UNITED NATIONS ESCAP
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21C Frontier R&D Program
Sustainable Water Resource Research Center

THE FIRST Asia-Pacific Coastal Aquifer Management Meeting:

MAPPING FOR SYNERGY IN THE TWENTY-FIRST CENTURY

9-11 December 2009

Ambassador Hotel, Bangkok, Thailand

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Overview

A large portion of the world's population inhabits areas near the coastline, and this puts significant stress on surface and ground water resources. In addition, sea level rise due to climate change is expected to adversely impact coastal water resources, in particular, ground water resources. A UN report predicted that nearly 45% of the world's population are at risk due to sea level rise. In other parts of the globe, ground water in coastal areas has received considerable attention from various sectors of society, including scientific communities, due to a host of other issues potentially impacting of ground water resource security. In Asia and the Pacific, scientists, engineers and managers who are concerned with coastal ground water have not had opportunities for a specialized forum. To this end, a group of water experts, from academia, governments and international organizations with a common interest in the management of coastal aquifers for socio-economic development, has cooperated to initiate the Asia-Pacific Coastal Aquifer Management Meeting (APCAMM). The first APCAMM is to be held in Bangkok in early December 2009. The second APCAMM is expected to be held in 2011.

Purpose

The purpose of the APCAMM is to provide a very specialized forum for scientists, engineers, water resource managers and planners to share their problems and ideas on management of coastal ground water. This meeting is expected to provide a good opportunity to meet well-known and respected scientists and engineers in the Asia-Pacific region, as well as to identify future opportunities for collaboration in coastal aquifer management for sustainable socio-economic development.

Topics

Topics of the 1st Meeting would include, but not limited to:

- Issues in management of groundwater in coastal areas
- Impacts of increased water demand on coastal water resources and ecosystems
- Aquifer storage and recovery (ASR) and managed aquifer recharge (MAR)
- Advances in groundwater modeling
- Effects of climate change and sea level rise
- Submarine groundwater discharge
- Tidal dynamics of coastal aquifers
- Geochemistry of coastal aquifer systems
- Case studies

Program Agenda

Day 0: 8 December 2009 (Lobby Lounge, Ambassador Hotel)

Time	Event
17:30-18:30	Meeting-Scientific Committee
18:30-20:30	Ice Breaker

Day 1: 9 December 2009 (Catteleya Meeting Room, 3rd Floor, Ambassador Hotel)

Time	Event
8:00-16:00	Registration
9:00-10:15	Opening Ceremony
10:15-10:30	Coffee Break

Session I: Effects of sea level rise and climate change

10:30-11:00	Transience of Seawater Intrusion in Response to Sea-Level Rise – *Adrian Werner*
11:00-11:30	Groundwater Management & Climate Change in the Asia-Pacific – *Salmah Zakaria*
11:30-12:00	The Model of Sea Level Rise in Indonesia – *Dewayany Sutrisno*
12:00-13:30	Lunch Break

Session II: Advance in groundwater modeling

13:30-14:00	SEAWAT: Its Concept and Applications - *Weixing Guo*
14:00-14:30	Estimation of Saltwater Content at a Pumping Well in Coastal Aquifer using Sharp Interface Model - *Lei Shi*
14:30-15:00	Design of Optimal Injection Well in Coastal Areas – *Namsik Park*
15:00-15:30	Refreshment Break

Session III: Impacts of increased water demand on coastal water resources and ecosystems

15:30-16:00	Impact of Land Reclamation on Coastal Groundwater Systems – *Jiu Jimmy Jiao*
16:00-16:30	Mitigation of Water Stress in Coastal Zones – *Weixing Guo*
16:30-17:00	Development of Alternative Feedwater Intakes for Membrane Water Treatment Facilities –*Michael Goff*
17:30-20:00	Welcome Reception

Day 2: 10 December 2009 (Catteleya Meeting Room, 3rd Floor, Ambassador Hotel)

Time	Event
9:00-15:00	Conference Registration Open

Session IV: Case studies of saltwater intrusion and eco-efficient management of groundwater resources of coastal cities (1)

9:00-9:30	Groundwater Management in the Emerging Concept of Water Security in Asia-Pacific – *Ti Le-Huu*
9:30-10:00	Numerical Assessment of Seawater Intrusion in Manukan Island, Malaysia – *Sarva Mangala Praveena*
10:00-10:30	Hydrochemical Evolution of Groundwater in Shenzhen after Land Reclamation: Major Ion Chemistry of Coastal Groundwater – *Kouping Chen*
10:30-11:00	Coastal Aquifer Management after the Asian Tsunami in Sri Lanka - *Ranjana Piyadasa*
11:00-11:15	Tea break

