Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-01 Room:102 Time:May 27 14:15-14:45

Use of compound specific isotope analysis (CSIA) on investigation of soil and groundwater contamination

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In order to consider the effectiveness of CSIA on investigation of soil and groundwater contamination, stable carbon isotope ratio (d{sup}13{/sup}C value) of each CVOC product that becomes potential source contaminant was measured and the effectiveness of CSIA on investigation of soil and groundwater contamination was examined by investigating the d{sup}13{/sup}C value distribution about each CVOC on a soil and groundwater contaminated site.{cr/}

In this analysis, experimental reagents and the industrial reagents of CVOCs produced in Japan about CVOCs products that become potential source contaminants were collected and the d{sup}13{/sup}C values of these products were measured using Elemental Analyzer/Isotope Ratio Mass Spectrometer (EA/IRMS).{cr/}

As the result of measuring the d{sup}13{/sup}C values about four tetrachloroethene (PCE) products and four trichloroethene (TCE) product, d{sup}13{/sup}C values of PCE were -37.29 to -29.77 permil ant that values of TCE were -33.49 to -27.18 permil. The range of the d{sup}13{/sup}C values on PCE products was greater than that on TCE products.{cr/}

The d{sup}13{/sup}C values of CVOC increase by the isotopic fractionation according to the degradation process by the microorganism and hardly change in a physical process such as the dilutions and volatilizing. Therefore, there is a possibility to be able to specify the contaminant source based on the result of CSIA of the contaminant.{cr/}

On the groundwater investigation in a soil and groundwater contaminated site by PCE as a primary source, The d{sup}13{/sup}C values of each CVOC in groundwater were measured by CSIA using Gas Chromatograph/Combustion/Isotope Ratio Mass Spectrometer (GC/C/IRMS), and two dimension distributions of the d{sup}13{/sup}C values in aquifer were estimated about each CVOC. It is reported that the uncertainty of the d{sup}13{/sup}C value is within the plus or minus 0.5 permil under the ideal condition, though the problem remains in the reliability of low concentration samples. The groundwater investigations were done in August and December, 2007.{cr/}

In August, the d{sup}13{/sup}C values of PCE in the monitoring well of RW-C which installed into the source area was -27.03 permil and the value in the monitoring well of A-3.0 which is located 40.4 m downstream side of RW-C was -23.10 permil. The d{sup}13{/sup}C values of cis-1,2-dichloroethene (cis-1,2-DCE) was the lowest in A-3.0 with -25.60 permil and increased toward the downstream and lower side. From these data, the situation in which cis-1,2-DCE were produced by degradation of PCE from RW-C and moved to each depth on the downstream side was estimated. From the groundwater quality data such as DO, ORP and sulfur, it was thought that the cause of the increase of d{sup}13{/sup}C value on cis-1,2-DCE is a reductive dechlorination by microorganism.{cr/}

In December, contamination mechanism which was estimated from the d{sup}13{/sup}C values data was same with the one in August. Therefore, it was estimated that the movement mechanism of contaminant is steady. {cr/}The d{sup}13{/sup}C values of PCE in December increased 2.67 to 3.36 permil compared with August in RW-C and A-3.0, and the d{sup}13{/sup}C values of cis-1,2-DCE in December increased 0.18 permil compared with August in RW-B which located 33.6 m upstream side of RW-C. On the other hand, the d{sup}13{/sup}C values of cis-1,2-DCE in each depth of each point on downstream side of RW-C in December decreased 0.11 to 0.59 permil compared with August. It is important to accumulate the knowledge about the seasonal change of d{sup}13{/sup}C values of CVOCs in soil and groundwater. {cr/}These results show that there is a possibility to estimate the contamination mechanism from the situation of d{sup}13{/sup}C values distribution of CVOCs measured by CSIA if the reliability of the d{sup}13{/sup}C value measured by CSIA can be secured.

Keywords: soil and groundwater contamination, stable carbon isotope, compound specific isotope analysis, chlorinated volatile organic compound

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-02 Room:102 Time:May 27 14:45-15:00

A study on the origin and recharge process of shallow groundwater in the east Musashino upland, Tokyo

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Water environment of urban area largely varies with stage of urbanization. Generally, infiltration rate of precipitation has been decreased because of increasing of impermeable surface such as constructions and paved roads and of developing of sewerage network. On the other hand, leakage from sewerage becomes the source not only of groundwater but of pollutants. To maintain urban water environment and use groundwater as water resource, it is important to clarify the origin and recharge process of groundwater.

East Tokyo Metropolis is the economic center of the Tokyo Metropolitan Area and has been developed since the end of 19th century. East Tokyo Metropolis is topographically divided into the western upland (Musashino upland) part and the eastern lowland (Tokyo lowland) part. In the upland part, about 280 springs are still remains in 2003 (Tokyo Metropolitan Government, 2003). Also, Inamura and Yasuhara (2008) studied delta-18O and delta-D of groundwater that discharged to the Shakujii River that flew on the upland and evaluated origin of the groundwater. According to Inamura and Yasuhara (2008), the groundwater is mainly recharged by precipitation. These results suggest that infiltration route of precipitation still remains in the upland area. This study aims to clarify the origin and recharge process of shallow groundwater in the Toshima Ward that is located on the upland. Toshima Ward is surrounded with the Shakujii River and the Kanda River, and the central part of this ward is a city center. Western and eastern part of the ward is residential area. Prevalence of networks of water pipe and sewerage in this ward is 100%. We collected groundwater samples from 13 shallow private wells (depth is shallower than 10m) and 9 deep wells (depth is 20 to 30m) and measured major dissolved ions and stable isotopic compositions of O and H. Also, land-use, especially grassland and bare ground, in around the shallow wells were checked by using Google Maps and Street View.

