Report of Overseas Field Training
FOLENS Program
Tokyo University of Agriculture and Technology

Field Investigation of Groundwater Quality in Bangkok

Magatt Thiam
D2, Environmental & Agricultural Engineering Department, United Graduate School of Agriculture

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Abstract (approximately 200 words)

Between 2013/11/25 and 2013/11/29 we have conducted a field training in Bangkok, Thailand. The objective was to investigate one aspect of the groundwater of the aquifer complex in Bangkok. In situ measurements of electro-conductivity (EC) and temperature were done from 14 locations (of monitoring wells). These measurements targeted 3 superposed aquifers identified by the code names, from top to bottom, by PD, NL and NB. Salinity maps constructed from the measured EC values showed that the aquifer NB has the best water quality (salinity mostly lower than 0.9 g/L); while the shallowest aquifer (PD) displayed a lower water quality compared to others,(more than 2.05 g/L as salinity value on the investigated area). Aquifer NL, intercalated between the 2 mentioned above, has lower quality than NB (located below it) but seems have a better water quality than the aquifer PD (located above it). However this aquifer NL has salinity value often greater than 1.0 g/L. This shows that the deeper the aquifer the better is its water quality. It also indicated that the groundwater depletion occurred in the shallowest aquifer and that the seawater intrusion started to take place as if it was submerging the underlying aquifers.

I. Contents and activities

The field training in Bangkok, Thailand, took place between 2013/11/25 and 2013/11/29. We were accompanied by Professor Yuji Kohgo and Associate Professor Hirotaka Saito, our supervisors. This trip was facilitated by Assistant Professor Aksara Putthividhya of Chulalongkorn University. On November the 25th, field visit preparations were set throughout a meeting we had with members of the Department of Groundwater Resources (DGR) of Thailand. In this session, main problems related to groundwater were presented. We also had to clarify our aims, goals of FOLENS program and main research orientations in our laboratories.

Initially, we planned to collect the groundwater electro-conductivity, temperature, water table and localization data from 54 wells. However, after discussing with the DGR members, the planning was changed due to some constraints. Finally a set of 20 monitoring wells were proposed by them. Thus, an objective of data collection from 5 locations per day was set.

The main goals of this field survey were:

1. To experience one aspect of groundwater quality field survey;
2. Gain an understanding of seawater intrusion in a multi layered system of confined aquifers;
3. Use the collected data for seawater intrusion simulation as a trial in my own study.

