprehensible legends that assure a transfer of precise hydrogeological data into planning societal benefit areas.

Isotope hydrological and hydro-chemical characterization of groundwater in Lower Saxony, Germany
Abstract n°2402

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KEYWORDS: Stable isotopes, hydro-chemistry, groundwater, Lower Saxony

Groundwater samples are collected on a routinely basis in Lower Saxony (47.618 km2) in Germany using a special field sampling vehicle for groundwater which allows in-situ and online monitoring of pumping rate, conductivity, temperature, pH-value, turbidity, and redox potential. Besides hydro-chemistry, stable isotope analyses (deuterium, oxygen-18) have been conducted at the BGR LBEG laboratories in Hannover for the last three years (since 2013). More than 300 samples have been analyzed to date and are interpreted for seasonal and spatial patterns as well as for surface water influence. Stable isotope concentrations vary between -3.17 ‰ and -9.31 ‰ for delta 18O and between -21.4 and -66.6 ‰ for delta 2H, respectively. Deuterium excess values vary between 14 ‰ and 3 ‰. The isotopic characterization of groundwater in relation to precipitation and surface water patterns might allow a better understanding of recharge processes and aquifer vulnerability on the large scale.

Impacts on Freshwater Resources Related to CO2 Storage in Saline Aquifers
Abstract n°1551

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KEYWORDS: CCS, environmental risks, groundwater protection

Injection and storage of CO2 into deep saline aquifers changes geophysical and geochemical conditions in the storage environment. Such changes in greater depths, however, may subsequently lead to adverse impacts in the shallow subsurface. Here, freshwater aquifers might be influenced during and after injection – indirectly by pressure changes and directly by CO2 or saline formation water migrating along natural occurring faults and fractures or through faulty boreholes. While pressure perturbations may lead to deformations at the surface in the range of millimeters, the main concern is the vulnerability of shallow freshwater resources. CO2 entering freshwater not only decreases pH, but may subsequently dissolve and mobilize potentially toxic metals. The mixing of native saline formation water or CO2-enriched saline formation water with ambient groundwater increases salinity and electrical conductivity and may result in severe damages and contamination of fresh groundwater. Geophysical, geochemical, and biological parameters, often interdependent, can be used for monitoring strategies. The two main reasons for monitoring shallow aquifers in the vicinity of deep CO2 storage reservoirs are- (1) provisions for health, safety, and environment, (2) verification of safe injection management and storage operation according to plans. A broad and site-specific monitoring program, operating on different time and spatial scales prior, during, and after injection together with THMC modelling, laboratory and field experiments, are highly recommended for safe geological CO2 storage and general groundwater protection. Diffusive and localised leakage associated with geological CO2 storage cannot be excluded, but, by selecting suitable storage locations, potential impacts on the environment can be reduced. This presentation gives a review of possible impacts on freshwater aquifers.

Paleo-modelling the formation and development of the freshwater lens on Langeoog Island, Germany
Abstract n°1932

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KEYWORDS: freshwater lens, modeling, islands

Langeoog is a barrier island located in the North Sea, Germany. It extends approximately 12 km east-west and 1.5 km north-south. Dune areas of up to 20 m a.s.l. can be found predominantly along the northern part and eastern ridge of the island, protecting it from flooding. Three distinct freshwater lenses are present+ the westernmost one is tapped for local water supply. Langeoog consists mainly of medium to coarse sands, containing randomly-occurring clay deposits up to several metres thick. In general, hydraulic conductivity increases with depth. Paleo-reconstructions of the geomorphologic development of the island showed that Langeoog formed around 2500 years BP. Because dunes started to form by sand accumulation and prevented certain areas from flooding, a freshwater lens started developing. This original sand island of Langeoog, however, formed at a location several hundreds of metres northwest of its current location. By successive sand accumulation, redistribution and removal by the wind and sea, the island migrated over time. In this study, we model the formation and development of the freshwater lens under Langeoog, including the geomorphologic changes over time. As large areas were flooded in the past, the freshwater lens was partly destroyed. Anthropogenic groundwater abstraction during the last century is also acknowledged, as well as dam constructions leading to hydrological changes on the island. To our knowledge, this is the first study that simulates the paleo-evolution of a freshwater lens up to its current state, showing that steady-state may hardly be assumed for the present situation.