Session V: Poster session*

11:15-11:20	Introduction of Posters
11:20-12:00	Hydrologic Analysis of Groundwater Level and Electrical Conductivity Data for Jeju Island in Korea –*Jeong-Seok Yang* The Correlation Analysis between the Moving Average of Precipitation and Groundwater Level at Coastal Region of Jeju Island in Korea –*Jeong-Seok Yang* Saturation Indices of Groundwater Contaminated by Seawater in Small Tropical Island's Aquifer – *Ahmad Zaharin ARIS*
12:00-13:30	Lunch break

Session VI: Case studies of saltwater intrusion and eco-efficient management of groundwater resources of coastal cities (2)

13:30-14:00	Modeling of Saltwater Intrusion in the Floridian Aquifer System of Southwestern Florida, USA – *Zhongwei Li*
14:00-14:30	Mapping of Fresh and Saline Groundwater in Coastal Aquifers in the Nam Dinh Province (Vietnam) by Electrical and Transient Electromagnetic Soundings – *Hoang Van Hoan*
14:30-15:00	Delineation Prevention of Salt/Freshwater Encroachment in Prospective from Basin, India - *Subhash C. Singh*
15:00-15:15	Refreshment Break
15:15-16:30	Discussion (Next Meeting) - All Participants
16:30-17:00	Closing Ceremony

Day 3:11 December 2009

Time	Event	Venue
Post-conference Trip: LEADER: Dr Apichart Anukularmphai, President of Thailand Water Resources Association		
07:30	All attendants assemble at Ambassador Hotel	
08:00	En route to Suphan Buri	
10:00	STOP 1: Bureau of Groundwater ResourcesRegional 2 Theme: Hydrogeology of Suphan Buri Province	
10:30	En route to Amphoe Si Prachan, Suphan Buri	
11:00	STOP 2: Ban Wat Koh Amphoe Si Prachan, Suphan Buri Province Theme: Groundwater resources management	
11:45	En route to lunch	
12:00	Lunch	
13:00	En route to Ang Thong	
14:00	STOP 3: Model Farm, Ang Thong Province Theme: Agricultural use of groundwater	
15:00	En route to Ayutthaya Historical Park	
15:30	STOP 4: Ayutthaya Historical Park Theme: sightseeing, and souvenirs	
17:00	Return to Bangkok	

Committees

International Scientific Committee

Most members of the founding group are serving in the International Scientific Committee.

- Dr. Namsik PARK, Dong-A University, Korea (Chairman)
- Dr. Weixing GUO, Schlumberger Water Services, USA
- Dr. Timothy Yoon-Seok HONG, Wairakei Research Centre, New Zealand
- Dr. Jiu Jimmy JIAO, Hong Kong University, Hong Kong
- Dr. Kenji JINNO, Kyushu University, Japan
- Dr. Quy Nhan PHAM, Hanoi University of Mining and Geology, Vietnam
- Dr. Ranjana PIYADASA, University of Colombo, Sri Lanka
- Dr. Mohamad Pauzi ZAKARIA, Universiti Putra Malaysia, Malaysia
- Dr. Adrian WERNER, Flinders University, Australia
- Dr. Jichun WU, Nanjing University, China

Local Organizing and Advisory Committee

Dr. Ti Le-Huu leads the crucial local efforts for the first Meeting. Members of the Local Organizing and Advisory Committee are:

Mr. Chote TRACHU, Director General, Department of Groundwater Resources, Ministry of Natural Resources and Environment, Royal Thai Government

Dr. Ti LE-HUU, Chief, Water Security Section, Environment and Development Division, United Nations Economic and Social Commission for Asia and the Pacific

Dr. Apichart ANUKULARMPHAI, President, Thailand Water Resources Association

Mr. Ganesh PANGARE, Coordinator, Regional Water and Wetlands Program, Asia, IUCN – The World Conservation Union

Mr. Thierry FACON, Head of Water and Natural Resources Group, Regional Office of FAO for Asia and the Pacific

Dr. Ashim Das GUPTA, former Professor of Water Resources, Asian Institute of Technology

Dr. Salmah Zakaria, Economic Affairs Officer, Water Security Section, Environment and Development Division, UN-ESCAP

List of ABSTRACTS

1. **Coastal Aquifer Management After the Asian Tsunami in Sri Lanka-Ranjana**, by U.K. Piyadasa[1], K.D.N.Weerasinghe[2], J. A. Liyanage[3], L.M.J.R. Wijayawardhana[2]

2. **The Correlation Analysis between the Moving Average of Precipitation and Groundwater Level at Coastal Region of Jeju Island in Korea**, by Jeong-Seok Yang[1], Nam-Ki Kim

3. **DELINEATION AND PREVENTION OF SALT/FRESH WATER ENCROACHMENT IN A COASTAL AREA: A GEOPHYSICAL PROSPECTIVE FROM BENGAL BASIN, INDIA**, by Subhash C. Singh & P.C. Chandra

4. **DESIGN OF OPTIMAL INJECTION WELL IN COASTAL AREAS**, by Namsik Park [1], Lei Shi [2], Lei Cui [2], Junyeong Park [2]

5**. Development of Alternative Feedwater Intakes for Membraine Water Treatment Facilities**, by Michael D. Goff P.G.