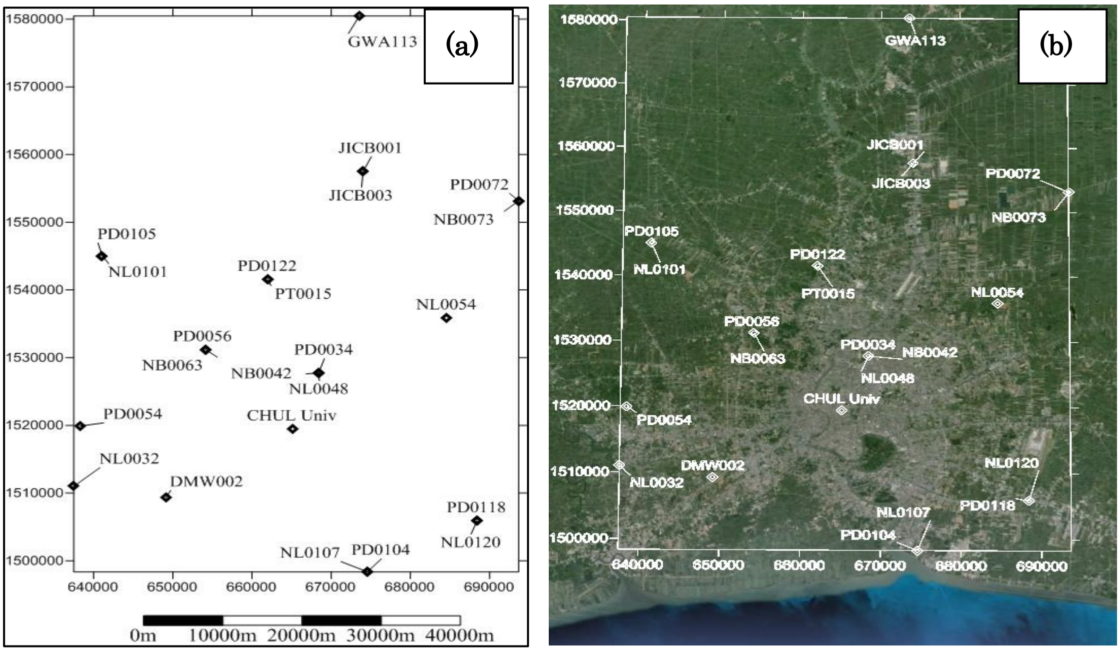

Figure 1: location of visited monitoring well; (a): base map, (b): map overlaid on Bangkok area (satellite image on (b) is from Google Earth)

Bangkok (Fig. 1(b)) is located on the delta of the Chao Phraya River; its population has doubled between the 1970s and 2000. Rapid development of the city was a cause of the population increase which is nowadays over 6 million. The region of Bangkok extends on 10,315 km^2 while the metropolitan area extends on 2,844 km^2 for a population density, in the metropolitan area, of 3727 people/km^2 **[2]**. The consequence of such a situation led to a high demand on water resources.

This study required us to take in situ measurements, in groundwater monitoring wells, using an electro-conductivity (EC) and temperature diving sensor. The sensor was attached to a graduated 100 meters length cable; allowing us to take measurements every 10 meters into the borehole. The sensor has to be programmed in order to take measurements every 10 seconds; the water table was also measured. The groundwater system beneath Bangkok consists of 8 levels (table 1) **[7]**. Our target was the aquifers PD, NL and NB.

Aquifer	CODE	Zone
Bangkok Aquifer	**BK**	50-m
Phra Pradaeng aquifer	**PD**	**100-m**
Nakhon Luang Aquifer	**NL**	**150-m**
Nonthaburi Aquifer	**NB**	**200-m**
Sam Khok Aquifer	**SK**	**300m**
Phaya Thai Aquifer	**PT**	350-m
Thonburi Aquifer	**TB**	450-m
Pak Nam Aquifer	**PN**	550-m

Table1: Groundwater system under Bangkok area

Source: *World Bank website*

In table 1, the gray pattern indicated the aquifers we have targeted.

The literature about groundwater resources exploitation of these aquifers with regards to environmental changes seems to be more oriented on land subsidence related problem rather than groundwater quality degradation. Only few of our references did give a brief description about groundwater quality. Groundwater depletion in coastal aquifer usually induces seawater intrusion which in return causes the fresh water quality reduction. And heavily depleted aquifer causes the creation of more void spaces in the aquifer. Then large ground surface pressure from metropolitan areas, located on top of such depleted aquifer, may cause the compaction of this aquifer; in other words land subsidence happens.

The DGR members indicated to us that the most serious issue, from their perspective, was the land subsidence. A report of some cases studied by the Institute for Global Environmental Strategies (IGES), based in japan, however did mention about the risks of groundwater quality deterioration in Asian cities **[4]**. They state: ’The pollutants differ from place to place, and are even site specific, but naturally occurring pollutants (e.g. fluorine), salinization due to sea water intrusion, and coliform contamination caused by domestic waste water were identified”**.** Land subsidence issue is an existential problem[1] and is due to (i) Over-pumping of groundwater and (ii) loading and settlement of the upper clay layer[2] **[5].**

II. Findings and achievements obtained, significant experiences and lessons

EC was measured along with the temperature. It was noted that the temperature increased when measurements were progressively deepened within the borehole. This temperature variation between the water table and the deepest measurement point was generally between 1 and 2°C. However, this variation didn't affect the corresponding EC values that much (for EC: generally 0.05 to 0.2 gap between the shallowest and the deepest measurement point). Tables 2 to 5 indicate the EC values at different wells. Figure 2 give a descriptive and representative profile of EC and temperature measurements at 3 wells.

