Urban Subsurface Environments

Newsletter Volume 3 April 2007

Full-scale implementation of the project "Human Impacts on Urban Subsurface Environment" started in April 2006 and the project members have conducted field experiments, surveys and data gathering in the target cities.

Summary of the field activities of the Urban Geography, Gravity, Material and Urban Heat groups and initial research results are featured in this volume of our project's newsletter. This issue also contains contributions from our Visiting Research Fellow and graduate student.

Inside this issue

Progress of Project 2-4 FR in 2006

Makoto Taniguchi (RIHN)

The second year of full research of the project started in April 2007. Currently, the project has more than 50 members, and the interim evaluation in March 2008.

Progress of the project in 2006

Field surveys on subsurface environment in targeted cities have been conducted (6 times in 2005 and 9 times in 2006), and monitoring of subsurface environments has started.

Assessments of natural and social data in each city have been made, and the structure of the project database based on GIS have been made.

Preliminary models such as GRACE, groundwater flow, and DPSIR have been established in each sub theme.

In order to evaluate the origin and process of material loads to subsurface, isotopes and chemical analyses of water samples have been made, and new tracers (CFC, Kr etc.) techniques have been introduced.

Subsurface thermal signal can be used to reconstruct the history of urbanization.

International Symposium on "Human Impacts on Urban Subsurface Environment" was held, and proceeding was published. Co-operations with international research agencies (UNESCO-GRAPHIC, GWSP-Asia etc.) have been made.

Future work and challenges

The 2nd international workshop will be held in Bali island, Indonesia on December 3-7 2007, to evaluate the interim results and find additional themes and problems of the project.

In order to present the interim results of the project, a special issue of STOTEN (Science of Total Environment, Elsevier) is being prepared.

Domestic project meeting will be held at Kumamoto on November 19 to 21.

More than 10 field trips to the study areas are now planned (See project HP)

New approaches on relationship between groundwater and religion will be launched.

New observation system by uses of CFC, KR and absolute gravity measurement will be tested, and inter comparison with different observation methods will be operated.

Visiting Research Fellow

Dr. Shaopeng Huang, Associate Research Scientist of the University of Michigan, arrived in RIHN last April 14 and will stay here for three months as Visiting Research Fellow.

By training, Shaopeng is a geophysicist, specializing in geothermics. His current research interests include climate reconstruction based on borehole temperatures; changes in subsurface temperature as part of global climate change; detection of a terrestrial climate signal from lunar surface and subsurface data; geoinformatics and numerical modeling; and terrestrial heat flow and thermotectonics.

Outline and Progress of Urban Geography Group

Akihisa Yoshikoshi
Ritsumeikan University

Research Title

"Changes in the Hydrological Environment Accompanying the Urban Development and its Influences on the Subsurface"

Purpose

Not only the subsurface but also the earth's surface have shown large-scale transformations.

The purpose of this research is to identify correlations and regularity between urban development and changes in hydrological environment, and their influences on the subsurface through comparative studies among megacities whose urban development vary in speed, timing and form.

As the earth's surface forms the boundary among the atmosphere, the lithosphere and the hydrosphere, substances such as water, pollutants and heat, move among them through the earth's surface that plays the key role in their movement. Conditions and transformations of the earth's surface, especially in urban areas, affect the quality and quantity of their movement.

Research results are expected to conclude that stages of urbanization and changes of hydrological environment in respective urban areas are closely linked with the speed of influences on the subsurface. Therefore, experiences and measures taken in Japanese megacities through their development processes can help resolve anticipated problems in other Asian cities.

Other outputs from this group research, such as geographical maps, will provide other groups with bases for putting on layers.

Research Members

Akihisa YOSHIKOSHI	Group Leader, *Ritsumeikan University*
Tomomasa TANIGUCHI	*Rissho University*
Yuichi KAGAWA	*University of Shiga Prefecture*
Masahiro KATO	*Ritsumeikan University*
Akio YAMASHITA	*Rakuno Gakuen University*
Taiko TODOKORO	*Ritsumeikan University*
Itsu ADACHI	*JICA*
Makoto TANIGUCHI	*RIHN*
Manabu INOUE	*Ritsumeikan University*

The Urban Heat Group, headed by Toshiaki ICHINOSE, *National Institute for Environmental Studies*, will integrate with the Urban Geography Group starting April 2007.

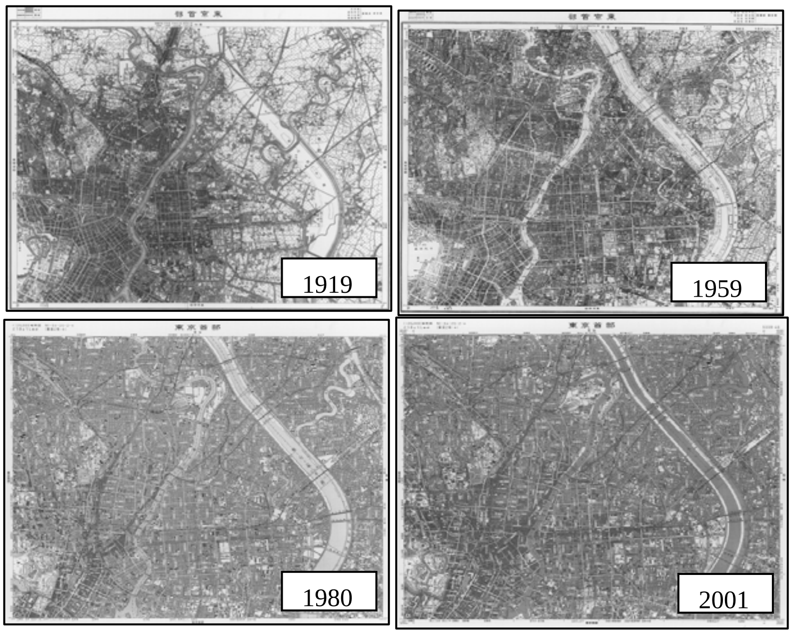

Fig. 1. Expansion of urban area in central Tokyo

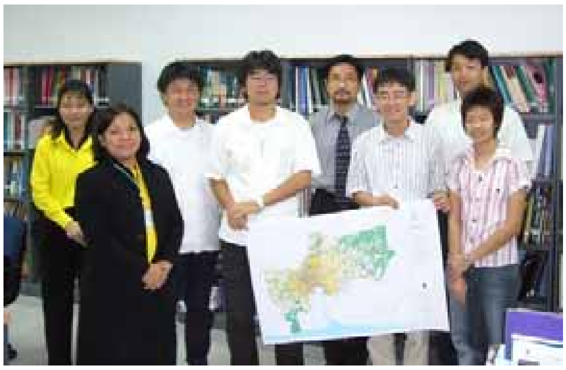

Fig. 2. Field survey in Bangkok, August 2006

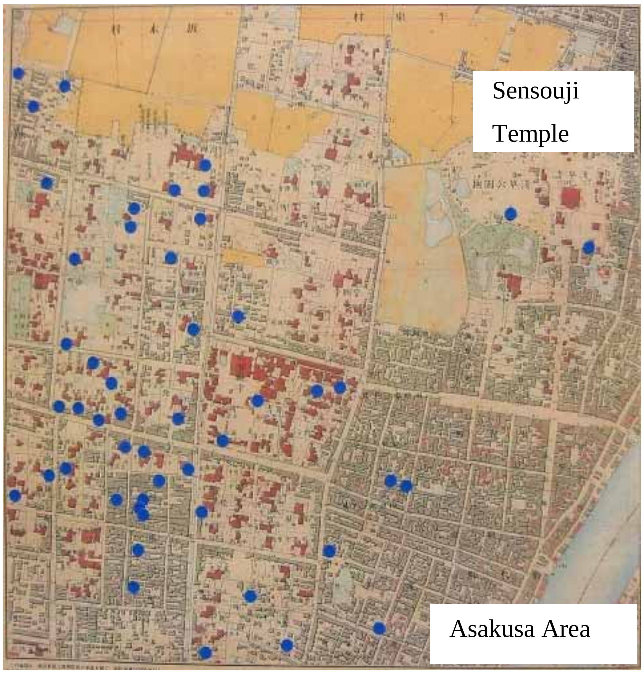

Fig.3. Distribution of wells in Tokyo, 1928

Sites of research:

Main Sites: Tokyo, Osaka and Bangkok

Sub-sites : Jakarta, Manila, Seoul and Taipei

Method

I. Understanding periodical changes in urbanization, land use, and hydrological environment and subsurface condition of selected mega cities in Asia by literature review, statistics, geographical data, aerial photographs and satellite images, etc.