Delta-18O and delta-D of all groundwater samples ranged between precipitation (weighted average of GNIP TOKYO data) and tap water (Inamura and Yasuhara, 2008). This result showed that the groundwater in this area was recharged by precipitation and tap water. We calculated mixing ratio of precipitation and tap water using isotopic data of groundwater samples and two end members (precipitation and tap water). As a result, contribution of precipitation was from 48.4 to 75.9% except for one sample (shallow groundwater: 20.5%). On the other hand, ratio of grassland and bare ground in topographical catchment area of shallow wells that were estimated from topographical map with a scale of 1:2500 and 5m mesh DEM were 11.6 to 22.4%. The contribution of precipitation and the ratio of grassland and bare ground showed positive correlation. Results of this study showed that precipitation was still major source of groundwater. Infiltration routes of precipitation were considered to be not only public parks and car parks but also yards and under of eaves in detached houses.

Keywords: urban groundwater, land use, recharge process

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-03 Room:102 Time:May 27 15:00-15:15

Distribution and origins of nitrate in shallow groundwater in the Shakujii river catchment, central Tokyo, Japan

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Water chemistry of shallow groundwater in the Shakujii river catchment in the downtown Tokyo is discussed with special reference to its nitrate and chloride concentrations. The catchment is divided into the highly urbanized lower reaches (Toshima, Kita and Itabashi Wards) and the upper reaches which have been urbanized to a lesser extent (Nerima Ward, and Nishi-Tokyo and Kodaira Cities). In 2009 and 2010, shallow groundwater samples were collected from ca.150 wells of less than 10m deep. Groundwater occurs in the Kanto loam layer and/or underlying stream terrace gravels.

As a result of the water chemistry analysis, shallow groundwater in the Shakujii river catchment proved to be characterized by a surprisingly high nitrate concentration with an average of 44.0mg/l in Toshima Ward; 39.3mg/l in Kita Ward; 39.4mg/l in Itabashi Ward; 39.4mg/l in Nerima Ward; 37.2mg/l in Nishi-Tokyo City; 26.7mg/l in Kodaira City. A maximum value of 231.9mg/l was found in the groundwater sample from Nerima Ward. The enriched delta-^{15}N and delta-^{18}O values of nitrate especially in the lower reaches suggest leaking sewers is a potential source of nitrate in shallow groundwater of the Shakujii river catchment.

Keywords: Tokyo metropolitan area, urban area, shallow groundwater, nitrate, chloride, leaking sewer

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-04 Room:102 Time:May 27 15:15-15:30

Pharmaceuticals and personal care products (PPCPs) and anthropogenic gadolinium in groundwater in central Tokyo

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Together with an increasing concern about water scarcity caused by climate change, groundwater can serve as a supplementary source of water in Tokyo for various purposes including drinking, landscaping, water in emergency, water for spraying to mitigate heat island in summer. However, studies have shown that some of groundwater in Tokyo was polluted by various contaminants including nitrogen, bacteria, organic carbon, and perfluorinated compounds, some of which originate from domestic wastewater. Therefore, for the protection of groundwater quality, assessing groundwater pollution by domestic wastewater in the city-wide scale is needed.

With that aim, we measured pharmaceuticals and personal care products (PPCPs) and anthropogenic gadolinium, which are considered to be specific to domestic wastewater. Measured PPCPs include carbamazepine, a quantitative tracer of sewage in groundwater reported in overseas, and crotamiton, which has been reported to be conservative and hardly attenuated in soils in Japan. Anthropogenic gadolinium, which supposedly originates from contrast media for magnetic resonance imaging (MRI) in hospitals, has also been reported as a conservative tracer of wastewater in groundwater.

Totally 50 groundwater samples were taken between October to December 2007 in 19 wards in central Tokyo: 32 sites from unconfined aquifers with approximately 10-30m of depth; 16 sites from confined aquifers with approximately 30-500m of depth; 2 sites from springs on the Musashino Terrace. For PPCPs measurement, samples were filtered (0.7um), spiked with deuterated surrogates, concentrated with solid phase extraction, purified with 5% water-deactivated silica gel column chromatography, and analyzed by GC-MS. For measurement of anthropogenic gadolinium, samples were filtered (0.45um), added with 60% HNO3 (1%(v/v)), spiked with bismuth as an internal standard. Gadolinium was measured together with the other rare earth elements by ICP-MS. Concentration of anthropogenic gadolinium was calculated as difference of total gadolinium measured by ICP-MS and geogenic gadolinium estimated with samarium and terbium when ratio of total- to geogenic gadolinium exceeds 1.3.