Table 2: measured EC values on monitoring wells belonging to aquifer PD

EC value in mS/cm					
PD0054	**PD0034**	**JICB003**	**PD0122**	**PD0118**	***PD0104***
1.27	3.4	1.65	4.62	3.33	2.00

Table 3: measured EC values on monitoring wells belonging to aquifer NL

Wells aquifer NL / EC value in mS/cm			
NL0054	**NL0107**	**NL0032**	**NL0101**
0.92	6.37	1.66	1.26

Table 4: measured EC values on monitoring wells belonging to aquifer NB

Wells aquifer NB / EC value in mS/cm				
NB0042	**Chul Univ**	**NB0063**	**JICB001**	**NB0073**
0.60	6.00	0.54	0.52	1.69

Table 5: measured EC values on monitoring wells belonging to other deeper aquifers

Wells deeper aquifer / EC value in mS/cm		
GWA113	**DMW002**	**PT0015**
0.49	0.30	0.73

[1] According to our discussion with the hosts the land subsidence problem is more important than any other known issue
[2] Soft clay layer within the aquifer complex beneath Bangkok

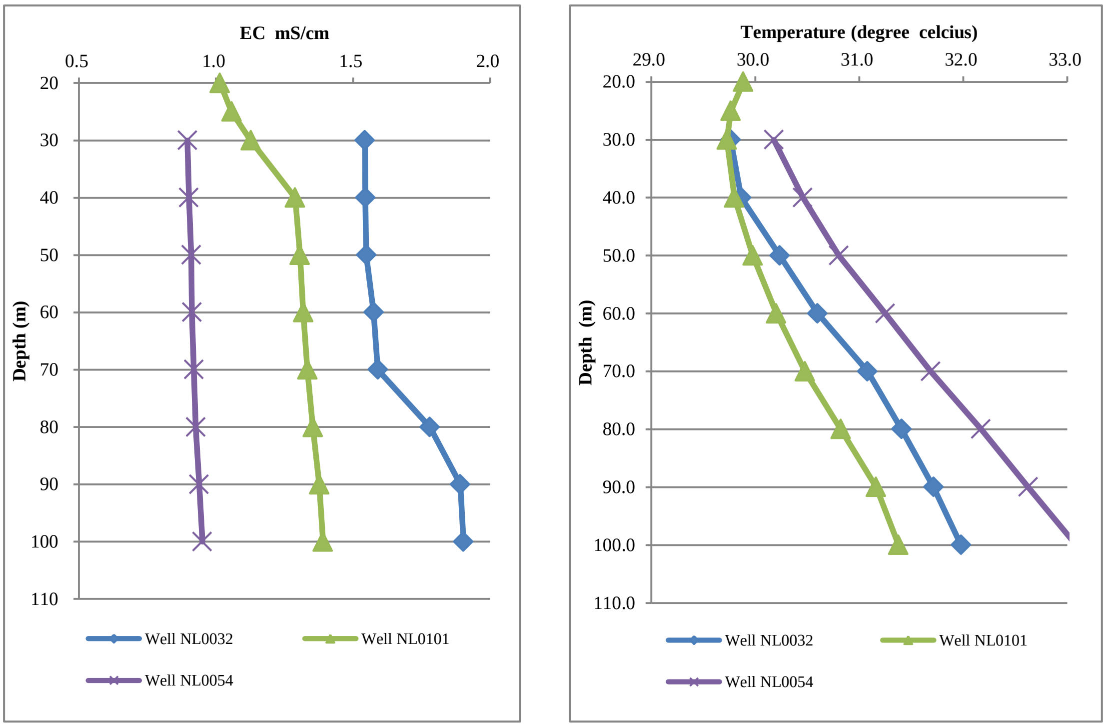

Figure 2: (a): typical EC profile within wells (3 wells); (b): typical temperature profile within wells (3 wells)

Collected EC values from these 3 levels were converted to salinity and mapped for every specific aquifer with GIS software. Mapping was also done for the different aquifers' water table. The salinity maps showed that the NB aquifer has lower salinity compared to the 2 others. The map in Fig. 5(b), aquifer NB, shows relatively low salinity values while the highest salinity are found in the south which is closer to the Gulf of Thailand.