II. Processing of historical data by following periods and factors:

(a) Periods (tentative):

Tokyo : 1900 and every 20 years thereafter up to the present

Osaka : 1920, 1960 and present

Thailand and others : 1930 1970~80 and present

(b) Main layers (tentative)

- Land use
- Water area
- Groundwater use
- Groundwater level
- Subsidence

III. Digitizing of map data and GIS mapping

IV. Examining the correlation and regularity, both periodical and spatial change of hydrological environment and condition of subsurface.

Progress

I. First year (2006)

Field surveys and data collection

Bangkok, Aug. 2006

Seoul, Mar. 2007

Tokyo and Osaka, several times

Collection of maps and aerial photographs

Maps from Geographical Survey Institute of Japan

Aerial photographs from Japan Map Center

Agreement on usage of old geological map data with Geographical Survey Institute of Japan

Scanning of existing maps available

Collection of bibliography related to urban development

Data exchange with the Center for Spacial Information Science at the University of Tokyo through joint research

Four Group meetings

Kyoto (February)

Urawa (March)

Kyoto (July)

Kyoto (September)

II. Second year (2007, plan)

Field survey and data collection

Taipei, Bangkok and Jakarta

Tokyo, Osaka

Scanning maps and GIS mapping

Understanding the development patterns of each city

Analyzing changes of water area and land use

Formulation of theory on the correlation and regularity between urban development and changes of hydrological environment

Contribution to "STOTEN"

Presentation at symposiums and conferences

Research Reports of Gravity Group

Preliminary gravity and GPS survey in Jakarta city

Jun Nishijima

Department of Earth Resources Engineering., Faculty of Engineering, Kyushu University

Introduction

It is necessary to monitor the aquifer balance of pumping and recharge in the long-term use of groundwater. The pumping of ground water causes mass fluid movement and mass redistributions, which can cause measurable gravity changes and ground deformation at the ground surface (Fig.1).

Repeat gravity measurements have been applied at the geothermal power plant and the erupting volcano. In New Zealand, Gravity decreases of up to 1000 micro gal have been measured after 30 years of production from the Wairakei geothermal field (Allis and Hunt, 1986). In Japan, the observed gravity changes depend significantly on changes in shallow groundwater level change. Nishijima (2006) applied a multivariate regression model and eliminated the effect of shallow groundwater level change in order to extract the gravity change associated with the production and injection of geothermal fluid (Fig. 2). These studies suggest that repeat gravity measurements are an effective method to monitor underground water flow. But there is no study for the application of the repeat gravity measurements for urban water resources problems. We are planning to make a repeat gravity and GPS survey at Jakarta and Bangkok to monitor the changes in aquifer balance.

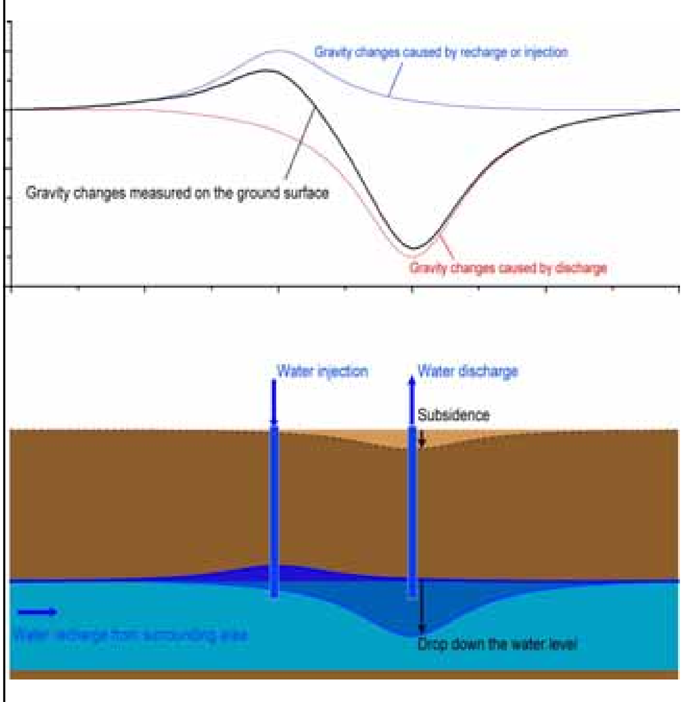

Fig. 1. Concept of repeat gravity measurements for groundwater monitoring

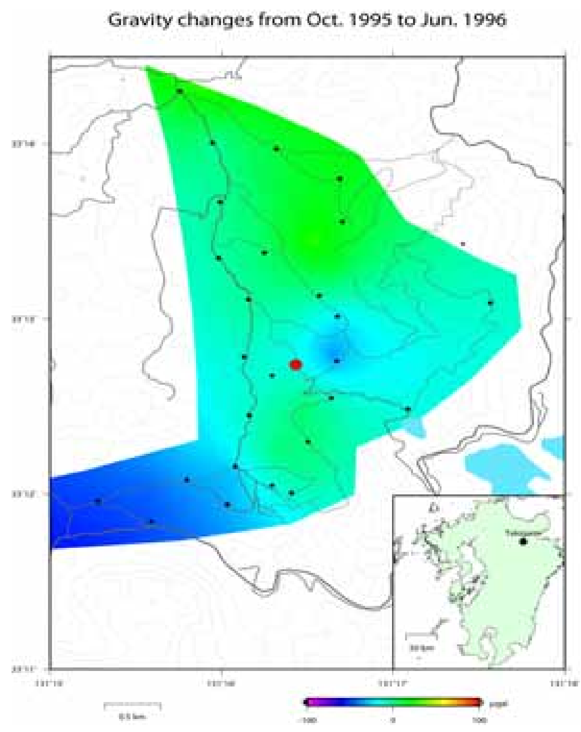

Fig. 2. Contour map of the gravity change at the Takigami geothermal field, Japan. A rapid decrease of gravity (up to 80 mgal) was observed in production area just after the commencement of geothermal power plant.

Preliminary survey in Jakarta

We carried out a preliminary gravity and GPS survey in Jakarta. This survey was conducted from September 4-13 2006. We got cooperation from Institute of Technology Bandung (ITB) and BAKOSURTANAL to conduct ground subsidence survey and repeat relative gravity measurements. The ground subsidence survey using GPS has already been started by ITB. Many benchmarks are established by ITB (Fig.3). We went to some benchmark to check the benchmark size and noise level. Fig. 4 shows the benchmark for GPS survey. We selected four benchmarks in order to measure the GPS and gravity using the A10 absolute gravimeter. We also carried out a 2km interval gravity survey to clarify the underground structure (Fig. 5). We will estimate the two-dimensional density structure model.

Fig. 3 Distribution of GPS station (yellow circles) established by ITB. Blue circles show the location of the observation wells.

a)

b)

Fig. 4 GPS survey (a) and Gravity measurement (b) at the benchmark (Kuningun).

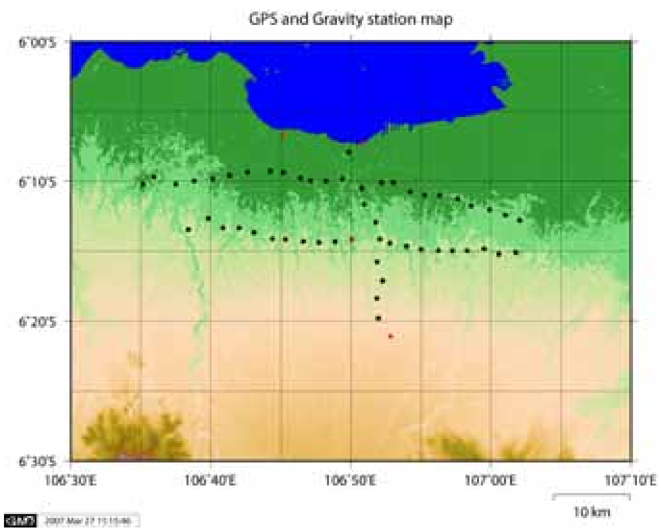

Fig. 5 Location of gravity survey points (black circles). Red triangles show the gravity stations for absolute gravity measurement.

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Evaluation of Seasonal Cycles of Terrestrial Water Storages in JMA Land Data Analysis

Toshiyuki Nakaegawa

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The satellite gravimetry missions such as GRACE and CHAMP are expected to retrieve changes in terrestrial water storages (TWS) at continental-scale river basins from the time varying gravity fields. This retrieval requires the global distribution of the TWS since gravitational anomaly at a point is a result of the redistribution at the global scale; therefore, a dataset of the TWS estimated from a numerical model as restraint condition must be prepared. In this project, the TWS estimated from the Land Data Analysis (LDA) routinely performed by the Japan Meteorological Agency (JMA) has been used. This article reports the reproducibility of the seasonal cycles of the TWS.