PPCPs were detected in 21/32 sites (66%) from unconfined aquifers, 2/2 sites (100%) from springs, and 7/16 sites (44%) from confined aquifers. More detection in unconfined aquifers and springs than confined aquifers indicates that groundwater was polluted by domestic wastewater near the ground surface. Detection in confined aquifers was mainly located near the border between the Musashino Terrace and the Tokyo Lowland. We estimated that the Tokyo layer, which is the main confined aquifer in that area, was polluted by the infiltration of upper unconfined groundwater. Concentration of PPCPs in groundwater was 1-2 orders lower than that of sewage influent, while in some groundwater PPCP concentration was comparable with sewage influent. Among six PPCPs measured, carbamazepine and crotamiton were most frequently detected (19/50 sites and 18/50 sites, respectively). PPCPs were detected in four sites where E. coli was detected. It was considered that PPCPs were more widely detected than E. coli because E. coli is more easily attenuated by sorption to soil surface and die-off in groundwater.

Anthropogenic gadolinium was detected in seven unconfined aquifers and one confined aquifers. The distribution of PPCPs and anthropogenic gadolinium was quite different: at only three sites both compounds were detected. E. coli was detected in none of anthropogenic gadolinium-positive sites. Those differences may arise from the distribution of the compounds in wastewater. PPCPs are considered to be widely contained in domestic wastewater, while it was reported that anthropogenic gadolinium was highly abundant in effluent from MRI-equipped hospitals. Therefore, it was considered that anthropogenic gadolinium-positive groundwater may have a strong influence by effluent from MRI-equipped hospitals.

Keywords: groundwater pollution, domestic wastewater, pharmaceuticals and personal care products (PPCPs), gadolinium, E. coli

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-05 Room:102 Time:May 27 15:30-15:45

Microbial contamination in spring at Otomeyama Park in Shinjuku Ward

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Spring water has been widely used for drinking, cleaning and agriculture because of its more stable supply than surface. Spring water is therefore, deeply linked to life of community residents. Springs are also valuable amenity spaces for local residents.

According to the national survey conducted by the Ministry of the Environment in 2008, 6.9% (295/4290) of groundwaters violated the environmental standards. It is also likely that spring water is contaminated. According to our groundwater quality in the central of Tokyo, we found that Escherichia coli (*E. coli*) was detected from 80% of spring water (4/5), 19% of unconfined ground water (11/58), and 5.2% of confined ground water (3/58). Since *E. coli* in spring water could be a major barrier to the usage of spring water for landscape and amenity microbial contamination of spring water is a matter of concern.

In this study, we surveyed microbial contamination of spring waters at Otomeyama Park in Shinjuku Ward, Tokyo. Shinjuku Ward is planning to extend Otomeyama Park, where spring water is expected to be used as amenity water. We measured water quality parameters on amenity use such as pH, odor, appearance, *E. coli*, turbidity, chromaticity, especially focusing on *E. coli* and total coliform (TC).

In order to understand recharge sources of spring water at Otomeyama Park, we collected topographical data based on boring explorations to infer the aquifer of spring water.

Then, we periodically investigated spring water quality at Otomeyama Park. Ground water samples in the same aquifer were also collected from surrounding wells, and were subjected to water quality analyses.

pH in spring water was in the range of 6.55-7.35, *E. coli* 1-4150 CFU/100-mL, TC 230-21000 CFU/100-mL, turbidity 0.2-20 degrees, and chromaticity 0.0-18.5 degrees. In particular, *E. coli* exceeded a guideline value for reclaimed water as amenity water. Turbidity and chromaticity also exceeded the guideline values during wet weather. *E. coli* and TC in ground water obtained from the wells near Otomeyama Park were 146-1100 CFU/100-mL, and 508-25650 CFU/100-mL, respectively, which were comparable to those in spring water. Ratios of TC to *E. coli* in spring water and ground water were higher than those in sewage, indicating TC was relatively abundant in spring water and ground water. We will investigate *E. coli* and TC in spring water during wet weather and those in the soils at Otomeyama Park to evaluate their sources.

Keywords: spring, urban groundwater, amenity use, *E. coli*, water quality standard

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-06 Room:102 Time:May 27 15:45-16:00

Leaching properties of heavy metals and metalloids from natural sediments in plain side of Saitama Prefecture.

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In order to evaluate the various characteristics of the heavy metals and metaloids contained in the natural sediments distributed over plain side of the Saitama Prefecture, Japan, we examined the leachabilities of arsenic (As), lead (Pb), iron (Fe), chromium (Cr), manganese (Mn), etc. for natural sediments which has no effect of anthropogenic contamination. All the analysis samples were obtained on the Arakawa lowland, the Nakagawa lowland and the Oomiya upland which are located in central part of the Saitama Prefecture. We measured the total contents and the leachabilities of these heavy metals for a total of about 150 samples (22 sites) collected in the depth from 0m to 10m. Chemical compositions of the specimens were determined using X-ray fluorescence spectrometry (XRF) while the solution water chemistry was analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP/MS).

In this paper, we will discuss the leachabilities of these heavy metals and metaloids to solution through the leaching test base on the backgroud mentioned above.