The PD aquifer, shallowest one among the 3, has however higher salinity values (Fig 3(b)) and displays a completely different salinity distribution compared to NB aquifer (Fig. 5(b)) and NL aquifer (Fig. 4(b)). For aquifer PD (3(b)), contour lines indicate high salinity values converging toward a center point located nearby the well PD0122 (salinity approaching 4.0 g/L)...

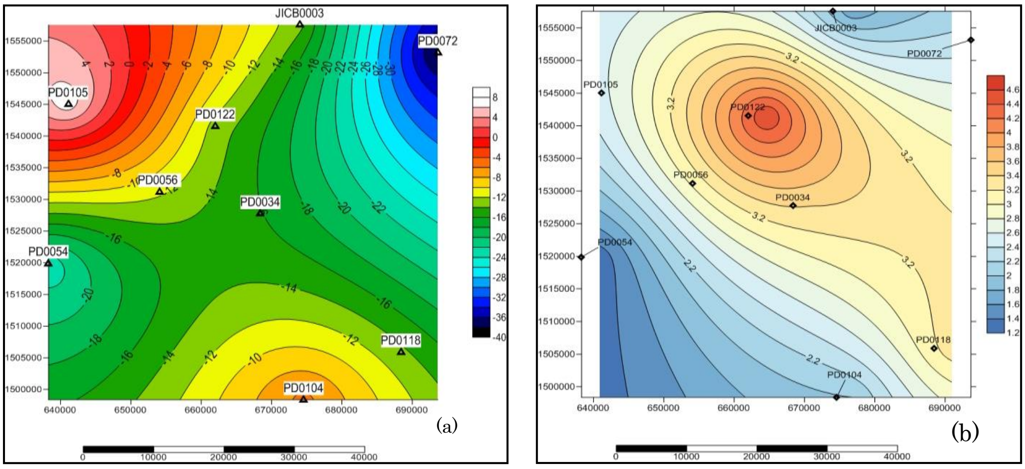

Fig.3: (a) Water table contour (unit m) of PD aquifer; (b): salinity contour of the PD aquifer (unit g/L)

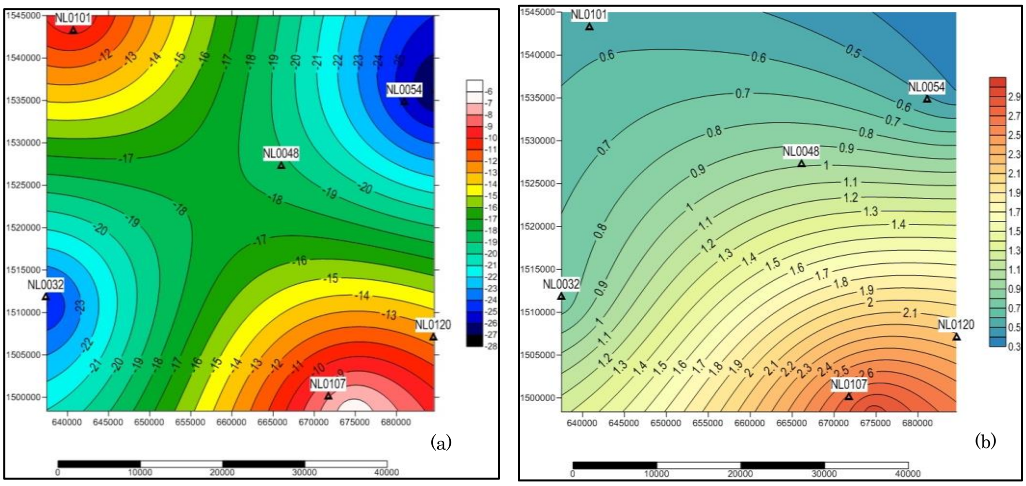

Fig. 4: (a) Water table contour (unit m) of NL aquifer; (b): salinity contour of the NL aquifer (unit g/L)