Figure 1 presents the comparison of 70 climatological mean of the TWS between the LDA and observations. Figure 1a depicts the relative errors of the amplitude of the TWS. They are less than 10% in the Amazon, the Mississippi and the Lena River basins, in the top 10 of the largest basins. Figure 1b depicts the correlation coefficient of the seasonal cycle. While the correlations are high at the river basins located in areas such as the Tropics and the Asian Monsoon region, those at the other river basins are generally low. Figure 1c depicts the lagged months. The phases are generally earlier, similar to those of river discharge. Only four river basins have a late phase, while most of the remaining river basins have an early phase. The phase at the Congo River basin and at some of the rivers discharging into the Arctic Ocean are more than three months earlier. This low reproducibility of river discharge and TWS is probably due to insufficient tuning of the effective velocity and the lack of implementing anthropogenic and retention effects in lakes. Therefore, LDA generally captures the climatological seasonal cycles of these hydrological variables.

The TWS produced by LDA may be useful for gravity satellite mission analysis as well as land surface initial conditions in weather forecasts and hydrological studies as long as users recognize the issues mentioned above. Moreover, the estimation accuracy for the TWS by GRACE is about 10mm for a basin area of 2.5×10^5km every 30 days, which is sufficient for the model evaluations and may be valuable for improving reproducibility.

Gravity Group Members

Prof. Yoichi Fukuda (Leader), *Graduate School of Science,Kyoto University*

Dr. Tosiyuki Nakaegawa, *Meteorological Research Institute, Japan Meteorological Agency*

Dr. Jun Nishijima, *Faculty of Engineering, Kyushu University*

Satoshi Ueno, *Graduate School of Science, Kyoto University*

Takashi Hasegawa, *Graduate School of Science, Kyoto University*

Sachio Shimose, *Graduate School of Engineering, Kyushu University*

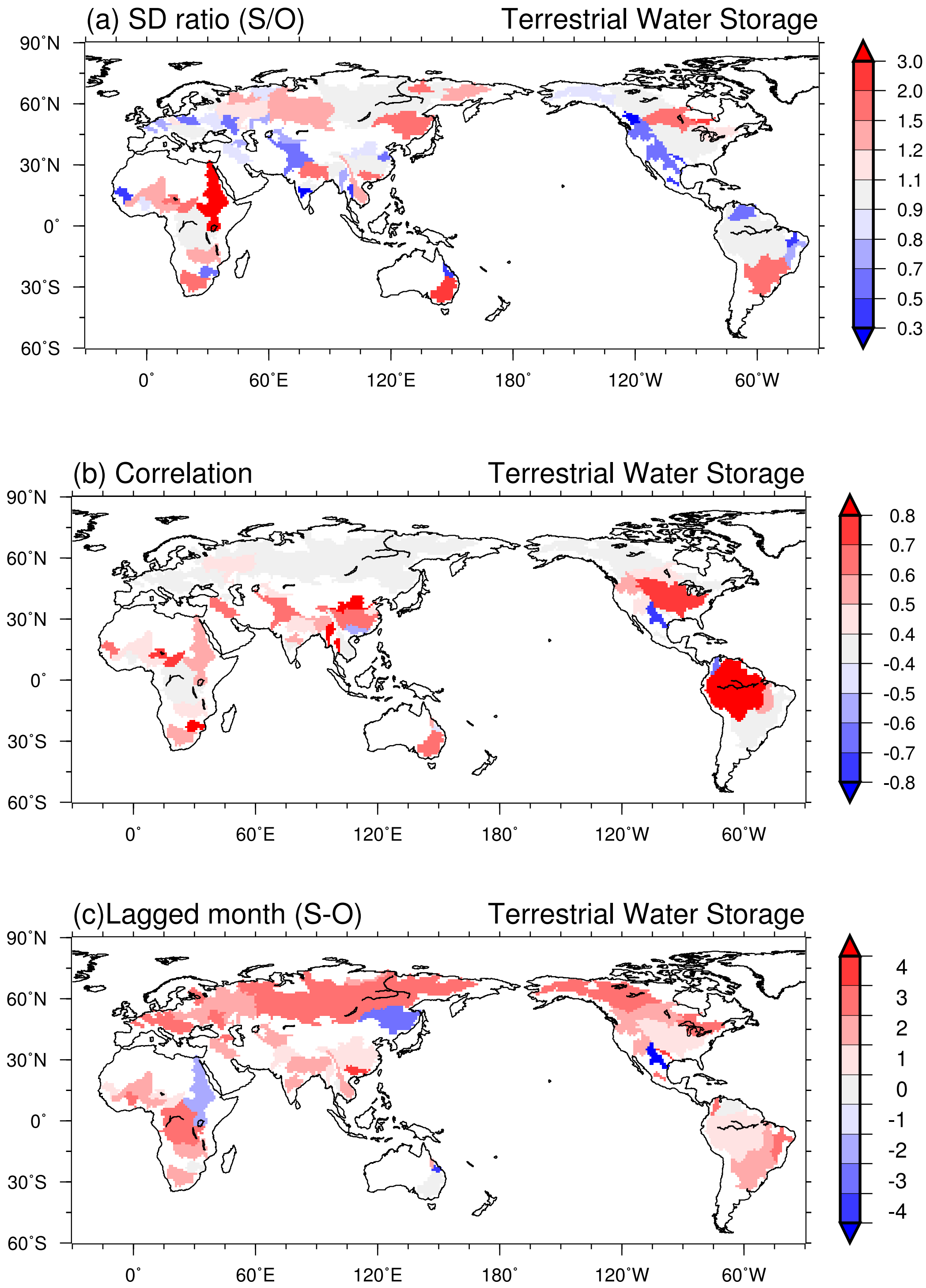

Fig. 1. Comparison of 70 terrestrial water storages between LDA and observations. (a) Ratio of standard deviation. (b) Correlation coefficient. (c) Lagged month. Note that these are all computed for climatological means.

Research Reports from Material Group

Reconstruction of metal and organic pollution due to urbanization of Metro Manila

Fernando Siringan

Marine Science Institute, University of the Philippines

Visiting Research Fellow, RIHN

Task

As an Invited Research Fellow, my task is to help RIHN`s Project 2-4 "Human Impacts on Urban Subsurface Environments" establish the history of metal and organic pollution due to the urbanization of Metro Manila utilizing the sediment record for reconstruction. Three sediment cores were acquired for this task, one each from Manila Bay, Laguna de Bay and La Mesa Reservoir, representing a marine environment, a natural fresh water lake and a man-made lake, respectively.

Study Area

Fig.1. Metro Manila and the basins where the cores were

Population Growth - Metro Manila、the capital of the Philippines is comprised of 14 cities and 3 municipalities and includes Manila, Makati and Quezon City (Fig.1). Metro Manila has an area of 636 km^2 or 0.2% of the country`s land area. As of 2005, it hosts 11.29 million people or 12.9% of the country's population (Fig. 2). In 1903, the political units of what now comprise Metro Manila had a population of 0.26 M. This grew to 1.54 M in 1950 and to 9.93 M by 2000 (Fig. 2). The expansion of Metro Manila which is spilling rapidly over its boundaries emanates from Manila, the oldest city of the metropolis (Fig. 3.)

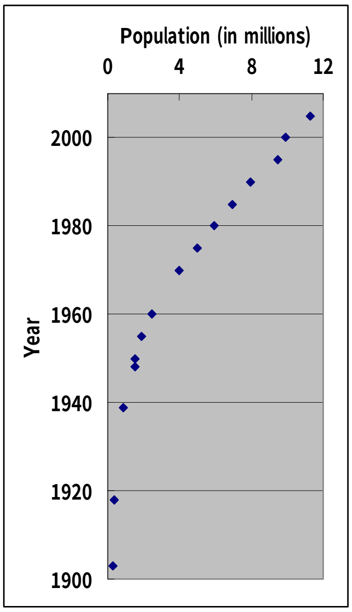

Fig.2. Population growth of Metro Manila from 1903 to 2005[1]

Physiography and Geology

Metro Manila is bounded by Manila Bay to the west and Laguna de Bay to the southeast with Pasig River cutting across the region (Fig. 1). Along its western side, Metro Manila is composed of coastal lowlands underlain by relatively thin veneer of coastal and alluvial sediments. The central portion is a plateau underlain by distal facies volcaniclastic materials with elevations mostly within 10 to 40 meters but exceeding 100 meters on its northeast end. The eastern flank is a lowland area underlain by lake and fluvial deposits.

Core Sites

Manila Bay is a semi-enclosed bay with a surface area of 1800 km^2 and a coastline of approximately 190 km. It is an important historical, cultural and economic resource of the Philippines contributing as much as 52.5 percent to the national GDP (PEMSEA 2006). It has an average depth of 25 m and is approximately 52 km long, with widths varying from 19 km at its mouth to 56 km inside the bay. The bay has a watershed area of 17,000 km^2 comprised of 26 catchment areas and is home to about 30% of the country`s population. The Pasig River, with Metro Manila within its watershed, discharges into the bay large amounts of waste from domestic sources since only 15% of the population is connected to the Metro Manila sewerage system (IMO 1994).