6. **ESTIMATION OF SALTWATER CONTENT AT A PUMPING WELL IN COASTAL AQUIFER USING SHARP INTERFACE MODEL**, by Lei Shi [1], Namsik Park [2], Lei Cui[1], Junyeong Park[1]

7. **GROUNDWATER MANAGEMENT & CLIMATE CHANGE IN THE ASIA-PACIFIC**, by Salmah Zakaria

8. **GROUNDWATER MANAGEMENT IN THE EMERGING CONCEPT OF WATER SECURITY IN ASIA-PACIFIC,** by Ti Le-Huu

9. **Hydrologic Analysis of Groundwater Level and Electrical Conductivity Data for Jeju Island in Korea**, Jeong-Seok Yang[1], Nam-Ki Kim[2]

10. **Hydrochemical evolution of groundwater in Shenzhen after land reclamation: major ion chemistry of coastal groundwater** , by [1]Kouping Chen, [2]Jiu Jimmy Jiao

11. **IMPACT OF LAND RECLAMATION ON COASTAL GROUNDWATER SYSTEMS**, by Jiu Jimmy Jiao

12. **MAPPING OF FRESH AND SALINE GROUNDWATER IN COASTAL AQUIFERS IN THE NAM DINH PROVINCE (VIETNAM) BY ELECTROCAL AND TRANSIENT ELECTROMAGNETIC SOUNDINGS**, by HOANG V. H$^{(1)}$, hoanghoandctv@gmail.com); LASSEN, R$^{(2)}$; TRAN V. L$^{(1)}$; VU, V. H$^{(1)}$; TRAN T. L$^{(3)}$; PHAM Q. N$^{(1)}$ and LARSEN

13. **Mitigation of Water Stress in Coastal Zones**, by Angeline Kneppers, Weixing Guo

14. **The Model of Sea Level Rise in Indonesia**, by Dewayany Sutrisno, Suwahyuono, Anggoro

15. **Modeling of Saltwater Instrusion in the Florida Aquifer System of Southwestern Florida**, USA, by Zhongwei Li, Jefferson Giddings

16. **Saturation Indices of Groundwater Contaminated by Seawater in Small Tropical Island's Aquifer**, by Aris A.Z., Zakaria M.P., Praveena S.M., Abdullah M.H.

17. **Numerical Assessment of Seawater Intrusion in Manukan Island Malaysia**, by Praveena S.M., Abdullah M.H., Aris A.Z., Bidin K.

18. **SEAWAT: Its Concepts and Applications**, by Weixing Guo

19. **Transience of Seawater Intrusion in Response to Sea-Level Rise**, by T. Watson, A.D. Werner, C.T. Simmons, J.D. Ward

Coastal Aquifer Management after the Asian Tsunami in Sri Lanka

Ranjana.U.K. Piyadasa[1], K.D.N.Weerasinghe[2], J. A. Liyanage[3], L.M.J.R. Wijayawardhana[2]

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The Indian Ocean tsunami of 26th December 2004 was a natural disaster that swept entire coastal areas away and resulted in the deaths of approximately 30000 people in Sri Lanka. About ¾ of the coastal strip of Sri Lanka was severely damaged on an unprecedented level. Groundwater contamination, in excess of the World Health Organization (WHO) guidelines value of 1000 µ semions/cm, has been observed in many parts of tsunami affected coastal belt. This paper mainly focuses on groundwater pollution due to saline water flooding during the tsunami and remediation process in southern coastal belt of Sri Lanka. The main objective of the research study were: to develop the groundwater salinity distribution maps using the GIS applications, to identify factors influencing salinity in tsunami affected areas, to delineate the groundwater potential zones in the area and evaluate the groundwater recharge in the area. The present study indicates that salinity concentrations of as are prevalent in shallow groundwater of the tsunami affected southern coastal strip. There exist a closed relationship is identified between topographical map & groundwater distribution map. After four years tsunami, most of the affected wells were back to previous salinity level but some identical pockets groundwater salinity level still high.

The Correlation Analysis between the Moving Average of Precipitation and Groundwater Level at Coastal Region of Jeju Island in Korea

Jeong-Seok Yang[1], Nam-Ki Kim[2]

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Groundwater level (GWL) data sets from coastal regions of Jeju Island in Korea were analyzed. GWL fluctuation dependency on precipitation was well shown even though the GWL data lengths are shorter than six years. Six regions were selected by checking the missing data. Daily and monthly GWL data for the six regions in Jeju Island were analyzed. Pumping is assumed to be uniform in the analysis. In the year of 2005 and 2008, the annual precipitation is less than 200mm (or more) comparing to other annual precipitation and this affected GWL. There was little GWL increase at the wet season (from June to September) for whole six regions in the years. GWL increase was not obvious even though the precipitation is more than 300mm from June to September in 2005.

