Altering water and soil heat regimes with hot water applied for soil disinfection

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Applying hot water for soil disinfection becomes popular in Japan. Hot water application aims to disinfect soil pests with heat of hot water from 75 to 95 °C. Keeping soil temperature over 55 °C for 10 seconds to 4 hours has the effects on disinfecting the soil pests. The amount of hot water application is usually decided by farmer’ s experiences. Excess amount of hot water applied would result in ground water pollution and high fuel costs for a water boilers. The main objective of this study was to find out the unique differences between changes in the volumetric water content and the soil temperature in soil applied hot and tap water. In addition, because previous studies about temperature dependency of soil physic parameters were under around 60 °C, we figured out the temperature dependencies of the dielectric permittivity and thermal property.
We measured the changes in the volumetric water content and the soil temperature in upland soil treated hot and tap water. The amount of both treated water was 185 L m^{-2}. The hot and tap water were prepared as 95 °C with a water boiler and 25 °C, respectively. The volumetric water content was estimated by dielectric permittivity measured with TDR (Time Domain Reflectometry) sensor and the soil temperature was measured with the type-T thermocouple at 5, 10, 20, 40, 60, 80, and 100 cm deep from the soil surface, respectively. Temperature dependencies of the thermal diffusivity and the dielectrics permittivity were revealed. The thermal diffusivity and the dielectric permittivity of Kanto loamy soil were measured from 30 to 90 °C every 10 °C with the cylinder method and TDR, respectively.
The volumetric water content increased from soil surface to deeper soil with hot water application. The volumetric water content in soil in tap water treatment was higher 0.15 m^3 m^{-3} than it in hot water treatment from 5 to 20 cm depth during each water application. Soil temperature from 5 to 40cm was kept over 55 oC more than 4 hours, especially, soil temperature above 10 cm soil depth was raised over 80 oC for a few hours. The dielectric permittivity at 55 and 70 °C in high water content is smaller 15 and 30 % than it at 25 °C. We observed those differences between the volumetric water content in each treatment, because the temperature dependency of the dielectric conductivity.
Temperature dependences of dielectric permittivity of Kanto loamy soil were different at each water content. Especially, it was stronger at high water content. We observed that traveling time of waveform for calculating dielectric permittivity changed shorter with rising soil temperature. Temperature dependence of thermal diffusivity of Kanto loamy soil was strongest at relative water content is around 0.3. We thought that temperature dependency was enhanced by exiting the water vapor.

Keywords: Hot water soil disinfection, Water infiltration, Thermal property, TDR

Newly Developed XRF (X-Ray Fluorescence Spectrometer) Reference Standard Material Targets Low-High Content of Heavy Metals Analysis

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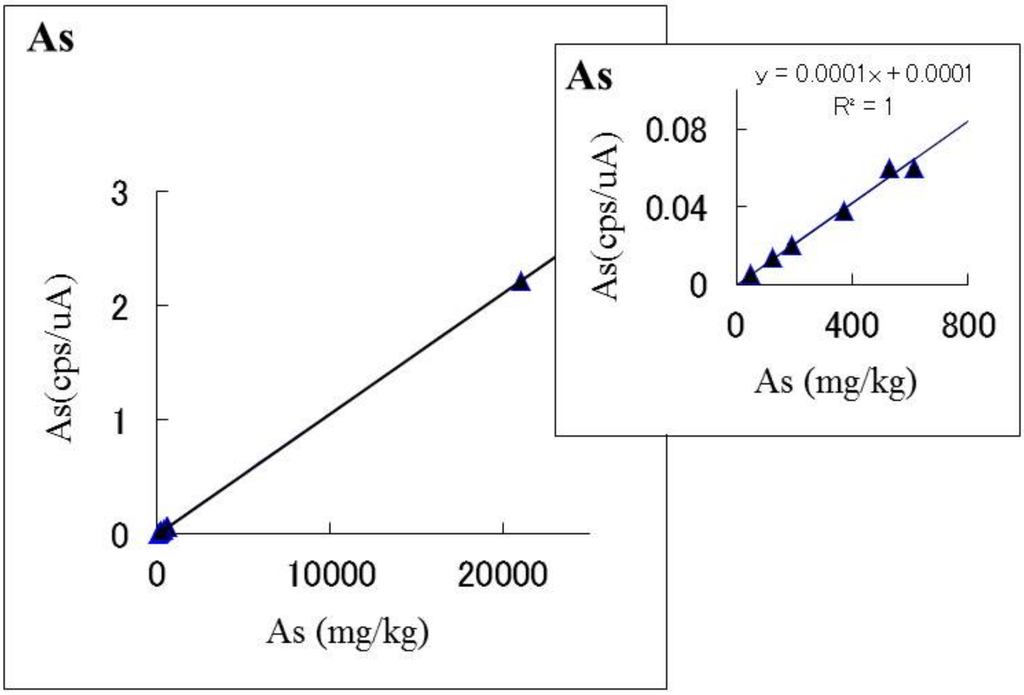
This research describes, in detail, the properties and application of newly developed eight Reference Standard Soils (ME1 Group) for XRF analysis including, experimental design, and the element analysis methods used to provide certified, reference, and information mass fraction values for 63 to 208 trace element constituents. The accuracy and detection limit of the analysis of heavy metals are affected by instrument, method and data processing error. XRF analysis of heavy metal is one of the time and cost savings process compare to conventional ICP-MS. The total number of portable XRF has been over 45000 all over the world at the stage of year 2010. Soil Standard has been used worldwide for the determination of major, minor, and trace element content of soils and similar materials. For precise results by XRF analysis high quality soil sample for calibration line preparation is mandatory. We succeeded to develop Reference Standard Materials for the determination of heavy metals in highly contaminated soil from the trace amount to high content (1 ppm −20000 ppm) by extending calibration line. Emphasis is placed on determination of priority pollutant elements (e.g., Cu, Zn, As, Cd, Pb). No chemicals are added to prepare Reference Soil. These New Reference materials provide the highly precise XRF results equivalent to ICP-MS data that cover the element mass fraction ranges that would be expected in typical soil samples analyzed by environmental research sections.