Keywords: heavey metal, arsenic, lead, water-rock interaction, leaching, sediment

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-07 Room:102 Time:May 27 16:00-16:15

Heavy-metal concentration of forest soil in Chichibu region, Saitama prefecture

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Total nitrogen concentration in stream water in the upstream regions of Ara river is increasing because of nitrogen saturation presumably caused by nitrogen atmospheric deposition. Atmospheric emission of heavy metal is also increasing with the developments in industry. If air mass containing high nitrogen emission flows in forested ecosystems from urban area and causes nitrogen saturation, heavy metal derived from human activities should also deposit on forested ecosystems and contaminates stream water and soil. In addition, leaching of nitrogen may be altered by the deposition of heavy metal through disturbing the metabolism of soil microbe.

To evaluate the atmospheric heavy metal per se and the effect of heavy metals to the nitrogen leaching, we compared Cr, Zn, Pb, Cu and Sb concentration in 1M-HCl soil solution. Sampling was performed twice: one before rainfall and the one after the rainfall. Soil samples were collected from the trench in Chichibu region where the nitrogen saturation is reported. In addition, we measured Cr, Zn, Pb, Cu and Sb concentration in 1M-HCl soil solution at 8 points near the stream of various stages of nitrogen saturation.

Decrease ratio of heavy-metal concentration at the trench between before and after rainfall (Cr 53%, Zn 49%, Pb 10%, Cu 15%, Sb 2%) was positively correlated with ionization tendency ($Cr > Zn > Pb > Cu > Sb$). It is suggested that elements with high ionization tendency leaches easier than that with low ionization tendency. It is contemplated that the effect of heavy metal on nitrogen metabolism of soil microbe is in the same range among the 8 points because heavy metal concentration in soil solution near the stream was nearly identical at every point. Thus, the difference of nitrate concentration in stream water at the 8 points may be caused not by the effect of heavy metal on nitrogen metabolism of soil microbe but by the direct reflection of the amount of atmospheric nitrogen deposition.

Soil Sb concentration at the headstream area of Ara river (1.9ppm) was higher than that at other areas (0.2-0.6ppm). This may be the effect of Chichibu mine, which had been operated at the headstream area of Ara river. It is recorded that bournonite ($CuPbSbS_3$) and jamesonite ($Pb_4FeSb_6S_{14}$) were mined at Chichibu mine. There is a possibility that Sb emitted from the mine is stay behind or the base materials of the soil of the headstream area of Ara river have much Sb.

For these reasons, we considered that heavy metal has little effect on the nitrogen leaching to the stream water and nitrogen concentration in stream water corresponds to the amount of atmospheric nitrogen deposition.

Keywords: forest soil, heavy-metal contamination

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-08 Room:102 Time:May 27 16:30-17:00

Hydrogeological Modeling Results of Kanto Groundwater basin

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At the alluvial lowland in the central part of the Kanto plain, intensive drawdown of groundwater head due to excessive pumping caused the considerable land subsidence in the past times, and on the contrary, remarkable rise of the confined groundwater head depending on the regulation of groundwater withdrawal has brought adverse affect on many important infrastructures such as underground railway stations in late years. In order to understand such behaviors of the groundwater, it is essential to clarify actual conditions of the regional groundwater flow system within the Kanto plain. Primary specific approaches are to analyze basic data, and also to grasp the hydrogeological structure. For several years, authors have experimented with the hydrogeological structure modeling of the Kanto groundwater basin. In this conference, we will explain the basic concept for the modeling composed of groundwater basin coverage limitation, hydrogeological stratigraphic classification and hydrogeological structure evaluation.

The coverage of the Kanto groundwater basin was decided from the distribution of Pleistocene and/or Holocene formations which contain aquifer systems and are subject to recharge, storage and flow of groundwater. The extent is generally coincide with commonly called Kanto plain.

At first we experimented with the hydrogeological stratigraphic classification based on geological stratigraphic correlation in the whole Kanto plain. However, it proceeded with difficulty because no geological research for the whole Kanto plain was carried out previously and, in case of the researches for specific areas, interpretation and/or classification was considerably different by every local governments and/or research institutes. We adopted a deliberate policy of the five basic conditions for the correlation of geological layers, such as (1) use of almost all of the previous relative studies' fulfillments, (2) application of the latest knowledge on the geological stratigraphic classification, (3) use of the isotopic stage of oxygen, and so on. As the result of the trial, we classified Quaternary sediments into nine hydrogeological layers as shown below. Within the geological formation of Pleistocene age, Kazusa F. was divided into the layers-VII to IX, Shimousa F. was divided into the layers-III to VI, and terrace deposits were corresponded to the layer-II. Fan deposits of Pleistocene age and Alluvium were corresponded to the layer-I. The layer-IX is considered to be the hydrogeological base rock according to its facies and present groundwater development condition.

The hydrogeological structure was evaluated as the following steps. (1) Fist of all, depth to the hydrogeological base rock and the basement of the layer-IV (the lowest layer of Shimousa F.) were determined according to available drill-logs of production wells and the previous study results on the geological structure. (2) Then, hydrogeological profiles were prepared on the basis of the existing geological cross-sections considering the hydrogeological stratigraphic classification. (3) Finally, according to the hydrogeological profiles, basement contour of each hydrogeological unit; the layers-I to VIII, was prepared. The basement contours; fruits of the hydrogeological structure evaluation, show two basin-like depression areas near the northern part of Saitama Prefecture and in the Tokyo bay off the coast of Chiba city. Long axis of the basin-like area near the northern part of Saitama Prefecture is parallel to and concordant with the nearby active fault. In addition, these basin-like structures become clear more and more in the deeper layers. Since there seem to be close relation between the fault activity and the basin-like depression, it is necessary to pay attention to this hydrogeological conditions especially in case of evaluating the distribution of the groundwater flow indexes such as groundwater head, quality and temperature.