Three precipitation data sets near the GWL gauge stations were collected and analyzed. Trends were analyzed for annual (total), daily, and annual maximum daily precipitation. Annual total precipitation increases for two regions and slightly decreases for one region.

The correlation between the moving average of precipitation and GWL was analyzed. The moving average concept has been used to consider precedent precipitation and infiltration or percolation time to reach groundwater table. We expected relatively short moving average period because of porous geological formation of Jeju Island, however the moving average period is longer than 30 days. It seems the subsurface water flow by the precipitation (snow, shower, etc.) from high-level area near Hanra Mountain plays a role of precedent precipitation. The maximum value of correlation coefficient is 0.93 and other regions also show high correlation coefficients.

Key words: Groundwater, Precipitation, Moving average, Coastal region, Jeju island

Delineation Prevention of Salt/Freshwater Encroachment in Prospective from Basin, India

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On the east coast of India, the coastal plain of the river Kasai and Subarnarekha stretched in Midnapur district of West Bengal, is rimmed mostly by a strip of sedimentary column and holds prominent aquifers at different depths. The disturbed coastal hydrodynamics and some socio-economic developmental issues pose severe environmental problems in the coastal plain. In such coastal tracts, over-exploitation of groundwater may induce the sea water to encroach the fresh water aquifer and deteriorate the quality of groundwater therein. Sustainability of groundwater development, hence, warrants a detailed mapping of the saline-fresh groundwater interface and monitoring the salinity ingress. In order to strike a proper balance in the coastal hydrodynamics for environmental protection, a scientific prognostication of the problems has been attempted through various tools and techniques of surface and subsurface geophysical methods. In the 90 km long Haldia-Contai-Digha coastal strip of Midnapur district, West Bengal India, occupied by Tertiary and Quaternary sediments, the results of 82 deep resistivity sounding helped delineate the near surface, coast-ward thickening saline groundwater zone underlain by fresh water aquifers, the saline/fresh groundwater interface and the deeper fresh water aquifers. Along the coast line, the interface occurs at maximum 135 m bgl at Junput near Contai. It is traced up to 30 km inland in Haldia_Kolaghat area, at a depth of 20 m bgl. Significant is the identification of an 8 km wide, 30 km long coast parallel saline groundwater trough passing 9 km inland through Contai. Its bottom is 300 m deep. The resistive, thick fresh water bearing granular zones are more prominent towards Digha than around Haldia where mixing of clays with sand is common. This paper through a set of synergistic study has recommended achieving sustainable development of the endowments of environmental resources without jeopardizing the coastal ecology.

Design of Optimal Injection Well in Coastal Areas

Namsik Park [1], Lei Shi [2], Lei Cui [2], Junyeong Park [2]

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[2] Dept. of Civil Engineering, Dong-A University, Korea

In coastal areas saltwater intrusion is one of the major factors that limit groundwater development. When groundwater has to be developed to satisfy demands that exceed the "safe yield", groundwater can be augmented by injecting surplus surface water. When water is available, injection can be maintained throughout a year. In areas with wet and dry seasons water may be available only during wet seasons. In this case intermittent availability of injection water must be accounted for in designing an injection system. In practice design of a such system, either continuous or intermittent, is usually selected from a few alternatives based on intuition. However, most cases involve complex situations including complex hydrogeology and interfering wells for which intuitive design is questionable.. In this work, a simulation-optimization model is developed to identify an optimal injection system to sustain an over-exploiting freshwater pumping well. It is assumed that over-exploitation is maintained throughout the year and that the injection well is operated during wet seasons. The objective function is the minimization of injected volume of water. Saltwater intrusion and dry wells are considered as constraints. An example application is made on a small hypothetical island with poor hydrogeologic conditions for groundwater development. Changes in saltwater contents in a pumping well subject to injection rates or locations are investigated through a sensitivity analysis The applicability of the simulation-optimization model and the need for a rigorous optimization technique are demonstrated.

Key words: optimal injection, simulation-optimization model

Development of Alternative Feedwater Intakes for Membrane Water Treatment Facilities

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Global concern over the availability and quality of drinking water has increased significantly over the past decade. Increasing demands and depletion of quality drinking water sources have necessitated the development and implementation of new technologies to provide adequate, drinking water supplies. Membrane treatment has been described as "the best available technology" for potable water treatment by the US Environmental Protection Agency. Seawater intakes can make up 50% of the cost of developing a seawater desalination plant. Traditional designs may create significant challenges to pretreatment of the raw water due to natural water quality variations and constituents found in surface water. Operations and maintenance of complicated pretreatment processes significantly increase the overall cost of producing potable water from seawater and other surface water sources. Recent developments have been made on alternative intake designs to limit the effects of challenging water quality variability in surface water supplies. Designs are specialized to the local environment and take advantage of natural filtration processes. Utilization of alternative intake designs can reduce the adverse effects of biofoulants in feedwater from surface water sources. Information will be presented on the conceptual design of alternative intakes and their benefit over traditional intakes.