Laguna de Bay is the largest lake in the Philippines. Based on a 1963 chart, at mean lower lake level, which is equal to mean sea level, Laguna de Bay has a surface area of 929 km^2, a volume of 2.32 x 10^9 m^3 and an average water depth of 2.52 m.

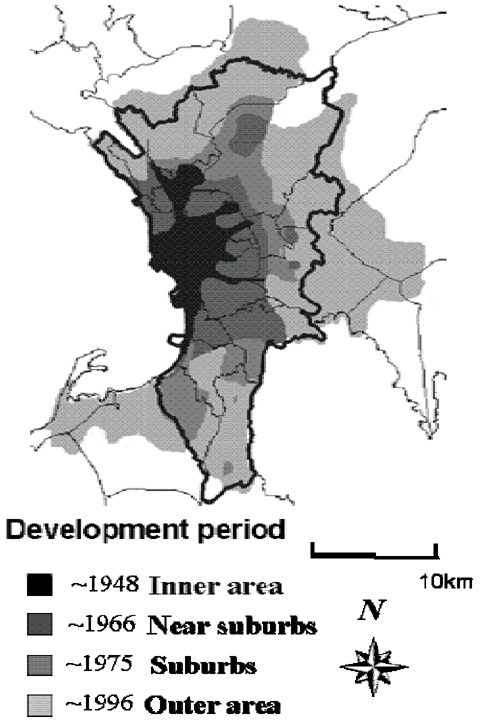

Fig.3. Expansion of Metro Manila from around 1948 to 1996 (modified from Midorikawa and Baustista, 2002)

The lake has a total catchment area of 3,820 km^2 (Richter 2001) with 35 tributaries draining it (Zimmer and Bendoricchio 2001) but with only one outlet to Manila Bay, the 25.5-km long Napindan-Pasig channel. With lake levels only 1 m above mean sea level, the river flow reverses during some dry seasons, resulting in saltwater inflows into the lake (Santos-Borja 1994).

The La Mesa Dam, an earth dam that backstops the La Mesa Reservoir, is in the north eastern portion of Metro Manila. It was first constructed in 1929 with storage capacity of 45.36 Mm^3. It was raised in 1959 to a maximum storage capacity of 50.5 million cubic meters. The reservoir has watershed with an area of only 27 km^2 (JICA, 1992) however a fraction of the trans-basin water transfer from other dams pass through the reservoir before they are distributed to filtration plants that supply most of Metro Manila`s water needs. In total, the reservoir accounts for about 11 percent of the surface water supply. Furthermore, the La Mesa Reservoir may account for more than 12 percent of the total recharge of Metro Manila`s aquifer system although the reservoir area is just a bit greater than 4% of the metropolis` land area.

The La Mesa Reservoir core shows lower concentrations of Pb relative to Manila bay and Laguna de Bay with 7.28 ppm as highest. Cu concentrations are higher than Manila Bay`s but are lower than Laguna de Bay`s. Furthermore, unlike in Manila Bay and Laguna de Bay cores, the La Mesa Reservoir core does not show a clear upcore increase in Pb and Cu concentrations. However, Zn shows a slight increase upcore and its concentrations are relatively similar with the two other sites. Cu and Zn, Zn and Pb and Cu and Pb have correlation coefficients of -0.15, 0.56, and 0.31, respectively.

Methods

The choice of sampling points in the three water bodies were based on identification of potential sources and pathways of pollutants, water circulation and prior knowledge of sedimentation from changes in bathymetry. The cores were acquired using a gravity corer in Manila Bay and La Mesa Dam and a modified Livingstone corer in Laguna de Bay. Sampling ensured that the sediment-water interface was preserved.

Geochemical work for metals was undertaken at Hiroshima University with Shin-ichi Onodera, Kazuhiko Takeda and Mitsuyo Saito. The sediments were oven dried at 60 ^oC until constant weight then ground with agate mortar and pestle. About 0.2 grams of sediment were placed in Teflon vessels and partially digested using 2 ml of HNO_3 and 4 ml of HCl. An hour after introduction of acids to the sediments, the Teflon vessels were sealed and microwaved with a step-wise increase in vessel pressure at 20, 30 and 40 psi`s at 5 minute durations. Digestant was filtered through a No. 6 quantitative ashless filter and diluted to 100 ml. Al, Ba, Ca, Cd, Co, Cr, Cu, K, Fe, Mn, Ni, Pb, Sr, Ti, and Zn were measured using a Perkin Elmer Optima 3000 ICP-AES. A 5 ml aliquot added with 0.2 ml 10% $SnCl_2$, and 0.2 ml 1:1 H_2SO_4 was analyzed for total Hg using a NIC RA-3 Mercury Analyzer. A 10 ppb Hg standard solution was prepared using 10 mg L-Cysteine, 2 ml HNO_3 and 1000 ml H_2O.

Sample Results

The three cores exhibit variation in metal concentrations, associations and patterns of change through time possibly due to differences in sources, pathways and relative mobilities of the metals in the basins. The Manila Bay and Laguna de Bay cores both exhibit an increase in the concentrations of Cu, Pb and Zn, upsection; Cu and Zn almost doubled while Pb increased by more than 4 times (Figure 4). The range of Pb concentrations is similar for Manila Bay and Laguna de Bay but Zn and Cu concentrations are higher for the latter. Furthermore, Zn is about twice the concentration of Cu in Manila Bay, but it is consistently lower in Laguna de Bay. Cu and Zn, Zn and Pb and Cu and Pb have correlation coefficients of 0.95, 0.81, and 0.90, respectively in Manila Bay and 0.90, 0.62, and 0.62, respectively in Laguna de Bay. Timing-wise, in Manila Bay, Pb and Zn appear to have started increasing at the same time while Cu started to increase earlier. In Laguna de Bay, Cu and Zn appear to increase at the same time and earlier than Pb.

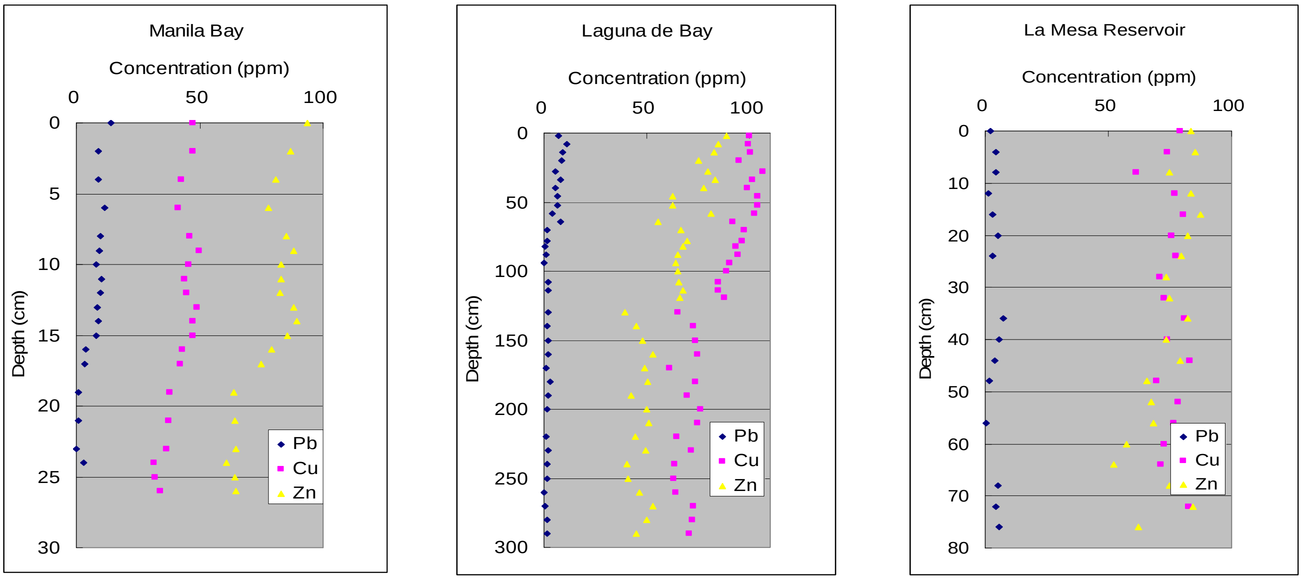

Fig.4. Concentrations of Pb, Cu, and Zn in the Manila Bay, Laguna de Bay and La Mesa reservoir cores.