Keywords: Kanto groundwater basin, Regional groundwater flow system, Hydrogeological modeling

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-09 Room:102 Time:May 27 17:00-17:15

Long-term Transition of Pumping Rate and relationship with Confined Head in Kanto Groundwater Basin

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At the alluvial lowland of Tokyo metropolitan area, intensive drawdown of groundwater head due to excessive pumping caused the considerable land subsidence in the past times, and on the contrary, remarkable rise of the confined groundwater head depending on the regulation of groundwater withdrawal has brought adverse affect on many important infrastructures such as underground railway stations in late years. In order to understand such behaviors of the groundwater, it is essential to clarify actual conditions of the regional groundwater flow system within the Kanto plain. Primary specific approaches are to analyze such basic data as pumping amount and also to put groundwater indexes such as groundwater head in order. Since those data will be utilized conclusively for numerical simulation of regional groundwater flow system, it is required to estimate long-term pumping rate backward until the period of very few groundwater usage in order to improve the precision of the simulation quantitatively.

For several years, authors have attempted to reconstruct the long-term transition of hydrogeological conditions in the whole Kanto groundwater basin. In this conference, we will demonstrate method and result of the backward estimation of the pumping rate before the second world war, and relationship between the reconstructed pumping rate and the confined groundwater head actually observed.

As it was considered that both use of submersible pump and the land subsidence in the Kanto plain started with the 1920's (Taisho Era), the estimation was extended back to the 1920's. On the other hand, data on pumping rate after around the 1970's are available in case of the Kanto groundwater basin. After a process of trial and error, it is clarified that there is a clear correlation between GNP and the total pumping rate. Therefore, the pumping rate before around the 1970's was principally estimated adopting the correlation except for 1945, the year of war end, where the pumping rate was assumed to be 0.

As for the groundwater head monitoring, observation of the confined groundwater head at the alluvial lowland of Tokyo metropolitan area had been commenced at the beginning of the 1950's. The confined groundwater head continuously descended till the middle of the 1960's, then ascended rapidly in reversal until the middle of 1980's. After then, the confined groundwater head has ascended slowly until now. Whereas the long-term transition of the pumping rate is quite concordant with the long-term variation of the confined groundwater head, the estimation of the pumping rate before around the 1970's is considered to be sufficiently valid.

At the alluvial lowland of Tokyo metropolitan area, on the other hand, the pumping rate of surrounding area has close relation with the confined groundwater head in case after the middle of 1980's. According to the relation, it has been possibly predicted that the confined groundwater head will ascend more if the pumping rate will decrease in future.

Keywords: Kanto groundwater basin, Regional groundwater flow system, Pumping rate, Confined groundwater head

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(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-10 Room:102 Time:May 27 17:15-17:30

Simulating Past and Future Hydraulic Potentials by Groundwater Flow Modeling in Kanto Groundwater Basin

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While flood and drought doe to potential climatic change often occur and we have to take care of big earthquake, the voice of groundwater necessity as excellent water resources becomes louder. However, it is difficult to understand the quantitative mechanism on groundwater, because the groundwater is invisible and it has the large regional differences. Our study group has been collected and examined the data about the hydrogeological information, the groundwater flow index and the water budget to evaluate the mechanism of groundwater flow system in whole Kanto groundwater basin. Based on these examinations, three-dimensional groundwater flow analysis was performed on the distribution area of the Kanto Plain aquifer, and tried to understand the groundwater system and predict the future changes in hydraulic potentials.

The hydrogeological structure is classified into 10 units (I, II, III-1, III-2, IV, V, VI, VII, VIII and IX) based on examination results of the different geological strata on the depositional age and sedimentary environment. And the 9 units except IX are adopted as the model aquifers and incorporated into the model to quantify the hydrogeological structure. In the analysis, Visual MODFLOW equipped USGS three-dimensional finite differential groundwater flow model MODFLOW- 2000 was used. A model grid is about 2km size rectangle shape (four times the area of the 3rd order mesh defined by Japanese government). Simulated period is 84 years from 1920 through 2003 and the transient analysis was performed per year to reproduce the observed potential fluctuations in observation wells especially focusing on the area among Tokyo and southern part of Saitama Prefecture, where the large groundwater potential depression was occurred in 1970s as a result of the excessive pumping and the potential continues to ascend after pumping regulation. Pumping rates, one of the important model inputs, were reexamined for the model grid and distributed to the main model aquifers. Though the hydraulic parameters were assigned to every hydrogeological units, the Layer-I corresponds to the alluvium were subdivided into different hydrogeological classification because Layer-I is different in nature of marine or fluvial. To progress model calibration, the different hydraulic property was assigned to Layer-II (gravel Layer) in the Musashino Terrace where is difficult to reproduce the hydraulic potentials.