Key words: Desalination, feedwater, alternative seawater intake

Estimation of Saltwater Content at a Pumping Well in Coastal Aquifer using Sharp Interface Model

Lei Shi [1], Namsik Park [2], Lei Cui[1], Junyeong Park[1]

1 (Dept. of Civil Engineering, Dong-A University, Korea),
2 (Professor, Dept. of Civil Engineering, Dong-A University, Korea)

For groundwater development in coastal areas, one of the main concerns is saltwater intrusion. Sharp-interface approximation is known to be applicable to regional groundwater flow problems. For small scale problems where salinity variation is important, variable density flow and solute transport modeling approach is needed. However, use of the variable density model is rather difficult especially when a simulation-optimization approach is considered where the simulation model has to be invoked many times.

In this study, applicability of a sharp interface model in estimating salinity is investigated. Laboratory sand-tank experiments are conducted to measure salinity of water taken from pumps. Observation data is compared with computed values using a sharp-interface model. A variety of experiments are conducted: steady and unsteady experiments, partially and fully penetrating wells in freshwater and saltwater zones. Comparison between numerical results and the experimental results indicates that the sharp interface model can be used to estimate the saltwater content of pumped water.

Key words: sharp interface model, saltwater intrusion experiments, saltwater content

Groundwater Management & Climate Change in the Asia-Pacific

Salmah Zakaria

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The unprecedented emission of GHGs from development activities have resulted in distinct climate variability and extremes as well as anticipated sea level rise. These include impact on fresh water resources from escalated extreme events of cyclone and typhoons and inundated coastal area with resultant sea water intrusion. This will have effect on coastal water resources and consequently on its communities of human, fauna and flora. This paper reviews key challenges and discusses the management of the groundwater resources within the context of climate change, coming up with some key conclusions and recommendations, for the Asia-Pacific Region.

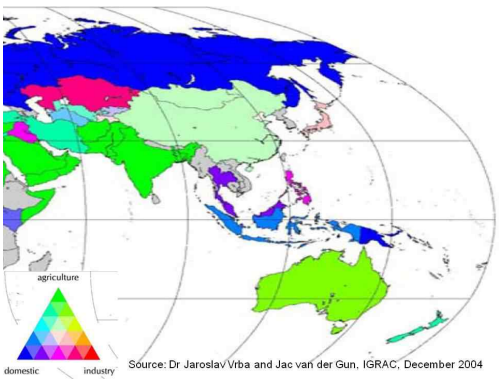
Key words: climate variability, extreme events, groundwater, sea water intrusion

Groundwater Management in the Emerging Concept of Water Security in Asia-Pacific

Ti Le-Huu

Chief, Water Security Section, Environment and Development Division, ESCAP

Asia-Pacific is on the verge of water scarcity. Being the production house of the world, many countries of Asia-Pacific are exploiting their natural resources, including the water resources, beyond their carrying capacity. Management of coastal aquifers, which are the important sources of freshwater that feed the rapid economic growth of the region, is facing increasing challenges. This paper reviews key challenges and discusses the management of these water resources within an emerging concept of water security for socio-economic development in the twenty-first century. On the basis of this examination, key policy recommendations are formulated for more effective regional cooperation on water resources management in the region.



Key words: water security, groundwater management, Asia-Pacific, socio-economic development

Hydrologic Analysis of Groundwater Level and Electrical Conductivity Data for Jeju Island in Korea

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The groundwater level data sets for six regions near coastal area in Jeju island were collected and analyzed. All the data show groundwater level fluctuation depending on the wet and the dry season. The electrical conductivity data sets for sixteen regions were collected and analyzed. The observation data started from 2008 and there was only seasonal data (four data points) for 2008. These data showed seasonal change of electrical conductivity for the regions. Besides the electrical conductivity data, the chloride concentration data was also collected to check the saltwater intrusion. The chloride concentration for the east region of Jeju island showed higher value than other regions. The electrical conductivity data for early summer season showed usually high value and it looks like there are the following two reasons.

(1) The groundwater level is low due to the small amount of precedent precipitation.
(2) Saltwater intrusion is occurred by sea level rises due to temperature increase.

The electrical conductivity values from early summer to fall (the wet season) for most regions in Jeju island show decreasing tendency and the high amount of precipitation can play major role to the phenomena. We could also observe high groundwater level in the wet season. The electrical conductivity values show increasing tendency after the wet season because of low precipitation. It seems that saltwater wedge moves toward inland in dry season and the electrical conductivity data showed the maximum value at the end of the dry season.