Keywords: Reference Standard Soils, XRF, Heavy Metals, High Concentration


As
As(cps/uA)
3
2
1
0
0
10000
20000
As (mg/kg)
As
y = 0.0001x + 0.0001
R² = 1
0.08
0.04
0
0
400
800
As (mg/kg)

Semiannually alternating exchange of intermediate waters east of the Philippines

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Intermediate water exchange in the northwest tropical Pacific is explored with the temperature, salinity, and current measurements of a mooring system deployed at 8°N, 127.05°E during 2010–2014. For the
first time, prominent semiannual variability (SAV; with the maximum power at ~ 187 days) of subthermocline
meridional flow along the Mindanao coast is revealed. A significant correlation between meridional flow and
salinity is found at intermediate depths. This provides direct evidence for the alternating transports of South
Pacific and North Pacific Intermediate Waters by northward and southward undercurrents, respectively. Further analysis with an eddy-resolving ocean general circulation model demonstrates that the SAV is generated locally near the western boundary, manifesting as large-scale subthermocline recirculation and leading to alternating northward and southward flows near the Mindanao coast, which plays an efficient role
in the intermediate water exchange of the northwest tropical Pacific. Mechanisms underlying the observed
SAV are discussed

Keywords: Strong semiannual variability, Significant correlation between current and salinity, Semiannually reversing water exchange

Numerical Analysis of Mass and Energy Transport in Subsurface and at the Soil-atmosphere Interface using HYDRUS

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It is broadly accepted that mass and energy fluxes in the subsurface in general, and in arid and semi-arid regions in particular, are closely coupled and cannot be evaluated without considering their mutual interactions. While the subsurface processes are commonly implemented in existing models, which often consider both isothermally and thermally induced water and vapor flow, the effects of slope inclination, slope azimuth, variable surface albedo and plant shading on incoming radiation and spatially variable surface mass and energy balance, and consequently soil moisture distribution, are rarely considered. These factors have been recently implemented into the HYDRUS model. In this presentation, the effect of soil heterogeneity and surface roughness on mass and energy fluxes in the subsurface and at the soil-atmosphere interface is evaluated numerically with the HYDRUS model. Additionally, we will demonstrate the use of the HYDRUS model to simulate processes relevant to the ground source heat pump systems.

Keywords: HYDRUS, Soil-atmospheric interface

Underground temperature change in the alluvial fan of the Nagara River, central Japan

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Generally, the underground temperature is constant except near-surface. The temperature in the near-surface (e.g. above 10 m depth) is annually changed due to the effect of seasonal change of ground surface temperature. As the thermal conductivity of rocks and soils are quite low, this seasonal change of ground temperature cannot reach below a certain depth. This depth is dependent on not only the thermal conductivity of rocks or soils but also the groundwater flow in a vertical direction. The constant temperature in a certain depth is almost consistent with the average of ground surface temperature. Low temperature geothermal uses such as ground-coupled heat pumps and groundwater heat pumps apply the temperature difference between surface and underground to the thermal energy use. As the underground temperature is constant, the underground becomes a heat source in winter and a heat sink in summer. Alluvial fans are recharge areas of groundwater and that rapid groundwater flow are expected. In this study, we clarify the distribution of the underground temperature in an alluvial fan to understand the potential of low temperature geothermal energy.
Study area is an alluvial fan of the Nagara River, central Japan. This alluvial fan is located in the marginal area of the Nobi plain. The underground of this alluvial fan mostly consists of sands and gravels and often intercalate thin fine sand and silt layers. The aquifers are divided by these sand and silt layers. The underground temperature of this area had been measured from May 2013 to May 2014 and from April 2016 to February 2017. The temperature is measured in boreholes with the length of 30 m. The measurement is performed once a month by a thermistor thermometer with the interval of 1 m depth. Ground temperature change in each depth of each well is well fitted by a sine curve. Average temperature, phase difference and amplitude of the temperature change in each depth of each well are calculated from the fitted sine curves. The results of underground temperature measurements show that the temperature profiles of most wells can be divided into two zones; the shallower apparent thermal conductive zone and the deeper thermal convective zone. The former is characterized by the decrease of amplitude toward downward, while the latter is almost constant temperature in the zone.
The thermal diffusivity is calculated from the temperature profiles of the shallower apparent thermal conductive zone. The distribution of the calculated thermal diffusivity is characterized by the lower values in the middle part of the fan and the higher in the marginal part. The thermal diffusivity cannot be calculated near the apex of the fan due to almost no shallower apparent thermal conductive zone. The values between the middle and marginal parts are greatly different. This suggests that the difference of the value results not from the thermal property of the formations but from the vertical velocity of the groundwater flow. The ground surface in the middle part is mostly covered by a silt layer and this would prevent water infiltration from the surface.
The temperature distribution in the deeper thermal convective zone is as follow. Phase difference of ground temperature against the river temperature basically increases from north to south in the southern side of the river. Although some wells far from the river seem to be out of sequence, the travel times of the groundwater from the river to these wells would be more than 1 year. The value of the phase differences of these wells should be added 1 or 2 years. The phase differences in the northern side of the river show different and complicated characteristics relative to the southern side. This suggests that the groundwater flow along the old river channels and from the tributary river plays an important role in the underground temperature distribution of the northern side. The distribution of the annual average temperature shows

