Development of regenerative water resources in semi-arid regions

Methods and processes – synopsis of a package solution

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This wonderful falaj is in Wadi bani Khalid, Al Sharqiya Region.
Introduction

- Established methods of water supply in semi-arid regions:
  - Sources
  - Wells
  - Desalination plants of sea water
Further used and not used potentials of regenerative water resources on the basis of seasonal rainfall events

- Recharging of groundwater with different methods
- Dams, usually overspill dams
- **Subsurface storage** of precipitations from **defined** catchment areas
Methodology

Catchment area

1st step: Selection of catchment areas, precipitation

- Definition of suitable catchment areas with satellite supported mapping
- Presentation of suitable regions of interest (ROI) with additionally high resolution satellite supported mapping
- Detailed measurements of precipitations in every regions of the catchment area
- Climate studies for long time prediction of precipitation
Methodology

Catchment area

2nd step: Hydrology, hydrogeology

- Determination of hydrological runoff processes in the whole catchment area
- Hydrogeological characteristics for determination of possible losses by infiltration and evaporation
- Determination of really runoff in the stream network in the catchment area
Methodology

Catchment area

3st step: Measures of hydraulic engineering

- Determination of hydromechanical characteristics and the possible amount of sediment load in the catchment area
- Determination of hydraulic engineering measures to handle sediment load (for example gabions)
- Determination and dimensioning of intermediate dams (self-cleaning dams) and of secondary collection conduits
- Dimensioning of main dam (usually overspill dams)
Methodology

Construction of underground artificial galleries

1st step: Dimensioning of underground artificial galleries for water storage

- Determination of the regional amount of drinking water and other water uses
- Determination of possible water yield in the catchment area under consideration of climate studies
- Determination of the necessary capacity of the storage system in the worst case situation under consideration of possible long term influences
- Determination of the underground storage system on the basis of regional geological fact (blindtunnels, tunnels with perforation through a mountain massif)
Methodology

Construction of underground artificial galleries

2st step: Using of new tunnelling technology

- Ideal positioning for the regional application of the tunnel boring machine (TBM)
- Exploration boring along the planned tunnel line to find out the geological and hydrogeological conditions
- Estimation of impacts on existing water supply systems (for example AFLAJ)
- Planning for a production plant to produce tubbings
Methodology

Construction of underground artificial galleries

3rd step: Design of storage units

- Presentation of the construction of storage unit
- Estimation of tectonically influences to dimension the thickness of tubbings
- Dimensioning of the inside wall under consideration of statics calculations of the present hydraulic pressure also with possible tectonically influences (for example earthquakes)
Design of storage units
Methodology

- Determination of water chemical influences to the building material by long term storage, for example of changing pH-values and/or ions in solution

Solutions:
- Using of durable building materials for a long term guarantee for the substance of the building (for example: fiberglass, carbon grids)
- Coating of specific materials (with bactericide effects) on the inside wall for prevention of materials losses or changes of the water quality
Methodology

Construction of underground artificial galleries

4st step: Guarantee for operating ability and water quality

- Installation of water indicators and sensors for every storage unit
- Installation of a pumping system along the service tunnel:
  - for filling the storage units and for water supply
  - for pressure balance of every storage unit
- Installation of electrodes to produce bactericidal ions to prevent contaminations together with additional methods
- Automating of the whole storage system with IT-Solutions
Advantages/Disadvantages

Construction of underground water storage systems

Advantages
- Storage of defined volumes of water for a projectable water management
- Very small losses by evaporation, no losses by infiltration
- Clear reduction of contaminations
- High security to influences from outside
- Wide range for using in semi-arid regions, in special cases are 2-3 heavy rainfall events of at least 15 mm enough
- Regional decentralized applications are possible like combination over more catchment areas
- Supply in supra-regional water supply systems in the case of abundant runoff and vice versa
Advantages/Disadvantages

Disadvantages

- High costs for implementation
Cost-benefit-estimation (worst case)

Example: Standardized storage unit

Demand: 4000 inhabitants
Per head-demand: 110 litre water per day

Necessary storage capacity: 160,000 m³ per year

Costs for implementation: 84 Mio. € +/- 2 Mio. € (87 Mio. $)
(water intake, water storage, water treatment for users)

Period of amortization: 60 years

> 0,96 € (up to 1 $) per inhabitant and day
Conclusion

The package solution as well as components of the package solution can be individual applied for the following purposes:

- for compensation of already existing water shortages, especially in semi-arid regions
- as a balance to expected water deficits by climate change
- to bridging arid time windows, which are in many regions of the world presently make settlements almost impossible
- in developing, emerging and industrial countries, in which the water capacities demands for large storage capacity
- in tropical as well as in as in semi-tropic regions, in which drinking water is endangered through microbial, viral as well as organic contaminants
Conclusion

- in crisis regions, in which water shortage continuous conflict potential is
- in from natural disasters endangered regions
- to reduce results of heavy rainfall events as a positive companion effect, that in semi-arid regions can presently lead to flooding disasters as well as
- for agricultural application in regions until now unsuitable therefore, at least contributing to regional self-sufficiency
Day after