On-going Work

Age dating by ^{210}Pb and ^{137}Cs is underway at RIHN using a Seiko EG&G MCA 7700 with Takanori Nakano and Takahiro Hosono. Pb isotope work, to retrace fossil fuel consumption, will be performed by Atsushi Ando with Takanori Nakano Pb, C and N isotope analyses are planned to be conducted at RIHN with Yu Umezawa. Retracing of the development of Metro Manila, for correlation with the geochemical data, is in coordination with Shinji Kaneko and Karen Jago-on.

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[1] Compiled from Magno-Ballesteros 2000; JICA 1992; http://books.mongabay.com/population_estimates/full/Metro_Manila-Philippines.html; and NSO website.

Research Progress in 2006

Takahiro Hosono and Takanori Nakano

Research Institute for Humanity and Nature

In this section, we would like to report the research activities of Material Group in the first year of the project. In previous volume of the newsletter (Vol. 2, Oct. 2006), Dr. Onodera introduced the objective, schedule, and members of the Material Group. So, here we would like to report our field activities and some results from chemical analysis.

Field research

It can be said that 2007 was a field research year for Material Group. We traveled around Manila, Bangkok, Osaka, Jakarta, and Taipei during the period of April to October. The schedule was kind of tight but, with great support of many people in each city, we could finish completely the first year's field research. First of all, I would like to say thanks from my hart to every body for supporting our research activities.

In the research site we usually divide ourselves into two-four member groups to drive in and around the city for sample collection. The main activity of the field research was groundwater and stream water collection (Fig. 1). Another important activity was establishment of rainwater station for chemical analysis, marine sediment core sampling at bay area (Fig. 2), and SGD (submarine groundwater discharge) study. Fig. 4 shows locality for groundwater sampling, rainwater station, sediment core sampling, and SGD study site.

Fig. 1. Groundwater sampling in Taipei with Dr. Chung-Ho Wang and his colleagues.

Chemical Analysis

Material Group is divided into two working groups: (1) group for nutrients & nitrate pollution and (2) group for mineral & metal pollution (Fig.3 shows the chemical analysis for latter group).

Fig. 2. Dudi Prayudi of LIPI (Indonesia) helps in sampling core sediment in Jakarta.

We are interested in the phenomenon of “metal enrichment” in groundwater, which might occur at reduction condition. In general, water with little nitrate ions contains large amounts of manganese (Fig. 4).

A.

B.

Fig. 3. A) Extraction of metals from water samples; B) Mass spectrometer for radiogenic isotope analysis

This suggests the possibility that such metal enrichment will advance in reduction condition, where nitrate and sulfate ions are decomposed by bacterial activity. Nitrate pollution is a big problem itself however, if groundwater is in a reduction condition, which might be controlled by geological or topological setting, this problem will shift to the metal pollution in the next step. We are now interested in understanding the mechanism of metal enrichment based on this idea. Future analysis and evaluation for metal pollution looks important to search a solution of metal pollution problem.

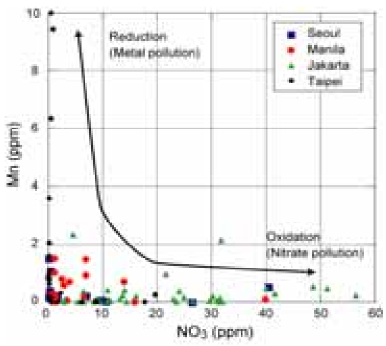

Fig.4. Nitrate concentration vs. manganese concentration in groundwater samples

Fig. 5. Gamma-ray spectrometer machine for age-dating.

Rainwater collection has already started in each station. According to the preliminary results, Taipei and Jakarta rainwater marked very high lead concentration (54 ppb and 2 ppb, respectively). Continuous monitoring should give interesting results regarding metal pollution of precipitation.

We are doing primary processing for marine sediment core samples. Sedimentation age is now being analyzed with Dr. Fernando Siringan (University of Philippines Diliman) by means of gamma ray spectrometer at RIHN (Fig. 5). More detailed analysis will be conducted in the future with Dr. Su at National Taiwan University.

Age Dating of Groundwater Using CFCs as a Tracer

Maki Tsujimura [1], Kazuyoshi Asai [2], Kiyohiro Ohta [1], Kazuhiro Hasegawa [2], Jun Shimada [3], Makoto Taniguchi [4]

1: Univ Tsukuba, 2: Geoscience Lab Co Ltd, 3: Kumamoto Univ, 4: RHIN

1. Why is dating by CFCs necessary?

Residence time of groundwater is essentially important factor to elucidate the hydrological processes in a certain region. The radio isotope of ^3H has been used for dating of groundwater and surface water since 1960's, however the ^3H is ineffective recently in Japan, because the ^3H concentration of precipitation has been approximately under 5 T.U. during recent 10 years.

Chlorofluorocarbons (CFCs) has been broadly used for dating of young groundwater instead of ^3H since 1990's, because (1) the atmospheric mixing ratios of these compounds are known and/or have been reconstructed over the past 50 years (Fig. 1), and (2) concentrations in air and young water are relatively high and can be measured (Busenberg and Plummer, 2000).

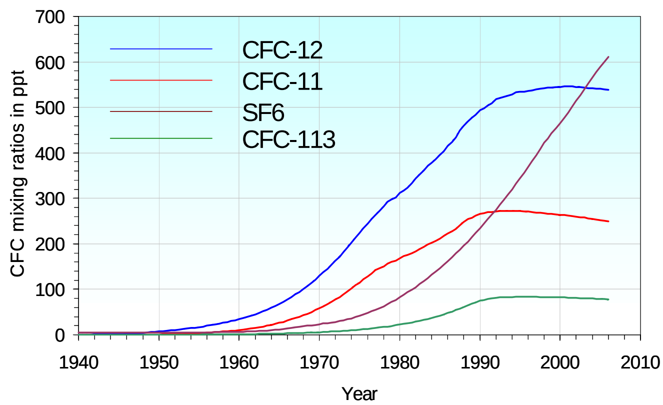

Fig.1. Temporal change of CFCs concentration in the atmosphere (USGS)

In Japan, however, the CFC's has been used only by oceanographic scientific community, whereas there has been previously no data on CFCs concentration of terrestrial water such as groundwater, soil water and surface water. An establishment of analytical and calibration scheme is highly required also in Japan.

Factors affecting CFCs concentrations in the groundwater were previously suggested (Table 1) based on the data taken in Europe and USA. Considering site specific conditions, importance of factors might be different in Japan as compared with that in Europe and USA. For example, the factors of urban atmosphere and contamination seem to be more important in Japan, because large cities are located adjacently each other. It is possible that the CFCs can be used not only for dating but also for tracing the history of contaminant in Japan, and observed data of CFCs in the spring and groundwater are indeed necessary.

Table 1. Factors affecting CFCs concentrations in groundwater (revised from Plummer and Busenberg, 2006).

Factor	Environment	Process	Effect	Reference
Recharge Temperature	Shallow groundwater	Over-estimate of recharge altitude Under-estimate of recharge altitude ±2℃	Under-estimate Over-estimate 1 year (< 1970) 1-3 years (1970-1990) > 3 years (> 1990)	Busenberg et al (1993)
Excess air	Fissures of rock	Addition of air trapped and dissolved during recharge.	Under-estimate	Wilson and Mcneill (1997)
Recharge altitude	Mountainous region	Water recharged at high altitude dissolves less CFCs because of lower barometric pressure. ±1000m	A few years (< 1987)	Busenberg et al (1993)
Thickness of unsaturated zone	>10m	Air in deep unsaturated zone is older than that of the modern troposphere. 0-10m 30m	Over-estimate < 2 years 8-12 years	Cook and Solomon (1995) Busenberg et al (1993)
Urban atmosphere	Metropolis	CFC mixing ratios in urban and industrialised areas can exceed regional values.	Under-estimate	Szabo et al. (1996) Oster et al. (1996)
Contamination	Industry region	CFCs added to water from local anthropogenic sources	Under-estimate	Thompson and Hayes (1979) Busenberg and Plummer
Microbial degradation	Anaerobic environments	No degradation in aerobic environments CFC-11,113	Over-estimate	Sonier et al. (1994) Deipser and Stegmann (1997)
Absorption	Organic-rich sediment	Sorption of CFCs onto particulate organic carbon and mineral surfaces. CFC-113>>CFC-11,12	Over-estimate	Cook et al. (1995)