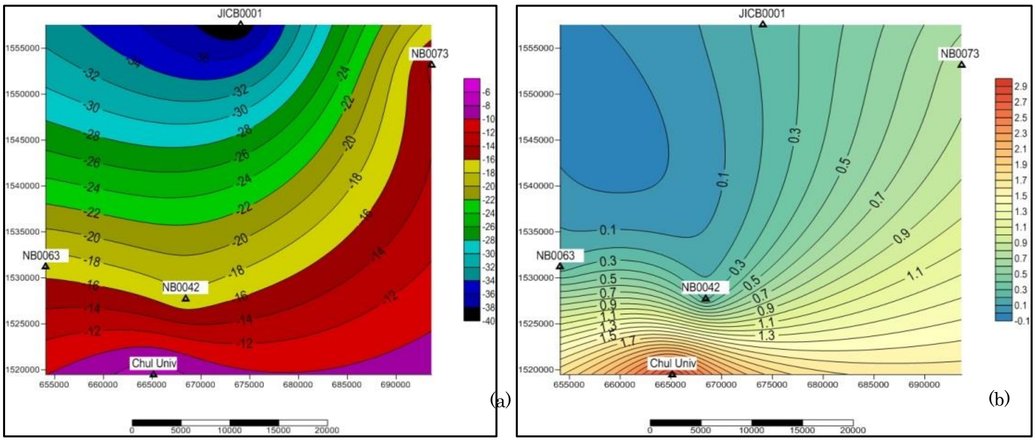

Fig. 5: (a) Water table contour (unit m) of NB aquifer; (b): salinity contour of the NB aquifer (unit g/L)

For aquifer NL (Fig. 4(b)), the salinity decreased northward and northwestward while higher salinity values are noted in the south (ranging between 1g/L and 3.0g/L)

Some measurements in deeper aquifers of this complex were taken and it was noted that the deeper the aquifer location, the lower the groundwater EC.

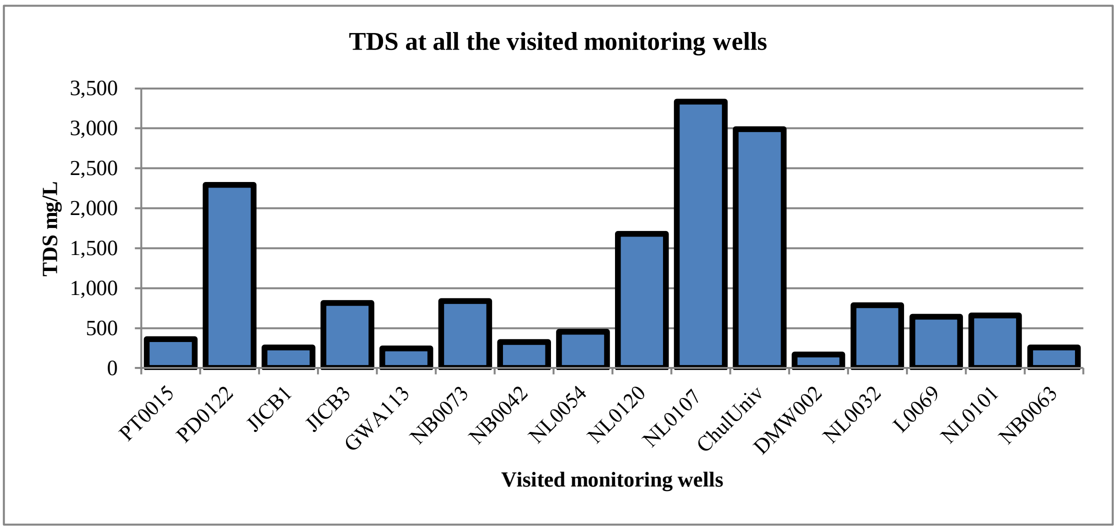

Fig. 6: Estimated Total Dissolved Solid (TDS) from the measured EC values of the visited monitoring wells