Key words: groundwater level, precipitation, electrical conductivity, saltwater intrusion

Hydrochemical Evolution of Groundwater in Shenzhen after Land Reclamation: Major ion Chemistry of Coastal Groundwater

Kouping Chen[1], Jiu Jimmy Jiao[2]

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[2]Associate Professor (The University of Hong Kong, jjiao@hku.hk)

The need for more valuable land has encouraged reclamation in coastal areas of Shenzhen in the past decades. Land reclamation can alter the fresh-salt water relationships in coastal aquifers. The purpose of this study is therefore to identify the effect of land reclamation on groundwater chemistry especially the major ions in the groundwater bodies and examine the spatial and temporal variations of groundwater chemistry after land reclamation. Coastal land reclamation activities prolonged the groundwater flow path from land to sea and may hamper the connection of the coastal groundwater and the sea water. So in some extent land reclamation decrease the pressure of sea water intrusion.

Inspection of major ionic composition of more than 200 groundwater samples in this study area indicated that three different water types located in different zones on the rout to the sea: Ca-HCO3 type groundwater; K+Na-Ca-HCO3-Cl type groundwater and Na-Cl saline groundwater. In particular, the Na-Cl type groundwater was close to the coastal line and the Ca-HCO3 type groundwater was about 2 kilometers away from the coastal line. Meanwhile the rMg/rCa and the (rMg+rCa)/rNa ratios strongly implicated that the Ca-HCO3 type groundwater gradually evolve to the K+Na-Ca-HCO3-Cl type groundwater after land reclamation. In a broad sense, the reactions responsible for the groundwater hydrochemical evolution in the study area were ion exchanges when the equilibrium of the coastal groundwater and seawater was disturbed by land reclamation. Temporal variations of (rMg+rCa)/rCl ratios also indicated that Ca-HCO3 type groundwater was changed for K+Na-Ca- HCO3-Cl type groundwater.

Key words: Groundwater, hydrochemical evolution, land reclamation, ion exchange

Impact of Land Reclamation on Coastal Groundwater Systems

Jiu Jimmy Jiao

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Land reclamation has played a significant role in the urban development process in coastal areas in many countries. While reclamation provides valuable land, it also creates various engineering, environmental and ecological problems in coastal areas. The direct impact of land reclamation on coastal engineering, environment and marine ecology is well recognized and widely studied. However, it has not yet been recognized that reclamation may change the regional groundwater regime. This talk first presents analytical studies on the change of water level and seawater/groundwater interface induced by land reclamation. It is shown that it may take tens to over 100 years for groundwater system to approach a new equilibrium. The degree of the modification of the groundwater system and the time required for the system to approach a new equilibrium depend on the hydraulic conductivity of the fill materials and the reclamation scale. Then the talk presents numerical case studies about the possible modification of the regional flow system at Penny's Bay, Hong Kong due to land reclamation.

Key words (four or five): land reclamation, coastal aquifer, seawater/groundwater interface

Mapping of Fresh and Saline Groundwater in Coastal Aquifers in the Nam Dinh Province (Vietnam) by Electrical and Transient Electromagnetic Soundings

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The spatially distribution of fresh and saline groundwater in the coastal aquifers in the Nam Dinh province in Vietnam was mapped by a combined use of DC electrical (Multi-Electrode-Profiling - MEP) and transient electromagnetic (TEM) soundings.
For MEP-mapping of the shallow layers, down to approximately 40m, we used an ABEM equipment with an electrode distance of 5m in Wenner configurations. We used a Protem 47 instrument (Geonics Ltd.) for the TEM mapping of the deeper layers, down to depths of approximately 120-140m, and a 40m by 40m transmitter loop with a turn-off time of the transmitter current of 2.5 μsec. The secondary generated magnetic field was recorded using a 1m by 1m receiver coil in the centre of the transmitter loop, a setup like this has been used successfully in others similar groundwater studies elsewhere in the world.
At the studied field site, the MEP profiles were able to demarcate areas with shallow fresh and saline groundwater. Fresh groundwater was in some locations observed down to 10m, whereas on other locations near surface saline groundwater was encountered from the water table. Overall the electrical noise level at the field site was low and of the 166 conducted TEM soundings, 143 could gave useful results and could be interpreted with three, four or five layer models using the software SEMDI/SITEM. As resisitivities of the upper 5-10m are poorly determined with the TEM methods, more emphasize was on the interpretation of deeper layers in the inverted TEM models. In the mapped area, saline groundwater is present in the Holocene sediments from depth of few meters and down to approximately 50 m, and these sediments have in the models an apparent formation resisitivities between 0.5 to 4.2 Ω*m. Using a formation factor of 2.0 for these layers, this corresponds to water concentrations of chloride between 1400 and 15000 mg/L. The formation resisitivities for the Pleistocene aquifer was between 1 and 180 Ω*m, representing areas with fresh groundwater (Cl < 250 mg/L), brackish water (Cl between 250 and 500 mg/L) and saline groundwater (Cl > 500 mg/L). We assumed a formation factor of 5.0 for the coarse-grained, Pleistocene fluvial deposits. Abstraction of groundwater from the Pleistocene aquifer from nearby boreholes confirms this presence of fresh water in larger parts of the studied area.
Where the inverted TEM data required a five-layer earth resistivity models, with a resistivity of the lowermost layer of 30-55 Ω*m, this poorly resolved layer is interpreted as representing the underlying Neogene deposits. Drilling of a national monitoring borehole close to the field site revealed Neogene deposits from 120m below surface, but the depth to this geological boundary is most likely highly variable due to differences in local subsidence rates in the area which is effected by block faulting.
Keywords: saline groundwater, transient electromagnetic sounding, Multi-Electrode Profiling, mapping