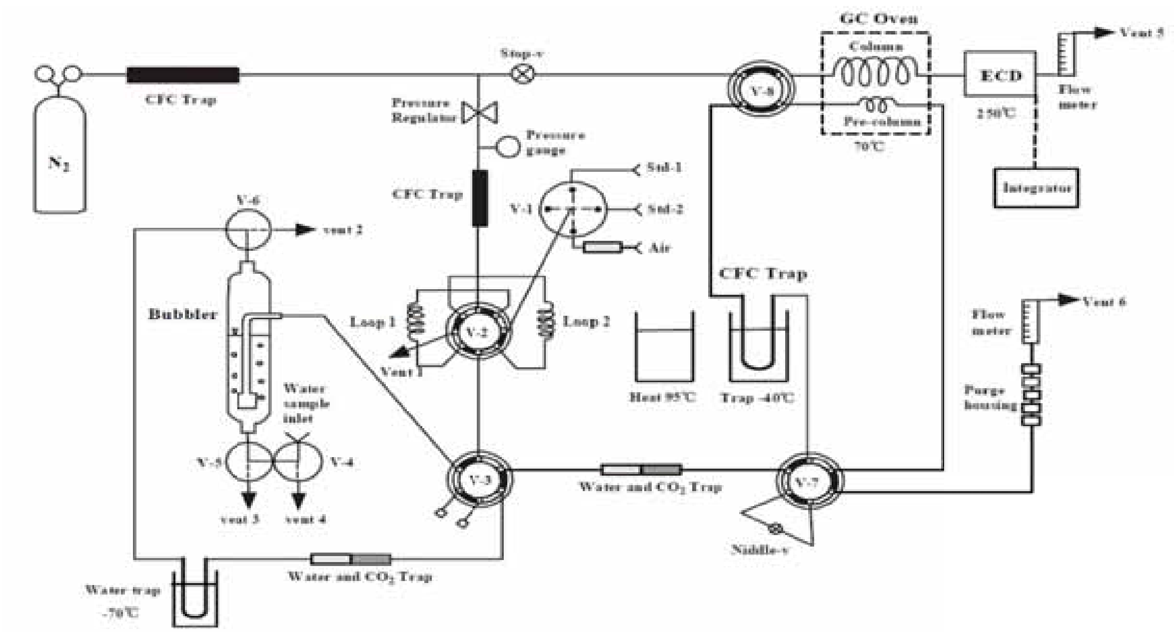

Fig. 2. System line diagram showing preparation and analysis of CFCs concentration of spring, stream and ground waters.

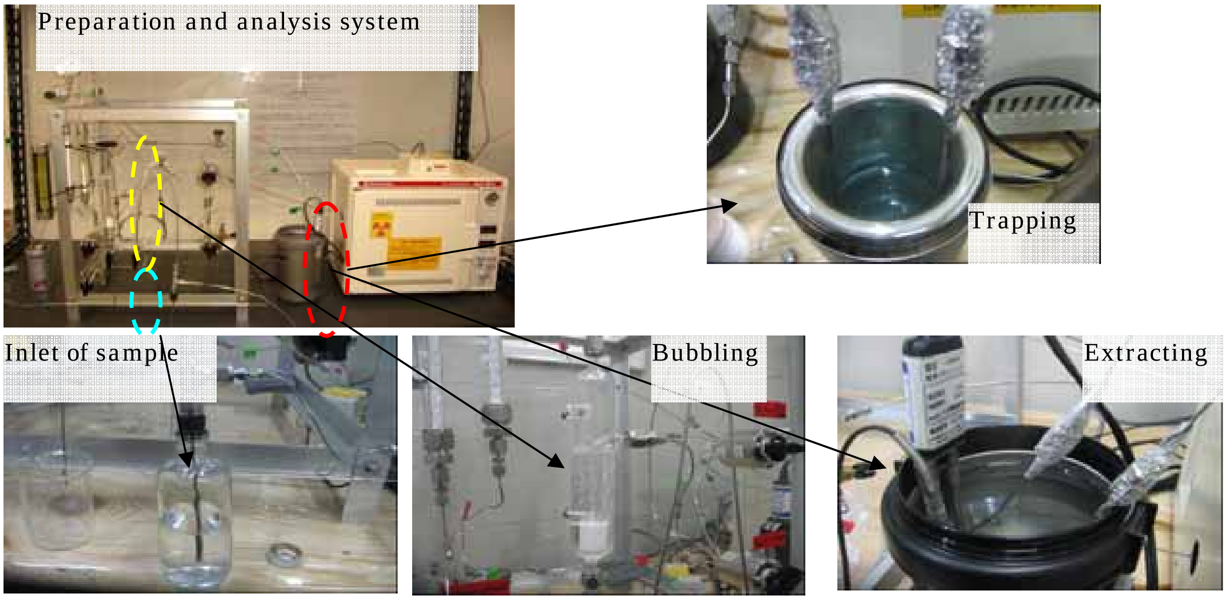

Fig. 3 Photographs showing preparation and analysis system.

2. *Analytical system*

We have completed a new analytical system of CFCs concentration in spring, stream and ground waters based on purge and trap method (Busenberg and Plummer, 1992), which is the first one in Japan (Fig. 1). The preparation line consists of inlet, bubbling, trapping and transforming systems (Fig. 2). A water sample with volume of approximately 40 mL is injected to the line by gas pressure, and then the CFCs in the sample are extracted by bubbling of N_2 gas (100 mL/min x 8 mins.). The extracted CFCs are trapped by coolant at a temperature of approximately 40 ℃ (dry ice-ethanol), soon after trapping, the CFCs are turned out to the line at a temperature of 95 ℃ and induced into the gas chromatograph. A 100 % of contained CFCs in water sample can be trapped and analyzed using this preparation line.

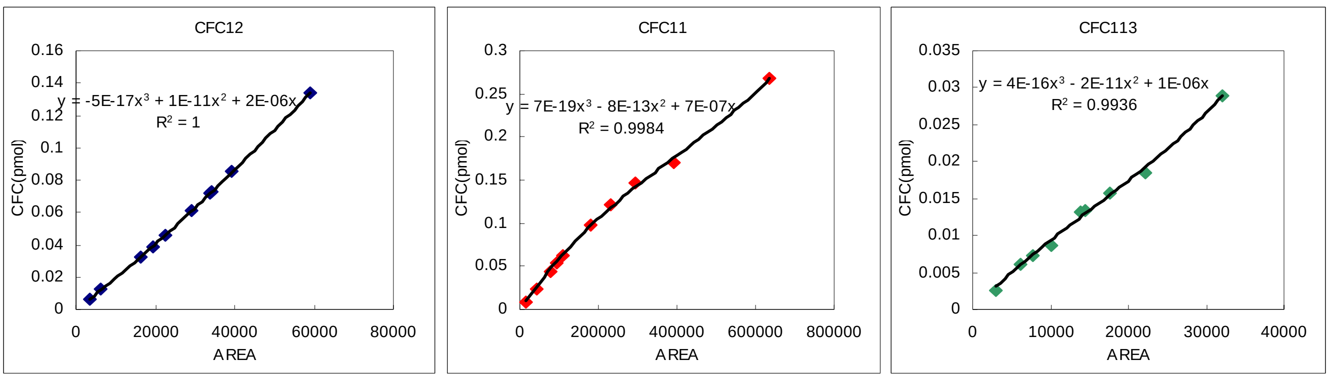

Fig. 4 Calibration lines of CFC-12, CFC-11 and CFC-113.

Calibration curves of CFC-11, CFC-12 and CFC-113 are shown in Fig. 4. The analytical accuracies of CFC-11, 12 and 113 are 0.10 %, 0.23 % and 1.38 %, respectively, and those are enough considering annual variation of CFCs concentration in the atmosphere.

3. Application of CFCs to Shiranui and Ashigara catchments

Sampling of spring and ground waters was performed to apply CFCs in Shiranui catchment, country region along the coastal area, Kumamoto Prefecture, southwest Japan, and Ashigara, suburban region, Kanagawa prefecture, 60 km southwest of Tokyo where the groundwater flow system has been observed by potential measurement using boreholes and tracer approaches.

The observed CFCs concentrations of spring and ground waters are within the range of those in the present atmosphere in Shiranui, whereas those of Ashigara are much higher than those of the present atmosphere. A contamination by factories using CFCs should affect on those of groundwater in Ashigara.

Residence times of spring and ground waters were estimated to be 15 years in headwater and 25 years in mid-stream region of Shiranui.

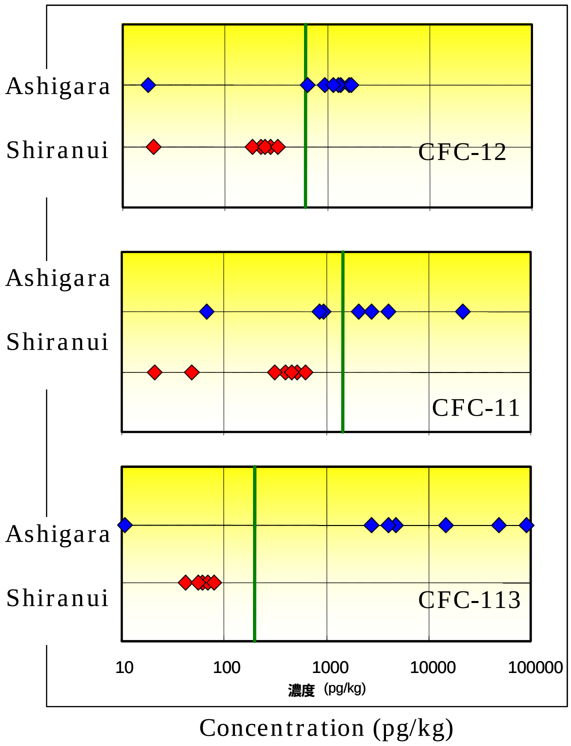

Fig. 5 Analyzed CFCs concentrations of spring and ground waters in Ashigara and Shiranui.