The actual groundwater heads can be classified into two types; one is nearly steady state that does not show the successive fluctuation and the other is in ascending process after intense drawdown. The former can be recognized in the shallow observation wells and the latter can be recognized in the deep observation wells. The model could simulate these feature of the wells especially screened at the position deeper than layer-V. This means that the successive fluctuations observed are consistent with the pumping rates around the observation points. In Layer-VII (main aquifer) calculated potential distribution in 1999, there is the potential depression extending from northeast Tokyo to east part of Saitama Prefecture. This result suggests that there is groundwater flow system towards the central region of the potential drop from the margin area of Kanto groundwater basin. The ascending trend of the observation well after the regulation is continuing now in the lowland. According to the predictive calculation using the calibrated model, about 5m groundwater head rise will be occurred at the terrace and that marginal area in Tokyo after 50 years if the present pumping rate is kept. This regional groundwater flow model is being applied to the simulation of land subsidence in clayey layer for the northern part of Kanto Plain by coupled groundwater flow/land subsidence with nested grid scheme.

Keywords: Groundwater flow model, Kanto groundwater basin, Regional groundwater flow system, Coupled groundwater flow/land subsidence model

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-11 Room:102 Time:May 27 17:30-17:45

Development of the water-resources analysis system The analysis of the amount of groundwater of Yamato-River Basin -

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The water resource analyzer is developed for analyzing the Yamato River basin. So, the basin was shortage water for 2 million people living. The shortage water was obtained by the adjoined other basin, Kidu river and Kino River. The water was used for industry or rice field or orange. It is important to know the amount of water resource for when city is not securable enough water as it has no rain. The analyzer system consists by some systems, the data is exchange together, and it shares same data. The data was on text or on image. The system relate the color information or text data to the hydrological information (rainfall, temperature, calculated amount of evaporation etc..) , land use, geological data(Geology, altitude, soil condition), city information (people, sewage system, supply water system, dams etc..) , industrial data(Scale, Sales, Kind etc..) and The River information (The river form database make up by tree node, flow rate). We have original GIS software developed by the Author, the water resource analyzer, Trirnia-Hexa diagram viewer, the water quality database include stat and graph making.

The river water level at Ouji observing station changes around 32m. the both of river water and groundwater level at Ouji is low in all observing station in Nara basin, it is estimated groundwater of Nara basin corrected at Ouji and flow out of catchment at Ouji.

The amount of presipitation was calculete by using Meteorological Agency data of average 2002. The amout of dam water is sum of effective amount of water. The amount of pond water is created by degital map and GIS data. The amount of water from other basin is calculted by max of Watering plan of the Japanese government. The river flow is calculeted by sum of day flow at Ouji obseving station in 2002. The amount of eaporation is calculeted by Thornthwaite method dusing month average temperature of Meteorological Agency data. The water in the Nara basin is shortage, so it means difficult to calcuete amount of groundwater from other water source. Generally, it is difficult to mesure amount of groundwater directly, as amount of groundwater is estimated by the other water calculation.

The water balanse from 1960 to 2005 is usually shortage, the Nara Basin has water problem. It is inportant to make sure of necessary water in the Nara basin.

Results of water balance disagree with actual phenomenon. The amount of the precipitation and provided water from other basin is equal to the amount of the river flow and the evaporation. As the geological condition of mountain around the basin is granitic rock, surface water was infiltrating poorly, and then flows into the Nara Basin directly. And the flow observing station is only located lower stream in the basin. So, the flow value assign evenly by an area, flow out value reduced a generous amount of value. The groundwater level was seasonally changed with precipitation at round the Nara Basin. So, the response of precipitation is quick comparatively, groundwater level changes about 50 cm per 100mm/month of precipitation in east of Nara Basin. It is estimated that water level changes seasonally in water input area. However, the groundwater level is flat or little changes in annual at central Nara Basin. The water level of river at the west Nara Basin is low in the whole basin, so it is estimated that all water of the Nara Basin is collected to this area.

Keywords: water resource, amount of groundwater, water quality, Analysis system, GIS

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AHW024-12 Room:102 Time:May 27 17:45-18:00

Subsurface warming observed in a long-term temperature monitoring beneath the reclaimed land in the Tokyo Bay area

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A long-term monitoring of subsurface temperature and multiple measurements of a temperature-depth profile have been conducted at the observation well in the reclaimed land along Tokyo Bay, to make clear subsurface temperature and groundwater environment changes. Temperature changes were found in the comparison of the temperature-depth profiles, and their changes showed different tendency by depths. The changes was large at the part shallower than the depth of 20m (upper part of the Yurakucho bed). Groundwater has been pumped up due to construction works around the observation well. It was considered that the subsurface temperature changes was caused by effects of local human activity. Moreover, continuous subsurface temperature increase was found at the depth of 30m (lower part of the Yurakucho bed) and 40m (the Tokyo bed). Tendency of the temperature increase was larger at the shallow depth. This suggests that human activity have affected subsurface thermal environment and groundwater environment beneath the reclaimed land along Tokyo Bay.