Referring to the guideline for drinking water, by the World Health Organization (WHO), we can alternatively use the TDS values (Fig. 6) to interpret the data. Thus, this would lead us to say that TDS values lower 600 mg/L are indicative of a good water quality (especially regarding its palatability) **[8]**. As for wells with TDS values between 600 and 1200mg/L the quality might be considered acceptable. However, TDS greater than 1200 mg/L might not be commonly recommendable for consumption. However according to the Thai standard, the allowable limit is between 750 and 1500mg/L **[2]**.

Even though the data we have collected were limited, they however confirmed the reality of the seawater intrusion which is already known **[7]**. This limited study is not meant to conclude in the existence of seawater intrusion; rather the above comment was done after simple analogy from other reference **[1, 2, 3, 4,** and **5]**.

In this field trip we conducted a survey to measure one parameter or water quality indicator: EC. Measurements were done on a multi layered confined aquifer system (PD, NL, and NB among others) beneath Bangkok. Measured EC values from aquifers PD, NL and NB were used to construct salinity maps for each aquifer. The maps showed also that the salinity decreased progressively towards the north. In another hand, it was noted that the deeper the aquifer location, the lower was the EC value. Another remark was the temperature measured into the borehole was increasing with the depth of the measurement; these measurements done simultaneously with EC would allow us have more precise EC value.

The practical experience from this trip has familiarized me with the innovative tools we had used to collect the data. Experiences gained in the preparation period and during the fulfillment of the trip regarding the interaction with different people would be very beneficial for my future career in the environmental field.

III. Achievements and its future vision

The field trip we conducted in Thailand, Bangkok, allowed us to measure EC, temperature and water table; these are basic parameters when investigating groundwater in general. The EC value is an indicative parameter of water quality (can indicate water salinity). However the experience learnt from the groundwater related issues in Bangkok is important for me and will cause me to take into account different aspect related to the environment, when planning future groundwater exploitation in my country. This is due to my sudden awareness regarding land subsidence which in fact when it isn't detected may lead to severe disasters when events such as floods occur. Therefore I have become more attentive regarding the expansion of urban areas on or nearby aquifer systems that are being exploited. This will encourages me to consider such consequence in groundwater management.

IV. Acknowledment

This field were conducted with the help of different counterparts, collaborators and volonteer Thai students from Chulalongkorn University. Therefore we remain grateful to all those individuals who brought their contributions in order for us to fulfill the oversea field trainin in Thailand.

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The member of the Department of Groundwater Resources of Thailand had the most critical role to play in our training and for that we express our profound gratefulness to them for all they did.

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I'm personally grateful to my supervisors, to Associate Professor AKSARA and her students; and to FOLENS program for Between 2013/11/25 and 2013/11/29 we have conducted a field training in Bangkok, Thailand. The objective was to investigate one aspect of the groundwater of the aquifer complex in Bangkok. In situ measurements of electro-conductivity (EC) and temperature were done from 14 locations wells. These measurements targeted 3 superposed aquifers identified by the code names, from top to bottom, by PD, NL and NB. Salinity maps constructed from the measured EC values showed that the aquifer NB has the best water quality (salinity mostly lower than 0.9 g/L); while the shallowest aquifer (PD) displayed a low water quality compared to others,(up to 2.05 g/L as salinity value on the investigated area). Aquifer NL, intercalated between the 2 mentioned above, has lower quality than NB (located below it) but seems have a better water quality than the aquifer PD (located above it). However this aquifer NL has salinity value often greater than 1.0 g/L. This shows that the deeper the aquifer the better is its water quality. It also indicated that the groundwater depletion occurred in the shallowest aquifer and that the seawater intrusion started to take place as if it was submerging the underlying aquifers.

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V. Reference

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Supervised by Professor Yuji KOHGO