The Model of Sea Level Rise in Indonesia

Dewayany Sutrisno
Suwahyuono
, Anggoro

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Increases in global mean temperature will have numerous effects on coastal and archipelagic countries. The earth's oceans will expand, sea level will be rise and reducing the land availability for human social economic activity. International Geographical Union's Commission On The Coastal Environment reported that coastal recession has been occur in more than 70 % of the world coastal area. Sea level rise is believed to be the major issues that cause these problems. Dealing with this condition, a study to see the impact of changing global mean temperature to the sea level rise was employed. A shoreline retreat model based on Geographical Information System (GIS) was also developed to predict the future impact of sea level rise on coastal environment. This model was also become a tool for analyzing the best management scenarios to mitigate the impact of sea level rise. By taking some example from Indonesian Islands, analyses of tidal data and field observation show that there is a tendency of sea level rise within the study area that cause by global warming. The analysis also shows that the shoreline retreat was also occurred. The simulation of the model that is included the policy scenarios indicate that the model can be applied as a tool for mitigating and predicting the impact of the sea level rise within the islands' of study.

Key words: Sea level rise, GIS, model, shoreline retreat

Modeling of Saltwater Intrusion in the Floridan Aquifer System of Southwestern Florida, USA

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To meet the increasing water demand projected for the next 20 years (2005-2025) as population increases in the Southwestern Florida, considerate groundwater water, in supplement with traditional water sources, will be withdrawn from the Floridan Aquifer System in the region. Potential contamination of groundwater due to saltwater intrusion caused by increasing groundwater pumping will be one of primary concerns for the coastal communities. A quasi-steady state density-dependent flow model at a sub-regional scale was developed using SEAWAT to simulate sub-regional flow patterns and general Total Dissolved Solid (TDS) concentration distributions in the coastal region, and to predict potential saltwater intrusion in this area. The model domain covers an area of almost 50,000 square km from southwest of Lake Okeechobee to the Keys of south Florida and from the groundwater divide at the middle of Florida to about 32 km off the west shoreline. Primary aquifers modeled include the middle Hawthorn aquifer, the upper Floridan aquifer, the Avon Park permeable zone, the first permeable zone of lower Floridan aquifer and the Boulder zone from top to bottom. The model was calibrated to observed potentiometric heads and TDS concentrations, sub-regional submarine discharge in the aquifers; specially, the simulated heads were calibrated to the potentiometric map (Meyer, 1989). The calibrated results showed that regionally groundwater in the modeled system is recharged from the northeastern boundary in central Florida and discharges to the Gulf of Mexico and the Straits of Florida. In addition, TDS concentrations increase from brackish water in the northeastern corner to saltwater in the southwestern, and from the upper aquifers which are brackish to the lower aquifers which are mostly filled with seawater. A saltwater/fresh water interface is generally observed approximately around west coast shoreline. The calibrated quasi-steady state model provides a useful modeling tool to study the potential saltwater intrusion (i.e., TDS concentrations change and location of freshwater/saltwater interface) due to increasing groundwater demand from Floridan Aquifer System in the southwestern Florida in future.

Key words: Southwestern Florida; Floridan Aquifer System; Quasi-Steady State; SEAWAT

Saturation Indices of Groundwater Contaminated by Seawater in Small Tropical Island's Aquifer

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Groundwater is a crucial resource in Manukan island as it is the only source of freshwater available in the island. The aquifer has deteriorated to a high degree, during the last decade. Nine domestic wells were sampled to probe the hydrochemical components that influence the water quality. Geochemical data on dissolved major constituents in groundwater samples from Manukan island reveal the main processes responsible for their geochemical evolution. The results using statistical analyses, graphical method and numerical model output (PHREEQC) showed that the groundwater was chemical highly enriched with Na and Cl an indication of seawater intrusion into the aquifer as also supported from the Na-Cl signature on the Piper diagram. From the PHREEQC simulation model, calcite, dolomite and aragonite solubility showed positive mean values (0.65; 1.11; 0.51 respectively) of the saturation indices (SI) indicating supersaturation which attributed from the simple mixing and eventually cation exchange process. This processes later on lead to mineral precipitation condition of water by these minerals.

