3D- GEOLOGICAL AND GROUNDWATER FLOW MODELLING OF DROUGHT IMPACT AND RECHARGE POTENTIALITY IN KHATT SPRINGS AREA, RAS AL KHAIMAH EMAREATE, UAE

by

P. Wycisk , M. Al Assam, S. Akram, M. Al Mulla, D. Schlesier, A. Sefelnasr, N. B. Al Suwaidi, M.S. Al Mehrizi, and A. Ebraheem

Joined Research Work of
Ministry of Environment & Water, Dubai, U.A.E.
Martin-Luther University, Halle, Germany
Khatt Spring Pilot-Project

Data Source: Satellite Image by Ras Al Khaymah Municipality

United Arab Emirates

Graphic by ArcMap
Khatt Spring Pilot-Project

Overview

Area of the Khatt Basin Project

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Ministry of Environment & Water, Dubai, U.A.E.
Dept. of Hydrogeology & Environmental Geology,
Prof. Dr. P. Wycisk
Martin-Luther University Halle, Germany
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Martin-Luther-University Halle, Germany
Data Basis of the Khatt Spring Pilot-Project
Khatt Spring Pilot-Project

DEM = „Digital Elevation Modell“

Legend:

- Intervall Contours of DEM
- Altitude in m
- City

Data Source:
DEM by USGS (2003)
Seamless Data Distribution System
Earth Resources Observation and Science
Satellite Image by USGS
DEM processing by Andrea Hanf

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Geology

Legend:
- Quaternary: carbonate sand
- Quaternary: fluvialite deposits
- Quaternary: sand dunes
- Cretaceous: Shale, Clay
- Jurassic-Cretaceous: Limestone
- Permo-Triassic: Limestone
- Cambrian: Gabbros and Ultrabasios
- Cambrian: Metamorphios Quartzite
- Location of Project wells

Data Source:
Geological Map (1979) by
Government of the UAE
Ministry of Petroleum and Mineral Resources

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Wells and Profiles

Legend:
- Location of Project wells
- Geophysical Profil
- Geological section
- City

Data Source:
Satellite Image by USGS
wells by IWACO
Geophysical Profile by A. M. Ebraheem, and others
Geological section by IWACO (1986)

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A subsurface geological cross section in the east-west direction
Khatt Springs Project

Hydrogeological map of the study area
Water table fluctuations in wells RK-14 and Khatt-1 in response to the amount of annual precipitation. The water table measurements are shown as monthly values.
Annual flow rate variations in the north and southern springs in response to the yearly amount of precipitation.
Development of the Drawdown of the Groundwater Level
Khatt Spring Pilot-Project

Groundwater Level 1969

Legend:

30 Groundwater Level in 1969
amsl in m

Data Source:
Satellite Image by USGS
Groundwater Level Data by IWACO
thematic setting up by A. M. Ebraheem

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Khatt Springs Project

Drawdown of Groundwater Level from 1969 - 2005

A drawdown of up to 65 meters happened in this period. Major geomorphologic units and agricultural lands are also shown.
Khatt Spring Pilot-Project

Groundwater Level 2005

Legend:

30  Groundwater Level in 2005
     amsl in m

Data Source:
Satellite Image by USGS
Groundwater Level Data by IWACO (2005)
thematic setting up by A. M. Ebraheem

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Map 10:
Groundwater Level of the year 2005
Development of the Groundwater Salinity
Khatt Spring Pilot-Project

Groundwater Salinity 1969

Legend:

1000
2000
Groundwater Salinity of the year 1969 in mg/l

Data Source:
Satellite Image by USGS
Salinity Data by IWACO (2005)
themetic setting up by A. M. Ebraheem

Map 4: Groundwater Salinity of the year 1969

Khatt Basin, U.A.E.

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Groundwater Salinity 1986

Legend:

1000
2000
Groundwater Salinity of the year 1986
in mg/l

Data Source:
Satellite Image by USGS
Salinity Data by IWACO (1986), Groundwater Study (Project 21/81)
Thematic setting up by A. M. Ebraheem

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Map 5: Groundwater Salinity of the year 1986

Khatt Basin, U.A.E.
Khatt Spring Pilot-Project

Groundwater Salinity 2005

Legend:

1000

Groundwater Salinity of the year 2005 in mg/l

Data Source:
Satellite Image by USGS
Salinity Data by IWACO (2005)
Thematic setting up by A.M. Ebraheem

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Difference of Groundwater Salinity from 1969 - 2005

Legend:


Data Source:
Satellite Image by USGS
Salinity Data by IWACO (2005) and by Halcrow and Partners (1969)
Thematic setting up by A. M. Ebraheem

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3D Geological Model of the Khatt Basin Area
Khatt Spring Pilot-Project

- Land-Use
- Hydrostratigraphy
- Water / Groundwater
- Groundwater Salinity
- Contaminants
- Geology
- Hydrogeologie
Khatt Spring Pilot-Project

Khatt Basin Area

Location of the bore-holes
Khatt Spring Pilot-Project

39 used bore-holes overlying the georeferenced satellite image and a transparent geological map
Khatt Spring Pilot-Project

39 constructed cross-sections, satellite image and geological map

Exaggeration 3x
Volume body of the Musandam-Limestone (green) and 39 constructed cross-sections
Khatt Spring Pilot-Project

Overview study area (ca. 2000 km²), geological map linked to the DEM (200 x 200 m)
Khatt Spring Pilot-Project (animation)
Khatt Spring Pilot-Project

Geological Map

Virtual Bore-hole

3D-Model

Virtual Cross-Section
GIS-based 3D Groundwater flow model for WRM in Khatt Spring Area
GIS-baed 3D Groundwater flow model for WRM in Khatt Spring Area
GIS-based 3D Groundwater flow model for WRM in Khatt Spring Area
Conclusions & Recommendations

• GIS tools were used to build a complete data base in khatt spring area. This data base has been very useful for building the first 3D geologic model for an area of about 2000 km2.

• The developed 3D geological model of Khatt Springs area allows different types of visualization, calculation and predictions as well as the subsequent operation within hydraulic models. It also minimized the need for statistical or geostatistical interpolation between stratified scattered boreholes which in most cases give inadequate results.

• The time scale of groundwater recharge was correctly implemented in the groundwater flow model and the simulation results showed the necessity of a transient model approach.

• The simulation results of the GWF model indicated that it could be possible to rehabilitate the Quaternary Aquifer in this area and stop salt water intrusion in this area IF the socio economical impact can be tackled in the first 15 years.
Thank you, for your attention