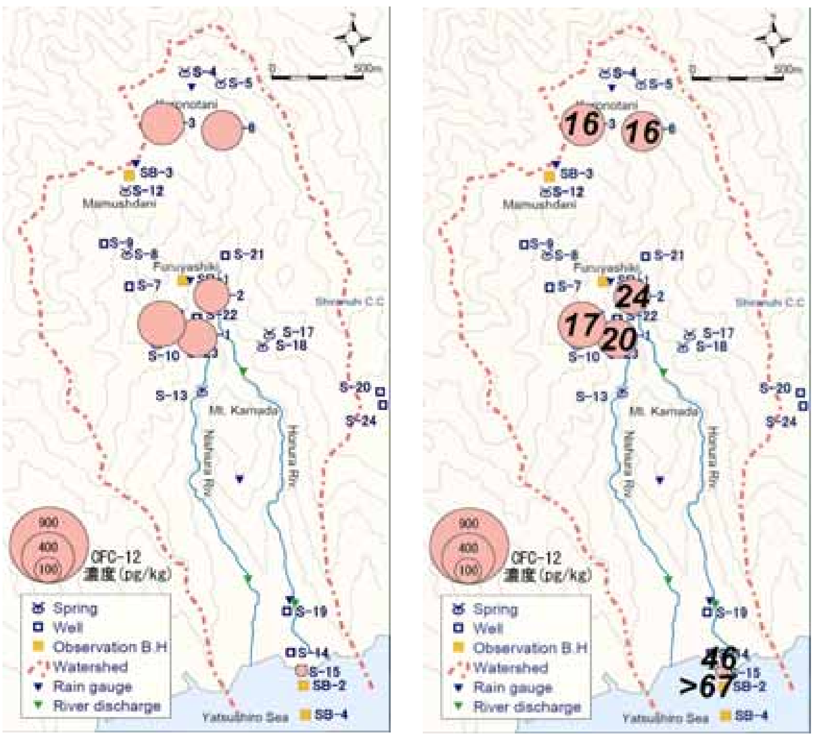

Fig. 6. Spatial distribution of CFC-12 concentration (left) and residence time (right) of spring and ground waters observed in Shiranui catchment.

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Urban Heat Group

Meteorological Data Accumulation and Field Survey

Toshiaki Ichinose[1], Kumi Kataoka[1] and Yingjiu Bai[2]

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[2] Tohoku University of Community Service and Science

Purpose of the Urban Heat Sub-group

The purpose of this sub-group is to accumulate and analyze meteorological data (air and soil temperatures, precipitation, duration of sunshine, amount of cloud, wind velocity, etc) for constructing dataset to compare with subsurface environment. The group especially focuses on the analysis of long term trend of temperature difference in urban area and suburban area and clarification of the influence of urbanization on subsurface temperature profile.

This year our sub-group collected meteorological data, examined its quality by field survey, and then discussed the expansion of high temperature area in preparation to analyze temperature difference in urban area and suburban area.

Data accumulation

Meteorological observations in large Asian cities have begun around 1900 and the meteorological data for approximately the past 100 years is available for discussion of long term trends. For example, the periods with temperature data existing at representative cities in our study areas are given as follows: Tokyo (1876-), Osaka (1883-), Nagoya (1891-), Seoul (1908-), Bangkok (1951-), Taipei (1897-), Jakarta (1866-) and Manila (1956-).

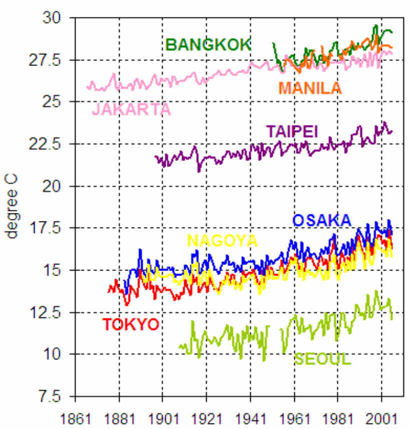

Fig. 1. Variations in yearly average temperature in each city.

Figure 1 shows variations in yearly average temperature in each city. In most of these cities, temperature has increased by approximately 2.5 deg C in the 21st century. The increase, especially after 1950s is remarkable.

We examined these increasing trends from the point of observatory relocations by field survey.

Summary of field survey

There exist relocations of observatories as well as changes of observation techniques, although they are sometime ignored and the data are treated as continuous data. We introduce current environment of observatory in Bangkok, Seoul and Tokyo and past relocations of them, and discuss the data continuously.

Bangkok

Representative observatory of Bangkok is called “Bangkok Metropolis.” Current “Bangkok Metropolis” is located at Chaloemprakiet. Fig.2 and 3 show “Bangkok Metropolis.”

Data is recorded manually on paper and digitalized later. Surrounding environment, specially mentioned, is that large pond exists at west side of observatory.

Fig.2. Current “Bangkok Metropolis” and Thai Meteorological Department

Fig. 3. Observation methods at “Bangkok Metropolis”

Fig. 4. Relocations of observatory “Bangkok Metropolis”

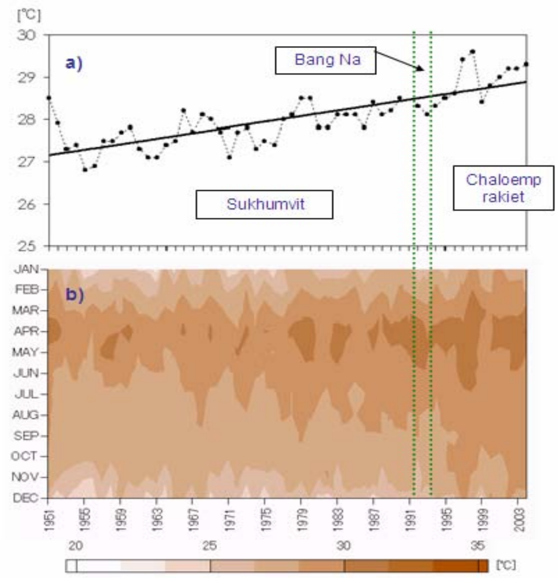

Fig. 5. Variations of a) yearly and b) monthly average temperature at “Bangkok Metropolis” (1951-2004).

Observatory “Bangkok Metropolis” was relocated twice in the past. Figure 4 shows the change of location of observatories. "Bangkok Metropolis" was first transferred from Sukhumvit (downtown of Bangkok) to Bang Na (where currently Thai Metrological Agency is located). "Bangkok Metropolis" was relocated again, and moved to Chaloemprakiet (downtown of Bangkok).

Figure 5 shows the relocation information of observatory in addition to yearly and monthly average temperature trends. There is no large gap when the observatories were moved. Therefore, it is considered that yearly and monthly average data can be used for analysis without revision.

Seoul

Representative observatory of Seoul is called “Seoul.” Fig.6 and Fig.7 show “Seoul” observatory. Currently, data is recorded automatically.

Observatory “Seoul” has not moved from its original location in 1907. However, it is located at northwest side of downtown, and its altitude is a little bit higher than that of downtown. This might be affected when surface data and subsurface data are compared.

Fig. 6. Observatory “Seoul” and Korea Meteorological Administration.

Fig.7.Altitude of observatory “Seoul”

Fig.8. Observatory “Tokyo” and Japan Meteorological Agency

Tokyo

Representative observatory of Tokyo is called “Tokyo.” Fig.8 shows “Tokyo” observatory. Currently, a highway exists next to the observatory.

Observatory “Tokyo” is relocated three times. Fig.9 shows the places of observatories relocated. Observatory "Tokyo" was firstly relocated from Toranomon to Kitahanebashi. Then, it was relocated to Hitotsubashi and to Otemachi.

Figure 10 shows the relocation information of observatory in addition to yearly average temperature trend. There seems to be a gap when observatory “Tokyo” was relocated from Kitahanebashi to Hitotsubashi. Although the reason of this gap may not be the result of relocation, this gap has to be paid attention when surface data and subsurface data are compared.