Keywords: subsurface temperature, groudnwater flow, Tokyo Bay, reclaimed land, subsurface warming

Japan Geoscience Union Meeting 2011
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AHW024-13 Room:102 Time:May 27 18:00-18:15

Two year Performance of the Ground Source Heat Pump System in Central Tokyo

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According to the statistics published by the Ministry of Environment, the installation number of the ground source heat pump system in Tokyo Metropolitan exceeds 50 in 2009. A ground source heat pump system was installed for a small office building in Central Tokyo two years ago. It is made mainly up of a water-source heat pump unit, 8 boreholes of 75 m deep for heat exchanger, and polyethylene pipes. Coefficient of Performance (COP) of the heat pump system was 4.3 in average for the first year. Forty nine percent of electricity was reduced by the ground source heat pump system, compared to the conventional air source heat pump system previously worked there. Geology of the building site is unconsolidated Quaternary sediments of gravel, sand and silt, and their thermal conductivity was estimated to be 1.8 W/m/K. Thermal energy of 51 GJ was produced from the ground source and that of 53 GJ was discharged there during the first year.

In the second year, the temperature in the summer was much higher than that of the usual year, resulting in much recharge of heat energy into the ground. The heat pump system was switched from ground source to air source to accommodate the high ground temperature at the beginning of the autumn. As the result of this control the ground temperature became to be equal to the original one when the heat pump operation was just two years old. Such good balance of subsurface heat exchange suggests sustainability of the heat pump system working for the building.

Keywords: ground source, heat pump, thermal conductivity

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-14 Room:102 Time:May 27 18:15-18:30

Development of potential assessment on ground-source heat pumps

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In several kinds of renewable energy, solar and wind energies have tools for potential assessment such as METPV and wind map, respectively, while ground-source heat pumps do not have such tools. Recently, several local governments try to estimate potential resources on renewable energy. Development of an assessment method is desirable to compare several results on potential assessment. In this study, a potential assessment method on ground-source heat pumps is developed and is applied to Tokai region (Aichi, Gifu, Mie) and Kanto region (Tokyo, Chiba, Saitama, Kanagawa). Although there are several kinds of ground-source heat pumps, the subject of this study is only ground-coupled heat pumps with vertical heat exchangers. Because those with horizontal heat exchangers need the large premises and are difficult to install in Japan. Groundwater heat pumps is restricted by the regulation of groundwater pumping up. As this means that those cannot be installed in several areas, this study does not treat this type of ground-source heat pumps.

Potential of ground-source heat pumps is divided into the following two types. Resources are maximum heat extracted from ground and do not depend on land use conditions. Potential installation is a realizable value of heat extracted from ground based on land use condition, population distribution and so on. In this study, each value is decided as follow. The length of heat exchanger is 100m. The interval of them is 5m. Working period of air-conditioner is 2400 hours per year.

For a resource assessment, geology influences a maximum heat extracted from ground. Estimated resources are higher in the area of acidic igneous rocks and lower in the area of the Quaternary sediments. For a potential installation, land use and distribution of heat demand is important. Heat demand is higher in urban area. Comparing the resource with heat demand in each area, the resource of ground-source heat pumps is higher than heat demand in most areas.

Keywords: potential assessment, ground-source heat pumps

Japan Geoscience Union Meeting 2011
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AHW024-P01 Room:Convention Hall Time:May 27 10:30-13:00

Spatial distribution characteristics of stable isotopes in groundwater, spring water and precipitation samples at Kyoto

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Kyoto is an old city in Japan which has more than 1000 year's history. Kyoto basin spreads from Kyoto to Osaka Prefecture. The area of the basin is about 18 km from north to south and about 10 km from east to west. An alluvial fan is formed in the basin by the Kamo and Katsura river. The sand and gravel are deposit thickly at the alluvial fan, and the thickness is about 100 m at the fan head and from 300 to 400 m at the fan end. There is some aquifer in the basin and a large quantity of groundwater is stored in this basin, so many people who live in the Kyoto city have used the groundwater a long period.

In the Kyoto basin, the stable isotope of oxygen changes from -8.9 to -5.3 per mill and hydrogen changes from -58 to 35 per mill. The stable isotopes are relatively low with the high elevation and relatively high with the low elevation in the mountainous area. The stable isotopes in groundwater around Kamo river are constant (d^{18}O: -7.8 per mill, dD: -50 per mill) and don't depend on the groundwater level. Thus the isotopes of groundwater around Kamo river are almost corresponding to isotopes of Kamo river, it is assumed that the groundwater is recharged from Kamo river in this area. The SiO_2 concentration and water quality in groundwater and river water suggest this result.

The precipitation samples have been sampled every two months at three points of P-1 (32.5 m a.s.l.), P-2 (100 m a.s.l.) and P-3 (310 m a.s.l.) since September 2009. The water quality, stable isotopes of oxygen and hydrogen were analyzed for all precipitation samples. The amount-weighted value of d^{18}O is -7.9 per mill at P-1, -8.1 per mill at P-2 and -8.4 per mill at P-3. The altitude effect of precipitation in this area is -0.17 per mill /100 m for d^{18}O (r^2=0.981) and -0.7 per mill / 100 m for dD (r^2=0.819). The altitude effect of the groundwater and spring water near the precipitation sampling points also exists. In the future, we will estimate the groundwater flow and recharge area in Kyoto basin by using the stable isotopes in groundwater and precipitation samples.

