Hydrologic Engineering and Strategic Water Resources Assessment

From Urban Systems to Regional Scale

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Hydrology provides basic information and data for engineering of infrastructure such as bridges, dams and water supply and sanitation systems. Biogeochemical processes taking place in aquatic systems e.g. around springs, rivers, interstitial water, lakes and groundwater are often blueprints for technical engineering sanitation. The increased impact of human activity on the water cycle requires a broader definition of interactions between and mutual support of hydrology and civil engineering. The attempt is made to outline the benefits of such a cooperation as a strategy of Integrated Hydrologic Engineering (IHE). Three major aspects are highlighted based on case studies that also represent a framework for the development of future projects at the FHL.

Joint system analysis of hydrologic and engineered solutions

Water resources systems have become larger and span over entire national territories (and beyond): The National Water Carrier of Israel, similar structures in Namibia connecting all major aquifers and reservoirs, the planned canal de San Francisco in Brazil are used to transfer large amounts of water over hundreds of kilometers. At the same time these systems have become more complex and affect not only flows of water but also flows of matter (organic matter, salts, pollutants e.g. heavy metals). The example of water supply of Windhoek is presented that is consisting of groundwater use from aquifers, several inter-connected reservoirs, sanitation systems along their inflows and managed artificial recharge schemes (MARs). A thorough system analysis demonstrates that MARs - a smart solution - introduces a short-cut in the flow of solutes and matter (other than water) that leads to an auto-pollution of the water supply system over decades. Such complex systems can become vulnerable even though they consist of a series of good solutions. A system analysis including hydrologic and engineering aspects can avoid or reduce such problems.

Landscape engineering

What can we learn from Nabateans? Why does the demise of Euphrats marshland endanger the Persian Gulf and what does this mean for the Baltic Sea? During the last 30 years a wealth of knowledge has been derived from environmental studies on natural attenuation in groundwater, the role of interstitial biogeochemical processes on the retention of pollutants, on degradation processes in all major parts of the water cycle. At the same time hydrological processes are much better understood: Runoff production is not seen merely as a surface runoff process anymore, the role of wetted areas, groundwater response and ridging gives a more detailed and diverse picture. The potential of this knowledge is hardly applied. The Nabateans used knowledge on hydrological principles (and altered infiltration on hillslopes to increase runoff). In terms of water quality, natural and engineered wetlands have potential for sanitation, retention and removal of pesticides, organic pollutants and heavy metals. An example of designed pollutant traps, laboratory work, chemical modeling and appliation is given. In some cases a combination of hydrologic, hydraulic and biochemical aspects is required as for example for phosphate retention. Phosphate export from catchments is linked to peak discharge and high-erosion events. Natural river systems cut peaks, engineered systems optimized to prevent flooding convey peaks - and phosphate. An engineered phosphate retention system therefore needs to retain flood peaks in flood and nutrient retention areas. Wetlands and marshes of the Euphrat are a natural landscape-scale sanitation system. Degradation of this area has dramatically reduced its functioning and has led to an increase of nutrient export to the Persian Gulf. The same holds true for the Baltic Sea and degraded wetlands in a number of Baltic States (see UB, nitrate project in Lithuania and Poland). Retention of nutrients in landscape engineered systems (engineered wetlands) has potential for phosphate retention but also for pesticides and other organic pollutants. Research tools for the this aspect are proposed.

Strategic Planning of Water Resources

A recent project on Strategic Environmental Planning of the Erongo Mining region (Namib, West Coast of Namibia) and the National Water Resources Master Plan of Rwanda are introduced as examples of regional, national and multi-national activities for hydrologic engineering. The SEA Erongo showed that regional water resources are not sufficient for the growing mining sector. This led to an early decision to implement desalinization plants as a source of fresh-water for the mining sector, preserving local aquifers for farmers and local settlements. The drainage of the imported water is not solved completley and deserves further study. The National Water Resources Master Plan of Rwanda is an example of strategic planning at national scale. The massive expansion of irrigation projects and the planned expansion of hydro-power projects has unknown impacts on the regional and national water balance and potentially also affects base-flow of the Nile. The on-going project focusses on providing data on the impact of policies and on different land-use scenarios. This will lead to design proposals for flood retention, sustainable water resources management and sanitation.