Fig.9. Relocations of observatory “Tokyo”

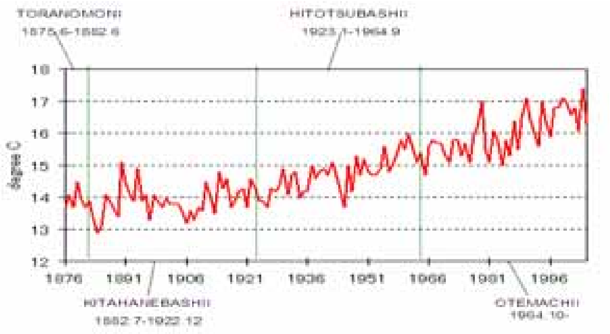

Fig. 10. Yearly average temperature at “Tokyo” (1875-2005)

Expansion of high temperature

Next, we analyzed how large the high temperature area expanded around the cities for preparing to analyze temperature difference in urban area and suburban area.

Figure 11 shows total hours exposed to 30 degree C or higher (1986 and 2000). In the case of Japan (Tokyo, Osaka, Nagoya), recent high temperature appears at approximately radius 30 km area around each city. When the heat problem by effect of urbanization is discussed, these radius areas should be considered in Tokyo, Osaka, and Nagoya.

As shown in Fig. 12, the number of observatory at the time when meteorological observation started is quite few compared with current number of observatory. A way of treating this problem is necessary to discuss in the future.

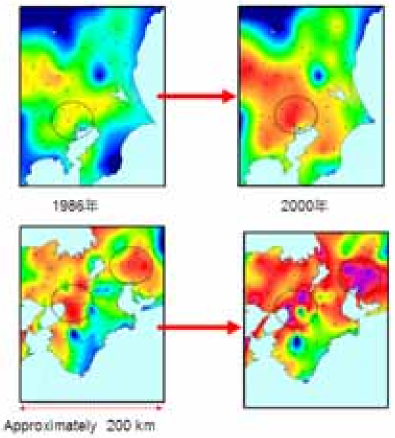

Fig.11. Total hours exposed to 30 degree C or higher (1986 and 2000)

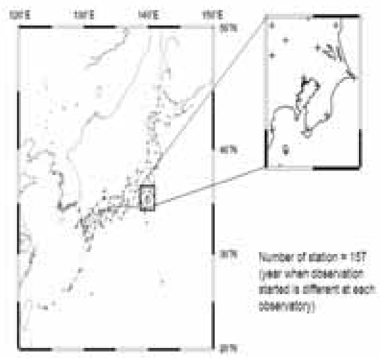

Fig.12. Meteorological observatories in Japan before the AMeDAS observation started in 1975.

Future plan

In addition to Bangkok, Seoul, and Tokyo, to collect the information of observatories in other cities and to discuss how to compile the data for comparing surface environment and subsurface environments are necessary.

After examining representative observatories of each city, we plan to construct the dataset about long term UHI (Urban Heat Island) index of each city to compare with subsurface environments.

Joint research with RIHN

Reo Ikawa

I am Reo Ikawa from Kumamoto University. Currently, I am studying isotope hydrology. Since high school I have been interested in studying groundwater systems of a semi-arid and arid region. During my undergraduate course in Akita University, I studied geology and realized the significant interactions between geology and groundwater hydrology. Therefore, I decided to learn hydrology in Kumamoto University.

In RIHN project, I am studying groundwater flow system in Seoul, Korea and Bangkok, Thailand. Groundwater is a vital resources domestic and industrial water supply in both advanced and developed countries. Recently, shallow groundwater pollution problem becomes a serious problem. As a result, particularly in developed countries, shallow groundwater is not suitable as domestic water. However, the necessity of groundwater development expands with the increasing population and economic growth and therefore, deep groundwater development advances rapidly.

In Korea, Seoul city is the most urbanized area, and groundwater is mainly used for industrial purposes. Recently groundwater quality degradation caused by expansion of subway pumping becomes a serious problem in central part of Seoul city. In the summer of 2005, we visited Seoul city and collected groundwater samples. With the isotope data of these samples, we tried to understand groundwater flow system. In 2006, we also went to Bangkok, Thailand for sampling. In Bangkok, shallow groundwater pollution already becomes a serious problem. Now, peoples use deep groundwater pumping out from more than 100m depth as domestic water. My work in Bangkok project is estimation of residence time of deep groundwater in several aquifers using tritium concentration. I think that my research work will help the groundwater management in Bangkok City.

ACKNOWLEDGMENT

We wish to thank all project members who have contributed to our newsletter. Your articles and reports are very valuable and informative. We hope for your continued support and cooperation in the succeeding issues of our newsletter.

ANNOUNCEMENTS

Japan Geoscience Union Meeting 2007
May 19-24, 2007- Makuhari Messe International Conference Hall, Chiba City, Japan

International Symposium and Workshop on Current Problems in Groundwater Management and Related Water Resources Issues
December 3-8, 2007
Bali, Indonesia

HydroChange 2008: Hydrological changes and management from headwater to the ocean
October 1-3, 2008,
Kyoto Garden Palace, Kyoto City, Japan

Call for Contributions

For the next issue, we would like to request article contribution again from each Group. It may be in the form of a summary report of the Group's activities or individual contribution from a member of the Group. We also encourage project members to discuss new methodologies or the use of new equipment in our research project. The newsletter will also provide special columns for our foreign counterparts, graduate students and the RIHN-based project researchers to share research updates and opinion on their involvement in the project.

For the third volume (October 2007), we would like to request the following Groups/individuals to give their articles for the newsletter:

1. Prof. Shimada's Group
2. Dr. Shinji Kaneko's Group
3. Dr. Onodera's Group
4. Dr. Momoshima
5. Dr. Robert Delinom
6. Dr. Takahiro Endo

To allow ample time for editing and layouting, we hope to receive your articles on or before September 28, 2007.

For inquiries, please send email to:

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Inter-University Research Institute Corporation

National Institutes for Humanities, Japan

Project 2-4 Human Impacts on Urban Subsurface Environments

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Human Impacts on Urban Subsurface Environments

This project will assess the effects of human activities on the urban subsurface environment, an important aspect of human life in the present and future but not yet evaluated. This is especially true in Asian coastal cities where population and density have expanded rapidly and uses of subsurface environmental have increased. The primary goal of this project is to evaluate the relationships between the development stage of cities and various subsurface environmental problems, including extreme subsidence, groundwater contamination, and subsurface thermal anomalies. We will address the sustainable use of groundwater and subsurface environments to provide for better future development and human being.

RIHN Corner

Yu Umezawa

Senior Researcher

http://yuumezawa.com

In March 2006, when I was preparing for my job interview at RIHN, I have not even imagined my current situation. At that time, I was at the Department of Botany, University of Hawaii. I was involved in a NOAA project to tackle alien algae, which has rapidly spread out at the coral reefs around Hawaii islands. I have studied about "the effects of anthropogenic nutrients inputs on coastal ecosystems, especially coral reef ecosystem for many years since I became a graduate student at Marine Biogeochemistry Laboratory at the University of Tokyo. I have always been interested in research which combines biogeochemical techniques (e.g., stable isotopes analyses in water and marine algae) and biological and aquacultural methods (e.g., nutrient-enriched experiments using algae). Actually the latter was the study which I wanted to learn in Hawaii, in order to better understand how algal chemical components reflect water qualities and related environmental conditions. Such a multidisciplinary study is very important for environmental science.

I became interested in the RIHN project because the concept and philosophy of RIHN is a collaboration of social science and natural science. Of course, I can not deny that the historical city of Kyoto was also attractive for me! After nearly a year since I started to work here, I'm quite satisfied with learning together with nice colleagues from different academic background. It is enjoyable to try to understand each other, because such a process gradually brings us more ideas by which we can tackle the environmental problems.

In this project I work as a member of Material Group, and mainly take charge of analyzing stable isotopes (SI) in nutrients (nitrate, nitrite and ammonium, and hopefully phosphorus, too in the future!) and organic matter in marine sediment core samples. High nitrate concentration in drinking water is one of problems threatening human health in Asian countries. $\delta^{15}N$ and $\delta^{18}O$ signatures in nitrate would give us more information about their sources and pathways at subsurface environment. Furthermore, I hope that we can successfully reconstruct historical change of anthropogenic effects on coastal ecosystem attached to mega-cities, by interpreting the profile of carbon and nitrogen contents and their δ–signatures in marine core samples together with other metal components.

My other tasks in this project are the management of GIS working group and coordination of many office work. We believe that GIS will be one of the effective tools to coordinate the data collected in each city, and to easily facilitate the sharing of information not only within our group members but with other researchers studying on water resources and management in each Asian city.

Occasionally (or more often) I may bother you with lots of inquiries and requests. I genuinely appreciate it if you would understand the situation and I am thankful for your scientific contribution and support to make this project successful. As a Senior Researcher at RIHN, I'm ready to hear any opinion and suggestions from all members to gradually improve our project.