Keywords: Kyoto basin, groundwater, spring water, precipitation, water quality, stable isotope

Japan Geoscience Union Meeting 2011
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AHW024-P02 Room:Convention Hall Time:May 27 10:30-13:00

Origin of chloride ion in groundwater in Kanto plain, Japan

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The Kanto Plain is the largest groundwater basin in Japan. There is the groundwater area with high Cl concentration (from 10 to 150 mg/l) in the depth of GL-100 to -300 m of the central part of the plain. This ground water area is thought to be made by regional groundwater flow, from the viewpoint of three-dimensional observations of groundwater quality, stable isotopes, and subsurface temperature. We performed a leaching experiment of chloride ion which used bowling core block drilling at Kasukabe. In the experiments, powdery sample (20g) made from piece of drilling core and pure water (100 mL) are mixed at a plastic container. And 24 hours later, chloride ion is measured by electrode. The experiments provided interesting results as follow: (1) The sample which showed highest concentration (95.2 mg/L) of chloride ion is collected from the core piece about 330m depth. (2) Range of chloride ion concentrations in the pore water estimated by an experimental result is from 13.2 mg/L to 2113 mg/L.

Keywords: Kanto Plain, Chloride ion, Leaching experiment

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW024-P03 Room:Convention Hall Time:May 27 10:30-13:00

Regional subsurface temperature profiles and the temporal variations in Saitama prefecture

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Ground heat exchanger system is spreading as the promising system as natural energy system in Japan. Subsurface environmental basic information (subsurface temperature , geological feature, hydraulic property) is essential for a design of ground heat exchanger system and an estimation of the energy efficiency. The final purpose of the study is to be useful for spreading of ground heat exchanger system through investigation of subsurface environmental information. In the presentation, we mainly talk about investigation method about subsurface temperature measurements and the result in Saitama prefecture.

We conducted to measure at 24 stations in 2009 (Jul 2009- Oct 2011) and 15 stations in 2010(Oct 2010- Jan 2011) using subsurface water observation well located in the plains of Saitama.

The observation well measured in 2010 is same as 2009, but the seasons are different (Summer season in 2009, and Winter season in 2010. Thermal gradient due to heat from deep part is about 20-30mK/m in Saitama area. The values are consistent with past reported results. Most stations have temperature inflection point at about 50m depth and rise toward ground surface. This temperature rises may be caused by global warming and/or the heat island effect of the city for a last century. Most temperature profiles are stable in time in the deeper than 100m depth. On the other hand, several profiles change. The stations are located in the agricultural region. The large amount of groundwater is pumped up in summer season. As one interpretation, seasonal pumping affects groundwater flow, and it may change subsurface temperature. For the understanding of temperature change, it is effective to perform temperature monitoring in the depth. We have a plan such a monitoring.

On the other hand, it is general known that the ground surface seasonal temperature variations are propagated into subsurface by thermal diffusion. As the propagated depth depends on subsurface thermal properties, and the depths are different in region For the measurements of the propagated depth, we made observation wells of 15m depth and 30m depth in CESS (Center for Environmental Science in Saitama). The 15m observation well made in March, 2010, and the 30m observation well made in January, 2011). We measured the temperature distribution of the 15m observation well in October, 2010 and January, 2011. As a result, seasonal temperature variation propagate shallower than about 8m at the station.

It is important that the regional characteristic of subsurface temperature distribution and subsurface temporal temperature variation for understanding of subsurface environment.

Our study is significant model case for applying to other areas.

Keywords: Subsurface temperature, Seasonal temperature variations, thermal gradient, Kanto plain, Saitama

Japan Geoscience Union Meeting 2011
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AHW024-P04 Room:Convention Hall Time:May 27 10:30-13:00

Study on development of potential map for geothermal heat pump system

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Geothermal heat pump (GeoHP) system, which utilizes the shallow geothermal energy for cooling and heating, hot water supply and snow melting, is one of the energy saving systems. The system is widely used in Europe and the United States for years, and recently, in China and Korea, the installations spread rapidly. In Japan, however, its use is limited because of the lack of information on the advantage and the high initial most during installation. The promotion of the GeoHP system requires evaluating the effective utilization of the geothermal energy, verifying the stability of the system in long-term running and designing the environmentally friendly system. For these purposes, the potential of the geothermal heat pump system should be evaluate quantitatively and the suitable utilization of the energy also should be proposed. The aim of this study is to develop the potential map for the geothermal heat pump system. In this presentation, we review the previous studies about the geothermal heat pump potential (and potential map) and propose the approaches for the development of the potential map.

There are 2 main types of GeoHP systems, one is the system using groundwater directly and the other is the system using the heat exchanger. Both systems can be used as the ground heat storage system. The efficiencies of those systems are influenced by the geological and hydrogeological setting, but the contributions of each condition for it have not been demonstrated enough. There are some studies about the geothermal potential in Japan. In those studies, the geological settings, the groundwater level, the thickness of aquifer, the groundwater yield, the quality of groundwater, the groundwater velocity and the regulation of the pumping were applied for the system using groundwater directly as the indexes for the potential evaluation. On the other hand, for the system using heat exchanger, the geological settings, the groundwater level, the thickness of aquifer, the temperature of subsurface and the groundwater velocity were also applied. Few studies, however, about the quantitative evaluations of each index for the efficiency were performed. As future works, the organizing the previous studies and the quantitative evaluating the indexes empirically and analytically are required for the practical potential map for GeoHP systems.

Keywords: Geothermal heat pump system, Groundwater, Potential map, Geological information