Key words: Groundwater, seawater intrusion, PHREEQC, saturation indices

Numerical Assessment of Seawater Intrusion in Manukan Island, Malaysia

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A numerical assessment of seawater intrusion in Manukan Island has been achieved by applying a three dimensional variable density model. SEAWAT-2000 was used to investigate the current status of seawater intrusion and to recommend the suitable groundwater management option in Manukan Island. The numerical model simulation indicated that there is about 14.5% of freshwater and seawater mixing in low lying area of Manukan Island which is attributed to overextraction of freshwater from the aquifer. The upconing process is taking place at the beneath of the pumping well leads the advancement of the seawater at the bottom of the aquifer result from the density difference between seawater and freshwater. In the consideration of Manukan Island groundwater management options, reduction in pumping rate option is capable to restore and protect the groundwater resources in Manukan Island. Chloride concentrations decreased by 21.9% from 2899 mg/L to 2264.1% mg/L by reduction of 25% in pumping rate. Thus, reduction of pumping rate is very much essential to lessen the seawater intrusion and sustain water resources on a long-term basis in Manukan Island.

Key words: Groundwater, chloride, pumping rate, groundwater management

SEAWAT: Its Concept and Applications

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As the water supply demand increases in coastal areas, groundwater contamination due to saltwater intrusion and coastal aquifer management become more important. Modeling of groundwater flow with variable density is commonly required as a decision-making tool for water resource management in coastal areas.

SEAWAT is a computer program developed by the U.S. Geological Survey for simulation of groundwater flow with variable density. SEAWAT couples two widely used computer programs, MODFLOW 2000 and MT3DMS. MODFLOW was modified to solve the variable-density flow equation by reformulating the matrix equations in terms of fluid mass rather than fluid volume and by including the appropriate density terms. It uses the concept of equivalent freshwater head in its flow simulation. Multi-species solute transport is available so several species of solutes can be simulated in the same simulation. In the latest version, SEAWAT is capable of simulating heat transfer together with groundwater.

During the development of the SEAWAT program, the changes to exiting input and output files of MODFLOW and MT3DMS were kept minimal so exiting MODFLOW/MT3DMS model input files can be used directly with minor modifications. The input and output files can also be viewed with most existing pre and post processing graphical user interfaces such as Visual MODFLOW, PMWIN and Groundwater Vistas.

Since the introduction of SEAWAT in 1998, it has become the most popular software used in saltwater intrusion and coastal aquifer management. It has been applied in more than one hundred countries in the world.

Key words: Flow with variable density, Groundwater modeling, SEAWAT;

Transience of Seawater Intrusion in Response to Sea-Level Rise

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Climate change is expected to impact upon the freshwater resources of coastal aquifers, which are relied upon heavily due to approximately half of the global population residing in coastal areas. In particular, sea-level rise (SLR) will induce landward migration of the freshwater-saltwater transition zone (TZ), i.e., seawater (or saltwater) intrusion (SWI), jeopardising freshwater availability. Thus, in order to facilitate the management of fresh coastal groundwater resources, developing a comprehensive understanding of the SLR-SWI relationship is crucial. However, the important issue of the timescales associated with SLR-induced SWI has to date been essentially overlooked. With the exception of a small number of site-specific investigations, the focus in the literature has been on steady-state analyses. This study adopts a numerical modelling approach in order to explore the temporal behaviour of SWI in response to SLR within a typical unconfined coastal aquifer framework. A suite of quantitative indicators is applied to scrutinise the model outputs to assess a variety of transitional measures. The representative response times of the saltwater wedge 'toe' vary from months to several centuries, whilst the centre-of-mass height of the saltwater wedge is always more rapid, exhibiting maximum response times of the order of decades. Therefore, for example, traditional freshwater-saltwater interface depth monitoring networks are perhaps insufficient for estimating the transient inland penetration of the saltwater wedge due to the lag between the vertical and horizontal response rates. The modelling results suggest that there is no general relationship between the transient responses of the watertable and saltwater wedge, contrary to literature inference for the sea-level drop case. A preliminary comparison between the cases of a rise and drop demonstrates a temporal asymmetry in the response of SWI to sea-level change, with a sea-level drop inducing a significantly more rapid response than SLR: a finding that is significant for SWI remediation measures. Furthermore, whilst it is a well-established understanding that sharp-interface SWI models tend to overestimate the inland extent of the toe at steady-state predicted by more realistic dispersive models, this work suggests the possibility for a temporary 'overshoot' of the post-SLR steady-state predicted by a sharp-interface model due to dispersive processes and/or inland boundary effects. Thus, the proposed "upper limits" of potential inland migration extent proposed by sharp-interface approximations are challenged.

Key words: Sea-level rise, seawater intrusion, climate change