that the wells near the river are lower temperature. The average temperature of the river water is lower than the average air temperature of study area. These lines of evidence suggest that the area near the river is the recharge area.
For the low temperature geothermal use, the natural change of the underground temperature is important for the efficiency of the heat pumps. The area where the phase difference is 6 months is the best, because the efficiency of the heat pumps becomes higher when the temperature of the heat source is lower during cooing and higher during heating. The potential study of the low temperature geothermal uses should contain the annual temperature change in the alluvial fans.

Keywords: underground temperature change, alluvial fan, Nagara River

Transport in strongly heterogeneous porous formations: Anomalous transport and validity of the First-Order solution

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Transport of a nonreactive solute in natural aquifer is deeply influenced by the spatial distribution of the hydraulic conductivity *K*, in particular when in presence of strongly heterogeneous aquifers. We analyze here a few features of transport in such formations by recent theoretical advancements as well as accurate three-dimensional numerical simulations. We examine the impact of permeability structures on the Breakthrough Curve (BTC) of solute, at a distance *x* from the injection plane, under mean uniform flow of mean velocity *U*. The hydraulic conductivity *K* is modeled as a space random function, resulting in spatially variable velocity and concentration fields. The theoretical and numerical results permit to test and discuss a series of transport features which occur in strongly heterogeneous aquifers, like for instance the BTC tailing, connectivity and the occurrence of anomalous transport. The validity of the classic first order solution, formally valid for small variability of *K*, is also tested through a series of three-dimensional numerical simulations. It is seen that the first order solution is quite robust in predicting the BTC, providing a simple and effective solution to be employed in applications.

Keywords: Subsurface contamination, Breakthrough Curve, Stochastic subsurface hydrology

Numerical Evaluation on Subsurface water distribution from Ring Emitter Irrigation

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Water scarcity causes the utilization of arid land not maximal in supporting agricultural production in Indonesia. It requires an effort to use water as efficiently as possible to improve and maintain the stability of land productivity. One option to improve the water use efficiency is to use subsurface irrigation systems. Ring irrigation is one of subsurface irrigation techniques based on indigenous materials and skills, in which a ring-shaped emitter covered by textile is placed in the root zone. Investigating soil water dynamic in the root zone under such irrigation is essential in order to understand the combined effects of practices and management. The laboratory experiments were conducted to evaluate soil water content at different irrigation water pressure values (10 and 1 cmH_2O) in coarse sand and finer-texture silt. The experimental data were used to calibrate the HYDRUS 2D/3D. Simulation results were in good agreement with the observed data. This study demonstrated that HYDRUS 2D/3D is an effective tool to predict soil water dynamics under the ring emitter irrigation for coarse and fine soils, therefore HYDRUS 2D/3D can be further used to optimize emitter design and operation.

Sensible Heat Balance Determines Subsurface Evaporation or Freezing and Thawing Rates

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Recent advancements in fine-scale measurements of soil thermal properties provide new opportunities to observe heat transfer associated with soil-water evaporation in the upper centimeters of the vadose zone and with soil freezing and thawing in the soil profile. Heat-pulse sensors provide all of the necessary measurements required for sensible heat balance determinations. The residual from a sensible heat balance (i.e., the net sensible heat flux minus the change in heat storage) is attributed to latent heat from water evaporation/condensation in unfrozen soil or to latent heat from freezing/thawing in partially frozen soil. Evaporation estimates from the sensible heat balance provide depth and time patterns consistent with observed soil-water depletion patterns. Sensible heat balance is particularly useful for quantifying the initial soil freezing rates. Implementation of fine-scale measurement techniques for the soil sensible heat balance provides a new opportunity to improve the understanding of soil-water evaporation and soil freezing.

Keywords: Sensible heat balance, Subsurface evaporation, Soil freezing and thawing

